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# NRE Staff Report

DATA NEEDS AND COLLECTION METHODS FOR ANALYSIS
OF AGRICULTURAL PRODUCTION POTENTIAL

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ABSTRACT

Concepts and methods used in five developing countries by the Comprehensive Resource Inventory and Evaluation System (CRIES) project for the collection of data needed in national/regional analysis of agricultural production potential are presented and discussed. Recommendations concerning data to be gathered and methods to be used in future USAID technical assistance programs are offered.

Key Words

Agricultural planning; natural resources; soil and climate mapping; developing countries.

ADKNOWLEDGEMENTS

The concepts and methods presented in this report were developed by the CRIES project staff in its provision of technical assistance to five developing countries. The material presented herein benefited considerably from review comments of James Johnson and John Putman.

## FOREWORD

This report is one of a series of papers prepared by the Comprehensive Resource Inventory and Evaluation System (CRIES) project to assist the Agricultural Office of the Development Services Bureau of the U.S. Agency for International Development (USAID/DSB) prepare the natural resources section of an Agricultural Policy Analysis project. Other relevant papers and reports prepared by project staff are found in the Bibliography.

The CRIES project was joint between the U.S. Department of Agriculture (USDA) and Michigan State University (MSU) in cooperation with the USAID under PASA #AG/TAB 263-14-76. Participation of MSU was covered under Research Agreement #12-17-07-8-1955 between the USDA and MSU.

The CRIES project used 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 collaborated 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 retained a consistent approach to resource inventory procedures so that transfer of land resource information among countries might become feasible. Efforts were focused on the use of existing data, supplemented by primary data collection and informed judgement. The approach was 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.

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## SUMMARY

Between 1976 and 1981, the CRIES project provided technical assistance to planning units of agricultural and natural resources agencies in five developing countries. The intent of the assistance was to provide the training and means for participating country staff to better evaluate national/regional policies directed at achieving agricultural production potential. Project staff, USDA and MSU professionals in agricultural economics, botany, remote sensing, soils science, agronomy, and systems science, endeavored to introduce well-tested U.S. techniques into the agricultural planning environment of the Dominican Republic, Costa Rica, Nicaragua, Syria, and Honduras.

Generally, CRIES encountered enthusiasm among planning agencies for the technical assistance offered. This was not surprising since each country was actively trying to increase crop and/or livestock production for domestic and export markets. Land and water resources were seen as limiting factors to this objective. Consequently, country agencies were generous in providing the local professional and support staff and logistical assistance necessary for CRIES participation. Even so, the amount of local input was sometimes less than desired due to severe shortages of skilled personnel and of agency funds for field surveys and for computer support.

This paper reviews data needs and collection methods for the CRIES approach to analysis of agricultural production potential. The approach has not been static but as will be indicated has been dynamic as new conditions and situations were encountered within and between each country. In view of the costliness of primary data generation, the variety of natural resources problems facing agriculture in developing countries, the paucity of data, skilled staff, support facilities, and funds which CRIES encountered, two general recommendations concerning data needs and collection methods are made. First, it is strongly suggested that before and even during data generation, the analyst(s) meet with the decision-makers for whom the data are of use. The analyst could thereby verify that he still understands the user's perception and priority of the resource problem(s) being studied. Second, it is suggested that the level of data detail and reliability should be appropriate for the problem at hand. Priorities should be established for gathering and updating the various data sets. Although these priorities would vary by country, a general set is provided.

# INTRODUCTION

In many developing countries, one-half or more of the population gains its livelihood directly or indirectly from agriculture. Hence, the sector is frequently relied upon to play a major role in national economic development. Pressures to increase commodity production to satisfy domestic and export markets, to increase domestic saving and foreign exchange, and to enlarge domestic markets for manufactured goods are constantly growing. Rising demand for agricultural commodities translates directly into higher derived demands for natural resources. A major issue in many countries, then, is to determine the current and potential ability of the country's resource base to produce and to meet these commodity demands.

Conditions constraining national agricultural production potential are widely varied. Governments are often only generally aware of problems such as underutilization of potentially highly productive soils, undesirable production practices like slash and burn agriculture, and inadequate infrastructure for commodity storage and marketing. They realize that a more profound understanding of the nature and extent of sector problems and of impacts of alternative "solutions" to them is necessary to more fully reach their country's agricultural production potential.

This paper focuses upon the data and data collection methods needed to assess, within the context of agricultural information systems, agricultural production potential from a national/regional perspective. The concepts and methods presented are those developed and/or tested in the Comprehensive Resource Inventory and Evaluation System (CRIES) project.

Organization of the paper is as follows:

Conceptual basis of agricultural information systems (AIS).
Agricultural production potential.
The CRIES project approach to analysis of agricultural production potential.
Data needs and collection methods under the CRIES approach.
Recommendations for future work.

## CONCEPTUAL BASIS OF AGRICULTURAL INFORMATION SYSTEMS

Over the past several decades, national and international agencies have financed innumerable efforts to produce data and information on sector problems and paths to development. Unfortunately, a literature review in the natural resources disciplines suggests that the proliferation of data and analyses has often not produced desired results. Typical criticisms of these agricultural information efforts include: users are not clearly specified, problems are imperfectly described, simplifying assumptions of theory upon which researchers base their work and the resultant implications of those assumptions on "solutions" proposed are not discussed, relationships modeled are too simple to be useful in so heterogeneous a sector, or conversely by other critics, models are too complex to be understood.

The breadth of criticisms levied suggests that closer attention be paid to determining how useful information is generated. Demand for information presupposes a problem(s) about which information is needed and one or more persons who have a use for the information. These two components and several intermediate components of a generalized information system are depicted in Figure 1.

The fundamental reason for the existence of an information system is the presence of a problem or set of problems. A clear specification of the problem is absolutely essential if the researcher is to meet the decision-maker's needs. In general, any resource problem is multi-faceted. For example, if the problem is only stated as periodic flooding of rural lands, the researchers may concentrate only on ways to protect the affected area from flooding without having time, funds, nor inclination to determine if flooding is the major cause of low incomes of rural people, the real problem of interest to the decision-maker. Furthermore, concentration on flood protection methods (primarily requiring civil

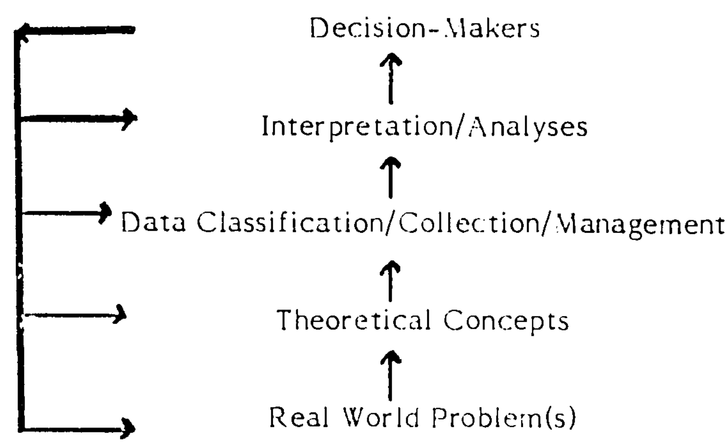


Figure 1. -- A Generalized Information System (adapted from Bonnen, 1975, p. 758).

engineering data) may lead the researcher to ignore determining beneficial effects of flooding or possibilities of changing cropping systems and their location (requiring soils, agronomic, and socio-economic data). To reiterate, the problem must be specified as it is perceived by the decision-maker. This requires periodic communication between the decision-maker and the researcher as perceptions of the former may change.

The cost of generating reliable data on all aspects of a problem is normally prohibitive. Once the problem is identified, the researcher must be able to use theoretical concepts to reduce the problem to a manageable size. Usually this requires interaction of several disciplines. For example, the agricultural economist knows that an infinite number of factors, some quantifiable and others not, will determine how any one farm operator manages his operation. Economic theory hypothesizes that the operator is rational, i.e., that he operates to maximize profits. This simplification allows the economist to concentrate on gathering data on costs and returns of various operations. Other researchers similarly must reduce the problem to those parameters that they have been trained to know are significant. In this way, researchers focus their efforts on developing the most important data sets while still recognizing their incompleteness.

Data classification, collection, and management (data storage and retrieval) are pursued in various ways depending on the problem, data to be gathered, and skills available. Some of these are discussed below. In the next step of interpretation and analysis of the identified problem, the major production of information is created. The degree of its usefulness depends wholly on its use by the decision-maker. Figure 1 is drawn to show that the process occurring in an agricultural information system is iterative. The decision-maker who may be the Minister of Agriculture or members of his staff may, by interacting with the researchers, suggest modifications of any of the previous stages -- problem definition, application of theory, kinds of data gathered, and choice of analysis undertaken -- until the desired level and quality of information is obtained.

## AGRICULTURAL PRODUCTION POTENTIAL

Effective agricultural planning and policy analysis in developing countries requires knowledge about supply conditions of agricultural products. Knowledge about both physical and economic supplies of the resource base with and without development allows analysts to trace through underlying production processes to determine derived demands for land and water.

The physical supply of the natural resource base is determined either by primary inventory or compilation from existing secondary sources. These data may be considered <u>resource capacity data</u>. They measure the innate potential of the resource base. They are collected less frequently than the <u>performance data</u> outlined below but, because of the enormity of the collection task, should be collected on a continuing basis.

Physical supply categories of the resource base are:

land - this is broadly defined to include data on all of the earth's surface (soil, minerals, water, etc.) as well as climatic phenomena such as sunlight, precipitation, wind, etc. Each component is composed of units of differing quality with respect to agricultural production. In addition to making quality rankings, physical scientists interpret each component in terms of its use in agriculture, for example, corn yield or erosion production under a particular kind of management.

human - this category includes demographic data and types and quantities of skills important to agricultural production.

institutional - this category includes data on customs, attitudes, infrastructure consideration (market location, transport facilities), and tenure, water rights, government agency responsibilities and effectiveness.

Short-run economic supply of the resource base is determined by identifying the current use of the land, human, and institutional resources for agricultural production. This current use is a function of the quantity, quality, and location of the resource base, of the costs of using the base in alternative ways, and of commodity prices. Economic supply is quantitatively equivalent in equilibrium to the derived demand for land, human, and institutional components of the base. Generally, derived demand for these components shifts as a result of changes in the technological processes (or input prices) used to produce commodities and/or to changes in commodity prices.

In addition to gathering physical and economic supply data, analysis of agricultural production potential requires generating data on a) capacity of the resource base when it is modified with development practices such as drainage (land), academic training (human), and reorganization (institutional). These investments in the resource base directly affect the capacity of that base over the long run; and b) performance of the unmodified or modified resource when it is used in a previously untried way such as using improved seed where only native varieties had been common.

The second general type of agricultural data -- <u>performance data</u> -- are generated in determining economic supply. These data account for inputs to commodity production processes, inputs such as land, labor, chemicals, seeds, capital equipment, management, and input prices; product outputs or yields; commodity prices; and marketing costs. Because performance data tend to fluctuate more widely than resource capacity data, they are collected more frequently.

The discussion has been broad up to this point. An enormous variety of data could be gathered. Specification of data sets to be generated are even still dependent upon the perception of the agricultural production potential problems held by a given group of decision-makers. Limits to budget, staff, and facilities require that priorities be set on each parameter to be measured and the quality to be obtained. The CRIES project's approach is one path to narrow this exercise.

## THE CRIES PROJECT APPROACH TO ANALYSIS OF AGRICULTURAL PRODUCTION POTENTIAL

Between 1976 and 1981, the CRIES project provided technical assistance to developing countries in land classification, inventory, and analysis. Stated objectives of the assistance were to develop within a country the means to evaluate national/regional agricultural production potential. This required:

1. developing a nationally-consistent natural resources classification and analytical framework; and

2. helping national planning agencies strengthen their capacity to determine the extent, quality, and use of the resource base, and to evaluate impacts of alternative uses of that base.

Intended users of the information produced were public officials with policy-making responsibilities at national/regional levels and their immediate technical staff. It is recognized that these users would usually need other types of information in addition to that about production potential in order to make decisions on policies, programs, and projects in the agricultural sector.

Budget limitations led CRIES to restrict itself to the following activities:

- classifying and compiling reliable secondary data or generating a limited amount of primary data on the land (soil, water, climate) resource base.

- classifying, compiling, or generating data on current use and associated costs and prices of the cultivated cropland and pastureland parts of the resource base.

- storing resource base and resource use data in computer files, displaying geographic data on maps, and undertaking economic analyses of current use patterns and of alternative policies on agricultural production potential.

- training host country staff in each of the above.

Activities planned but not undertaken would have included gathering data on human and institutional aspects of the resource base, gathering further detail on crop and livestock production practices and establishing on-going sample survey programs to significantly raise statistical reliability of resource base and use parameters, and developing technical coefficients on prospective development operations and new management practices.[1]

## DATA NEEDS AND COLLECTION METHODS UNDER THE CRIES APPROACH

### Land Resource Base

CRIES staff prepared a land resource base report for each participating country.[2] The reports provide planners with additional capability to explore national/regional questions about current and potential capacity to produce alternative levels and mixes of food, fiber, and export crops. They provide a basis for determining comparative advantage of various land resources in production of agricultural commodities. Prepared from a variety of available sources using different methodologies and from recent satellite imagery and field collection of plant specimens, each report suggested areas that would merit analysis of more detailed surveys and preparation of new resource data.

### RPU-PPA Concepts

To provide for analyses of comparative advantage in the use of agricultural resources, CRIES staff determined that these resources be inventoried and aggregated into relatively uniform areas for which reasonable, unique estimates about land use, crop productivity under various management practices, and development options could be made. In addition, these resource units needed to be geographically identified and mapped so that they could be cross-referenced with administrative boundaries, data on resource use, and other information essential to assessing production potential.

The need for both a homogeneous resource area and a geographically identified resource planning unit led to definition of a) a homogeneous resource area called a Production Potential Area (PPA), and b) a geographically and cartographically identified unit called the Resource Planning Unit (RPU).

In the context of national/regional analysis, RPUs and PPAs were defined as follows:

> Resource Planning Unit -- An RPU is a geographically delineated unit of land that is relatively uniform with respect to land forms, kinds and patterns of soil bodies, climates, and potential vegetation.

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[1]Important USDA methods for collection, summarization, and dissemination of performance data are described in Johnson, James B., et al. The Relationships Between the Area-Frame and CRIES Projects. Staff Report AGESS 810720. NRED/ESS/USDA. Washington, D.C. 20250. July 1981.

[2]These were the Dominican Republic, Costa Rica, Honduras, and Syria. Work was undertaken, but not completed, with the Ministry of Agriculture in Nicaragua to prepare such a report.

Production Potential Area -- A PPA is an aggregate area of individual soil bodies and associated 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 analysis and planning. PPAs are not mapped because their geographical extent and location are generally too detailed for national/regional planning.

The RPU and PPA concepts reflect relationships among soils, climate, and plant growth necessary for agricultural production. Soil characteristics such as broad moisture and temperature regimes, the presence or absence of diagnostic horizons and soil properties, and other factors differentiate soils and, in turn, affect the adaptability and vigor of plants. Variations in climate are reflected in the distribution of specific plant species within broad vegetative patterns.

RPUs are generally composed of a variety of similar and often contrasting soil bodies and climates which may occur in intricate and complex spatial patterns. Such complexities, however, are generally regular and repeating in nature and are uniquely different from the spatial patterns of other RPUs.

RPUs serve several purposes. They divide the landscape into natural, physiographic planning units. Described with respect to their topography, soils, and climate, they can serve as reference points for field technicians. Since they are map units with an obvious geographic location, it is possible to determine their agricultural use from existing data. This is important because most tabular resource data are only available by administrative and not by natural boundaries.

RPUs are usually too varied to permit agronomic interpretation.[3] Hence, the individual major soil bodies and associated climates composing an RPU become the analytical areas, the PPAs, for agricultural potential analysis. Most RPUs have two or more PPAs. Estimated agronomic interpretations at the PPA level are possible because of greater homogeneity in soils and climate. Major criteria for defining PPAs are soil properties, particularly slope, depth, texture, and drainage. As indicated, PPAs are not mapped because their geographical extent and location are generally too detailed for national/regional mapping.[4] Thus, PPA data on land use, costs, etc. must be disaggregated from the RPU of which the PPA is an unmapped part. Policy choices can be based upon estimates of the area, distribution, and patterns of PPAs within an RPU.

[3]RPU = PPA when there is one PPA in the RPU.

[4]At the same time, those interested in project-level planning could map these national-level PPAs for a particular region or subregion into project-level RPUs. More detailed soils and climate analysis would then be done within these new project-mapped RPUs to create project-level PPAs.

PPAs are recognizable from the source materials used in developing the basic soil and climate studies. The criteria for establishing PPAs may also be described by example. Consider a geographic area consisting of steeply sloping limestone ridges with shallow stony soils separated by level or nearly level ground with deep nonstony soils; the two kinds of landscape are of nearly equal extent and the climate is uniform throughout the area. Neither landscape by itself is sufficiently extensive to be considered an RPU, so the two landscapes are mapped as one unit. The steep ridges comprise one PPA and the intervening level ground comprises the other PPA; each has unique potential, or lack of it, for agricultural use.

The proportion of an RPU that is represented by a PPA is etimated on the basis of the resource scientists' accumulated knowledge about the RPU. In some instances, the figure can be based on field observations, in other cases by use of reference maps, and in yet other situations by use of judgement and previous experience. Rarely would precise measurement of the extent of PPAs be undertaken.

Data Collection

Soils. In order to work with the RPU and PPA concepts, a knowledge of the kind and distribution of soils is essential. This knowledge is most easily acquired from published soil surveys or related subjects such as geology or vegetation.

Soil surveys provide data on soil quality, extent, and location and predictions about how soils will behave under specified conditions. Soil surveys provide determinations and predictions of the following soil qualities: 1) susceptibility to deterioration, that is, erosion; 2) suitability for management operations and land preparation. Irrigation and drainage are management operations that require considerations specific to particular regions; 3) crop yield response to different sets of management practices; and 4) identification of constraints on land use. These constraints may be permanent, such as slope; removable with periodic attention, such as restricted drainage; and removable with continuing attention, such as lack of nutrients.

The three elements of a soil survey are: field and laboratory study of soil properties and characteristics; classification such that one soil or group of soils varies from another in one or more properties to such a degree that the combinations of all properties result in different crop responses to management. A hierarchical classification, the U.S.D.A. Soil Taxonomy, permits grouping soils into the category (order, suborder, great group, subgroup, family, series) most appropriate for evaluating national/regional production potential; soil mapping in order to be able to make more precise statements about mapped subdivisions of the area than about the area as a whole. Soil descriptions and the proportions of the soils in each map unit are included with the map.

Choice of survey intensity is a function of the problem to be analyzed, budget and staff availability and skills, and availability of base maps and other sources of information. If topographic maps, for example, are unavailable, other sources such as aerial photos, radar imagery, satellite imagery, mosaics of such photos, planimetric maps, orthophotos, or tabular data, would be used. To a much lesser extent, availability of other land resource information such as weather records, maps of geology, land use, and of vegetation, weather station data, etc. influences the degree and/or feasibility of soil resource inventories at different levels of detail.

Data reliability and cost among alternative survey designs can be ranked from 1 (most reliable and most costly) to 6 (least reliable and least costly): 1 -- detailed field study with remote sensing (aerial photography, satellite imagery) support; 2 -- detailed study without remote sensing; 3 -- reconnaissance study with remote sensing; 4 -- reconnaissance study without remote sensing or only remote sensing with field checking; 5 -- exploratory study without remote sensing or only remote sensing; 6 -- schematic compilation only (Cline, 1978).

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

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

reconnaissance - only a part of the boundaries are observed on the ground. Requires some field work although parts of the maps created may be generalized from detailed maps for some areas. Should be preceded by a schematic map from available evidence on relief geology, climate, and/or vegetation. Sample areas are checked on the ground; also called "semi-detailed."

exploratory - boundaries are obtained from existing sources; soil associations are identified through limited field checks.

As indicated above, field study may be supplemented with both satellite imagery and aerial photography. Many of the soil-forming alterations of underlying geologic material underway for eons are significant in the landscape formation. The balance between erosion/sedimentation and climate/living organisms influences to a large degree where certain soils will occur and what their properties will be. Interrelationships between geologic material, landscape, land use, and soil help form the basis for large area soil delineation. A multi-stage approach to determine soil-landscape information could include interpretation of small-scale, e.g., 1:500,000 black-and-white multispectral Landsat imagery complemented by use of both dry and wet season false color composite imagery; interpretation of low-altitude aerial photography; and field verification of mapping units and sampling of representative soils.

Costs of soil surveys in developing countries depend on a variety of factors such as climate, transportation, health problems of field personnel, wage levels, availability of secondary data (topographic maps, meteorological data and maps, aerial photos, orthophotos, photomosaics, satellite imagery), and country requirements that laboratory and mapping work be done in national facilities. Reviews of cost estimates vary widely. For example, in one widely cited work, a study by the Organization of American States for tropical Ecuador, presented the relative costs of detailed, semi-detailed, and reconnaissance soil surveys as 24, 8, and 1, respectively (OAS, 1964).

Faced with lack of time and funds to undertake a national soil survey, the general approach followed was to standardize existing soils studies to one common soils classification and to use studies from related disciplines, satellite imagery, and limited field observation in order to produce a nationally consistent soils inventory. The procedure carried out in one representative country is described in some detail as follows:

> In Honduras, information about the kinds and distribution of soils is found mainly in generalized studies dealing with the country as a whole or in major portion and a few large-scale soil maps of small areas. Some additional detailed information is found in special studies on soil related subjects such as land use, forestry, and climate. For purposes of this study, the former sources were of greater importance because of their more specific applicability to soils and because they afforded wider coverage. The more detailed studies of relatively inextensive areas were consulted for the purpose of characterizing units in the generalized studies. In general, data on the physical environment, the physical and chemical properties of the soils, and cultural practices were meager.
>
> Principal sources used were the 1969 publication Los Suelos de Honduras with its 1:300,000 scale map prepared under the leadership of C.S. Simmons; the OAS Mapa Parcial de Honduras at 1:250,000 scale with a draft report prepared by Kirk P. Rodgers, and visual inspection of the Chamelecon, Sula, Siria, Talanga, Comayagua, and Choluteca valleys and southern coastal plains. The Simmons map provided little or no information on the composition of soils in the valleys. These sources provided the basis for delineating areas of kinds of soil on the soil map to be compiled. A list of principal sources is provided in an appendix of that report.
>
> In the previously published works, several systems of classifying soils had been used. By using descriptive materials that were available, the soils were reclassified in terms of a common system, 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. Data were sufficiently meager that the classifications derived should be considered tentative pending completion of more detailed studies.

Landscapes were characterized in terms of ranges of slope and nature of the underlying materials. Ranges of slope were estimated from topographic maps of 1:250,000 and 1:500,000 scales available in the United States and from satellite imagery. The nature of the underlying materials was obtained from sources dealing with geology and from information available in legends of soil maps.

The base map for the newly compiled soil map consisted of the sheets of the 1:500,000 topographic map of Honduras. Soil map units were delineated on mylar overlays (USDA/MSU, 1980, pp. 5-7).

Climate. Climate classification is highly complex. In contrast to soils, no one system is widely accepted. Choices of parameters considered important to plant growth vary widely. They include mean temperature measured annually, by season, month, day, and hour; highest average; lowest average; solar radiation, indications of frost and probabilities of frost; effective temperatures for plant growth; number of wet or dry seasons; rainfall distribution; day length; effective radiation; continentality of climate; degree days in combination with a variety of precipitation and moisture indices, with potential evapotranspiration (PET) and often available soil moisture (calculated in various ways).

Some of the differences between systems, for example, annual vs. daily temperature, are probably due to different end purposes of the classification. Still there are fundamental conceptual differences. The following quotation is representative of many specialists:

> "We have a vast accumulation . . . of quantitative descriptive data about weather and climate. These descriptions have been systematized . . . into many classifications. Few tell the working farmer anything he does not already know, though some have led . . . planners to disaster" (Bunting, 1968, p. 312).

Part of the problem is that in different agricultural situations, different climatic factors are critical to plant growth. L. Holdridge, J. Papadakis, G.W. Thornthwaite, and others note that a certain level of rainfall in the tropics provides only a dry climate whereas the same level in a cold climate creates a relatively damp environment due to differences in PET. PET and the various derivations from it such as moisture regime attempt to show that availability of water to plants is not totally dependent on rainfall.

In fact, a Thornthwaite associate claims that precipitation is totally irrelevant in Holdridge's Plant Life Zone Chart, a ecosystematic classification widely referenced in the Americas. He feels that within the tropics and especially when the problem of tropical savanna vegetation associations are considered, the role of climate loses importance. In contrast, some experts feel that the broad classification of climatic and vegetation types is more closely related to rainfall than to any other parameter (WMO, 1976). Perhaps the best system for practical application will ultimately require a regional approach.

The role of climatic/ecological data to determining a country's national/regional agricultural production potential is important but apparently no more than supplemental to other resource data at this point in time. An appreciation of the drawbacks of crop group recommendations on the basis of less-than-adequate climatic data is suggested by the following quotation:

> The much more difficult one (problem) is to predict the agricultural prospects of a new region from climatic data which are usually incomplete or fragmentary. In my own experience, it is usually possible to tackle this negatively; one can exclude areas because the period during which rainfall equals or exceeds potential evaporation (the favorable period) is too short in too high a proportion of years; but to make a positive recommendation from survey data alone, that a specific new type of agriculture should be established is an exercise in which I hope never again to be involved. The uncertainties involved are so great that, without the experience of at least five seasons of experimental research and pilot scale farming, no recommendations should either be made or accepted. This is one of the most important lessons of the contrasted experiences of the East African Ground Nuts Scheme and the development of the Sudan rainlands (Bunting, p. 365).

Climate and vegetation parameters considered significant in the CRIES-assisted countries were: length of and average precipitation and temperature during the wet season(s), similar data for the dry season(s), average annual temperature and precipitation, and monthly evapotranspiration.

CRIES used several methods to gather and map climatic data. This varied by country but the basic procedure was to obtain published meteorological data (precipitation and temperature, average annual and average monthly) records for each weather station and maps drawn from these data. Usually, comparisons of climatic studies revealed numerous inconsistencies. Botanists would then gather naturally occurring plant specimens throughout the country where land transportation was feasible. Their knowledge of plant requirements and limited observation from low-flying airplanes allowed them to map areas of similar macroclimates.

**Creation of RPUs and PPAs**

Creation of RPUs and PPAs is largely a matter of judgement. Knowledge about the kinds of soils, climate, natural vegetation, and their distribution are combined to create broad segments of the landscape that are relatively uniform with respect to the physical environment within which specific kinds of farming can be carried out with expected results.

The actual process of identifying and mapping RPUs involves superimposing transparent mylar copies of the working-level soil and climate draft maps over topographic base maps. Areas that are relatively uniform with respect to or which have similar patterns of topography (particularly slope), climate, and broad soil groupings are outlined. The size and number of delineations is strongly influenced both by the need for a legible map and by the validity of the resource data.

As an illustration, a simple RPU may be one in which a single soil grouping on uniformly sloping topography occurs in a single climatic region, i.e., a hypothetical area of Typic Ustifluvents on level (0-3 percent slopes) lands having 800-1100 mm annual precipitation which falls mostly between May and November. In contrast, more complex RPUs comprising several combinations of slopes, soils, and climates which occur due to changes in altitude, aspect, and/or latitude may be quite common.

Figure 2 presents the RPU map produced for Honduras. Figure 3 presents the soil and climate properties of one RPU and its component PPAs in both text and tabular form.

**Agronomic Interpretations for Agriculture**

In the last section of Figure 3, Interpretations for Agriculture are presented. The degree of detail was a function of the resource data available. In one country, Honduras, only general interpretations for agriculture concentrating a) on soil potential for cropland use under four types of cropland management, and b) on limitations and restrictive features of the land resource base for production could be made. In another country, Syria, greater availability of resource data, in particular about the extent and use of water, permitted making both general interpretations and crop specific recommendations to denote where major crops or crop groups would be adaptable and some qualitative indication of their yield potentials by PPA.

In the Honduras study, the general interpretations were: "soil potential for cropland" and "factors limiting land use." Recommendations were made based solely on knowledge soil scientists had of soil features and attributes.

Soil potential for cropland use is a partial expression of expected soils performance in a given climate and under a particular kind of management. Only the physical soil characteristics such as texture, internal drainage, and depth were considered since chemical characteristics were not known. Three soil potential ratings -- good, fair, and poor -- were estimated for four different kinds of cropland management.

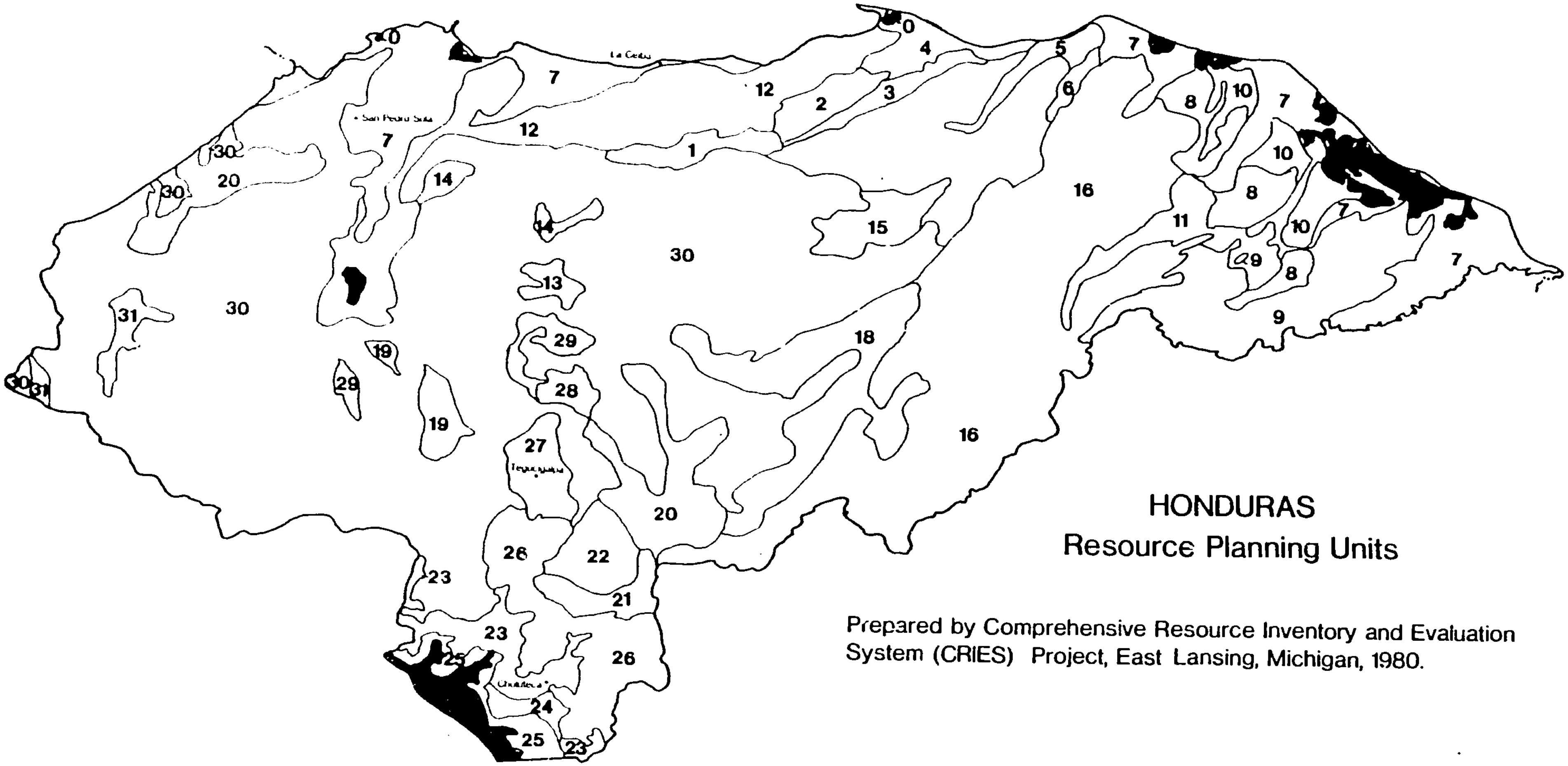


Figure 2. -- Resource Planning Units for the Republic of Honduras

Figure 3. -- RPU 12 for the Republic of Honduras

## Description of RPU 12 and Its Three Production Potential Areas

RPU 12 consists mainly of the Nombre de Dios Mountains (Atlantida) and a westward extension of the area lying east of the Ulua Valley and southward around Lake Yojoa. This area of 602,000 hectares ranges in elevation from sea level to more than 2,000 meters. Soils are shallow to moderately deep. Warm temperatures prevail all year. Annual rainfall is high with less rainfall in the west and minimum rainfall occurring between November and April. Three PPAs are distinguished on the basis of differences in soils and slopes.

PPA 12-1, nearly 90 percent of the area, is a complex of shallow (lithic) and moderately deep soils, all of which occupy the steep slopes of mountains and hills. Most prominent are Lithic Eutropepts, Lithic Rendolls, Typic Tropohumults, and Typic Dystrandepts. Because the soils are shallow and stony and all are steep and erodible, this PPA is most suited for forest use.

PPA 12-2, about 5 percent of the RPU, has two principal soils, Typic Tropohumults and Typic Dystrandepts, that are not so shallow and steep as those of PPA 12-1. Because of their hilliness, however, their use should be limited to tree crops, pasture, to avoid severe erosion.

PPA 12-3 makes up the remainder of the RPU. Chief soils are Typic Dystrandepts, Typic Tropohumults, and Fluventic Eutrochrepts. These undulating to rolling soils can be reasonably productive with row crops on the gentler slopes and hay and pasture or tree crops on more rolling areas.

Parameters of Production Potential Areas in RPU 12

| PPA PROPERTIES | 12-1 | 12-2 | 12-3 |
|---|---|---|---|
| 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)[1] 1550-3550 mm. | |
| average temperature | | 23-27°C | |
| - Wet Seasons | | | |
| average monthly precipitation | | 150-300 mm. | |
| average monthly temperature | | 23-26°C | |

Figure 3 (continued)

| PPA PROPERTIES | 12-1 | 12-2 | 12-3 |
|---|---|---|---|
| months | | From May through October; from May through December, January or February. | |
| - Dry Seasons[2]<br>average monthly precipitation<br>months | | Very variable due to the variability of the wet season. | |
| **SOILS** | | | |
| principal components | Lithic Eutropepts<br>Lithic Rendolls<br>Typic Tropohumults<br>Typic Dystrandepts | Typic Tropohumults<br>Typic Dystrandepts | Typic Tropohumults<br>Typic Dystrandepts<br>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 |
| **INTERPRETATIONS FOR AGRICULTURE** | | | |
| soil potential for cropland | Management Type<br>I: poor; II: poor; III: poor; IV: poor | Management Type<br>I: fair; II: fair; III: poor; IV: good | Management Type<br>I: good; II: fair; III: fair; IV: good |
| factors limiting land use | slope; shallowness; stoniness; erodibility | slope; erodibility | slope; erodibility |

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

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

A "good" rating implied high production potential at low long-term risk to the soil and for the expected crop. Soil and climate limitations were minor. If necessary, soil limitations would be easily correctable.

A "fair" rating implied average production potential and some risk to the soil. Soil limitations presented some difficulty in use of equipment and required special management practices to produce the above average yields naturally occurring in a PPA rated "good." These limitations included moderate wetness, low available water capacity, erodibility, slope, subsoil restrictions, salinity, and poor physical conditions for tilth. In those areas where soil limitations were minor or nonexistent but seasonal dryness was important, a "fair" rating was also used.

A "poor" rating implied low yields or unacceptable production potential and/or high risk to the long-term productivity of the soil resource. Either severe climate or soil limitations were present. Typical soil limitations included 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).

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. As a result, PPAs described as being poorly drained or excessively drained or that were 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. Soil properties adversely affecting potential included: shallowness to bedrock; depth to restricting layer; wetness; susceptibility to flooding; steepness of slope; texture; stoniness; extreme acidity, sodicity, or salinity; and erodibility. The major climatic feature was seasonal dryness.

In contrast to the Honduran study, data were available to permit making two levels of interpretation for each PPA in the Syrian study: a general interpretation for agriculture with ratings for inherent productive capacity, susceptibility to erosion, and most intensive land use; and major crop recommendations.

Inherent productivity denoting soil capacity to produce acceptable crop yields was inferred from information on soil mineralogy, parent materials, soil reaction, and moisture relationships. Ratings were very low, low, moderate, and high.

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

Most intensive land use, cropland, pastureland, rangeland, and woodland, denoted the recommended use affording maximum sustained production of cultivated crops or permanent vegetation consistent with soil and climate potentials and limitations. Cropland use could be differentiated relative to irrigated and nonirrigated uses.

The second level of interpretations, major crop recommendations, by PPA, indicates where major crops or crop groups were adaptable. They provided an indication of yield potential under alternative management levels and under dryland and irrigated conditions. Yield potentials were expressed as high, medium, or low.

When a crop or crop group was rated "high," PPA conditions were reported or inferred to be compatible with known requirements of the crop or crop group. When rated "medium," PPA conditions were considered to be marginal 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," PPA conditions were considered to be incompatible with several of the known crop requirements. Yields could be highly variable from year to year. "Low" ratings were also used to acknowledge that crops with highly variable yields were traditionally cultivated to some extent in the PPA.

The crop groups employed for the recommendations in Syria were: small grains; fruit trees (rosaceous and non-rosaceous); oil crops; cotton; pulses; tuber/bulb crops; vegetables; olives; grapes; and citrus.

## Current Use of the Land Resource Base

Interpretations made in the county land resource base reports were agronomic in nature. Their specificity depended upon the information available. Once the physical resource base was so defined, CRIES proceeded to develop socioeconomic data sets. The collection of these agricultural performance data, described in the following section, and associated with PPAs, would make possible economic interpretations needed for resource decisions. CRIES approached socioeconomic data generation in three stages. In the first stage, available sources and remotely sensed imagery were studied to determine major land use. Secondly, a more detailed study of available materials was undertaken to estimate cropping patterns by RPU and PPA. In the third stage, cropping pattern data would be refined and input costs for representative crop production activities, marketing costs, commodity prices, etc. would be generated. This third step was to be implemented by an in-country team with a CRIES resident advisor. Although training in methods took place in several countries, this step, a very intensive process, could only achieve a beginning in one country, the Dominican Republic.

Agricultural performance data measure inputs, outputs, and other aspects of the performance of the sector. Periodicity of collection varies by country and parameter; it may range from every ten years (for example, level of farm machinery investment as measured in the national census) to every year (for example, crop area harvested as measured in annual surveys).

Due to the high cost of primary data generation, the need for data covering the entire country, and the high importance placed on training country staff in concepts and procedures, the CRIES approach emphasized a) training in concepts and the advantages/disadvantages of alternative procedures; b) studying methodologies of existing studies and then, if appropriate, incorporating that data to the extent possible into a first approximation of a nationally-consistent data set; c) generating primary national/regional data using techniques considered highly cost-effective and readily manageable by host agency staff; and finally, d) discussing concepts of techniques capable of generating statistically reliable data and supporting agency efforts to train staff and obtain the facilities necessary.

## Major Land Use

The CRIES project used several methods to develop major land use (cropland, pasture, forest, etc.) estimates by RPU and then inferentially by PPA, the homogeneous but unmapped analytical units within each RPU. Choice of methods depended upon the availability, currency, and reliability of existing studies and the skills and facilities of the national agency.

In each country with which CRIES staff worked, the starting point for major land use data was the most recent Census of Agriculture. Many problems unique to each country arose in trying to use this data but in all cases it was the only national level source of information available. Each country also had data sets gathered in special use or problem surveys such as surveys to determine the extent of coffee rust or to determine area planted and production of basic grains. These were taken more frequently than the dicenial census.

Because all such information was collected by political unit, such as county or province, allocation methods were required to distribute these data to the natural resource units of RPUs and PPAs. Occasionally auxiliary sources of mapped land use data were available from sources such as commodity commissions. Often the data were limited in usefulness because they did not fully exhaust the land resource base, i.e., only land used for agricultural purposes had been surveyed, or the data were out-of-date and not representative of current land use.

Visual interpretation of Landsat imagery was often used to develop maps of major land use and/or cover types. Visual interpretation of Landsat can be a cost-effective method for delineating major land uses when it is used appropriately. It does not require highly skilled personnel nor expensive computer facilities. Land cover/use classifications were selected to be closely compatible with the land use categories for which statistics were periodically collected by the participating government.

A brief discussion of methods and concepts used in two countries, quite different in terms of climate, soils, and data sources, to determine major use of RPU and PPA, is presented to illustrate the CRIES approach.

Dominican Republic. Major land use information was derived largely from an eight-year old Census of Agriculture. Because the Census accounted only for land in agricultural uses, these areas were subtracted from total land areas in each political region to establish nonagricultural uses by political region. Total land area in each political region and RPU were estimated by digitizing both the official political map of the country with its province and national boundaries and the RPU map and then using CRIES computer software (CRIES, July 1980) to measure RPU land areas by region. Census estimates of major agricultural land use were assigned to RPUs by simply multiplying region estimates by the ratio of RPU size to region size. Additional adjustments were made based on non-census information of irrigated and nonirrigated areas.

Discussion with Dominican staff about the reasonableness of this procedure led to a second method -- that of visually interpreting Landsat satellite imagery -- to refine use allocation. A mosaic of the most cloud-free images (over the 1972-1979 period) was created for the country. Interpretations of 12 land cover/use classifications were made. Limited field checking was done to assist the interpretation task. The categories were: urban and built-up; sugarcane; mixed agriculture; marginal agriculture; pasture; rangeland; limited rangeland; predominantly deciduous forest; predominantly coniferous forest; wetlands; barren/open; and water.

The total area in each category was digitized and measured by each planning region using the software package.

Syria. Major land use data provided an example of precisely defined categories for which data were gathered annually. The categories were: cultivable land; steppes and pastures; rocks and sand; water; buildings and roads; and forest. "Cultivable land" was further defined into quite explicit subcategories:

1. Cultivated: land usually in agricultural rotation.
   (a) Perennial or seasonal crops.
   (b) Land fallowed for two years or less.

2. Uncultivated: land which could be cultivated if some form of land improvement preceded cultivation.

The major land use "cultivated land" was 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 had an uninterrupted water resource available for two agricultural years or land which may have had a deficient water resource for no more than one season in no more than four years.
   (b) Nonirrigated.

In contrast to the Dominican example, Syrian statistics were additive for total nonagricultural and agricultural uses.

A visual interpretation of Landsat imagery to provide a generalized land cover/use map was undertaken. Interpretation categories differed slightly from those used in the Dominican Republic. They were: intensive agriculture, extensive agriculture, range, water, urban, forest, orchards, and barren. Land cover/use categories were mapped, digitized, and measured. These area measurements were compared to official statistics on major agricultural land use to determine the extent of expected underreporting.

Cross-tabulations of imagery interpretations were also made by RPU in order to compare current use by RPU with agronomic crop and crop group recommendations made by RPU. Such comparisons identified lands by RPU and region which could be safely retained or brought into cultivation, cultivated lands which should be shifted to other uses, and lands with irrigated crop potentials. Thus, with just this amount of data: major land use area by RPU and crop group agronomic interpretations by RPU, national staff could begin to estimate national/regional production potential. This inventory work could be done relatively quickly and relatively inexpensively. Further economic analysis such as that envisioned in CRIES would need increasing detail on resource use.

**Agricultural Land Use Detail**

The CRIES approach to economic analysis of agricultural production potential required further data on current use of the agricultural components of major land use. The precise set of parameters needed was, again, dependent upon the unique set conditions characteristic of the agricultural sector in a particular country, and upon the type of analysis to be undertaken. The minimal set of data, area of major land use and broad agronomic interpretations for agriculture, was presented above.

An analysis of land use intensification over recent history, e.g., the past ten years, for various political regions (or RPUs), in combination with agronomic interpretations of land potential and crop yield estimates on similar soils and climatic regimes, could also indicate the extent to which a country was moving toward its production potential. Such analysis would require time series data on crop yields by management technique (combination of inputs and cultural practices), more precise agronomic interpretations than found in the minimum data set, and internationally comparable soils-yield-management data such as that prepared by the Benchmark Soils Project funded by USAID.

In several countries, CRIES emphasized interregional economic analysis of production potential. Partial budgeting and mathematical programming such as linear programming and goal programming were utilized. The techniques require cross-sectional data and benefit from regression analysis of time series data if available. The data set presented below is based on this approach. The data groups are:

- PPA area, by crop
- Management technique, by crop
- Input prices
- Product prices.

A variety of methods was used to disaggregate major agricultural use areas by RPU-PPA to areas of major crops and associated production by PPA. 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, the agricultural census and periodic surveys reported only areas harvested of the most important crops. Hence, auxiliary data sets were required to derive physical area of land occupied by crop. These included crop calendars and the specification of intercropping and multiple cropping patterns. For example, published statistics reported one harvested hectare for each of maize, beans, and short-season vegetables for one calendar year. If it was established that maize and beans were intercropped and the short-season vegetable was planted subsequent to the maize and bean harvest, then there was only one, not three, physical hectares of cultivated land. In this way, a multiple cropping coefficient by crop and political region could be established. Division of harvested area by these coefficients would establish physical crop areas. RPU-PPA level harvested areas were estimated using area proportion ratios as discussed in the preceding section. Field revision of estimates occurred on a case-by-case basis. Satellite imagery and aerial photography were not useful for this detailed identification.

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 level. The reliability of doing this varied by country because of the widely varying amounts of national/regional knowledge of such statistics held by country staff, biases held by such persons, inaccuracies in published data, influences of weather, etc.

The presence of much greater detail in Syria afforded the opportunity to determine physical land occupation more precisely. Syria annually published major land use estimates, cultivable land estimates, and harvested crop estimates at the national, state, and county levels. Crop uses of land were reported by season, by annuals, perennials, and fruit trees, and by irrigated and nonirrigated production. As major land uses were 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 use-intensity ratios were developed to assist Syrian agricultural planners assess 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.

The area farmed under "representative" management techniques multiplied by crop yield associated with the technique resulted in production levels that were compared to production data previously drawn from secondary sources. Adjustments to technique definition, to area estimates, or to expected yields could be made in order to equate the two independently derived production data sets.

In each of the CRIES-assisted countries, national sources on crop budgets were deficient in one or more of the following: the date the budgets were prepared, level of use of each input, only a generic name for the input (e.g., fertilizer), cost/unit of any input, repetitions of input application, annual budgets for perennials, machinery costs, or sources or methods of base data. Cost of production studies from different agencies usually were prepared with different methods. In all countries, no data existed either on area cultivated by "representative" production techniques or crop yield differentials by any type of soil or ecosystem grouping. Reliability of commodity price data varies widely among countries.

Faced with such a data situation, desiring to train national staff, and having no funds for surveys, the CRIES approach was to gather together existing studies however incomplete, discuss methods used for comparison with accepted economic/agronomic/soils concepts, and use team consensus judgements of informed national/regional staff (soils, agricultural economics, agronomy) to modify and/or develop anew these four required data sets: representative techniques (unique input and cultural practice combinations and costs); area by technique and PPA; estimated crop yield by technique and groups of PPA; and prices received by farmers. A sample format developed and tested in Nicaragua for collection of some of these data is presented in Figure 4.

Figure 4. -- Sample Format for Collection of Budget Data, by Management Technique and Crop

Variable Inputs

Seed
Chemicals
  Fertilizers
  Herbicides
  Other
Water
Machine Use, by Activity
Fuel
Labor, by Practice
  Hired
  Family
Interest
Other
Total Variable Costs

Average Yield for Technique I ___________
Farmgate Price for Crop X ___________
Gross Income ___________
Net Income ___________

In summary, methods used were consistent with accepted theoretical constructs and conditions often unique to a country. The process highlighted data activities on which the countries should put priority.

In several of the countries with which CRIES worked, USAID sponsored the construction and implementation of an area sample frame to gather agricultural production data on a statistically reliable basis. Recommendations for integration of the two projects are contained in a previous report written for USAID.

## RECOMMENDATIONS FOR FUTURE WORK

Several papers previously prepared for DSB/USAID contain CRIES activities and recommendations on land (Putman, January 1982), geographic information system (Lodwick, December 1981), the area frame and CRIES relationships (Johnson, July 1981), data aggregation (Sutton, April 1982), and land resource concepts and institutionalization of them (Johnson, September 1981). Recommendations in this section focus on future work in the area of agricultural information systems with particular emphasis on data collection methods. Previous recommendations will not be repeated but in some instances they will be further elaborated upon or reinforced for emphasis. The recommendations are humbly presented for the concept of agricultural production potential and analysis of it is not new. The kinds of resource problems that exist, the kinds of data needed to evaluate production potential and specific resource problems, the kinds of computer-assisted and noncomputer-assisted means to manage data, and the kinds of analytical techniques that are appropriate to skills and facilities levels in developing countries are well known in the national and international community.

Agricultural Information Systems

The principal set of recommendations to be made is that those responsible for building an information system repeatedly interact with users to determine their perceptions of the resource problems and their needs for analysis, and then proceed to generate data and information at a level of detail that is congruent to those needs. Information development should be treated as a process, a process such as that shown in Figure 1.

High priority should be placed on training nationals in survey design, statistics, soils science, agronomy, agricultural economics, hydrology and water economics, and systems science for natural resources data management and analysis. Training should precede or be simultaneous to data generation and analysis. Except under unusual circumstances, training should be done in the native language. One-year scholarships oriented toward developing practical skills quickly and tangibly useful on-the-job training in the host country agency should be at least five times as numerous as scholarships more oriented to academic degrees such as the Master of Arts. Scholarships designed to directly lead to a Ph.D. should be given attention only in the rarest of instances.

Data Needs

Except for climatic influence, the conceptual bases for each of the data sets needed for analysis of agricultural production potential are well developed. It is recommended that non-country specific efforts be initiated to study methodology of existing climate classification systems and to establish the role of climate vis-a-vis soils to plant growth in major ecosystems of the world.

It is not reasonable to ever expect achieving statistically reliable data among all, or even most, of the parameters needed for analysis of production potential. Given the presence of error levels, known and unknown, researchers should focus efforts on specifying relationships and collecting data (input-output, costs, prices) at levels of detail congruent with the needs of the user. Expenditure of much time and funds on developing relatively great detail and reliability in some parameters, such as soils, and poor detail and low reliability in others, such as definitions and areal extent of representative production practices, which must be associated with the reliable data, is difficult to justify.

Highly reliable data are expensive. In the face of limited budgets, staff skills, and facilities, problem definition and an inventory of skills and facilities help to set priority ranking on resource problems and then a priority ranking on each parameter to be measured. Figure 5 presents in a very general way a ranking of data collection priorities for analysis of agricultural production potential on a national/regional basis. The priorities set can only be determined on a country basis. However, the following general comments may be useful. Priority A is high; D is low.

Figure 5. -- Data Collection Priorities for National/Regional Analysis of Agricultural Production Potential

| Data | Priority | Periodicity/Notes |
|---|---|---|
| "Exploratory" soils inventory-nation | A | Update every 10 years |
| "Reconnaissance" soils inventory-departments | B | Use to locate development projects |
| Climate inventory-nation | A | Update every 5 years |
| RPU map-nation | A | Update every 10 years Use to select departments for reconnaissance soil inventory |
| Check meteorological stations | A | Update every 10 years |
| Installation of new climate data collection equipment | C | |
| Inventory reservoir capacity, stream flows, well capacities | B | Continuing |
| Satellite analysis of erosion, water problems | | |
| Areas currently irrigated | A | Update every 5 years |
| Areas with irrigation potential | B | Update every 5 years |
| Inventory use/nonuse of social and economic infrastructure in agriculture | B/C | Update every 5 years in frontier areas; 10 years elsewhere |
| Major land use-department | A | Update every 5 years in frontier areas; 10 years elsewhere |
| Major land use-RPU | B | |
| Cropping patterns-departments | B | Update every 5 years |
| Cropping patterns-RPU | C | Update every 10 years |
| | A will occur in those areas chosen for development projects | |

Soils

Develop a nationally-consistent soils map and descriptions. Use existing small area soils studies, interpretations of satellite, radar, and high-altitude photography, ancillary studies and maps of topography, geology, ecology, climate, and limited field observation. Describe physical soil properties; perform no chemical analysis. Make general interpretations of soil potential for broad crop types under generally defined (2 or 3) types of agricultural management. Assign priority A to this "exploratory" soil survey. Update the national inventory every ten years. Assign priority B to more intensive, "reconnaissance" surveys of selected departments. These surveys are to be used by high-level planners to locate development projects for which more costly, "detailed" surveys would be undertaken.

Climate

Prepare national map of isohyets and isotherms for major wet and dry (or winter and summer) seasons from data series of existing meteorological stations and interpretations of satellite images taken over several years at various times during the year, and existing vegetation/ecological studies. Do no field observation. Assign priority A.

Combine the national soils and climate maps to produce map of areas with similar natural potential for plant growth. Assign priority A. Relate to departments. (In CRIES terminology, this would be the RPU map.) Modify soils interpretations as appropriate. The product would be used only by high-level planners to determine funds allocations for the more intensive, reconnaissance level soils surveys in selected political departments suggested above. This combination activity should identify meteorological stations whose data is highly suspect. Update national climate maps every five years. Update homogeneous plant growth maps every ten years.

Review reliability of data collection of existing parameters at every meteorological station; discontinue those stations for which no inexpensive means are available to quickly increase reliability. Assign priority A. Install equipment in selected stations of expected high agricultural potential (dry-land and/or irrigated) and with current good access to markets to gather new, important parameters such as daily wind velocity and solar radiation. Assign priority C.

Water

Prepare inventory of reservoir capacity and problems of sedimentation that may be shortening useful reservoir life, average monthly stream flows, and wells and springs capacities and useful life. Assign priority B and update every ten years. Use satellite imagery and very limited aerial photography to determine recurrent flooding, areas of wetlands and poor drainage, erosion, and sedimentation affecting water quality in river and litoral areas where fisheries are economically important. Assign priority A in areas currently irrigated or priority B where surface irrigation appears to be highly probable in the near future. Repeat every five years. Modify homogeneous plant growth maps as appropriate.

| | |
|---|---|
| Human and Institutional | Concurrently with reconnaissance mapping of homogeneous plant growth areas in important political departments, develop and implement list frames to determine: 1) availability of agency programs to agriculture; 2) agricultural skills, use and reasons for non-use of agricultural agency services, use and non-use of agricultural infrastructure such as roads, marketing services, storage and drying facilities, cooperatives; and 3) effects of migration patterns on these items. Assign priority B to "1" and "2" and C to "3". Coordinate with area frame gathering production statistics discussed below. These data should be used by high-level planners to decide where to promote projects to intensify or change agricultural land use. Repeat every five years in frontier areas; every ten years in more mature, settled areas.<br><br>It is noted here that censuses are not recommended for data collection in any area. CRIES experiences suggest that they are very costly per se, inaccurate due to inadequately trained enumerators and incorporation of purely erroneous data, that they gather much data for which there are no effective users, and that lengthy delays in processing together with low budgets for publications and dissemination and inter-agency rivalries render tabular summaries non-obtainable to potential users both in the public and private sectors. |
| Major Land Use | Develop major land use data and map by political department and homogeneous plant growth areas utilizing satellite imagery and field verification of interpretations made. Assign priority A to use by department and B to homogeneous area. Repeat every ten years in settled areas; every five years in developing areas. Interpretation categories should be consistent with those used by FAO or the International Geophysical Union. Concurrent with the reconnaissance mapping of selected departments, major land use should be refined in those departments with the use of statistically reliable sample photography from low altitude light planes and/or existing studies of major use, vegetation, and/or ecosystems. |
| Agricultural Land Use | Current use of political departments by major crop and management technique should be developed using an area sample frame every five years, and every ten years in those homogeneous plant growth areas considered to have high potential for agriculture and access to markets of the selected departments. Attention should be paid to input descriptions, levels, and costs. Assign priority B to use by department and priority C to use by plant growth area. (Higher priority A to plant growth area will occur when planners reach the stage of deciding location of particular agricultural projects. Similarly, higher priority would result for determining the costs of surface and/or ground water development, drainage, and soil conservation measures when project location was under decision.)<br><br>Finally, priority C should be assigned to research, probably impacts of increased production on monthly availabililty of labor and other inputs and on storage and transport facilities. |

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