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PROJECT ON AGRICULTURAL PLANNING AND POLICY ANALYSIS
IN LATIN AMERICA AND THE CARIBBEAN
(PROPLAN/AP)

COLLECTION OF CONTRIBUTIONS

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A GUIDE TO INFORMATION AND POLICY ANALYSIS FOR AGRICULTURAL DECISION MAKING IN LATIN AMERICA AND THE CARIBBEAN

IICA
INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

San José, Costa Rica. 1981

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A GUIDE TO INFORMATION AND POLICY ANALYSIS FOR AGRICULTURAL DECISION MAKING IN LATIN AMERICA AND THE CARIBBEAN

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TABLE OF CONTENTS

FOREWORD

The purpose of the "Collection of Contributions" is to present the work done by consultans, external groups and institutions connected, now or in the past, with PROPLAN Projects of the Inter-American Institute for Cooperation on Agriculture (IICA). This document focuses on the area of Policy Analysis and was written specifically as a contribution to the Project on Agricultural Planning and Policy Analysis in Latin America and the Caribbean (PROPLAN/AP).

This document illustrates the role of information for policy analysis within the conceptual framework developed by PROPLAN [*]. In this sense, the document defines information as a product of a process that is only meaningful when carried out within an explicit conceptual framework. Different aspects of data gathering, modelling for policy analysis, complemented with some examples on assessing impact of alternative policies, are presented in this work.

The document is the product of an interdisciplinary and interinstitutional group effort. The content and responsabilities for the different chapters were defined and reviewed in different meetings held at M.S.U. and I.S.U., with PROPLAN coordination, in the early stages of the project.

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[*] PROPLAN, Conceptual framework of the Agricultural Planning Process in Latin America and the Caribbean: A comprehensive view of the policy analysis and decision-making process in the Agricultural Sector. Miscelaneous Publication Series No. 339, PROPLAN Document-1, IICA, San José, Costa Rica. 1978.

Although it is the product of a corporative effort, the professionals directly involved in the process were Michael Abkin, Tom Carrol, Gerry Ingvaldson and Manuel López-Blanco of Michigan State University and Lee Fletcher and Hylke Van de Wetering of Iowa State University. P. Lizardo de las Casas and Gonzalo Estefanell from IICA/PROPLAN were responsible for the overall coordination of this process, while M. Abkin was responsible for putting the document together and introducing the suggestions received along the reviewing process.

The opinions and interpretations expressed herein are the exclusive responsibility of the authors and do not necessarily reflect those of the Inter-American Institute for Cooperation on Agriculture.

Chapter I

Introduction: The Role of Information and Policy Analysis in the Agricultural Planning Process

Agricultural policy decision making, as any decision making, is rooted in a foundation of authority, responsibility, talent and information. Authority and responsibility are two sides of the same coin. That is, authority--or the power to make decisions--without responsibility is a dangerous situation, risking recklessness on the part of a decision maker who does not have to answer for the consequences of his actions. Responsibility, on the other hand--or accountability for the consequences--without authority can only result in frustrated and ineffective decision makers.

Talent and information can be similary paired. Talent, or skill, for decision making is not an easily acquired attribute, requiring a mixture of innate ability and practical experience and including such characteristics as creativity, a sense of timing, initiative, resoluteness and others. A key expression of decision making talent is the ability to acquire the right information at the right time and put it together in the right way as a basis for making a decision. In general, more and better information reduces uncertainty, thus increasing the potential for better decisions. Talent is necessary for that potential to be realized; however, without information or with poor information, even the most talented decision maker is severely handicapped.

Public agricultural decision making and generation of the information base necessary for that decision making are both part of the agricultural planning process. The former is carried out by the political process and the latter by the policy analysis process [1]. Indeed, the primary function of policy analysis is the creation and use of information for policy decision making. This guide is intended to provide a conceptual overview of the policy analysis process, its components and stages, and its role in agricultural planning. Subsequent manuals derived from the guide offer more operational knowledge in data system design and management, mathematical modeling, and analysis of policy areas. Particular reference is made to this process in the Latin American and Caribbean region. The overall aim is to contribute to the improvement of the quality of information supporting agricultural policy decision making in the region.

This first chapter briefly (1) introduces the concept of information, (2) relates information and the policy analysis process that generates it to the planning process, and (3) gives an overview of the components and stages of the policy analysis process. Succeeding chapters cover these components and stages in more depth.

THE NATURE OF INFORMATION

Knowledge, Information, and Data

Knowledge is broadly defined as a theoretical or practical understanding of some branch of science, art, learning, or other area. This understanding is gained through study, research, or practice and the acquisition of skills. Knowledge refers to more than the store of facts in the mind; it includes the contribution of mental processes to understanding data, perceiving relations, elaborating concepts, formulating principles, and making evaluations. A knowledgeable person possesses within his or her mental grasp a set of logically organized truths, facts, principles, and other objects of perception.

Disciplinary knowledge refers to a set of concepts, relations, and principles organized around the traditional academic disciplines, e.g. physics, economics, biology, etc. The store of disciplinary knowledge is modified and extended through the work of the "practitioners" of that discipline in universities and research centers around the world.

On the other hand, subject-matter knowledge refers to a set of concepts, relations, and principles organized around subject-matter areas that cut across the traditional academic disciplines, e.g., agriculture, energy, etc. Subject-matter knowledge is acquired, modified, and extended more often by practical men and women of affairs but also by disciplinarians engaged in multidisciplinary research.

The building blocks of knowledge are concepts and data. The human mind develops concepts or theory, as a way of simplifying the infinite complexity of the real world to something that is understandable and comprehensible. Concepts are symbolic representations which can be understood and communicated among human beings but which cannot always be directly measured. Humans operationalize concepts by establishing categories of empirical phenomena which can be measured and which are taken to be highly correlated with their associated concepts. The process of making measurements of real-world phenomena produces data. Thus, data systems grouped around disciplines or subject-matter areas include concepts, definitions of empirical variables (operationalization of concepts), measurement, and the store of data. An organized body of knowledge is based upon a data system and includes a set of concepts, relations, and principles developed through induction up from the relevant empirical data and through deduction down from a set of premises and tested against the empirical data.

What is information and how does it relate to knowledge? While possessing many of the same characteristics of knowledge, information is much more instrumental in nature. Information is gathered for the purpose of reducing uncertainty in human decision making. The value of information is much more situation-bound than knowledge. To be useful, information must be timely, consistent, and relevant to the problem or decision at hand. Information to support a particular decision may be drawn out of existing knowledge systems, or it may be acquired specifically for the current situation.

Information bears the same relation to data as does knowledge. Data are not information but rather a base from which information may be produced. Data may be collected as a part of an information-gathering process; that is, they are needed in order to make decisions with regard to certain problems. Raw data are direct measurements of symbolic concepts relevant to various aspects of problems, but are rarely appropriate on their own for direct use by decision makers. First, the data must be interpreted in the context of the problem under consideration. Techniques such as statistical and economic analysis are used to transform the data into information that can readily be used by decision makers. In a sense, data can be considered the lowest level of information, and successive interpretations and analyses of those data transform them into higher levels of information.

Consider the case of a national census. A simple example might consist of four items for each resident of the country: name, address, age and income. This set of raw data would be of little use to a decision maker. The data have not been presented in a specific problem context; they must first be interpreted in order to provide relevant information to the decision makers. For example, he may find it useful to know the distribution of population by income strata for various regions of the country.

Aggregation, as in this census illustration, is a simple, formal method commonly used to produce information. Other methods, such as statistical analysis techniques, may be far more complex. While formal analytical methods enable the transformation from data to information to be readily identified, the distinction between data and information is less clear when informal methods are considered. For example, a farmer reviewing his crop yields is familiar with the problem context and regards the yields as information, automatically, and perhaps unconsciously, using the yields as symbols for efficiency or profitability with implications for future resource allocations. Yet, a person unfamiliar with the crops and cultivation practices of the local area would consider the yields as mere data.

Types of Information and Philosophies of Analysis

Decision making involves choices among goals and actions consistent with a set of values and within the constraints of real-world conditions. Values are concepts about the goodness or badness of conditions, situations, or things as they affect the human situation. Goals are concepts about conditions not yet attained but which relevant values indicate should be attained. Actions refer to a sequence of behaviors designed to achieve a specific goal.

Three types of information are relevant to the decision-making process: normative, positive, and prescriptive. Normative information concerns the goodness or badness of conditions, situations, and things, and the rightness and wrongness of alternative goals and actions. Positive information concerns the status and behavior of conditions, situations, and things independent of their goodness or badness, rightness or wrongness. Prescriptive information concerns concepts and relationships that specicfy a course of action--in short, the decision rules.

As might be expected, different schools of philosophy have different positions on the applicability of these types of information, particularly the normative and positive, to social decision making.[1] Three philosophic positions have significantly influenced researchers and analysts involved in agricultural policy analysis: positivism, conditional normativism, pragmatism. Two others, outright normativism and existentialism, have been somewhat less influential.

Positivism in its pure form is based on the doctrine of Auguste Comte that the highest form of knowledge is simply a description of sensory phenomena. In pure positivism, the knowledge system comprises an accumulation of related facts but does not include the use of theoretical relationships unless they are directly observable. Logical positivism, more generally known as logical empiricism, however, does utilize

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[1] Much of the discussion that follows is based on [7].

theoretical relationships to interpret the facts. Proponents of both pure positivism and logical positivism deny that it is possible to develop objective knowledge about normative issues involving purpose, values, and cause. Thus, observations in the social sciences taken with this perspective would be limited to behavior, excluding the motivations that cause behavior. For example, data on farm operations would be collected and retained only for the purpose of describing how farm businesses were being operated but not for understanding why they were being operated that way.

Researchers and analysts concerned about making decisions related to agriculture are oriented to the solution of practical problems and, thus, have had to take normative considerations into account. However, most have stopped short of accepting outright normativism and instead have adopted the philosophic position of conditional normativism. Outright normativists assume that there are universal principles of goodness and badness that may be intuited, observed, or revealed. Conditional normativists, on the other hand, argue that goodness or badness is relative and can be determined only with respect to particular cultures and subcultures. The approach they follow is, first, to determine the values and goals being sought by relevant decision-making units. Then, taking these values and goals as given, seek ways to maximize the differences between the goods and bads in reaching the right solution to the specified problem.

The right solution is that which achieves the greatest difference between goods and bads. Therefore, it may be right to do a bad thing (the difference is negative) if nothing better is possible (including doing nothing). Similarly, it may be wrong to do a good thing (a positive difference) if other options would achieve even more goods.

The approach of practicing conditional normativists is not as simple as outlined above, however. The selection of the right course of action to solve a problem is very difficult when any one of four preconditions is not met: (1) an appropriate common denominator for measuring and comparing the goods and bads is not available, (2) relevant possible courses of action to increase social welfare include non-Pareto-better alternatives (a Pareto-better adjustment makes one or more people better off without making anyone worse off), (3) situations in which a unique optimum does not exist over the range of solutions, and 4) the appropriate rule for deciding among alternative solutions is not known (e.g., maximize gains, minimize losses, attain satisfactory values for a set of objectives without maximizing any one of them, vote, reach consensus among relevant decision makers, educate relevant groups to reach desired solutions, or rely on market forces).

The pragmatic school utilizes both normative and positive knowledge and information in working out solutions to practical problems but goes a step further and says the workability of a proposed solution should be the primary criterion for determing its acceptability. Pragmatists also emphasize the interdependence between ends and means or, in other words, between basic goals and values and the instruments used to obtain the goals. The value of the end is dependent on the costs invovled to obtain it, and, conversely, the value of means depends on the value of the ends.

Recently, the more formal propositions of the existential philosophy have become influential, particularly at universities. The existentialist places the importance of individual self-identity and freedom above the importance of both normative and positive considerations of conditions, situations, and things. This perspective derives from the existentialist's observation that in a world of conflicting philosophies and views there is only one indisputable fact--one's existence. As a consequence, the existentialist places greater emphasis on developing conceptual frameworks designed to solve the problems of people rather than on developing knowledge about the essences of conditions, situations, and things. The recent concern about equity as opposed to efficiency in agricultural policy decisions may derive from the existential viewpoint.

Uncertainty and the Economics of Information for Decision Making

It was stated earlier that information is required for use in the decision-making process. Implicit in this statement is the assumption that the information will contribute to better decisions. In essence, the information has value because it reduces the uncertainty which surrounds any decision.

Uncertainty is inherent in nature and especially prevalent in agriculture. Numerous factors, such as weather and international markets, have great influence on the agricultural sector but are beyond the control of decision makers. Relevant information pertaining to those factors may reduce the uncertainty and thereby allow for improved decisions with less chance of undesirable consequences. As the uncertainty of a situation increases, and/or as the stakes at risk in a decision increase, the value of information increases correspondingly. Consider the hypothetical example of a country that has decided to terminate import quotas on a certain commodity. Market uncertainty increases as producers are less sure of the price they will receive. Decision makers concerned with the commodity now need information about supply, demand and prices not only for the domestic market but also for international markets.

Collecting data and producing information are expensive processes. Personnel requirements include statisticians, enumerators, coders, programmers, and economic and other analysts. Computers are frequently needed to process the raw data. Dissemination of the data may also be costly. The aggregation of all such expenses incurred in producing the information may be considered to be the cost of the information.

It is not so simple to attribute a value to information. The efforts devoted to obtaining information are rewarded in improved decision making, that is, decisions that are more likely to be "right" or more apt to produce desired results (the pragmatists workability criterion). Therefore, the value of a unit of information is a function of the reduction in decision-making risk attributable to its use. As such, the benefits of a unit of information are related to its relevance, accuracy and timeliness. The collection of data and creation of information that are not relevant to current or future decisions wastes resources; that is, it incurs costs without returning any value in terms of reduced decision-making uncertainty. Accuracy is also important; unreliable information does not reduce uncertainty. Finally, information must be made available promptly. It loses its value within the decision-making process if presented after the decision has been made.

Resources which may be devoted to data and information are limited. Therefore, resource allocation decisions must be made with respect to providing only that information which is relevant in the context of the particular problem faced by the decision maker. Furthermore, since perfect accuracy is impossible, these decisions must determine the point at which the value of an additional unit of accuracy in terms of reduced decision-making uncertainty is not worth the cost of obtaining it.

POLICY ANALYSIS AND ITS RELATIONSHIP TO THE PLANNING PROCESS

The Conceptual Framework of the Agricultural Planning Process

Elements of the Planning Process

The agricultural planning process in Latin America and the Caribbean has been conceptualized [1] as composed of two structural elements--the--political-administrative system and the planning system--interacting with the socioeconomic system (Figure I.1). The dynamic interaction of these three elements, including the socioeconomic system, takes place through the characteristic processes associated with each of them: the policy analysis process of the planning system, the decision-making process of the political-administrative system, and the socioeconomic process of the socioeconomic system. The socioeconomic system and process are interpreted broadly here to include the physical and biological processes and interactions which are both managed by and place constraints on man's socioeconomic behavior. With the focus of this guide on policy analysis, Figure I.1 and the succeeding discussion highlights the planning system element of the planning process.

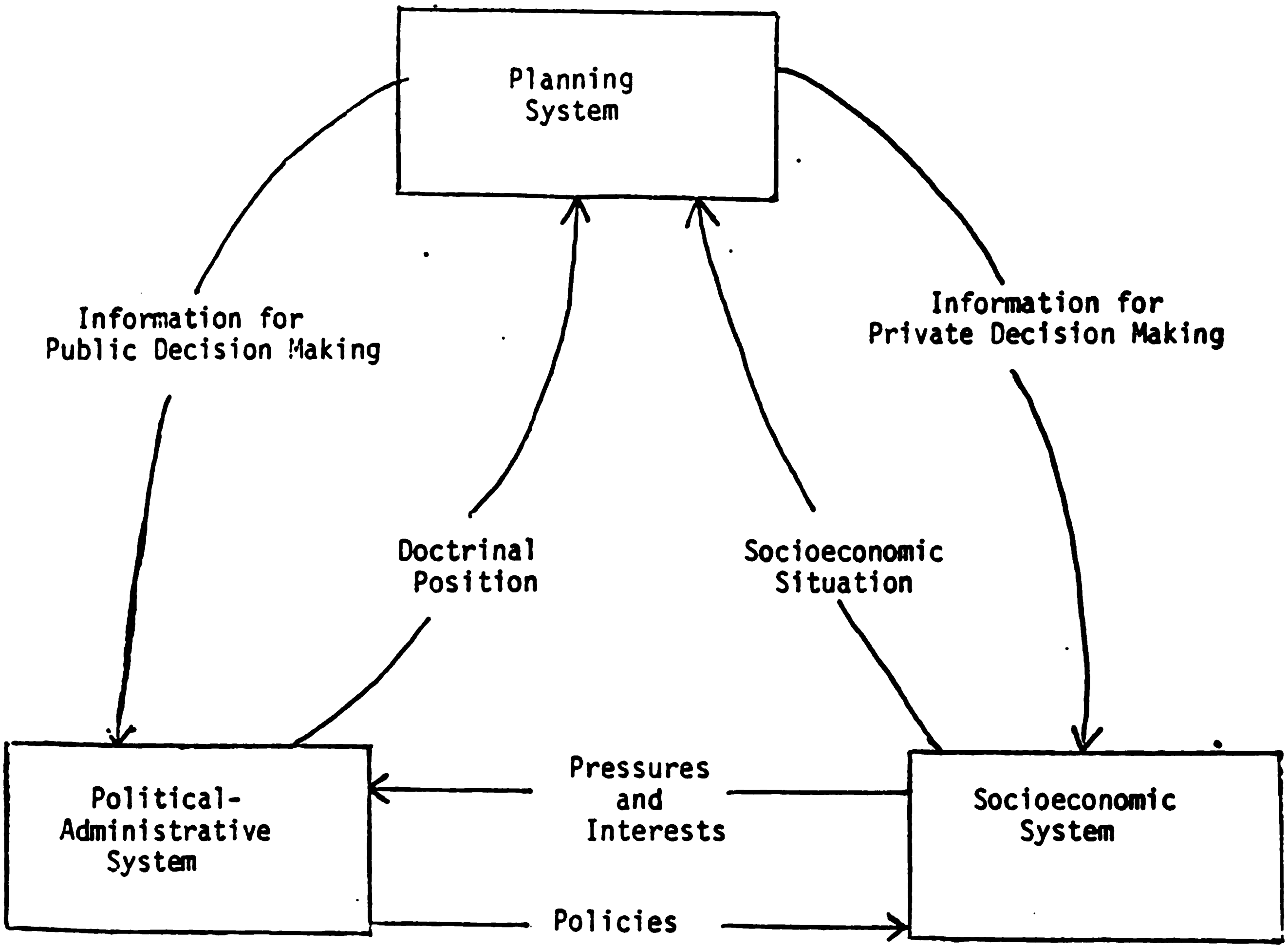

Figure I.1

Structural Elements of the Planning Process and Their Relationships to the Socioeconomic System

The essential outputs of the planning system are information for public and private decision making. In this context, "private decision making" includes all decision making taking place in the socioeconomic system, such as private enterprises, public corporations, households, etc. Correspondingly, "public decision making" in the political-administrative system encompasses government decision making at various levels, such as national, regional, provincial, local, etc. Public decision making information includes such items as feasible policy alternatives, the likely consequences of those alternatives, and supporting data and information to justify the needs for and formulation of the alternatives. Information for private decision making, on the other hand, while including similar items, will tend to cover them primarily with respect to adopted policy decisions. The degree to which information is included on alternatives considered prior to the final policy decision depends on the country's political system, particularly the relationship between the private and public sectors.

In generating this information, the planning system relies on the doctrinal position of the political-administrative system and on observations of the socioeconomic situation. The government's doctrinal position essentially represents the value system against which the planning system compares the socioeconomic situation and evaluates policy options and consequences. The socioeconomic situation also includes normative information on values held and problems perceived in and by the socioeconomic system, as well as positive information on the state of the system.

This normative information, or a portion of it, from the socioeconomic system is also communicated directly to the political-administrative system in the form of group and individual interests and political pressures. The nature and extent of this communication, and its impact on the government's doctrinal position, again depends on the political system of the country. Finally, implemented policies are the means by which the political-administrative system may influence the performance of the socioeconomic system.

Stages of the Planning Process

These elements of the planning process and the socioeconomic system interact dynamically throughout the three stages of the process [1]--formulation, implementation and control--as shown in Figure I.2. In particular, policy analysis is conducted not only in the policy formulation stage, with which it is commonly associated, but also in the implementation and control stages.

In the formulation stage, policy analysis is responsible for diagnosing the socioeconomic situation in light of the government's doctrinal position, formulating policy options, and analyzing their likely relative consequences with respect to the socioeconomic situation. For implementation, the policy analysis process provides information to decision makers in the socioeconomic system on justification for and potential impacts of implemented policies. It also monitors the day-to-day implementation management and proposes measures to correct occasional problems that may occur. Finally, policy analysis plays a central role in the control stage of the planning process through measurement, evaluation and review of the results of policy actions, leading to proposals for corrective measures for implemented policies as well as basic policy reformulations.

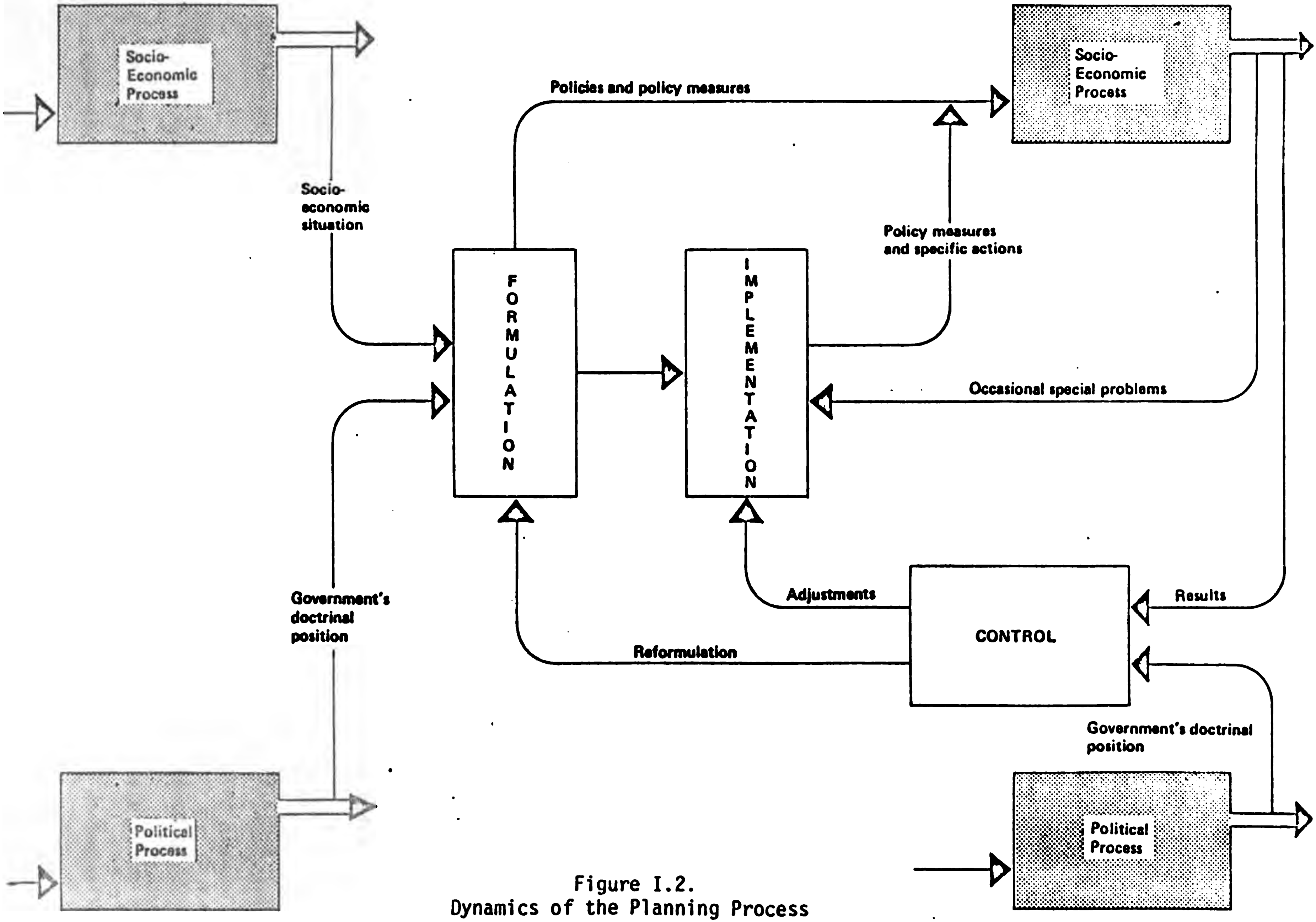

Figure I.2.
Dynamics of the Planning Process

In practice, all three stages take place simultaneously, and the boundaries between them are not always well defined. That is, the socioecnomic situation being diagnosed for policy formulation will certainly include results of earlier and current implemented policies and will thus entail aspects of policy control and reformulation. In addition, it may not always be possible to distinguish between the analysis of adjustments in the day-to-day implementation management and of more basic policy shifts. Therefore, the next section of this chapter does not refer to these three stages in describing the components and phases of the planning system and its policy analysis process--components and phases which come into play in a similar way at all stages of formulation, implementation, and control.

Overview of the Policy Analysis Process of the Planning System

In Figure I.1 above, the interactions indicated among the planning system, the political-administrative system and the socioeconomic system take place continually and simultaneously. To elaborate the planning system and its policy analysis process, however, it is useful to visualize the interaction as sequential and iterative, i.e., recursive rather than simultaneous. In Figure I.3, therefore, the planning system is shown generating information for decision making in the political-administrative and socioeconomic systems which then supply, respectively, the government's doctrinal position and the socioeconomic situation as bases for further policy analysis and generation of information. The planning system is elaborated in detail in the center of the figure and in the following discussion. This elaboration is based on concepts developed in [1, 2, 3].

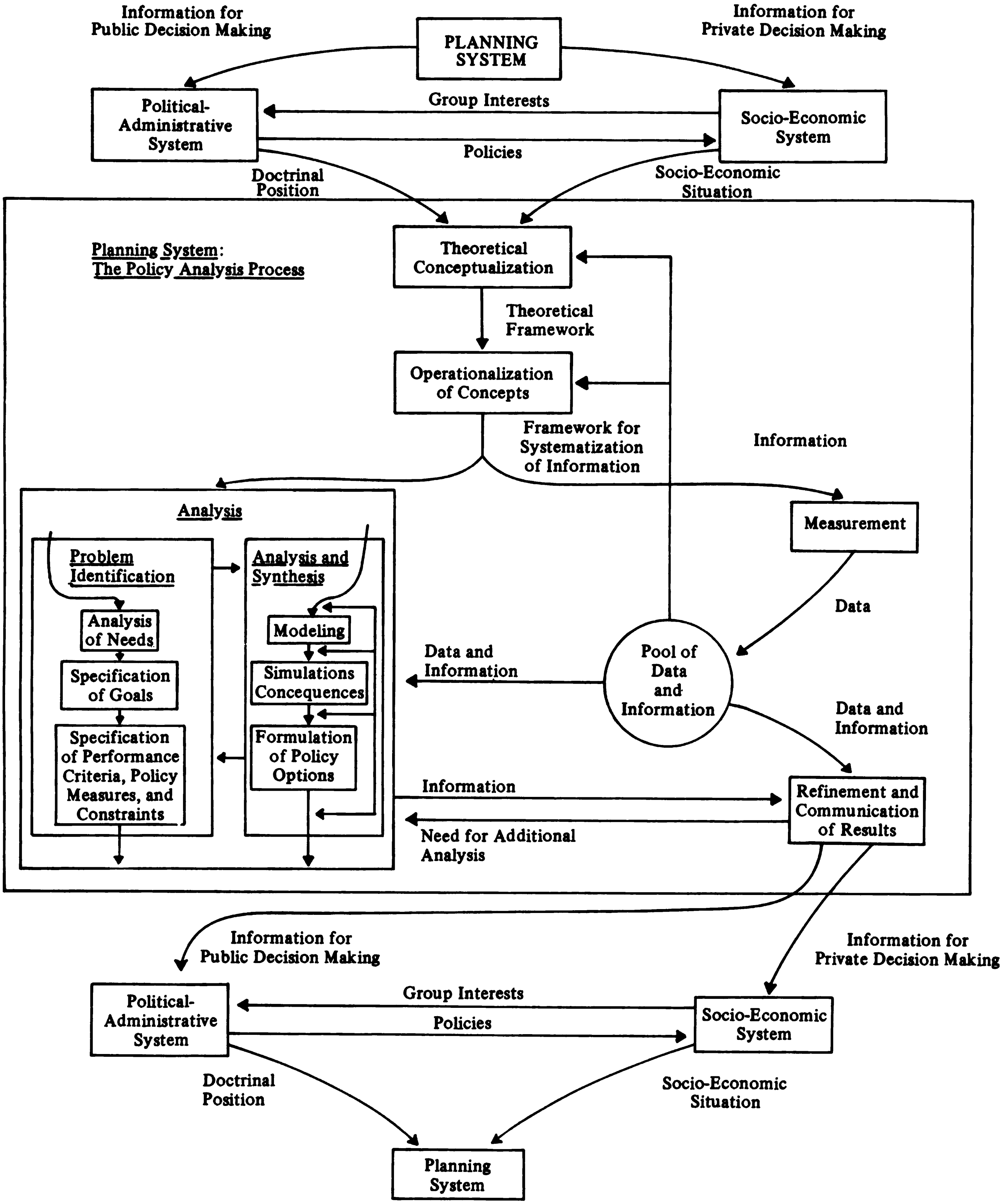

Figure I.3
THE POLICY ANALYSIS PROCESS
OF THE
AGRICULTURAL PLANNING SYSTEM

Policy analysis can be defined as the creation and use of information for policy decision making. There are five stages to the creation of that information: (1) theoretical conceptualization, (2) operationalization of concepts, (3) measurement, (4) analysis, and (5) refinement and communication of results. The functions and interrelationships of these stages are reviewed briefly in what follows and discussed in greater depth in succeeding chapters.

Theoretical and Operational Conceptualizations

It is impossible, and fortunately unnecessary, to perceive the real world in all its minute detail and complexity. Therefore, what we can know of the real world is both limited and shaped by our perceptions. These perceptions, in turn, are guided by the mental concepts we have of that real world. The collection of such concepts that we hold, often unconsciously, forms the theoretical framework which acts as a filter for our perceptions, and the process by which the theoretical framework is formulated and updated is theoretical conceptualization, a process which takes place both consciously and unconsciously. The theoretical framework for agricultural planning limits our perceptions of the real world to those aspects of the socioeconomic situation having a bearing on agricultural public decision making, aspects partly determined by the values of the decision makers as reflected in the government's doctrinal position.

Since theoretical concepts are largely held unconsciously and by many individuals and, therefore, tend to be vague and possibly even, at least in part, inconsistent, it is necessary for rational and effective planning that they be operationalized in an explicit, comprehensive and consistent framework. Such a framework represents a systematization of the information base of agricultural planning and includes three basic components.

The first component is a conceptual subdivision of the socioeconomic system into relevant subject or policy areas. A second component of an operational framework specifies the broad goals of agricultural planning and, with respect to the policy areas, the hierarchy of instrumental objectives and specific policy choices directed at the attainment of those goals. Finally, the framework identifies specific socioeconomic performance indicators to be measured and to form the basis for the evaluation of the socioeconomic situation, including the results of implemented policies, and for the analysis of policy options. There are perhaps an infinite number of ways the systematization can be defined, depending on the country's theoretical framework as influenced by its political system and the government's doctrinal position.

The discussion of the conceptualization of theoretical and operational frameworks for the systematization of agricultural planning information is further developed in Chapter II.

Measurement and the Pool of Data and Information

The systematization of information is a necessary prerequisite to measurement, since it specifies the variables to be measured and the units they are to be measured in. By definition, the direct product of the measurement process is <u>data</u> and the <u>data system</u> is composed of not only the measurement process with which it is usually identified, but also the processes of theoretical and operational conceptualization so fundamental to measurement.

There are five principal criteria by which a data system is evaluated: relevance, accuracy, consistency, timeliness and accessibility. The last four of these criteria refer to the three stages of the measurement process: data collection/data management and data dissemination. The structure and quality of data collection particularly influence the accuracy, consistency and timeliness of the data, while data management and dissemination both contribute to timeliness and accessibility. The relevance of data, however, depends on how well integrated the conceptualization processes are in the data system. The most accurate, consistent, timely and accessible data may yet be useless for policy analysis if the measurement process has not kept up to date with current data needs as reflected in the theoretical and operational frameworks.

Data, the product of measurement, flow into and augment the agricultural planning system's knowledge base of positive and normative data and information. The distinction made between data and information is that, while data represent the raw results of measurement, information is the result of processing that data through interpretation and analysis. In a sense, we can conceive of a continuum of information, with data located at the lowest end and the upper end unbounded. Any piece of information, then, will fall somewhere along that continuum depending on the degree of interpretation and analysis embodied in it.

The pool of positive and normative data and information is drawn upon by the other stages of the policy analysis process. In particular, information from the knowledge base is a key ingredient, along with the socioeconomic situation and the government's doctrinal position, in updating the theoretical and operational conceptual frameworks which guide further perceptions of the real world and, thus, further additions to the knowledge base itself.

The data system and its measurement process are further elaborated in Chapter III.

Analysis

The analysis stage of the policy analysis process converts data and information from the knowledge base, including past and present perceptions and interpretations of the socioeconomic situation and doctrinal position, into useful information for policy making. There are two phases of analysis: problem identification, and analysis and synthesis of policy options. While these phases are conceptually distinct, with problem identification logically preceding anaysis and synthesis, they are highly iterative. That is, the process cycles between the two phases, successively sharpening the problem definition, the formulation of policy options and the projection of their likely consequences in the search for policies which are optimum from the point of view of the decision makers in the political-administrative system.

The problem identification phase explicitly and systematically defines the particular policy problem to be analyzed, where a "problem" means a specific situation in which a decision has to be made. It includes, first of all, a needs analysis, which begins with awareness and identification of deviations between observed and desired physical, biological and socioeconomic conditions in the socioeconomic system. Based on this, the policy area and stage of the planning process (formulation, implementation or control) relevant to this decision-making situation is identified. Then, a specification is made of who has what needs, from which are derived appropriate goals and objectives for this decision problem. Finally, based on the specific goals and objectives, the scope of the analysis is defined through a detailed identification of (1) the time horizon of the analysis, (2) the criteria to be used in evaluating policy options, (3) the relevant available policy measures which can contribute to the make-up of policy options, (4) outside influences beyond the control of the decision maker but which may impact on the policy results and must, therefore, be considered in the analysis, and (5) any constraints on policy choices and/or system performance which must be considered.

The problem identification phase of analysis is discussed in further detail in Chapter IV.

Having thus defined in detail the scope of the particular policy problem to be analyzed, the analysis and synthesis phase formulates policy options to solve that problem and projects the likely consequences of those options. Modeling forms an integral part of analysis by abstracting the relevant aspects of the real world and providing a means of experimenting with various policy options by simulating their likely consequences. Modeling and models are viewed here in the broad, generic sense encompassing the spectrum of model types from informal, mental models to formal, mathematical models. Based on the results of such policy experiments, new options are formulated and tested iteratively to arrive at a set of desirable, feasible options for consideration by decision makers.

Chapter V gives an overview of approaches to the analysis of various policy areas as might be identified in the conceptualization process discussed in Chapter II. Each country in Latin America and the Caribbean may have a different way to categorize relevant agricultural policy areas, depending on its particular political and socioeconomic systems. Chapter VI looks at the areas of market intervention and price policy. Agricultural sector assessments using the nonformal, general equilibrium-consistency approach are reviewed in Chapter VII.

Chapters VIII - XI briefly discusses the concept of modeling and presents a model classification scheme. The process of mathematical modeling is elaborated in some detail, covering model specification, data sources and requirements, uses of computers, and credibility testing. Finally, the process of formulating policy options is discussed. Included are reviews of a sampling of mathematical modeling approaches for agricultural policy analysis including partial and general equilibrium models, optimization models, and system simulation models.

Refinement and Communication of Results

This stage of the policy analysis process represents the interface between analysis and decision making. The interaction with decision makers that takes place here is actually an integral part of analysis. Information on policy options and consequences not only augments the pool of data and information but is also used directly in this interaction.

The process places the analytical results in a form comprehensible and communicable to decision makers, who then react as to whether they feel they have enough information on which to base a decision. Typically, in early iterations they will not be satisfied and will indicate a need for additional information. This may imply a redefinition of the problem, in terms of objectives, performance criteria, policy measures, etc., and/or the formulation and testing of additional policy options. This iterative, interactive process of refining and communicating policy options and information continues until the decision makers in the political-administrative system are satisfied they have enough information to make an "optimal" decision--or at least until they feel they cannot afford additional time and resources for further refinements. The result, then, is information for public decision making in the political-administrative system and private decision making in the socioeconomic system. (See Chapter XIII).

Resources for Policy Analysis

A variety of types of resources is necessary to support an effective policy analysis process. These include human, technical, financial and institutional resources.

Manpower resources typically tend to be a limiting factor for agricultural policy analysis. Agricultural planning, by its very nature, requires informational inputs from many disciplines, such as economics, agronomy, animal science, sociology, statistics, public administration, etc. Therefore, the planning system must be able to draw on and coordinate talent in these various disciplines for use in policy analysis. Such talent is frequently a scarce commodity in developing countries, and, where it does exist, governments often find it difficult to compete financially for it against universities and the private sector. That is, financial resource requirements are not independent of human resource needs.

Technical resources include such things as computer services, libraries, research facilities, etc. These factors may not be as limiting as the manpower to use them, but they also have financial support implications.

Finally, institutional infrastructure can also be considered a resource necessary to support policy analysis. As implied in Figure I.3 the manpower and technical resources associated with the various components of the planning system--conceptualization, measurement, analysis, and interaction with decision makers in the political-administrative system, each component with its own bureaucratic and institutional structures--must be coordinated and supported institutionally for the effective and efficient generation of information for decision making.

These resource requirements and the development and management of them are elaborated in greater detail in Chapter XIII.

Chapter II

Conceptualization of Theoretical and Operational Frameworks for the Systematization of Information

ROLE AS FILTERS OF PERCEPTIONS

The purpose of every data system is to represent reality through the description of empirical phenomena, usually in quantified form. Prior to measurement, one must decide exactly what is to be measured and, more importantly, why. The goal is to identify data that faithfully describe the relevant aspects of the real world in order to be useful in the analysis and intepretation which generates information for decision making. This can be accomplished only when there are clear concepts of the reality that is to be measured. The infinite complexity of the real world is viewed in the context of these concepts and thereby reduced to a magnitude within grasp of the human mind. In this manner, the real world is filtered and only a portion is actually perceived. If the concepts do not adequately filter the real world, one cannot expect useful data to emerge from the data system.

Function of Inputs to Conceptualization

The importance of the process of conceptualization must not be underestimated, since it provides the foundation of any planning system. Inadequate conceptualization cannot be offset by increased effort in other parts of the planning system. Therefore, it is important to examine the inputs to the conceptualization process (Figure I.3).

Doctrinal Position of the Political-Administrative System

The political-administrative system exhibits the greatest influence on the conceptualization of public planning systems. It will perceive the world in light of its doctrinal position which reflects its concepts of both the present reality and an alternate reality which would better meet the needs of society. The political-administrative system applies its influence directly through its mandated policies pertaining to the planning system and indirectly through the appointment of personnel with similar concepts.

Socioeconomic Situation

The socioeconomic situation as a whole is the real world which is observed, measured and analyzed by the planning system. However, it also contributes to the form of the conceptualization as well. Specifically, it exhibits an indirect influence that is applied through the political-administrative system. Society's views are made known through such means as the election of officials, lobbying by private interest groups, demonstrations, letters to officials and newspapers, etc. In this manner these views may be reflected in the government's doctrinal position.

Information from the Knowledge Base

What is known about the aspects of the socioeconomic system relevant to agricultural planning is contained in the knowledge base. That is, it has been filtered through the conceptual and operational frameworks and processed by interpretation and analysis. Because of this filtering and processing, our knowledge about reality cannot be perfect. Nevertheless, if the filters and the models used in analysis adequately reflect that reality, we may have some confidence that the degree of imperfection does not unduly limit the usefulness of the information for decision making.

The socioeconomic system is not constant, however. In the same way that the conceptual and operational frameworks are influenced and updated by the changing doctrinal position, they must also evolve to remain consistent with the evolving socioeconomic system being observed. The knowledge base, imperfect as it is, is the only source of information available on these changes in the socioeconomic system and, therefore, is an essential input to the conceptualization and operationalization processes. If this input is missing or weak, then the concepts become obsolete and the consequent knowledge base increasingly diverges from reality.

Paradigm for Measurement and Analysis

Theoretical conceptualization, as described above, is the first of three components of a data system. (See Figure I.3.) Concepts, however, cannot be measured. The second data system component, therefore, operationalizes the concepts through the definition of empirical phenomena, or variables, related to them. The final component of a data system then, is the actual measurement of the empirical variables.

The process of analysis is also preceded by theoretical conceptualization and the operationalization of concepts, as is the process of measurement of data (Figure I.3). It is essential that both measurement and analysis be based on the same set of concepts and the same set of operational definitions. Otherwise, the supply of data from the data system will not satisfy the data requirements of analysis, thus reducing the quality of the resulting information for decision making. Such a mismatch can arise from obsolesence in the data system.

Obsolescence

The theoretical conceptualizations and operational definitions of the data system should be subjected to continual review and revision as needed to maintain consistency with changes in the socioeconomic system and in problems of concern to decision makers. This is accomplished through the feedback of information from the knowledge base (Figure I.3) on the socioeconomic situation and the government's doctrinal position. If this feedback is ineffective, however, or even nonexistent, as is often the case in agricultural data systems, a divergence between the conceptual bases of the data system and the analytical system results. This obsolescence of the data system is discussed further in Chapter III.

SYSTEMATIZATION OF INFORMATION: THE COMPONENTS OF AN OPERATIONAL FRAMEWORK FOR AGRICULTURAL PLANNING IN LATIN AMERICA AND THE CARIBBEAN

There are two principal objectives of an operational framework for agricultural planning:

i) to provide a systematic scheme within which data and information concerning the condition and performance of the socioeconomic system is to be collected and organized. This entails the definition of categories of empirical phenomena which are as highly correlated as possible with the concepts embodied in the theoretical framework (Figure I.3). Such a definition includes the specification of variables representative of those empirical phenomena and of units in which they are to be measured.

ii) to provide the conceptual basis for the analysis stage of the policy analysis process (Figure I.3.).

Three main inputs contribute, as we have seen above, to the definition of the operational framework:

a) the doctrinal position of the political-administrative system,

b) the socioeconomic situation, and

c) the pool of data and information relative to the development of the agricultural sector.

With respect to these three elements, the definition of the components of the operational framework has to be broad enough to respond to three possible developments: i) changes in the doctrinal position of the political-administrative system, i.e., new values, objectives, and relevant problem sets should be easily expressed in terms of the old operational framework; ii) improvements in the state of theoretical and empirical knowledge; and iii) changes in the socioeconomic system itself. Further, to avoid conceptual obsolescence, its evolution will also depend on a corresponding evolution of its underlying theoretical concepts.

There are two principal components of an operational framework for systematizing information for agricultural planning: 1) policy areas and 2) socioeconomic performance indicators.

Policy areas of agricultural planning are defined by goals, instrumental objectives subordinate to those goals, and policy choices available for attainment of those objectives. These are all derived from the doctrinal position of the political-administrative system with respect to development of the food, agricultural and rural sectors of the socioeconomic system. The goals are broad statements concerning the primary functions these sectors are expected to perform in the course of overall national devel-opment. Hierarchically, goals can be considered top-level values. Instrumental objectives, then, are lower-level values whose attainment are means to achieving the ultimate goals. Finally, policy choices are the activities, investments and other policy measures available to the political-administrative system for implementation to attain the objectives and goals. The socioeconomic performance indicators operationalize the concepts concerning those relevant dimensions of the real world which when measured will produce a precise image of the extent to which the main values (goals) are attained and of the differential impacts (benefits and costs) of the various policy packages on those values. The relevant dimensions are multiple and may relate to not only the highest rank values but the intermediate processes or activities (objectives and policy choices) which contribute to them.

We can illustrate the operationality of these concepts with the following example. Let's imagine a food deficit country with a booming population. Therefore, the highest rank value or goal of interest here is "Improved Food Supply" (Figure II.1). One of the institutional constraints fixed by the political-administrative system might be non-intervention in the population area, i.e., no family planning. This constraint limits policy options to the area of increasing the supply of food in order to keep up with the population growth. Furthermore, let's imagine that the country may have a lack of foreign exchange. This leaves only two means for increasing the food supply: increasing marketing efficiency (#13) and increasing domestic agricultural production (#11). The first option can only marginally affect the final supply of food, leaving the second one as the only way of effectively increasing the supply of food. Domestic agricultural production, then, can be stimulated in two ways (or a combination of both): i) increasing the scale of the production activities, i.e., increased land area (#15); and ii) shifts in the production function through improvements in the inputs used, i.e., increased yields (#14). Either of these options can be implemented in different ways, such as shown in Figure II.1, with different attached costs.

The combination of different investment and policy measures jointly with the exogenous (or at least not controlled) parameters of the population dynamics will produce, by means of the set of relevant, socioeconomic performance indicators, different images of the future. Those images together with their associated costs constitute the basis for the assessment, in the analysis stage of the process, of the relative desirability of alternative policy packages and their consistency with the goals and institutional constraints. On that basis it may be possible to answer such questions as:

i) To what extent is it possible with the current and future amount and quality of available resources to attain the goals under the political constraints set by the political-administrative system?

ii) What would be the opportunity cost fo so attaining this objective, in terms of sacrifices conceded in the attainment of other objectives?

iii) What could be the opportunity cost of different institutional-political constraints?

To define such an operational framework -- policy areas and socioeconomic performance indicators -- for the entire Latin American and Caribbean region would likely require a thorough examination of the region's development history, culture and social values, and at the end it would probably turn out that not just one but a set of operational frameworks would have to be developed for the different cases the Latin American and Caribbean countries would represent. At this stage, therefore, it is only possible to suggest a tentative framework for illustrative purposes.

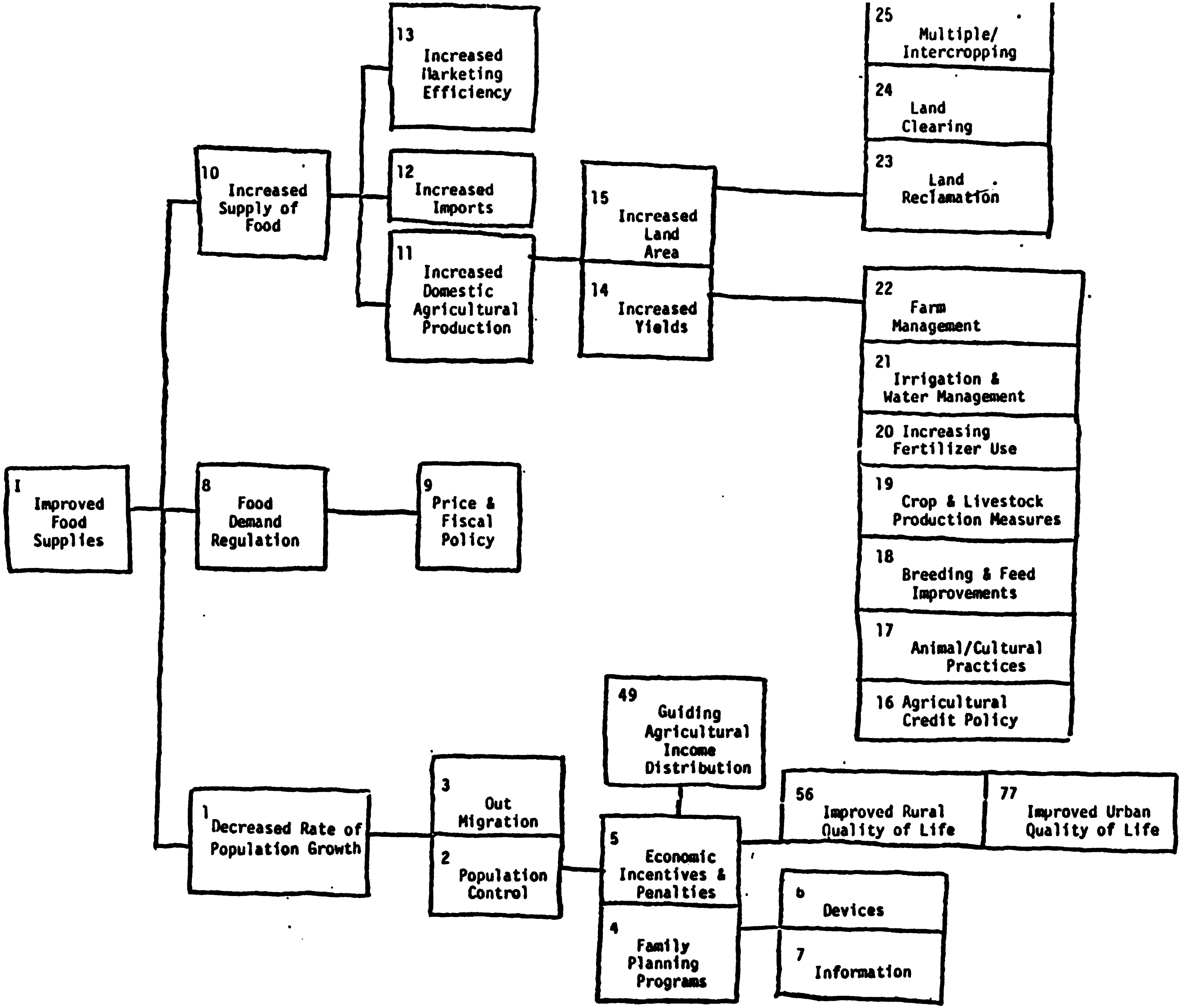

Figure II.1
The Policy Area of Increased Food Supplies

Policy Areas

Four major areas, or goals, are identified: improving food supplies, rural development and welfare, agricultural contributions to general development, and institutional development.

Improving Food Supplies (Figure II.1)

The major contribution of the agricultural sector to the rest of the economy is the provision of food commodities. Most of the Latin American and Caribbean countries are facing food deficits arising from an expanding population and the increase in nonagricultural incomes. Though agricultural output might also be rising at a fairly high rate, it nevertheless can hardly keep pace with the rising demand for food. The existence of certain population groups facing problems of malnutrition makes this a sensitive policy area.

Also, in countries where the agricultural sector represents an important part of the economy, success of any sound strategy for economic development requires the agricultural sector to provide an increasing food surplus in order to allow for greater nonagricultural employment. Transfers of labor from one sector to another have to be backed by a food surplus which represents the counterpart (a major share of it) of the wage fund earned by the nonagricultural workers.

Three important policy subareas may be stressed here: i) increased food supply (#10), ii) food demand regulation (#8), and iii) population control (#1). The illustration given above further disaggregates these areas.

Rural Development and Welfare (Figure II.2)

This policy area is concerned with raising the quality of life of the rural population and filling the gap which most likely exists when compared to urban conditions. We can assume at this point that living conditions in the rural areas will improve as: i) per capita agricultural income rises (#26), ii) the gains in incomes are evenly distributed over the rural population (#49), and iii) the infrastructure in rural areas is expanded (#56).

The second policy surbarea, income distribution, is especially important because it is related to the problem of malnutrition. The provision of an adequate (from the standpoint of the nutritional requirements) food supply is a necessary condition for the satisfaction of nutritional needs. It is, however, not a sufficient condition. The malnourished groups (short of an extended welfare system which most LDCs cannot afford) have to have the means, i.e. purchasing power, to effectively claim a greater and better diet (#49). Furthermore, the existence of an effective demand is also a necessary condition for increasing the food supply, i.e., by keeping prices and hence incentives to farmers at the right levels.

The first and second subareas (#26 and #49) represent somewhat conflicting means of improving rural conditions. The fact is that the rural economy is seldom homogeneous in its composition, so alternative policy packages will undoubtedly have differential impacts on the different groups present in the rural economy. An obvious example is the issue of mechanization versus greater agricultural employment. Thus, a careful assessment of the impact of different policies on different groups is required.

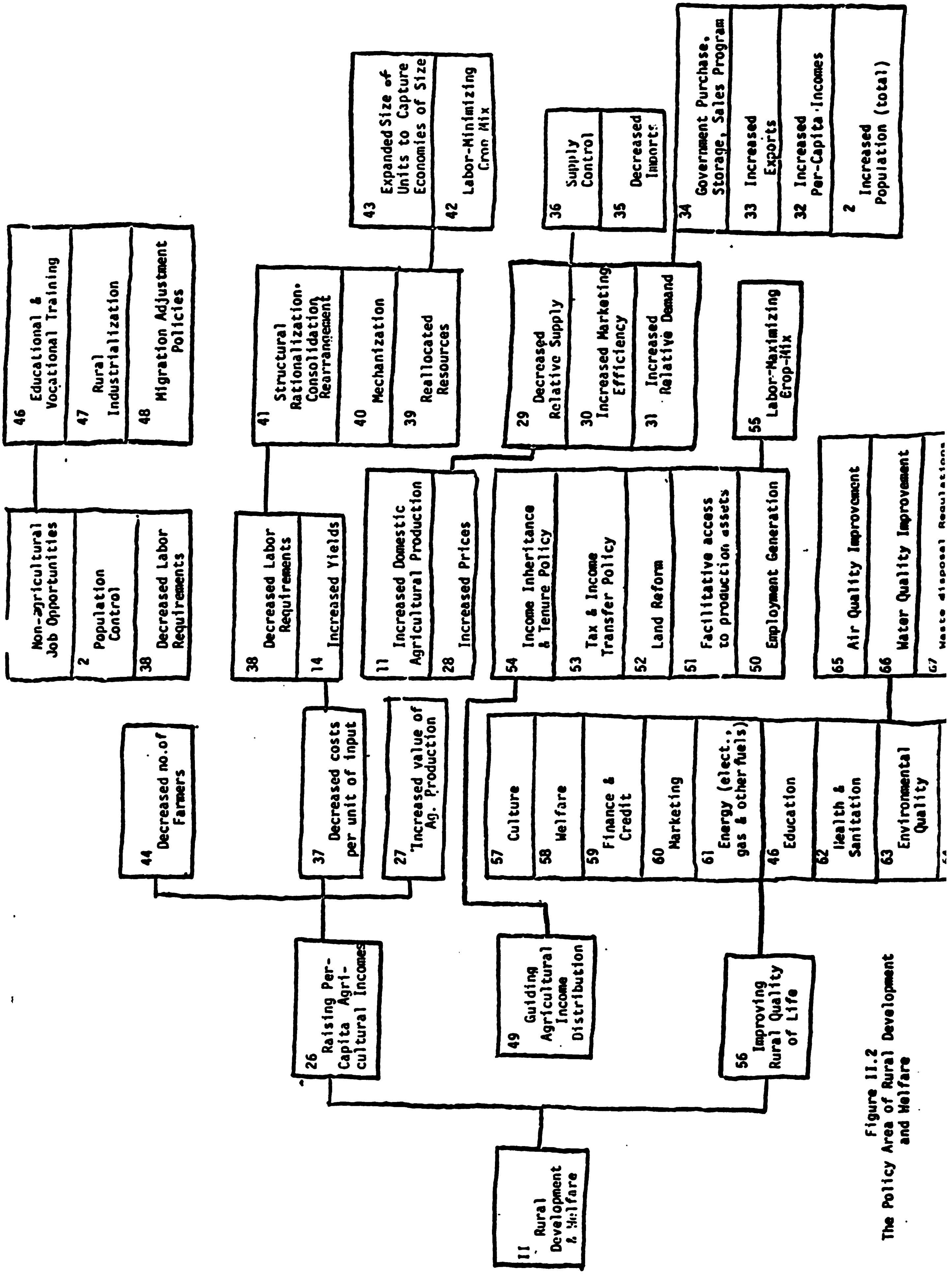

Figure II.2
The Policy Area of Rural Development and Welfare

The second subarea (#49) may also have an important (though as yet not completely understood) impact on the population area (#1, Figure II.1), thus contributing to the attainment in the long run of the goal of "Improved Food Supplies."

Agricultural Contributions to General Economic Development (Figure II.3)

Under this heading we consider the main contributions of the agricultural sector to general economic development. We can break down this area into three more precise though still broad policy subareas: i) balance of payments (#82), ii) increased urban quality of life (#77) and iii) agricultural contributions to the development of the nonagricultural sector (#70).

The first subarea reflects a critical concern for the Latin American and Caribbean region whose economies are usually driven by the dynamics of a dominant export sector. In many countries of the region this export sector is mainly agricultural, and its development (structure and rate of growth) is of critical importance for the entire economy. An important objective for the region in this subarea, therefore, is the diversification of exports to reduce the vulnerability of export revenues with respect to movements in international markets.

The second subarea (#77) is critically affected by the actual performance of the sector in the first two policy areas (#I and #II) already mentioned. A decay in rural welfare will, through increased migrations of population from rural areas, surely degradate the situation

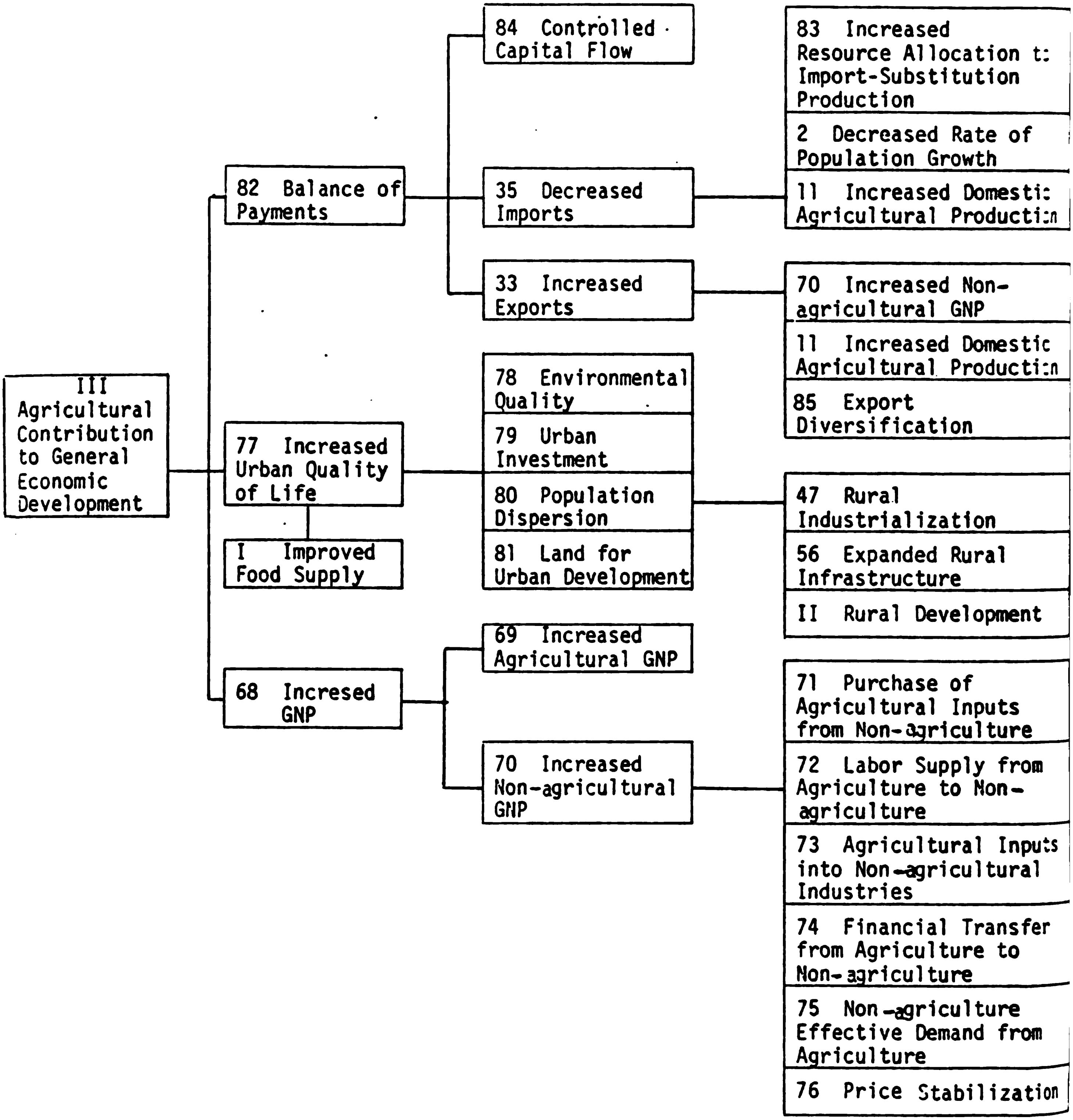

Figure II.3.
The Policy Area of Agricultural Contributions
to General Economic Development

in urban areas. Also, the urban nutritional situation is heavily dependent on improved food supplies, and their distribution.

In the third subarea (#68) we summarize the main linkages between the agricultural sector and nonagricultural sectors. The agricultural sector may provide labor, raw materials, land, financial resources (savings) and an effective demand to the nonagricultural sector. Enhancing all these contributions (though some of them may be in conflict, i.e., the transfer of savings and the provision of effective demand for nonagricultural commodities) will undoubtedly facilitate the process of economic development.

Institutional Development

Frequently, institutional objectives are explicitly put forward in plans and programs by governments. They depend upon the doctrinal position of the political-administrative system and relate to an institutional and political environment judged more desirable. These objectives could be, for instance, shifting the economy toward a socialist organization, maintaining a capitalist, free-market or controlled-market institutional organization; developing cooperativism and trade unionism in order to increase farmers participation in the economy, reinforcing collectivism, and so on.

These objectives may be considered ends in themselves or may be considered as means to attain other values, perhaps strict economic values. For example, collectivism may be emphasized as a means to offset malnutrition or extreme poverty, or a free-market organization can be regarded as economically the most efficient institutional set up with respect to the allocation of resources and products.

In general, however, actions in the institutional area are directed at reinforcing the political and social structure in power and affirm the political and social ideology of that structure. Hence, a condition for effectiveness in any policy strategy is consistency between objectives, means, and the institutional framework pursued by the political-administrative system.

Socioeconomic Performance Indicators

The hierarchy of policy areas discussed above provides a framework for identifying and categorizing operational variables indicative of the performance of the socioeconomic system. These indicators are to be measured for consideration in the evaluation of policy options and implemented policies. Some of them (such as population and income) will be measured directly and will then form the object of data collection, management and dissemination activities, as discussed in Chapter III. Others (such as per capita income) will be derivable from the directly measured ones.

For example, in consideration of the first three policy areas described above (Figures II.1-II.3), measurements of population are indicated, disaggregated perhaps by income class, residence (rural or urban) and occupation (agriculture or nonagriculture). Income also is needed for each population group and sector of economic activity. In countries where the distribution of productive assets is a policy issue, measurements of who owns what resources may need to be made.

In general, each policy area and subarea identified, as in Figures II.1-II.3, will suggest indicators to be observed in evaluating the attainment of its associated objective. The <u>operational</u> definition of these indicators must include detailed specifications of their exact nature and the units of measure associated with them. For example, "income" or "farm size" is not enough. Income can be gross or net, cash or in-kind, monthly or annual, calendar year or marketing year, enterprise or household, etc. Farm size cannot be measured without defining what is a farm, what land areas are to be included in it, who owns those areas, and who operates them.

Measurement of these variables is the responsibility of the data system, discussed in the next chapter. The analysis stage of the policy analysis process (Figure I.3), described in Chapter IV-XI convert the resulting data into useful information for decision making.

Chapter III

Measurement and the Data System

Based on the framework systematizing information for agricultural planning, which is the result of the processes of theoretical conceptualization and operationalization of concepts, the planning system undertakes the task of measurement. Since the product of measurement is data, the measurement process together with the fundamental theoretical and operational conceptualization processes make up what can be called the data system. The major data system components and problems to be considered are briefly decribed here. They will be discussed in greater detail below.

a) Review of Objectives. Variable definitions should be reviewed to ensure valid measurements. Definitions must be stated precisely. For example, it is not enough to ask for income to be measured. It is also necessary to clarify whether this is gross income or net income, before or after taxes, and so forth. Those in charge of measurement should also be aware of the degree of accuracy required.

b) Coverage. It is essential to define the population over which the variables are to be measured. This also includes the question of whether to use full or partial coverage. Partial coverage requires the use of a sampling technique to identify a subset of the population.

c) Method of Collection. Various methods of collection are available. Several of the more commonly used are documentary sources, observation, written questionnaires and personal interviews. Selection of a method depends in large part on the subject matter of the data and the resources available for collection.

d) Errors. There are many sources of potential errors, and it may well be impossible to eliminate all errors. Yet, it is important to keep errors to an acceptable level. Three facets of the problem will be examined -- avoidance, detection, and correction.

e) Field Staff. When personal interviews are used in the collection of data, the quality of the interviewers is of crucial importance. The investment in selection and training of field staff will be reflected in the quality of the data collected.

f) Processing and Analysis. After the data has been collected, they must be coded in a form appropriate for processing. Mechanical means, such as computers, are generally used for processing. In that case, development or acquisition of the necessary computer programs should be initiated with sufficient lead time to avoid delays in processing.

g) Dissemination. This is the final step in the data measurement process. Once the data have been processed, it is important to distribute the data quickly and in a form that can be readily used by analysts and decision makers.

STAGES OF THE MEASUREMENT PROCESS

Three stages of measurement are identified: collection, management and dissemination. These stages and their components are described below.

Data Collection

Coverage

Definition and identification of the population to be covered is not as simple as it sounds. One usually begins with a list of the population called the sampling frame. Consider a survey dealing with the earnings of small farmers. A small farmer may be defined as any farmer cultivating less than some specified amount of land. The sampling frame, perhaps from government records, may make it possible to identify land owners who are possible members of the defined population. Of course, some of these people may not be farming. A greater problem is that the records do not identify those members of the target group that are renting land. In such cases there are two alternatives. If there is reason to believe that the limitations of the sampling frame are not significant, one may proceed. If that assumption cannot be made, it is necessary to find other means of better identifying the population.

The next step is to decide the coverage. It may be complete, incomplete or a sample. A census is by definition a complete coverage of the population. Incomplete coverage implies that a substantial portion of the population has been artibrarily excluded. Sampling indicates that a part of the population has been purposefully selected by statistical methods.

Sampling is more widely used than either complete or incomplete coverage. It is cheaper than complete coverage and requires less specialized labor. In addition, surveys utilizing samples also require less time, thereby providing quicker results. Importantly, sampling offers more meaningful results than incomplete coverage. Moreover, sampling makes it possible, with statistical methods, to calculate a sample size which will yield results of desired precision.

Sample Selection

Sample selection involves two basic principles. First, avoid bias in the selection procedure; and, second, maximize the precision of data for a given expenditure of resources.

Bias in the selection may be due to nonrandom selection, an inadequate sample frame, or lack of participation or cooperation by some segments of the population. Simple random sampling is the most straightforward method of reducing selection bias. It implies that every member of the population has an equal probability of being selected for the sample. If a population is listed in random order and every nth member is selected, the result will be a simple random sample.

Precision of the sample may be increased through stratification. This technique involves the division of the population into a number of purposive categories called strata. For example, a population of farms may be classified (stratified) according to size, income, enterprise mix, geographic location, education level of the farmer, etc., depending on the purposes of the survey. Then, a random sample is selected from each of the strata. This assures that each of the strata is appropriately represented in the sample. Other more complex techniques of sampling have also been developed, all with the goal of increasing precision and reducing bias.

Methods of Collection

Several methods are used for the collection of data. The subject matter of the data and the resources available for collection are important determinants in choosing among them.

Documentary sources should not be ignored. It is possible that adequate data have already been collected by others. A national census is an example of a readily available source containing frequently used data. A disadvantage is that typically such data is available only in aggregated form, thereby excluding the possibility of obtaining data about individual members of the population.

Observation is frequently used to collect data pertaining to the physical and biological sciences. This method is best applied in situations where the observer has substantial control over the environment, as in laboratory experiments, physical counting, or other such direct measurement. Although observation is appropriate for obtaining crop yield data, for example, it could not be expected to work so well in determining a nation's population.

Two other methods of collection are direct questionnaires and personal interviews. Each has been widely used, and although they are quite similar, each offers advantages relative to the other. Direct questionnaires require fewer human resources and, thus, are considerably cheaper than the labor intensive personal interviews. Also, the anonymity of a questionnaire may lead to more accurate answers when asking questions of a personal nature. Personal interviews, on the other hand, allow the interviewer to follow up on unclear responses. Personal interviews also allow more complex questions to be included. Furthermore, delay in the return of questionnaires is avoided.

Data Management

Four considerations in the management of data are 1) error control, 2) editing and coding, 3) tabulation, and 4) storage.

Error Control

In the collection of data, one must be aware of the possibility of response errors. A response error arises when there is a discrepancy between the true value of a datum and its recorded value. It may be due to carelessness, but such errors are likely to balance out in the long run since one may expect as many errors in one direction as in the other. However, response errors may also be caused by bias of the observer, interviewer or questionnaire. If, in a survey of income, for example, the respondent is made to feel that a large income is socially desirable, he may be inclined to inflate his response. Errors of this type will lead to biased data. Response errors are also introduced by lack of cooperation from the respondents. Again, consider a survey dealing with income. If respondents think their responses will be used for purposes of taxation, they may understate income.

Bearing in mind that errors are likely to occur, it is worthwhile to consider ways to detect errors. In some instances, it may be possible to check previous records. For example, if a certain census is performed periodically, it is possible to check the new data against previous responses. Consistency checks are another technique, where the same data may be solicited in two different ways and the results compared. For example, an agricultural census may ask both for the total area a farmer works and for the area in each of various crops. An error is indicated if the sum of the crops exceeds the total. Another possibility is to repeat the data collection and compare the two sets. These techniques identify errors but do not always correct them. However, the identification of errors allows the statistician to calculate bounds for the accuracy of the data.

Editing and Coding

This phase of data management overlaps to a degre with error control. Editing seeks to ensure that the data are complete, accurate and uniform. Errors are corrected at this stage if possible.

Data must usually be put in a quantitative form prior to storage and dissemination. This is accomplished in coding. For example, farmers may be asked what crops they cultivate. This may be coded by assigning each crop a number and then listing the numbers corresponding to the farmers' responses; alternatively, it may involve a list of crops with each farmer responding positively or negatively as to whether he grows each. Coding schemes depend largely on the needs of the analysis which will be applied to the data.

Tabulation

Tabulation may be performed manually for small quantities of data, but it is more common to use mechanized means. Some sophisticated computer programs perform tabulations and offer some editing and coding capability, too. This format typically includes a certain degree of aggregation and facilitates storage, retrieval and publication of data for use by analysts.

Storage

Another facet of data management is storage. It is an important factor in the ease and economic feasibility of accessing the data. If data access is time-consuming or financially prohibitive, data utilization is discouraged.

A wide variety of storage media are available ranging from traditional manual methods to state-of-the-art computerized techniques. The traditional methods are based on maintaining hard copies of the data such as the original questionnaires or transcriptions of interviews. These are relatively inexpensive but not very accessible and require substantial amounts of space. However, they are well suited for back-up purposes. Microfilm can serve a similar purpose and offers the advantages of being more easily accessed and requiring less space than hard copies. A broad spectrum of storage media are included among the computerized techniques. Raw data have been traditionally stored on punched cards but magnetic tapes and diskettes are becoming more common due to greater reliability and less storage space. Processed data are typically stored on magnetic tapes and disks. Disk storage is more expensive but offers much faster access.

Decisions concerning storage usually involve a trade-off between the cost of access and the delay in retrieval. This may be viewed in the context of a spectrum of information including raw data at the lowest level and the results of analysis at the highest level. The inexpensive but slower hard-copy means of storage suffice for low-level information, while storage media offering near instantaneous retrieval are preferred for high-level information used by decision makers.

Data Dissemination

The final step of the measurement process is dissemination of the data to users in a form that is intelligible and readily accessible to them. It is important to include not only the data but also a statement describing the data collection methodology and other background information that will aid in understanding the data. For a technical audience, it is appropriate to include mathematical statements about the accuracy of the data.

Dissemination should occur as soon as possible after collection, since the value of the data for decision making will decrease with the passage of time. The data represent the real world at some past time, and, as that time moves further into the past, the data become a less reliable picture of the present world.

It is common practice to disseminate data through publications issued at regular intervals. Annual statistical reviews fall in this category and are produced in most countries. These publications tend to provide a historical perspective but cannot provide the data in the timely manner required by decision makers. Release of data at monthly, weekly and even daily intervals must be undertaken in order to adequately serve the decision makers.

It is unrealistic to expect that publications alone can fulfill all needs for data dissemination. Since it is impossible to foresee all applications, provisions must be made for the retrieval of data as required for special situations. Quick and easy data retrieval is made possible only after intelligent decisions have been made regarding data storage. Delays in and prohibitive costs of retrieving data may hinder the decision-making process even when the correct data have been gathered. Computer-based data management systems, often including remote terminals easily accessible to analysts, decision makers and other users, are increasingly being relied upon to furnish an efficient and effective retrieval capability.

DATA SYSTEM PROBLEMS

Indicators of Data Quality

The quality of data is generally evaluated in terms of relevance, consistency, accuracy and timeliness. All are important and, to a very large degree, independent of one another. Directing increased effort at one aspect of the data cannot be expected to offset weaknesses in other areas.

Relevance

Relevance of data has been discussed at length in Chapter II. In short, the data being collected must be highly correlated with those portions of the real world having a bearing on decision-making problems. Shortcomings in this area are evidenced by the frequent use of already available, secondary data when it would be better to collect new data more relevant to the current situation.

Consistency

There are three ways data are said to be consistent: 1) when the same variable is measured in exactly the same way over time; 2) when different measures of the same variable provide identical values; and 3) when the sum of the components of a variable equals the total as derived by an alternate method.

Household food consumption is an example where consistency is difficult to maintain. Household surveys and balance sheets are two methods of obtaining estimates of consumption, and the two are not likely to agree. In this case, it is important to maintain the same methods over time and indicate to users the method by which the particular data they may happen to be using were obtained.

Timeliness

The timeliness of data is perhaps the most frequently ignored criterion in data evaluation. It is common practice in many countries to issue an annual statistical summary for the agricultural sector, six months, a year, or even longer after the close of the statistical year. This may be satisfactory for academicians and researchers, but it is far from adequate for the continuous analysis and management required in decision making. The value of most data systems could be greatly enhanced by the more timely release of data.

Accuracy

It is unlikely that perfect accuracy in data can be achieved. Instead, concern must lie in the accuracy of the data relative to the purposes for which they are used. Accuracy is expensive to achieve and expenditures on it must be balanced against the expected uses and the sensitivity of results to the accuracy of the data.

Statistical Evaluation

Bias and precision are two terms often used in the evaluation of data. Bias refers to the difference between the statistical expected value of a variable obtained through measurement and the unknown actual value of that variable. The measurement procedure is said to be unbiased if there is no difference and biased if the difference is non-zero. Precision refers to the variability in measurement. High precision indicates that there is little statistical variation in measuring the variable, that is, repeated measurement will tend to cluster close to the expected value, which, if there is no bias, is also the actual value.

The bias in data collection is difficult to quantify. In order to do so, the actual value being sought would have to be known, but if it were, there would be no reason to collect the data in the first place. Bias may be avoided, however, through careful handling of the sampling and collection procedures. Precision, on the other hand, can be measured using statistical techniques which determine the variation in data measurement.

Obsolescence of Data Systems

Data systems are increasingly being afflicted with obsolescence, where the data being collected no longer present a realistic or relevant picture of the world. The problem has two parts, one being conceptual obsolescence and the other institutional obsolescence.

Conceptual Obsolescence

Conceptual obsolescence applies to the case where the data being collected were once appropriate but no longer reflect reality or the relevant aspects of it. This happens in spite of the fact that the data in question may have improved in accuracy. Such obsolescense arises when the conceptualizations of reality have evolved but the operational definitions of variables measured have not.

One source of conceptual obsolescence in agricultural data systems is the changes in the organization of agriculture which give rise to new concepts or modifications in existing concepts. Unless corresponding changes are made in the operational definitions of variables being measured, the data system will be measuring a reality which no longer exists.

Conceptual obsolescence may also be due to shifts in agricultural policy. Each time decision makers are faced with new problems, it is essential to ask whether the present data system supplies the critical data needed for analysis of policy options to deal with them. At such times, it is also beneficial to review the data system in search of data that are no longer required or relevant to current policy concerns.

Institutional Obsolescence

Obsolescence also occurs in the institutions involved in data measurement. Modification of administrative structures should not be undertaken without considering implications for the data systems that are involved. Conversely, changes in the measurement process -- for example, the implementation of a new sampling design -- may need to be matched by corresponding adjustments in the implementing organization.

Chapter IV

Identification of the Policy Problem to be Analyzed

The analysis stage of the policy analysis process is based on the same set of theoretical and operational concepts as in the measurement stage (Figure I.3). It also relies on the data resulting from measurement and on information in the knowledge base representing the accumulation of data and information from past measurements and analyses. There are two phases of analysis indicated in Figure I.3: problem identification, and analysis and synthesis of policy options. This chapter focuses on the first of these, while Chapters V - XI cover the second.

The conduct of any particular analysis depends, of course, on the policy problem at hand, that is, on the specific situation for which a decision has to be made. Identification of the needs and goals of that problem is the subject of the first section of this chapter. This is followed by a discussion of what must be considered in defining the relevant scope of the problem.

NEEDS AND GOALS

Deviations

The needs analysis begins with an awareness that some aspect of the socioeconomic situation--physical, biological or soicoeconomic--is not what it should be, according to the doctrinal position of the political-administrative system or established plan targets or some other reference standard. This awareness may arise from vague, nonspecific perceptions of the situation, from statistical analysis of measurement data, or from direct communication initiated by interested parties in the socioeconomic system. In effect, this first awareness that a problem may exist takes the form of felt deviations between observed and desired situations.

Let's introduce a simple example at this point which will be carried through the remainder of this chapter to illustrate the problem identification process. Suppose we, in the agricultural planning system of a controlled-market economy, have become aware that the consumer price of one of our main food staples, say maize, is rising more rapidly than expected or than we would like. This awareness stems from our own observation of corn flour prices in the capital city and of news reports of similar situations in other cities and rural areas of the country, and is confirmed by our own official statistics.

Planning Stages and Policy Areas

In general, the awareness of deviations will take place in a two-dimensional context. First, they will be in the context of a particular stage of the planning process--formulation, implementation, or control--as indicated by the inputs to those stages from the socioeconomic process in Figure I.2. Secondly, for whatever stage is involved, the apparent deviations will relate to one or more particular policy subject areas, such as land reform, food price, nutrition, etc. Thus, the needs analysis will identify the planning stage and policy area relevant to the problem to be solved.

In our maize price example, if we have an on-going price control program, the observed rising prices of corn flour and other maize products may indicate a need to take normal compensatory action (e.g., stock releases, imports) as part of the implementation of that program. The price rise may be such, however--e.g., large or rapid or persistent over time--that our normal program, as initially designed and implemented, may not be adequate to manage the present situation. The control stage of the planning process, then, would decide whether suitable adjustments can be made in the price management program and, if so, what those adjustments should be. Otherwise, if the problem appears to have deeper or more fundamental causes--such as the growth of maize production lagging behind that of demand, or possibly an outmoded and inefficient marketing system incapable of adequately servicing a growing, higher-income urban population--the formulation of new policies and programs may be necessary.

With respect to policy areas, market intervention policies--e.g., price, stock and import measures--may be identified as the relevant area if the problem is related to the implementation or control stage. In formulation, however, depending on the causes of the deviations, additional areas may also need to be considered. These might include, for example, maize production, land resources, consumption and nutrition, market improvement, etc.

Needs and Interests

Another determination which must be made in the needs analysis is who has what needs with respect to the apparent problem. This is essential in order to provide a suitable context for the evaluation of policy options for solving the problem. That is, what individuals and groups, or classes of individuals and groups, in the socioeconomic system and the political-administrative system have an interest at stake in, or are directly or indirectly affected by, this problem and potential solutions to it? What are the interests and needs of these affected parties with respect to this problem?

In the maize price case, relevant needs and affected parties might include: 1) the health and economic welfare of consumers, processors, transporters, marketers and maize producers; 2) the fiscal and foreign exchange position of the government; 3) the political welfare of the central and local governments and officials; and 4) the market potential for maize exporting countries. In policy formulation to deal with more fundamental causes of maize price increases additional interests to consider might include crop improvement researchers, agricultural engineers and construction companies, farm credit and other financial institutions, international donor agencies, etc.

Goals

Having identified the needs to be considered in solving the problem, the specific goal or goals to be attained can be stated in terms of closing the apparent deviation between observed and desired situations in light of the needs of the affected parties. With respect to the maize price problem, a goal might be to reduce the price to a desired range or to slow its rise relative to other commodities in such a way or to better serve the needs and interests indicated above while avoiding damages to them.

THE RELEVANT PROBLEM SCOPE

Within the context provided by the needs analysis, detailed boundaries are placed on the scope of the problem. These include identification of the relevant planning horizon, performance criteria, policy measures, and environmental influences.

Planning Horizon

The policy decision to solve the problem and the analysis to support that decision will be made within a specific time frame. The length of this planning horizon tends to be related to the stage of the planning process involved. For example, decisions made in the course of the implementation stage tend to have a shorter-term focus. That is, in the maize price case, adjustments in policy measures to regulate the maize price may only be concerned with the performance of the program over the next few days or weeks or months. Policy formulation, on the other hand, typically takes a longer-term view of the potential consequences of policy options.

These different time perspectives are also somewhat correlated with the comprehensiveness of the analysis required for the decision (discussed below). Again, in our maize price example, implementation adjustment decisions might only look at manpower or budget constraints and implications of the program's implementation, or the impacts on day-to-day price movements, stock positions, or import requirements. In modifying the program's, implementation design, however (i.e., control), or formulating new programs, a broader view including indirect as well as direct consequences will be necessary. Since time lags are inherent in the manifestation of <u>indirect</u> consequences, a longer time frame for the analysis is also called for. Further, formulation of policies to deal with fundamental determinants of maize price behavior--e.g., productive capacity and/or effective demand for maize and its substitutes--require a longer planning horizon in order to include the time lags of even direct consequences, such as breeding and disseminating new seed varieties, installing irrigation systems, or redistributing property rights.

Performance Criteria

As indicated above, identification of the relevant planning horizon is at least partly related to the comprehensiveness required of the analysis. One aspect of this comprehensiveness is the set of performance criteria identified as relevant to the problem. Performance criteria are variables in the socioeconomic system and the political-administrative system which are directly or indirectly influenced by the policy decision and which are to be 1) projected in analyzing policy options and 2) observed in evaluating implemented policies.

Two types of performance criteria can be identified with respect to the problem at hand: desired and undesired outputs of the system. In our maize example, if we are in the implementation stage of the planning process, we might be interested in performance in terms of government cash flow and budget balances necessary to operate the program (undesired), and daily or weekly consumer and producer prices and price movements for maize and maize products (desired or undesired). For the control and formulation stages, analysts might look at these same variables plus such others as annual maize self-sufficiency rates (desired) farmers' production responses to prices (yields and areas planted) (desired), farm income (desired), adverse income distribution impacts within the farm sector and between farm and nonfarm (undesired), impacts on consumption and prices of other commodities (desired or undesired), etc.

In principle, analysis in the formulation and control stages should be based on similar sets of criteria. That is, the performance of implemented policies should be evaluated with respect to essentially the same standards as are the policy options prior to implementation. Differences between the two sets of criteria may arise, however, as a result of changes in values occuring with the on-going evolution of the government's doctrinal position and the socioeconomic situation (Figure I.2).

Finally, the performance criteria identified must be consistent with variables measured in the data system or derivable from those variables. If not, this is usually an indication of inadequacies in the data system. Specifically, conceptual obsolescence in the data system (see Chapter III) may have led to a divergence between the conceptual foundation of measurement and that of analysis

Policy Measures

Definition of the scope of the problem also includes the identification of appropriate policy measures available for dealing with this particular problem. Again, these will depend on the stage of the planning process and the policy area involved.

For example, in the maize price situation, policy actions in response to emergent situations in the implementation stage might include, depending on the nature of the problem, increasing sales of government-held grain during a certain period of time, changing government grain prices, placing import orders, etc. Policy measures which might be considered in the formulation of new policies to manage the maize market include plant breeding research, extension, irrigation projects, introduction of new consumption substitutes, improvement of storage facilities, etc.

Of course, the avaialbe measures depend heavily on the country's political and socioeconomic systems and philosophy, actions which may be suitable for a free-market on controlled-market economy may not be feasible in a centrally planned system, and vice versa. But, whatever the system, there will be a set of measures appropriate to a particular problem which can be identified from a larger set of acceptable statutory or constitutional government actions. These will then provide the basis for defining the policy options to be anlayzed.

Environmental Influences

A final set of variables to be identified is outside influences on the system over which the policy maker has no control. That is, the socioeconomic system responds not only to policy stimuli but also to other external factors.

World prices and weather are two common examples of such influences on a country's socioeconomic system. But the relevant system for a particular problem may be smaller than the total socioeconomic system. Therefore, environmental influences from the point of view of the problem at hand may also originate from elsewhere in the socioeconomic system itself. With respect to the maize price problem, for example, the domestic prices of substitute commodities may be considered as external (or exogenous) factors in the implementation stage of the planning process but internal (or endogenous) variables in policy formulation. Similarly, farm size distribution may be treated as an exogenous variable impacting, perhaps, on maize land and labor productivity, but as an endogenous variable (even a performance criterion) in the formulation of land reform policies.

A general guideline to follow in deciding whether a variable (say, the price of wheat) should be treated in the analysis as an exogenous, environmental influence on the system (say, on the price of corn flour) or as an endogenous variable of the system is to answer the following questions. "Does the variable influence the behavior of the system, and does the performance of the system also influence the behavior of that variable?" In the example, does the price of wheat affect the price of corn flour (or some other variable of interest, such as maize consumption), and does the corn price affect the wheat price? If the anser to the first question is "yes" and to the second is "no", at least with respect to the time period under consideration, then the variable (wheat price) should be considered an environmental variable. If both questions are answered "yes", then the wheat price should be considered endogenously in the analysis.

Operationally, the distinction between environmental, exogenous variables and endogenous variables is that the former may be projected in the analysis independently of any policy options considered. Such projections may be the result of reasonable assumption or some other in-depth anlaysis which has been done. They are needed, however, because they do influence the behavior of the system and hence the effectiveness of the policies to be implemented. That is, the policy must be formulated in light of the environmental factors which are beyond its control yet which may counteract or reinforce its impact.

Constraints

Policy analysis must also consider constraints which may exist on either system performance or on policy inputs. Therefore, any such constraints should also be specified in identifying the problem.

For example, in the maize, price control program, available grain storage capacity cannot be exceeded; neither can seaport handling capacity (for both off-loading and storage). There may also be statutory constraints placed on the government grain prices or budget expenditures.

In general, policy options must be analyzed and formulated which are consistent with these constraints.

PROBLEM DEFINITION

The identification of the particular problem to be analyzed, then, can be summarized as a "problem definition." This is true whether the problem is narrow in scope--as in our maize price example, particularly in the implementation stage--or as broad as a comprehensive agricultural sector analysis (as described in Chapter V). The problem definition has the following general form:

> In order to achieve goals G over the time period T, thereby satisfying needs N, we seek a policy decision, formulated from the set PM of relevant available policy measures and consistent with policy constraints CP, which acts along with environmental influences EI to maximize desired performance PB and minimize undersired performance PU over the planning horizon T consistent with system constraints CS on such performance.

Figure IV.1 is a diagrammatic representation of a typical, controlled-market, socioeconomic system, with emphasis on the agricultural sector of that system. It grew out of a problem definition for an agricultural sector analysis exercise [10, Chapter 5]. It also illustrates the sets of policy and performance variables and policy areas from which

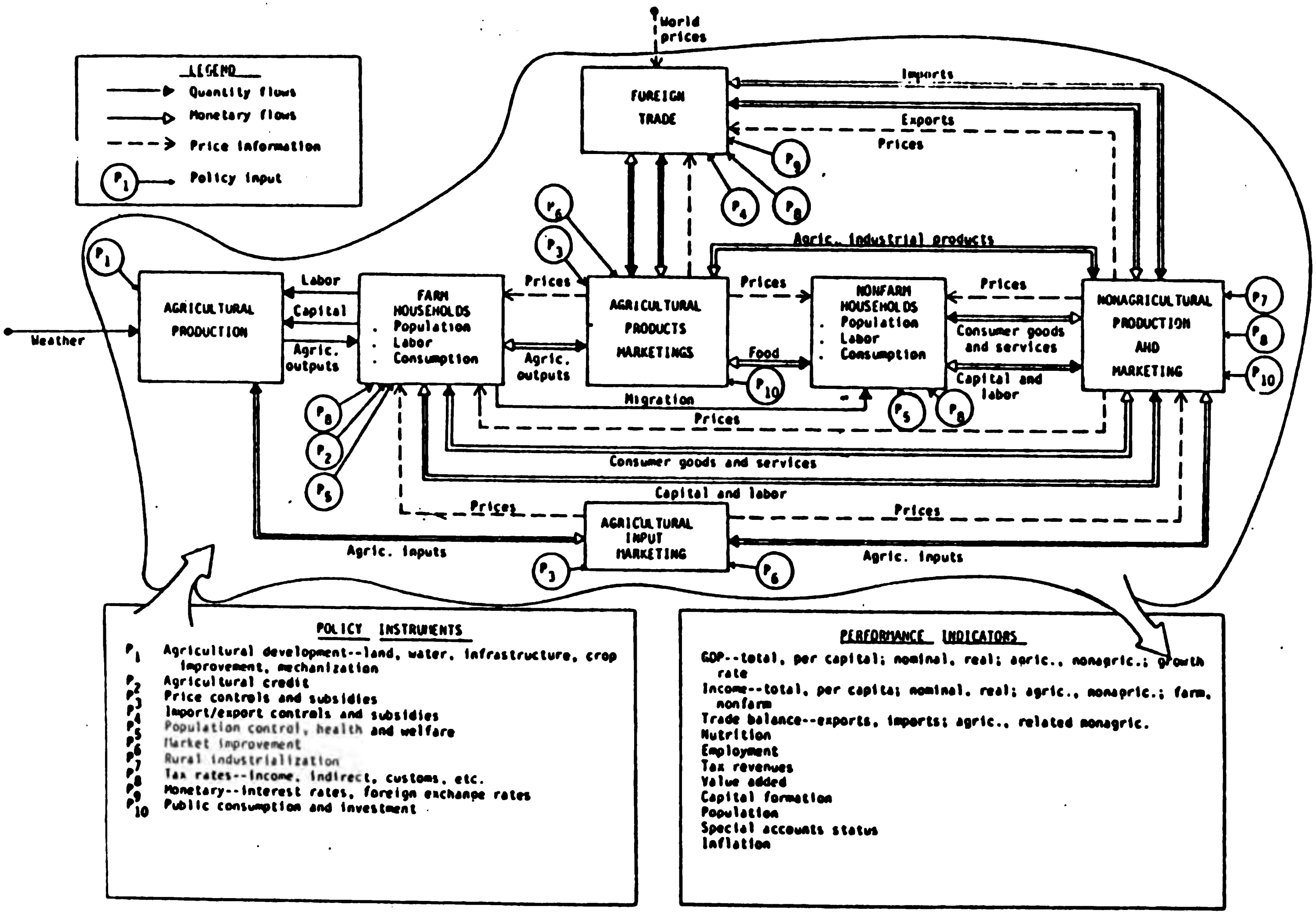

Figure IV.1. An Agricultural Sector Perspective of a Typical, Controlled-Market, Socioeconomic System subsets are identified in the context of more narrowly focused policy problems.

The diagram highlights the major interactions between the agricultural sector and the national economy through agricultural products marketing and the interchange of consumer goods and services, agricultural inputs, capital and labor between farm and nonfarm households and between agriculture and nonagriculture. The boundaries of this system are drawn around the national economy so that weather and world prices for agricultural commodities are identified as two major exogenous influences on the behavior of this system. The diagram also summarizes the important policy instruments available to national decision makers in influencing the behavior of the system and the places in the system at which these instruments can be applied. Finally, the diagram indicates some of the significant performance indicators that decision makers consider related to agricultural sector planning.

Once the scope of the problem has been thus defined, the analysis and synthesis stage (Figure I.3) formulates policy options for solving that problem and projects the likely consequences of those options. Informatión generated from that process will contribute to reaching a final decision. Along the way, however, that information may also indicate shortcomings in the problem identification and therefore necessitate a return to that stage. The next six chapters address the analysis and synthesis stage--Chapter V and VI from the point of view of the analysis of specific policy areas, and Chapters VIII-XI from the point of view of the development and use of models for policy analysis.

Chapter V

Agricultural Policy Analysis

Definitions of agricultural policy analysis

Policy analysis can take many forms. This very fact negates the existence of a definition sufficiently comprehensive to accomodate the very large number of specialized forms or methods of policy analysis. Nevertheless, most types of policy analysis involve four steps.

1) "to examine current and past ends and means of separate or interrelated policies affecting the institutions and performance of the private and public agricultural sector and its clients"
2) "to report, evaluate, or propose one or more desirable changes in the ends and means of such policy(ies) as suggested by the clients of the public agricultural sector, by the public agricultural sector itself, or by outside experts"
3) "to consider the feasibility of the desired changes under existing constraints and under relaxation of selected limiting constraints"
4) "to formulate on basis of the foregoing a set of immediately feasible desirable changes in ends and means and others which will become feasible only in a longer-run perspective"

I consider that a complete policy analysis should include all four steps, but genuine policy analysis may contain only one, two, or three of the steps mentioned. With respect to each of the steps mentioned most policy analyses will concentrate only on selected aspects within each step. For example, one type of policy analysis may examine *past* policies, but such an analysis is often different in objectives and methods from an examination of *current* policies. Similarly, a policy analysis which studies the desirability of a proposed policy under existing constraints will yield results very different from a policy analysis which focuses on the relaxation of constraints which must take place to make the proposed policy effective. These distinctions are not trivial matters, because they indicate that policy analysis by nature must be a very heterogeneous activity. Bibliographic research carried out for the LACPLAN project provides examples for any one of the combinations indicated above.

In the LACPLAN project, and in the remaining chapters of this manual, we emphasize the importance of administrative aspects of the policy decision making process. Decisions are made by organizations or persons representing those organizations. Most decisions will also be joint decisions, in the sense that they involve the participation of more than one institution. This type of policy analysis involves an examination of the doctrine and services exchanged among organizations which belong to the "ambiente economico social", the "sistema de planificacion" as explained in chapter one of this manual.

In the succeeding pages we emphasize a different, but complementary, aspect of policy analysis, i.e. the measurement of the incidence of proposed policies and the choice of optimal policies. We ask how a proposed policy will affect socially significant performance variables of the private and public sector and how, given this, the optimal level of the policy is to be determined. The analysis of the incidence of a policy (or policies) and the choice of the optimal level of the policy (or policies) are here treated as two sequential but nevertheless separate steps.

The reader familiar with large-scale linear or quadratic spatial, commodity or input programming models (16, 19, 22, 45, 48) will realize that with that approach policy incidence and optimal policies are solved for simultaneously. We do not follow that approach here, because we believe that the economist's contribution is primarily in predicting the incidence of policies. Given the absence of a unique social welfare criterion, the economist must by needs obtain information about the social welfare function, the objectives to be pursued, limitations as to the instruments to be used, etc. from the policy makers, i.e. from the "ambiente administrativo". The substitution of the economist's judgement as to what is to be optimized, e.g. agricultural value added or minimum production cost is arbitrary and possibly misleading. Since such methods are nevertheless often used in applied agricultural policy analysis, a separate section will be devoted to review such optimization techniques.

Since we also divorce ourselves from administrative or political aspects, we do not ask ourselves in this section how the interaction among institutions leads to the formulation of policies, nor do we ask which obstacles need to be overcome in the private and public sector to put the proposed policy into effect. Basically, we ask ourselves as to the benefits and costs of a proposed policy, should it be put into effect. We make no judgement as to the probability of its being put into effect.

It follows that the ex-ante measurement of benefits and costs of proposed policies is but a small part of the basic range of topics covered in this volume. It is nevertheless an important part. Policy decision making involves a choice between alternatives. The outcome of these alternatives can never be known with certainty, but it is desirable to reduce our area of ignorance as to probable outcomes.

The perception as to the impact of policies is very much influenced by the policy maker's or policy analyst's perception of the economic and social environment. It is this perception that influences a predisposition towards certain lines of action, either because they are needed or because experience has shown them to be effective. Major policy issues arise when the participants in the decision-making process have strong disagreements as to the need for action or its effectiveness.

Policies are always based on an implicit model or view as to how the socio-economic environment works, because it is through the latter that policy means influence policy objectives. Proponents of the major schools of economic thought (Marxist, structuralist, neo-classical) have irreconcilable perceptions as to how the socio-economic environment functions. Consequently, they will also differ on the role of the private and public sector and the specification as to ends and means for most policies. The major behavioral hypotheses of the above-mentioned schools are well known. For the purpose of policy analysis, it is important to state which of these hypotheses has been accepted or rejected implicitly or explicitly. In these pages we use the neo-classical principle, which assumes that producers and consumers are price takers while trying to maximize value added or utility.

The environment on which a given policy operates is often a subset of the total environment. Correspondingly, there will be a need for models of individual institutions (farms, firms, households, public sector organizations), of markets, of industries, of sectors, of regions and of the economy and whole. There are a large number of possible model variations for each of these. The policy analyst therefore explicitly or implicitly must make a choice. It might be argued that knowledge about the socio-economic environment almost automatically dictates the choice of model. That such knowledge is indispensible is not to be denied. But it should be knowledge not only about what is, but also what can be. The former is part of the diagnostic phase, the latter is part of the problem-solving phase of policy analysis. It is also by far the most difficult part, because one is no longer concerned with observation, but prediction.

Predictions are always subject to error. They are almost worthless under conditions of rapid structural change. When policy is the embodiment of structural change (e.g., agrarian reform, the creation of public enterprises, etc.) the analyst must anticipate an emerging model or environment. Correspondingly, the possibility of major predictive errors as to the impact of the policy embodying structural change is increased. This is also true for the remaining policies, because the constancy of essential aspects of the socio-economic environment can no longer be taken for granted. The methods discussed in this section therefore apply to marginal and not revolutionary change.[1]

A policy analyst, through experience or special study, usually has a preliminary inventory of desirable changes in the ends and means of policy X, as suggested by the different organizations belonging to the "ambiente economico", the "sistema politico administrativo" and the "sistema de planificacion" itself. This inventory of desirable changes can be referenced to the specific aspects discussed under steps 1 through 4 of our earlier definition. A diagnostic analysis of a given policy is relatively easy. To suggest arbitrary changes in a given policy is easier yet. But this does not capture the spirit of this section. It supposes the construction of a serious and logically positivistic argument in favor of changing or introducing a given policy.

Among other things, attention will have to be given to the opportunity costs involved in changing a policy. In a system working under effective constraints, a variety of opportunity costs must be taken into consideration. Methodologically, it requires an analysis of the direct and indirect displacement effects of changing a given policy. Its execution requires the existence of a model, which integrates the constraints and behavioral responses that characterize the "ambiente economico", the "ambiente politico administrativo" and the "sistema de planificacion". To my knowledge no such model exists. Consequently, one may have to settle for less, that is an analysis of the direct displacement effect.

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[1] While the outcome of revolutionary change cannot be predicted, the possible range of outcomes can be studied, see e.g. (63) on the impact of land expropriation and allotment.

The essential characteristic the problem-solving phase of policy analysis is that such incidence must be predicted. Such predictions must be based on an implicit or explicit model of the environment upon which the policy is to operate. Given the absence of a single model of universal validity, the analyst will necessarily have to make a choice. Several choices, in fact, if the analysis of each direct displacement effect requires a separate model. This requires a wide variety of proven knowledge about the behavioral response of the private and public sector. Under many circumstances, such knowledge will not exist. Policy decision making is, therefore, as much an art as it is a science.

Given the rudimentary state of the arts as to policy incidence analysis, most policy analysts settle for less. Under this approach, we do not ask about the predicted incidence of desirable changes. We merely inquire as to the feasibility of desirable changes. Some of the suggested changes will be feasible under existing constraints. To the extent that such changes were desirable, one might expect that they were implemented immediately or shortly afterwards. Administrative inertia may nevertheless militate against this. Authors such as Waterston[1/] see admisistrative inertia as one of the major reasons why agricultural policies fail.

Desirable changes may not be possible unless critical constraints are relaxed. These constraints can be references with respect to the steps mentioned in the basic definition. Their execution provides a program for action for each of the organizations involved. The study of policy implementation is essentially multi-disciplinary in nature. The study of ex-ante policy incidence is primarily in the domain of traditional economic theory.

These conclusions have important implications for the role of the economist in agricultural policy decision making. These two rules can be characterized

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[1/] Albert Waterston, Development planning: lessons of experience, Johns Hopkins University Press, Baltimore, 1969.

as that of being respectively an economist and planner. As an economist, he must be an expert in applying the received economic theory constituting the corpus of his profession. As a planner, he must be fully cognizant of the diversity of forces that impinge upon agricultural policy decision making.[1/]

The role of the economist in agricultural policy decision making

An economist usually does not participate solely qua economist in the agricultural decision-making process. Under normal circumstances, his role is that of planner. As a planner, he is a member of an organization. It is therefore the role of the planning organization that in ultimate instance dictates the role of the economist and economics as a discipline in the process of decision making. In order to understand the role of the policy analyst qua economist, we must understand the role of the economist qua planner.

We make the basic normative assumption that agricultural planners *should* play an important innovative and leadership role in agricultural planning and policy analysis, even if they actually do not play such a role. It assumes that planners have a normative set of objectives for agricultural development, even when actual objectives may differ. It implies that planners have a preference for certain policy areas rather than others, and it implies that planners have definite ideas as to how public sector resources should be allocated for agricultural development. It furthermore assumes that planners are rational, in the sense that the choice and intensity of the policies correspond to the set and level of objectives chosen.

An effective planner must have two roles, that of referee and that of player. As a referee, he must mediate the reconciliation of multiple

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[1/] It is therefore interesting to observe that the respondents of the 1978 LACPLAN survey of agricultural planning organizations do not stress the need for a multidisciplinary background of their personnel. See Table 29 in (29).

objectives with their corresponding instruments given limited financial and human resources at the disposal of the public sector. As a player, he must see to it that his own doctrine as to the objectives of development and consequent desirable instrumentation gets a fair hearing and acceptance. The role of referee requires technical expertise and organizational ability. The role of player stresses the political leadership role of the planner. He must exercise an important innovative role both as a referee and as a player. The issue to be explained in this section is how the agricultural planner can go about this in a systematic fashion.

The key idea is a simple one. It assumes that participation in decision making and planning requires knowledge about the current activities of the institutions that comprise the public agricultural sector. It assumes that information relative to these activities should be gathered in a systematic and continuous manner and that such information should be related to the actual and proposed role of the agricultural system and the nature of its outputs. Table 1 contains a typology of agricultural policies[1/] that affect agriculture-related outputs, inputs and services. We have constructed a preliminary list of 191 such measures. This list is evidently not complete, but our expectation is

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[1/] Policy. A specific decision (or set of decisions) designed to carry out a chosen set of actions.

	OUTPUTS, INPUTS, AND SERVICES																					
	rough direct public sector participation																					
THE OBJECTIVES OF AGRICULTURAL POLICY	141. common market trade agreements	142. bilateral trade agreements	143. generalized systems of preferences	144. special nutritional program	145. concessional food purchase agreem.	146. land use administration	147. water use administration	148. off-farm employment program	149. agr. extension--mechanization	150. agr. extension--animal husbandry	151. agr. extension--crops	152. agr. extension--fertilizer use	153. agr. extension--plant protection	154. agr. extension--improved seeds	155. agr. extension--forage	156. supervised credit	157. management of agrarian debt	158. supervision and control--transport.	159. supervision and control--storage	160. supervision and control--processing	161. supervision and control--wholesaling	162. supervision and control--retailing
consumption objectives																						
1.1 provide the urban area consumer with a regula of quality products at reasonable prices																						
1.2 protect the urban area low income consumer ag increasing cost of basic foodstuffs					+																	
1.3 provide the urban area consumer with access t foodstuffs outside a price guided exchange sy																						
1.4 provide for the adequate nutrition of nutriti vulnerable groups in urban areas				+																		
1.5 reduce the gap in the quality of the diet be urban and rural areas																						
1.6 provide for adequate nutrition of the populat locally depressed areas																						
1.7 provide the consumer with better information prices and quality																						
1.8 protect the consumer on sanitary and phytosa grounds																						
2. marketing objectives																						
2.1 provide for the efficient and rational organ of transportation																		+				
2.2 provide for the efficient and rational organ of storage																			+			
2.3 provide for the efficient and rational organ of processing																				+		
2.4 provide for the efficient and rational organ of wholesaling																					+	
2.5 provide for the efficient and rational organ of retailing																						+
2.6 provide for the stimulation of competition a orderly marketing																						
2.7 provide for the control and supervision of m power																						
3. production objectives																						
3.1 to adjust production to demand																						
3.2 to fully utilize available agricultural reso									+													
3.3 to improve the productivity of available agr resources						+						+	+									
3.4 to provide for increased availability of agr resources																						
3.5 to provide for increased availability of agr outputs, inputs, and services										+	+			+	+	+						
3.6 to improve the quality of the commodities, and services used																						
4. ownership and property rights																						
4.1 to provide for a more equal distribution of ownership of land							+															
4.2 to provide for a more equal access to the u natural resources such as water, fisheries, forestry																						
4.3 to provide for the stability of property ri																						
4.4 to provide for farm structures which are ec ically viable and socially desirable																						
4.5 to provide for a more equitable distributio land related income in joint-tenancy struct																						
4.6 to integrate farm structures with planned c regional structural adjustments																						
5. agriculture related income objectives																						
5.1 to reduce inter-sectoral income disparities																						
5.2 to reduce inter-regional income disparities																						
5.3 to provide for a socially desirable compen for land																						
5.4 to provide for a socially desirable compen for labor																						
5.5 to provide adequate income earning opportu for the agricultural labor force																						
5.6 to stabilize farm income																	+					
6. rural area development objectives																						
6.1 to facilitate structural agricultural adju parallel to regional and national developm																						
6.2 to improve the quality of rural life																						
6.3 to preserve the quality of the rural envir																						
7. national development objectives																						
7.1 to contribute towards capital formation in culture and agriculture related industries																						
7.2 to provide for an investable surplus in th agricultural sector																						
7.3 to contribute towards the formation and ou of human capital in agriculture and its po utilization in the non-agricultural sector								+														
7.4 to provide for foreign exchange earnings			+																			
7.5 to contribute towards public revenues																						
7.6 to provide for self sufficiency in basic f stuffs																						
8. international development objectives																						
8.1 to contribute towards the international sp ization of production	+	+	+																			
8.2 to contribute towards world wide security stability of food supplies																						

	MEASURES THAT AFFECT THE IMPROVEMENT OR PRESERVATION OF THE QUALITY OF AGRICULTURE RELATED OUTPUTS, INPUTS, AND SERVICES											
	through decree											thru incen-tives
THE OBJECTIVES OF AGRICULTURAL POLICY	163. establishing grades and standards	164. soil conservation legislation	165. water conservation legislation	166. rural ar., primary schooling	167. rural area secondary schooling	168. animal health regulations	169. phyto-sanitary regulations	170. mixing and milling ratio	171. measures against agric. pollution	172. measures against industr. pollution	173. control of chem. resid. in foods	174. publicize and promote [illegible] observance of quality related grades, standards and practices
consumption objectives												
1.1 provide the urban area consumer with a regula of quality products at reasonable prices												
1.2 protect the urban area low income consumer ag increasing cost of basic foodstuffs												
1.3 provide the urban area consumer with access t foodstuffs outside a price guided exchange sy												
1.4 provide for the adequate nutrition of nutriti vulnerable groups in urban areas												
1.5 reduce the gap in the quality of the diet be urban and rural areas												
1.6 provide for adequate nutrition of the populat locally depressed areas												
1.7 provide the consumer with better information prices and quality												
1.8 protect the consumer on sanitary and phytosa grounds											+	
2. marketing objectives												
2.1 provide for the efficient and rational organ of transportation												
2.2 provide for the efficient and rational organ of storage												
2.3 provide for the efficient and rational organ of processing												
2.4 provide for the efficient and rational organ of wholesaling												
2.5 provide for the efficient and rational organ of retailing												
2.6 provide for the stimulation of competition a orderly marketing												
2.7 provide for the control and supervision of m power												
3. production objectives												
3.1 to adjust production to demand												
3.2 to fully utilize available agricultural reso								+				
3.3 to improve the productivity of available agr resources												
3.4 to provide for increased availability of agr resources												
3.5 to provide for increased availability of agr outputs, inputs, and services												
3.6 to improve the quality of the commodities, and services used	+	+	+			+	+					+
4. ownership and property rights												
4.1 to provide for a more equal distribution of ownership of land												
4.2 to provide for a more equal access to the u natural resources such as water, fisheries, forestry												
4.3 to provide for the stability of property ri												
4.4 to provide for farm structures which are ec ically viable and socially desirable												
4.5 to provide for a more equitable distributio land related income in joint-tenancy struct												
4.6 to integrate farm structures with planned c regional structural adjustments												
5. agriculture related income objectives												
5.1 to reduce inter-sectoral income disparities												
5.2 to reduce inter-regional income disparities												
5.3 to provide for a socially desirable compen for land												
5.4 to provide for a socially desirable compen for labor												
5.5 to provide adequate income earning opportu for the agricultural labor force												
5.6 to stabilize farm income												
6. rural area development objectives												
6.1 to facilitate structural agricultural adju parallel to regional and national developm												
6.2 to improve the quality of rural life												
6.3 to preserve the quality of the rural envir									+	+		
7. national development objectives												
7.1 to contribute towards capital formation in culture and agriculture related industries												
7.2 to provide for an investable surplus in th agricultural sector												
7.3 to contribute towards the formation and ou of human capital in agriculture and its po utilization in the non-agricultural sector				+	+							
7.4 to provide for foreign exchange earnings												
7.5 to contribute towards public revenues												
7.6 to provide for self sufficiency in basic f stuffs												
8. international development objectives												
8.1 to contribute towards the international sp ization of production												
8.2 to contribute towards world wide security stability of food supplies												

	MEASURES THAT AFFECT THE IMPROVEMENT OR PRESERVATION OF THE QUALITY OF AGRICULTURE RELATED OUTPUTS, INPUTS, AND SERVICES																	
	through direct public sector participation																	
THE OBJECTIVES OF AGRICULTURAL POLICY	175. research in human nutrition	176. research in soils	177. research in water resources	178. research in civil engineering	179. research in mechanization	180. research in animal nutrition	181. research in animal genetics	182. research in animal health	183. research in plant nutrition	184. research in plant genetics	185. research in plant health	186. research in forestry	187. research in fisheries	188. research in processing	189. research in agric. economics	190. higher agric. education	191. international technical cooperation	Σ_i
consumption objectives																		
1.1 provide the urban area consumer with a regula of quality products at reasonable prices																		6
1.2 protect the urban area low income consumer ag increasing cost of basic foodstuffs																		9
1.3 provide the urban area consumer with access t foodstuffs outside a price guided exchange sy																		2
1.4 provide for the adequate nutrition of nutriti vulnerable groups in urban areas																		1
1.5 reduce the gap in the quality of the diet be urban and rural areas																		0
1.6 provide for adequate nutrition of the populat locally depressed areas	+																	1
1.7 provide the consumer with better information prices and quality																		0
1.8 protect the consumer on sanitary and phytosa grounds																		1
2. marketing objectives																		
2.1 provide for the efficient and rational organ of transportation																		4
2.2 provide for the efficient and rational organ of storage																		2
2.3 provide for the efficient and rational organ of processing														+				4
2.4 provide for the efficient and rational organ of wholesaling																		5
2.5 provide for the efficient and rational organ of retailing																		4
2.6 provide for the stimulation of competition a orderly marketing																		1
2.7 provide for the control and supervision of m power																		5
3. production objectives																		
3.1 to adjust production to demand																		2
3.2 to fully utilize available agricultural reso		+												+				11
3.3 to improve the productivity of available agr resources					+	+	+	+										18
3.4 to provide for increased availability of agr resources																		4
3.5 to provide for increased availability of agr outputs, inputs, and services			+	+				+		+	+	+	+					32
3.6 to improve the quality of the commodities, and services used																	+	14
4. ownership and property rights																		
4.1 to provide for a more equal distribution of ownership of land																		2
4.2 to provide for a more equal access to the u natural resources such as water, fisheries, forestry																		2
4.3 to provide for the stability of property ri																		1
4.4 to provide for farm structures which are ec ically viable and socially desirable																		5
4.5 to provide for a more equitable distributio land related income in joint-tenancy struct																		0
4.6 to integrate farm structures with planned c regional structural adjustments																		0
5. agriculture related income objectives																		
5.1 to reduce inter-sectoral income disparities																		0
5.2 to reduce inter-regional income disparities																		0
5.3 to provide for a socially desirable compen for land																		1
5.4 to provide for a socially desirable compen for labor																		4
5.5 to provide adequate income earning opportu for the agricultural labor force																		2
5.6 to stabilize farm income																		6
6. rural area development objectives																		
6.1 to facilitate structural agricultural adju parallel to regional and national developm																		1
6.2 to improve the quality of rural life																		0
6.3 to preserve the quality of the rural envir																		3
7. national development objectives																		
7.1 to contribute towards capital formation in culture and agriculture related industries																		11
7.2 to provide for an investable surplus in th agricultural sector																		2
7.3 to contribute towards the formation and ou of human capital in agriculture and its po utilization in the non-agricultural sector																+		9
7.4 to provide for foreign exchange earnings																		7
7.5 to contribute towards public revenues																		2
7.6 to provide for self sufficiency in basic f stuffs																		0
8. international development objectives																		
8.1 to contribute towards the international sp ization of production																		7
8.2 to contribute towards world wide security stability of food supplies																		0

that the agricultural policy[1] of most countries can be adequately described by less than this. If, in addition, we should focus on the more important policies, such a list would be even shorter. The purpose of the list is primarily to sensitize the reader to the possible range of agricultural policies.

The potential number of matrix entries is 26 x 191 or 4966 specific policy measures. Additional commodity and input dimensions increase the above number. On the other hand, many policy measures are output, input or service specific and diminish the above number. However, one conclusion holds; i.e., that for each country, one will very likely encounter a large and very diverse number of agricultural policies. It follows that the coordination of agricultural policy is therefore difficult, if not impossible. It also follows that if such policies are to be evaluated, singly or in combination, by means of analytical tools, one will very likely need a variety of such tools. Indeed, some of them may not yet exist, or if in existence, have not been validated as yet.

Agricultural policies can be grouped in various ways. In Table 1, we have adopted a classification which is particularly useful for economic analysis.[2] The underlying concepts are those of the production, distribution and demand

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[1] Agricultural policy. The totality of decisions originated in the institutions belonging to the public agricultural sector or public non-agricultural sector that affect the private agricultural sector and the private non-agricultural sector. These can be of four types:

1) Decisions originated in institutions belonging to the public agricultural sector that affect the private agricultural sector.
2) Decisions originated in institutions belonging to the public agricultural sector that affect the private non-agricultural sector.
3) Decisions originated in institutions belonging to the public non-agricultural sector that affect the private agricultural sector.
4) Decisions originated in institutions belonging to the public non-agricultural sector that affect the private non-agricultural sector.

[2] For an alternative classification, see Josling (34, 35).

for outputs, inputs and services. The policies then can be classified into four broad groups:

1. measures that affect the ownership of agriculture-related outputs, inputs and services;
2. measures that affect the production and supply of agriculture-related outputs, inputs and services;
3. measures that affect the demand, distribution and allocation of agriculture-related outputs, inputs and services;
4. measures that affect the improvement or preservation of the quality of agriculture-related outputs, inputs and services.

For purposes of planning, it is also very important to be explicit about their basic mode of implementation:

1. through decree of similar legal dispositions;
2. through incentives;
3. through direct public sector participation in the production of outputs, inputs and services.

Indicative planning will typically concentrate on policy incentives, but a majority of agricultural planners would favor an increased emphasis on implementation through legal disposition or through direct public sector participation. Agricultural planners must develop a capability of assessing the relative merits of these modes of implementation as related to specific policies. The fundamental changes between successive development plans can often be summarized in terms of the relative emphasis given to above modes of policy implementation.

An alternative classification would match individual policies with the institutions who are, in first instance, responsible for them. Typically, these would be related to agricultural credit, extension, research, land and water administration, marketing and other organizations of the public agricultural sector. The financial and human resources of these organizations can be considered as allocated to individual policies. This provides an important quantifiable linkage between individual policies and the annual budget for the public agricultural sector. It thereby facilitates the preparation of the annual operational plan for the agricultural sector.

Above schemes of classifying agricultural policies are not the only ones. One could correlate, for example, the policies listed in Table 1 with the degree of decision-making participation of agricultural planners in the tactical specification of the following aspects:

1. higher and lower order objectives
2. direct beneficiaries
3. institutional participation
4. forms in which the planning system participates
5. authority under which the planning system participates
6. phases in which the planning system participates
7. aspects on which the planning system must make decisions
8. required information and professional manpower
9. estimating the incidence of decisions
10. current levels of policy outputs
11. current levels of policy funding
12. current sources of policy funding

The role of planners in each of above twelve aspects has been considered in detail elsewhere (65). A few observations must be made, however, with respect to the first two aspects of above list.

The objectives of agricultural policy are related in the first instance to consumption, marketing, production, ownership and property rights, agriculture-related income objectives, rural area development, national development, and international development. For each of these objectives, several important sub-goals have been enumerated in Table 1, 44 in all. Missing from the above list is the triad of frequently listed macro objectives: growth, employment and equity. The objectives of Table 1 are close substitutes for growth, employment and equity, but their precise interconnectedness is by no means easily established. The problem of goal aggregation is of considerable practical and theoretical importance. It requires the existence of one ultimate goal; e.g., social welfare. It furthermore requires the measurability of the relative contribution of the attainment of sub-goals to this ultimate goal. The above scientific requirement cannot be fulfilled in agricultural planning unless social welfare is given a narrow interpretation as, for example, being equal to the sum of consumer's and producer's surpluses. But this definition leaves out important subjective income distributional considerations, the issue of ownership and property rights, and other development objectives listed in Table 1.

The adoption of a social welfare criterion, as mentioned above, is therefore normative and cannot claim to be representative of the outcome of a collective decision-making process. Ideally, a formally-approved National Development Plan can make such a claim. But for it to be truly so, one must suppose the prior participation of all those affected, particularly representative groups of the private sector. Planners therefore have an important role in the reconciliation of multiple objectives with their corresponding policies given limited financial, human and organizational resources at the disposal of the public agricultural sector.

Agricultural policies must result in the improved well being of people. The beneficiaries of agricultural policy are respectively the consumer, the

the owner-producer, the worker, the middleman, the public sector, the national and extra-national entities. Each of these categories has subcategories; e.g., the nutritionally vulnerable in urban areas. Often policies are designed for and influenced by special interest groups who represent the main beneficiaires of such policies. On the other hand, no specific policy measures are designed to benefit the politically disadvanteged, such as the unemployed workers or consumers in rural areas. A systematic qualitative, but preferably quantitative, analysis of the incidence of agricultural policy measures by beneficiaries is a practical way of assessing the equity aspects of a country's development strategy. Planning by objectives is fairly common in agricultural planning. Planning for and with the beneficiaries of agricultural policy is the exception. In policy analysis it might be a useful idea to start out with the clientele the plan hopes to reach. A subsequent step would cross-tabulate this with the objectives of agricultural policy as in Table 1. Such a cross-tabulation would provide for an improved qualitative assessment as to ~~whom~~ who is going to be benefited by the attainment of the objectives suggested in Table 1.

The interdependence of economic policies

Estimation of the economic incidence of proposed policies is technically the most challenging aspect of agricultural planning. Table 1 presents a checklist of 191 questions as to the economic incidence of selected agricultural policies. In principle, a single agricultural policy will affect all major and minor objectives listed in the left-hand column of Table 1. Technically, Table 1 can be considered as the reduced form of a very comprehensive agricultural sector model.[1/] Its features are the inclusion of a large number of objectives

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[1/] A reduced form is a system of equations, which expresses the endogenous variables exclusively in terms of exogenous variables. Endogenous variables are determined within the system, endogenous variables are determined without the system. For details, the reader may consult any textbook on econometric methods.

of social or political significance. Equally so, it offers a very detailed list of measures within the domain of the public sector that can be used to reach such objectives.

Table 1 is also remarkable because of what is apparently excluded. The very detailed spatial commodity and input characterization so typical of large-scale linear programming models is absent. Similarly, exogenous variables, such as income and population so typical of econometric models, are missing. This does not imply that detailed disaggregation of the spatial, commodity and input dimensions are irrelevant to estimating the incidence of policies. The implication is rather that the intersections in Table 1 already reflect the aggregated spatial, commodity or input effects, as, for example, in (15). Similarly, the intersections in Table 1 can be thought to reflect developments in exogenous variables, such as population and income.

Table 1 can be interpreted as the reduced form of a general equilibrium model. A select number of such large-scale models of the agricultural sector have been constructed (15, 19, 22, 45). None of them has been empirically validated. Most concentrate on the modeling of the private sector including only a small number of the objectives and policies mentioned in Table 1. Agricultural planners therefore may have to be satisfied with something less. In Table 1 we selected that objective on which a given policy would have its immediate impact. We deliberately ignored the fact that policies have important indirect effects on other major or minor objectives. Usually the bulk of such indirect effects would be limited to one or two additional objectives. Should this not be so, then all objectives must be simultaneously matched with all policies. The coordination of agricultural policies would then serve the primary task of policy administration.

TABLE 2

SCHEMATIC INTER-RELATIONSHIPS BETWEEN THE AGRICULTURAL SECTOR TARGETS AND AGRICULTURAL SECTOR POLICIES

INDEPENDENT VARIABLES / DEPENDENT VARIABLES	AUTONOMOUS VARIABLES		CONTROLLABLE VARIABLES	
	Agricultural Sector (X_1)	Non-Agricultural Sector (X_2)	Agricultural Sector (X_3)	Non-Agricultural Sector (X_4)
<u>Variables of social-economic importance</u>				
Agricultural Sector (Y_1)	A_{11}	A_{12}	B_{11}	B_{12}
Non-Agricultural Sector (Y_2)	A_{21}	A_{22}	B_{21}	B_{22}
<u>Variables of no social-economic importance</u>				
Agricultural Sector (Y_3)	C_{11}	C_{12}	D_{11}	D_{12}
Non-Agricultural Sector (Y_4)	C_{21}	C_{22}	D_{21}	D_{22}

The logical framework for a coordinated approach towards economic policy was originally elaborated by Professor Tinbergen (58, 59) and is basic to the theory of macro-economic policy (18, 46). The determination of alternative combinations of policies to attain socially and politically significant objectives can be illustrated by the quantification of the inter-relationships between the four principal sub-sectors that characterize the role of the agricultural sector in the national economy as in Table 2. Let us suppose for the time being that the "Sistema de Planificacion" has completed a quantitative analysis of all the variables which enter above scheme. Some of these variables are controlled directly by the public sector, e.g. the routine and development budget, wage rates, prices, the distribution of investment and imports, etc. Other variables are not directly controllable by the public sector, for example, agricultural production and employment. Nevertheless, these two variables are of great socio-economic importance. In fact, they usually are important strategic objectives of overall development policy.

Generally, it will be possible to determine a quantitative relationship between the dependent variables (Y) and the independent variables (X). These relationships are indicated by the coefficient matrices Aij; Bij; Cij and Dij in Table 2. An important problem in policy incidence is the determination of the policies (X_3) as related to the objectives (Y_1). Generally, there exists no simple direct relationship between objectives and policies. If so, however, then

$$\underline{1}/ \quad Y_1 = B_{11}.X_3$$

and by solving for the instrument or agricultural policy vector (X_3) in terms of the predetermined target or goal vector ($\hat{Y}_1$), we have

$$\underline{2}/ \quad X_3 = (B_{11})^{-1}. \qquad \hat{Y}_1$$

Generally, the inverse matrix $(B_{11})^{-1}$ will not be diagonal. Consequently, all targets in principle, influence all agricultural sector policies.

But this statement is never quite correct. The autonomous, or self-guided, variables of the agricultural sector also should be considered. Symbolically, therefore,

$$\underline{3}/ \quad Y_1 = A_{11} \cdot X_1 + B_{11} \cdot X_3$$

Where (X_1) is a vector of autonomous variables, e.g. population growth in rural areas. Solving above equation for the optimal agricultural sector policies (X_3) in terms of agricultural sector objectives (Y_1), we have

$$\underline{4}/ \quad X_3 = (B_{11})^{-1} \quad (Y_1 - A_{11} \cdot X_1)$$

From this can be seen that the optimal agricultural sector policies are influenced by both agricultural sector objectives (Y_1) and autonomous variables (X_1). But even this statement is not quite correct. The agricultural sector and non-agricultural sector are interdependent, and we must take account of this in policy incidence. First of all, we must take account of the planned objectives in the non-agricultural sector (Y_2) and its autonomous variabels (X_2). Secondly, we should not solve for the optimal agricultural sector policies independently of the optimal policies of the non-agricultural sector. The should be solved for simultaneously, i.e. policies should be coordinated between sectors. Symbolically

$$\underline{5}/ \quad B_{11}\, X_3 + B_{12}\, X_4 = Y_1 - A_{11}\, X_1 - A_{11}\, X_2$$

$$\underline{6}/ \quad B_{21}\, X_3 + B_{22}\, X_4 = Y_2 - A_{21}\, X_1 - A_{22}\, X_2$$

and solving these matric equations simultaneously for X_3 and X_4, we have

$$\underline{7}/ \begin{pmatrix} X_3 \\ X_4 \end{pmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}^{-1} \cdot \begin{bmatrix} Y_1 - A_{11} \cdot X_1 - A_{12} \cdot X_2 \\ Y_2 - A_{21} \cdot X_1 - A_{22} \cdot X_2 \end{bmatrix}$$

From matrix equation 7/ follows, that the optimal determination of agricultural sector policies must take account of

1) the objectives of the agricultural sector itself (Y_1).
2) the objectives of the other sectors (Y_2).
3) the projected development of autonomous, or self-guided, variables of the agricultural sector (X_1).
4) the projected development of autonomous, or self-guided, variables of the non-agricultural sector (X_2).

Above statement is little else but a generalized algebraic formulation of the process of policy formulation. The National Planning Agency determines the objectives (Y_2) and forecasts the development of the autonomous variables (X_2) on the basis of a macroeconomic model. The Ministry of Agriculture, and more particularly the Sector Planning Office, determines the strategic objectives for the agricultural sector (Y_1). The technical aspect of planning then involves the formulation of a set of internally consistent policies for the agricultural sector (X_3), given agricultural (Y_1) and non-agricultural objectives (Y_2) and projected autonomous developments (X_1, X_2).

According to above design, it requires specific quantitative knowledge about the Aij; Bij; Cij; and Dij interaction coefficient matrices. It encourages the view of looking upon the agricultural sector as a system with several important internal and external interdependencies.

From equation 7/ can be seen that the optimal agricultural policies must be revised if a change in strategic objectives should occur (which occurs not very often), or when the autonomous variables, i.e. the environment within which the policy operates, changes. The latter occurs frequently. Consequently, the implementation of policies makes it necessary to recalculate equation 7/ at least on an annual basis. As such, it can be a fundamental input into the preparation of the annual operational plan and budget. With unlimited financial resources, it will always be possible to reach all of the objectives in equation 7. The size of the budget for the typical Ministry of Agriculture is, however, such that not all objectives are attainable simultaneously, particularly if one formulates an ambitious target for one or more of the strategic objectives. Consequently, it is important to maintain a relative balance among the minimally acceptable values of the objectives in equation 7. In fact, it might even be desirable not to assign a priori values for these objectives, but to construct first Table 2. Systematic manipulation of the data in Table 2, as expressed in equation 7, will provide an estimate as to how strongly the stated objectives (Y_1) influence agricultural sector policies, and hence the required agricultural budget, including subsidies.

Given this, we know which combinations of agricultural objectives imply feasible agricultural policies. As indicated above, there are also reasonable lower and upper limits for agricultural policies. Consequently, the upper and lower limits on both objectives and policies must be considered simultaneously. Generally, it should be possible to generate several acceptable conjoint combinations of objectives and policies.

At this stage one might apply a sub-optimization procedure, such as goal programming.[1] Particularly important is the study of the impact of the relaxation of the effective boundary conditions of agricultural policies on strategic objectives. Such a study would shed light on the marginal social productivity coefficients of particular policies in relation to major objectives. It would therefore indicate which policies need revision if the agricultural sector is to improve its performance in terms of basic social objectives.

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[1] B. M. Wheeler et. al., Goal programming and agricultural planning, Operations Research Quarterly. Vol. 28, 1977. pp. 21-32.

Chapter VI

Analyzing Price and Market Intervention Policies

Most governments intervene in the price-setting mechanisms for food and other agricultural products in many different ways and for various reasons. In developing countries, governments often follow policies that lower the relative prices of agricultural products and increase the relative prices of industrial products. Tax, trade, credit and exchange-rate policies are commonly used instruments along with direct agricultural price and market-control measures. A study of price distortions in the Ivory Coast concluded that in the 1967-72 period, government policies: 1) discouraged agricultural output, 2) encouraged capital-intensive agricultural production techniques using imported machinery, 3) caused private profitability of new industrial activity to diverge substantially from social profitability, 4) resulted in negative value-added in the processing of agricultural exports, and 5) favored production for domestic and West African markets over international export markets. (Pursell, Monson and Stryker)[1/]

In contrast, developed countries often use product and trade policies to benefit farmers. The typical result is to create surpluses that often find their way to developing country markets and further depress domestic prices there. Peterson found that real farm prices received by farmers in

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[1/] For a review of other studies, see Lutz, E. and P. Scandizzo, "Price Distortions in Developing Countries: A Bias Against Agriculture." Euro. Rev. Agr. Econ. (forthcoming)

LDCs have been substantially lower than those received by farmers in developed nations.[2/] He showed that differences in product fertilizer price ratios on the order of four to five times or more existed in 1968-70. With few exceptions, price relationships were more favorable to farmers in developed countries than in the LDCs he studied.

The industry-urban biased development strategies adopted after WW II in many countries were based on the assumptions:

1) that industry provided a more rapid means of growth, and that achieving that growth depended upon large transfers of investible resources from agriculture to industry;
2) that higher food prices lead to higher urban wages and lower profits for manufacturing firms; and
3) that agricultural production is not very responsive to changes in intersectoral terms of trade.

Lagging agricultural production, food shortages, and rising urban food prices in many developing countries have led to increased concern over policies that reduce production incentives and lower food output. It is obvious that in many countries there is not enough food and that many physical, biological, and economic factors constrain agricultural production. At the same time, large sums of domestic and external capital are being allocated to raise food production in these countries. Schultz has been in the forefront of economists who believe that many low-income countries are foregoing needed and possible increases in agricultural pro-

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[2/] To avoid exchange-rate distortions, Peterson divided wheat-equivalent prices in domestic currency by the domestic currency price of commercial fertilizer. Thus, "real" prices reflect product-fertilizer price ratios.

duction as a consequence of economic policies. He has recently written:

> "It is my contention that the unrealized economic potential of agriculture in many low-income countries is large. The technical possibilities have become increasingly more favorable, but the economic opportunities that are required for farmers in these countries to realize this potential are far from favorable. Thus, for want of profitable incentives, farmers are not making the necessary investments, including the purchase of superior inputs. I argue that interventions by government are the primary cause of the lack of optimum economic incentives. Although it has not always been by design, the state of incentives in many low-income countries suppresses the economic opportunities of farmers." (Schultz, p. 7)

Greater emphasis by donor agencies and LDC policy makers on rural-oriented development strategies that meet basic needs, provide employment, and benefit the lowest income population strata, has also shifted interest to policy interventions more favorable to agriculture. The focus of this paper, however, is not on the evolution nor the effects of recent pricing policies in developing countries. Rather, its purpose is to provide an overview of the role of analysis in formulation and implementation of pricing policies, and a general survey of approaches that can be used to quantify the impacts of market interventions.

Policy Analysis Within the Planning Process

In a general sense, planning can be conceptualized as a process for controlling public-sector and private-sector actions that determine a country's economic and social development. The outputs of the planning process are public sector policies, leading to the definition of planning as a continuous policy-producing process. (IICA, p. 3)

The main agents within the planning process are the planners and the policy decision-makers. Planners are responsible for policy analysis, decision-makers for policy decisions.

Policies represent the application of all instruments available to the public political-administrative system for influencing the socioeconomic performance of the economy. Since agricultural development must be viewed within a context of national, multisectoral development, agricultural policies include all the instruments that affect the performance of that sector.

The political-administrative system, composed of policy decision-makers and executor agencies, is responsible for the formulation, implementation and control of policies oriented toward influencing actions of socio-economic agents to accelerate achievement of desired goals. Although planners are not responsible for policy decisions and administrative actions to implement policies, they have an important role to play in support of these actions. (IICA, pp. 12-36)

In a broad sense, policy analysis refers to all activities that generate and present information to improve the basis for decisions by policy-makers and implementation actions by executor agencies. Analyses can range from informal advice, possibly based on nothing more than intuition and opinion, to formal studies requiring extensive data gathering and processing. Policy analysis, -herefore, is the process that produces analyses for the purpose of improved public policy decision-making and implementation.

Policy analysis has an important role to play in each stage of the planning process. Its use is most familiar within the formulation stage, where its main contribution is to identify and compare policy alternatives. The elements of the policy analysis process can be identified as: 1) determining objectives, 2) designing alternatives, 3) comparing alternatives, and 4) interpreting and presenting results. These elements are discussed in more detail in a later section.

In the implementation stage, the primary role for policy analysis is in the specification of concrete policy measures. These measures represent specific actions to be carried out by the executor agencies of the political-administrative system. The role is to operationalize the policy decisions made by policy-makers.

The function of the control stage is to review and evaluate the policies and policy measures formulated and implemented by the political administrative system. (IICA, p. 31) The purpose is to feedback information on the postive and negative impacts of policies such that specific policy measures can be revised, corrective policy modifications can be instituted, or new policies can be formulated.

While policy analysis within the formulation, implementation and control stages can be presented as conceptually distinct, in practice it is more of a continuous activity. The same analytical framework and techniques used for the comparison of policy alternatives are also used to analyze the specific policy measures for the selected policies. Similarly, the evaluation of policies can be thought of as an *ex post* verification of the *ex ante* comparisons of policy alternatives.

As an example of these ideas applied to price policies, many countries have public policies for basic foodgrains that are supposed to balance the needs and interests of consumers, producers, middlemen, and the government itself. The design of a policy regime for foodgrains, for example, is what is meant by "formulation." The year-to-year application of specific policy measures within that regime is "implementation." The evaluation of impacts leading to revised policy measures or reformulation of the policy regime is "control." Policy analysis refers to all the activities within the planning system that provide information to policy decision-makers and executor agencies in the political-administrative system.

The approach advocated here does not mean that policy analysis is a panacea for all defects in public decision-making. Decisions on government policies are fundamentally political, not analytical; decision-making at the public level is the responsibility of politicians, not policy analysts. The goal of policy analysis is to help a policy-maker make a better decision than he otherwise would have made. But analysis is limited in many ways--by concepts, data, time, human resources. It can never provide a full understanding of real-world phenomena nor consider all factors that a decision-maker may take into account.

Moreover, there are other sources than analysts for assistance to policy-makers in choosing among alternatives. The decision-maker's own tuition and judgment, for example. Asking experts for opinions. Getting advice from interested parties. Bargaining with other officials and pressure groups. It is not necessary to believe that analysis can solve all public policy problems to claim that there is a definite need for it. It is sufficient if identifying policy alternatives and analyzing their various impacts can contribute significantly to the improvement of public policy decisions.

Diagnostic Assessments

A policy analysis is generally initiated after someone perceives a problem exists. A policy-maker, for example, may feel that the performance of the economy is deficient in terms of priority socioeconomic goals, and requests assistance in defining remedial policies. Or an official in an executor agency may have noticed that something is wrong with a program and request help to decide how to improve it. Frequently, special interest groups may suggest to public officials that a policy be initiated, modified or discontinued. The latter may then decide to have an analysis carried out.

When beginning to work on a problem, a desirable first step for analysts is to prepare a diagnostic assessment to define the problem and describe the problem area. (Quade, pp. 67-70) The purpose of the diagnosis is to answer the following kinds of questions:

1) What is the problem and how did it arise?
2) Which officials or agencies will make decisions and implement corrective actions?
3) What are the goals and objectives of relevant decision-makers?
4) What impacts and measures of effectiveness are important?
5) What groups or institutions will receive benefits from, or bear costs of, a solution to the problem?

With respect to market interventions, the diagnostic study should concentrate first on a qualitative description of the actual regime of trade, tax, subsidy and market control policies, with emphasis on the nature, extent, and administration of the interventions. Next, the study should undertake measurement of distortions created by the policies by comparing actual domestic prices to international alternatives through estimating producer and consumer "subsidy/tax equivalents." (Josling) Through this procedure, it is possible to estimate the distribution of costs and benefits and the effects on government expenditures from price policies affecting food and agricultural markets.

Fox has recently made a qualitative assessment of Brazil's minimum price policy, which operates through a set of minimum prices announced before the planting season. That study contains a review and analysis of the program particularly as it works in Northeast Brazil. The program's background and history were reviewed. Performance of the program was evaluated in largely descriptive terms. The primary focus was on the effects of the program in terms of stabilizing prices and expanding output. Little evidence that the program has functioned as a positive instrument of agricultural and economic policy was presented.

In a comparable study of Portugal, the World Bank went beyond a descriptive review of the extensive price controls throughout the Portugese food and agriculture sector to estimate producer and consumer "subsidy/tax equivalents." This procedure views the overall effects of various policies in two categories: those that act as a tax/subsidy to producers, and those that act as a tax/subsidy on consumers. In deriving these measures, border prices (cif import prices and fob export prices) are compared to domestic prices. Thus, the difference between an import price and a higher (lower) producer price measures the implicit producer subsidy (tax). Similarly, the difference between a final good's import price and a lower (higher) domestic market price is the implicit consumer subsidy (tax). The sum of the implicit subsidies (taxes) give an estimate of the net impact on the government budget.

The table below contains calculations for wheat in Portugal for 1976 using this methodology. It shows that the government was subsidizing both wheat production and consumption, but that wheat producers received the heaviest subsidy in that year.

PORTUGAL: WHEAT PRODUCER AND CONSUMER SUBSIDY EQUIVALENTS

		1976
Producer Subsidy Equivalent	mil esc.	720
(As % of Total Producer Value)		(19)
Consumer Subsidy Equivalent	mil esc.	340
(As % of Total Consumer Exp.)		(8)
Net Subsidy	mil esc.	1060
	(US$ million)	(35)

Source: World Bank, Prices and Subsidies in Portugese Agriculture, Report No. 2380-PO, Washington, 1979, p. 16.

Elements of Policy Analysis

Objectives, Criteria and Impacts

In choosing policies or making policy decisions, goals are most often multiple and likely to be conflicting. This complication exists even for an individual decision-maker, and is practically unavoidable where several officials or institutions have a voice in a decision.

It is also the case that the goals may not be clearly stated or even fully perceived. Apparently, there are political advantages in being ambigious about goals and stating objectives as broad statements of direction rather than as precise targets. In stating objectives, officials may not reveal what they really want, either to maintain an ideological position or because they are unsure about what they want. (Quade, pp. 86-6) Analysis can be of some assistance in reaching policy decisions even when the objectives are not agreed upon but the key to good analysis is a clear statement of goals. Until the goals a policy or program is supposed to accomplish are specified, information about alternatives and impacts has, at best, limited value.

In the case of price policies, governments often establish such vague and poorly defined objectives as consumers' welfare, producers' income, distribution of income, price stability, self-sufficiency, stable market supplies, lower public expenditures, etc. In this case, it is first necessary to establish with much more precision:

1) what objectives policy-makers want to achieve,
2) specific measures of performance for each objective, and
3) whether "more" or "less" of each measure is desired.

As an example, consider that a government specifies these five objectives for its foodgrain price policy: 1) attain self-sufficiency in foodgrain production, 2) stabilize market prices of foodgrains, 3) increase consumers' welfare, 4) increase incomes of foodgrain producers, 5) hold down government expenditures. Similar objectives have been reported in several case studies of price policies. (Mangahas, Timmer)

For each objective, alternative performance measures can be defined. In the case of farm income, for example, several concepts could be proposed. And after an income concept has been selected, questions about the distribution of the income impacts would arise. Thus, it may be much more important to know how income changes are distributed by size of farm, tenure type, and region rather than just know that farm income rose or fell.

The loss of welfare, defined as a loss of social real income (net social loss), is often calculated by the summation of changes in producers' and consumers' surplus (deadweight loss). This approach is derived from standard static partial equilibrium analysis based on the Marshallian economic surplus concept. (This concept is reviewed in Currie, et al.) It is used in the analysis of market interventions to provide an approximate measurement of allocative inefficiencies and welfare transfers between producers and consumers due to price distortions. Typical causes of price distortions are producers price supports, tariffs, quotas, export taxes, input subsidies, retail price ceilings, etc. These policies distort domestic producer and consumer prices away from international cif import or fob export prices (border prices). International prices at the same point in the marketing chain are used as reference points on the assumption that they represent a valid measure of the social opportunity costs of the commodities to the economy.

The basic analytical structure of the partial equilibrium evaluation of price distortions is presented elsewhere. For a "small" country, whose terms of trade are beyond its control, the loss of welfare (real income) from price intervention policies can be calculated as follows:[3/]

net social loss in production (NSL_p) (1)

$$= 1/2(Q_s^b - Q_s^p)(P_b - P_p) = 1/2t_p^2\eta_s V_p$$

net social loss in consumption (NSL_c) (2)

$$= 1/2(Q_d^b - Q_d^c)(P_c - P_b) = 1/2t_c^2\eta_d V_c$$

welfare gain of producers (G_p) (3)

$$= Q_s^p(P_p - P_b) - NSL_p$$

welfare gain of consumers (G_c) (4)

$$= Q_d^c(P_b - P_c) - NSL_c$$

change in foreign exchange earnings (ΔF) (5)

$$= -P_b(Q_s^b - Q_s^p + Q_d^c - Q_d^b)$$

change in government revenue (ΔR) (6)

$$= -NSL_p - NSL_c - b_p - b_c$$

[3/] For the "large" country case, whose terms of trade are dependent on quantities traded, border prices would be replaced by marginal revenues.

where:

Q_s^b = domestic production at border prices

Q_s^p = domestic production at domestic producer price

P_b = border price

P_p = domestic producer price

P_c = domestic consumer price

t_p = tariff as proportion of domestic producer price

t_c = tariff as proportion of domestic consumer price

η_s = price elasticity of domestic supply

η_d = price elasticity of domestic demand

V_p = value of domestic production at domestic price

V_c = value of domestic consumption at domestic consumer price

Q_d^b = quantity consumed at border price

Q_d^c = quantity consumed at domestic consumer price

This static framework and the simple formulae can be used to estimate the following effects of price interventions:

change in domestic production
change in domestic consumption
change in imports/exports
net social loss in production
net social loss in consumption
total net social loss
income gain (loss) of producers
income gain (loss) of consumers
change in government revenue
change in foreign-exchange earnings

In general terms, the agricultural sector in developing countries is being taxed through the price distortions that result from market intervention measures. As a result, these countries produce less and consume more than they would in the absence of the price distortions.

Trade and foreign-exchange effects depend on the combination of production and consumption effects. In the case of food commodities in developing countries with nominal protection coefficients (NPC) less than 1, imports are increased by the sum of the absolute values of the production and consumption effects.[4/] In their case the government is providing an implicit subsidy for domestic comsumption. Similarly, for exported commodities with NPCs less than 1, exports are reduced. In contrast, for export commodities with NPCs greater than 1, export subsidies are necessary to bridge the gap between the higher domestic price and the export price.

The estimated net social losses in production and comsumption depend linearly on the price elasticities of demand and supply and quadratically on the domestic-border price distortions. These effects can be large, as high as 10 percent of GNP (World Bank, Price Distortions in Agriculture).

Frequently, the internal income redistributive effects are even larger and possibly of more direct concern to policymakers. The framework sketched

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[4/] $NPC = 1 + \frac{P_p - rP_b}{rP_b}$

where P_p = domestic price, P_b = border price, and r = official exchange rate.

above gives estimates of the redistribution of income between producers and consumers and the impact on government revenue (eqs. (3), (4), and (6)). Consumers in developing countries generally gain from the price interventions. The losses to producers can be regarded as implicit taxes on agriculture.

The effects on government revenue and foreign-exchange earnings are also important to governments. If the government-revenue effect is positive, then an objective of government revenue generation is implied. If it is negative,pressure to design a price/trade policy regime to lower governments costs may arise. If foreign exchange is being lost, a foreign-exchange constraint on overall investment and development policy may be aggravated.

In considering goals, it must be remembered that costs and benefits of price interventions are not shared equally by all producers and consumers. Where food production is taxed, thus subsidizing consumption, the income-transfer effect represents a larger percentage change in the real income of low-income families but a larger absolute change in the real income of higher-income families. (Mellor) Where producers receive income gains via such devices as price supports, support subsidies, government purchases, and tariffs, large farmers utilize most of the subsidized outputs and market most of the price-supported output. Thus, price interventions not only transfer income between producers and consumers as a group but also affect income distribution within groups.

The partial-equilibrium framework presented in this paper does not consider the effects that price distortions have on agricultural productivity, capital formation, adoption of technology, employment, and migration. These longer-term, dynamic effects are possibly even more crtical to the compatibility between instruments and objectives of government policy than the impacts identified earlier. Through the growth process, they have many profound influences on the evolution of the economy. Extension of policy analyses to these long-term objectives is necessary to present a partial, confusing and conflicting set of policies from emerging over time but difficult with existing theoretical tools and data availability.

Choosing goals and specifying operational measures for goal achievement, therefore, is seldom an easy task. It is unlikely for most policy problems that the objectives can be taken as given. And when different officials disagree, the analyst must help the decision-makers clarify their objectives before he can assist them in determining which policy to select. Analysis can contribute to goal clarification in several ways:

1) by showing whether or not some objective is feasible,
2) by revealing conflicts among objectives, and
3) by identifying policy means that favor several objectives.

Indeed, this process of goal clarification may even help firm up goals. As noted by Quade, "...knowing what can be done may be extremely helpful in deciding what one should try to do." (p.84)

As previously stated, policy analysts are most often faced with multiple objectives rather than a single objective whose obtainment is the unique measure of success of the policy. The multiplicity of objectives poses no additional problem only when the goals can be compared through the case of a common unit of measurement of achievement. For example, if all objectives can be related to money costs and benefits, then a cost/benefit analysis is feasible. Otherwise, the noncomparability of multiple objectives must be dealt with in some other way.

The approach most directly comparable to optimization with a single objective is to establish a system of weights and structure the problem as one of vector maximization. Multiattribute utility analysis is an example (Keeney and Raiffa). Construction of multiattribute utility functions involves: 1) identifying objectives, 2) defining performance measures for each objective, 3) deriving a univariate utility function for each performance measure, 4) determining the relationships among the performance measures, 5) specifying the functional form of the multiattribute utility function, and 6) solving for the scaling constants associated with each attribute. The result is a utility function of the form

$$U(X) = \sum_{i} k_i u_i(X_i)$$

where U(X) is the multiattribute utility function that depends on the utility functions, u_i, for the performance measures, X_i, and k_i are scaling constants. This function incorporates the subjective risk perceptions of decisionmakers and uses their preference structure to enforce comparability among the multiple objectives. Thus, the tradeoffs among various objectives are implied by the form of the utility function that emerges.

A second approach is to order the objectives lexicographically and then optimize in sequence. After the objectives are ranked, an "optimal" solution is obtained with respect to the highest-ranked objective. Next, an "optimal" solution with respect to the second objective is sought under the constraint that the first objective is held at its optimal level, and so on for the other objectives. This approach assumes that after the higher-order objectives are satisfied to the fullest possible extent, there is still room for choices that contribute to lower-order objectives. If this flexibility does not exist, then the analyst can only explore the tradeoffs that are possible by deviating from optimality with respect to the priority objective. For example, a policy-maker might be told that a country's self-sufficiency in foodgrains would have to fall by X percent and prices to consumers rise by Y percent if government expenditures on its grain management program are to be held to Z dollars per year.

A third approach is to specify minimum levels of performance for certain objectives and use those levels as constraints while searching for optimal policies with respect to one or more other objectives. This approach at least keeps some objectives from simply being ignored without making the analysis hopelessly complex.

As a general rule, the more objectives that are considered and the more that distributional implications of policies are taken into account, the more difficult it is to obtain practical and acceptable weights to use in resolving conflicts among objectives. A solution is to simply present a "scorecard" of significant policy impacts, each measured in its natural scale. In this way, a broad spectrum of good and bad impacts can be provided, along with an indication of which groups get the benefits and which ones pay the costs. This method for presenting results is discussed more fully in a later section.

Identifying the Alternatives

If the goal of policy analysis is to help a decision-maker choose a policy, then it follows that identification of the set of alternatives is of considerable importance. No process of analysis will lead to the best alternative if it is not included in the feasible set! Thus, an important responsibility of the analyst is to search out or design a broad set of alternatives for analysis.

The search for alternatives is a creative act not subject to hard and fast rules. No general answers are possible to questions like, how can alternatives be identified or designed? Or, how many should be analyzed in depth and in what sequence?

Several factors tend to restrict the range of alternatives that decision-makers may wish to consider. The first is the conservative and parochial attitude of many officials and institutions. Maintaining the <u>status quo</u> and not considering alternatives that actively involve other institutions both serve to limit possible courses of action.

Another quite possibly serious limitation on the range of alternatives has to do with ideological considerations and political feasibility. Decision-makers may simply refuse to consider certain alternatives on ideological grounds,or feel that others are politically unacceptable to higher-level decision-makers, pressure groups or the electorate. It can be unrewarding even hazardous, to analyze unacceptable alternatives. Yet, what is not acceptable today may become the priority policy tomorrow! Moreover, without considering infeasible alternatives now, how will the social costs of the political restrictions ever become known? (Quade, p. 30)

These problems are part of the broader dilemma over role facing policy analysts. Should they analyze only marginal changes in policies within a given political/institutional context? Or should the basic socioeconomic structures also be considered as policy instruments? Most of the tools available to analysts operate on the basis of given technological and institutional structures. These tools are only able to estimate the effects of changes in policy instruments within the given structure. Only rarely can they handle questions of structural or institutional changes. For this reason, policy analysis is likely to have an inherent conservative, status-quo bias. The result may be that analysts consider only limited policy alternatives and neglect the very structural and institutional changes that may be required for equitable agricultural development and reduction of rural poverty.

Comparing the Alternatives

The core of any policy analysis is the prediction of the consequences that follow from the choice of various policy alternatives. For this purpose an analytical framework, or model, is needed to tell us what impacts will result, and to what extent the objectives will be realized, if a given alternative is chosen for implementation.

On the question of models, modesty is most appropriate! No model, nor any series of models, can incorporate all aspects of real world situations that are of interest to decision-makers. The validity of predictions from models depends on crucial uncertainties and unforeseen exogenous circumstances. Our current capability to design reliable models that can accurately predict consequences of policy choices is limited, especially where long-term dynamic impacts are at issue.

Models used for policy analysis range from verbal to mathematical, from simple to complex, from micro to macro, from static to dynamic, from deterministic to stochastic, from accounting to optimizing. Agricultural production processes have several well-known characteristics that complicate the modeling process. These include spatial dispersion, biological and weather dependence, and a large number of small-scale decision-makers. Such a complex interactive and interdependent system obviously operates dynamically and stochastically--a model that fully represents such a system is necessarily a dynamic and stochastic systems model. Continued efforts to construct and apply large-scale sector-wide simulation models are feasible and desirable. They are likely to be fruitful as sources of knowledge about the operation of socioeconomic systems, as fertile seedbeds of improved methodology for smaller scale modeling, and ultimately as useful simulators for direct policy applications. This conclusion, however, does not imply that large-scale computer models of some type should be the immediately utilized in all LDCs. Their high cost in terms of human, financial and time resources--and they are expensive tools--must be given explicit recognition in undertaking policy analysis work. Choices of approach and models should reflect:

1) clear formulation of problems to be analyzed and specification of purposes for which the model will be used;
2) quantity and quality of human and financial resources available;
3) quantity and quality of data available or feasible to collect for verifying and validating the model; and
4) needs and requirements of decision-makers intended to be aided or influenced by the analysis.

Models, then, are the means of generating information about the consequences of choosing a policy alternative. In trying to explicitly examine multiple and conflicting objectives, a wide range of policy alternatives, distributional effects, and uncertainties, the danger is that the model will become distressingly complex. To avoid this pitfall, some decision analysts suggest that decision-makers be led through a sequence of models of increasing scope and complexity. The problem is to balance simplicity and realism. If a model is too simple, it may lack credibility and explanatory power. If it is too comlicated, it may no longer be a useful aid to understanding by decision-makers. In practice, it will often be desirable to use a series of models, each increasingly complex and realistic. In this way, a decision-maker may be motivated to respond to the output of a simple model by asking just the types of questions that can only be answered by more complex ones.

The basic purpose in using models in policy analysis is to assess the effects of a changed policy situation so that predictions can be made about the likely consequences of the policy action. A "comparative statics" approach is the most common. This type of analysis involves three steps:

1) obtain a model solution under the existing policy situation,
2) introduce a policy change and obtain a new solution, and
3) compare the two static solutions to determine the impacts of the policy change.

The two main problems with this approach are first, the validity of the model in capturing the main aspects of the real-world situation, and second, the extent to which relevant impacts are reflected in the model results. This means that it is important to construct a model that is both sufficiently realistic with respect to the modelled economy and sufficiently comprehensive in terms of modelled impacts.

If the purpose of policy analysis is to provide quantitative measurement of the effects of policy alternatives on multiple economic and social objectives, then there is need to capture the socioeconomic relationships in the sector in formal analytical models. Notwithstanding this need, time and resource (both human and financial) limitations often do not permit the immediate development of a formal model. As a result, analysis may involve short-term, policy-oriented studies based on limited data and heavy dependence on qualitative approaches. Alternatively, a partial approaches may be taken that increase the use of quantitative methods but limit the scope of the studies to specified products, regions or economic impacts.

Where policy studies of limited scope and quantitative content are undertaken, their relationship to a long-term analytical approach to the entire sector could be understood from the very beginning. Thus, each partial or qualitative analysis can be oriented to an overall sector-analytic framework so that relationships and interdependencies can ultimately be identified and quantified. Short-term and subsector studies, then, could lead in time to a model of the sector that defines the economic structure and relationships of the system, introduces policy instruments, and evaluates alternative policies, programs and projects in terms of multiple economic and social goals. In this way analysts can slowly increase their capacity for assisting policy-makers in understanding tradeoffs among competing goals and in selecting the policy alternatives that contribute most to priority goals.

Chapter VII

Agricultural Sector Analysis

I. Introduction

There is a wide variety of kinds of questions about agricultural and rural development that all countries need to be able to explore analytically--using relevant tools and reliable data. They need to know, for example, how best to allocate resources among different crops. They need to know whether their land, labor and capital resources are being used efficiently in pursuit of their multiple goals. They need to know the implications of technological and policy choices on output, input, employment, and income distribution objectives. They need to better understand how agricultural change affects the total economy and how the agricultural sector is affected by growth and change in other sectors of the economy. At present, most LDCs are unable to obtain useful answers to these questions due to a lack of analytical capability and a poor data base. Nevertheless, in a number of countries, policy-makers are beginning to recognize the significance of the questions and the importance of the analytical capability needed to answer them, and to make provisions for sector-wide policy analysis in their staffing and budget plans as a crucial component of their overall planning system.

LDC interest in sector analysis has been encouraged by the policies of the major international assistance agencies. Several of these agencies have encouraged--and some have required--sector studies in support of their lending programs.

These studies have varied from very short-term assessments by foreign consultants to 6-12 month sector surveys and studies undertaken collaboratively by LDC personnel and visiting experts. AID and the World Bank have sponsored the largest number of these studies. They have tended to be mainly descriptive and have depended more on subjective judgment and evaluation than on formal analytical techniques. The AID and World Bank studies vary in scope and analytical approach. Some, including the Guatemala, Panama, Bangladesh, and Indonesia studies, have used formal econometric models of interesectoral economic relationships, while most others are purely descriptive surveys of available data and information. The series of Country Perspective Studies carried out by FAO with host government cooperation is another example of this type of study, although with more systematic and uniform attention to methodology than has characterized the AID and World Bank approaches.

The interest in these studies runs heavily to priorities for government investment programs and projects, especially those amenable to financing by the sponsoring agency. (The FAO Country Perspective Study series was not directly linked to external lending; assistance to country planners and policy-makers was its main purpose.) They are usually limited to available data and seldom result in any continuing or follow-up activity in the country. In some countries, overlapping studies have been undertaken by different agencies in close time proximity but with little or no attempt at coordination. Governments and aid agencies have legitimate needs for appraisal of alternative sector strategies and identification of priority policies, programs and projects. Achievements are likely to be limited, however, as long as the studies consist primarily of recommendations <u>from</u> foreign consultants <u>to</u> external assistance agencies based on superficial study of incomplete data of dubious quality.

This chapter reviews two representative examples of a macro-consistency approach to sector assessment. The conceptual framework for these studies was a general equilibrium view of agriculture in relation to the overall economy. These studies attempted to describe the role of agriculture in the overall process of economic development in the countries and identify the priority policies, programs and projects that would enhance the contributions of the sector to national development goals and objectives.[2]

II. The Two Sector Studies: Guatemala and Panama

The Guatemala sector study was sponsored by the Guatemalan Mission of AID with the approval and support of the Government of Guatemala. The National Planning Council, Ministry of Agriculture and Bank of Guatemala actively particpated in planning the study and assigned technicians to work with the research group. The study examined the structure of the Guatemala economy, its performance since 1950, and future prospects; and analyzed the contributions of agriculture in terms of output, income distribution, employment and balance of payments. Government policies and programs dealing with taxes, trade, research, education, credit, land settlement, prices and marketing were evaluated and changes to accelerate economic development recommended. The central concern of the study was policies to promote development and welfare in the large subsistence agricultural subsector consistent with overall economic and social objectives.

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[2] This discussion emphasizes the background, rationale and utilization of the sector studies. It does not summarize all their results nor present all of their policy recommendations. The complete studies are available in Fletcher, L. B., et al., Guatemala's Economic Development: The Role of Agriculture, Ames: Iowa State University Press, 1970, and Merrill, W. C., et al., Panama's Economic Development: The Role of Agriculture, Ames, Iowa: Iowa State University Press, 1975.

Panama's agricultural development was studied intensely by specialists during the 1970-73 period. Numerous reports on agricultural production, marketing, resource availability, and price policies were written by personnel from various agencies of the Government of Panama (GOP), the University of Panama, and international organizations. Much of this work was done in cooperation with or under the sponsorship of the Sector Study Commission (SSC) which was established at the National Planning Office and assigned responsibility for drafting a long-range agricultural development program. The commission's work was conducted in three phases. The first step was to collect and evaluate all available data related to Panama's agricultural development. This activity provided the SSC a general overview of the agricultural sector and allowed it to identify areas in which additional data and research were needed. Second, various government agencies and international organizations were asked to assist the commission with this reasearch. Most of the studies prepared in this second phase were treated as working documents and were not distributed widely; nevertheless, these reports represent the major component of the agricultural sector study.

The third phase of SSC work began in September 1972. The goal of this phase was to summarize the reports prepared during phase two and to relate their various program proposals, recommedations, and information to the general agricultural situation. The final sector study represented the results of the third phase.

A. Background of the Sector Studies

The primary purpose of these sector studies was to provide to the respective Governments and USAID Missions a policy-oriented economic analysis of the role of agriculture and the government's agricultural policies in relation to each country's economic and social development. In addition to the macroeconomic view of overall development, emphasis was placed on the organization performance of the agricultural sector and on specific policies and programs needed to improve the sector's performance.

The discussions in 1967-68 between the government and AID that led to the sector study originated in response to the widely accepted view that Guatemala was not achieving a satisfactory rate of economic and social development. Prospects for the economy were sufficiently poor that it seemed unlikely that even the modest annual grwoth rate of 4 percent that had been used by the Planning Council in its 1968-72 projections could be reached. The predominantly rural population was growing at about 3.1 percent per year, leading to rapid increases in the labor force. Employment opportunities were expanding much more slowly, especially in industrial occupations. Average per capita income was low, increasing hardly at all, and its highly unequal distribution was thought to be worsening. Educational, medical and other social services were available only to a relatively small urbanized proportion of the population.

The situation in the early 70's in Panama was quite different. Overall growth of the economy had been high and sustained for more than a decade. Little priority could be awarded to raising the growth rate by another percentage point; other goods were receiving higher priority. Panama's economy had performed well during the 1960's in terms of growth and price stability, and poorly in terms of full and efficient use of resources and an equitable distribution of income and wealth.

Structural transformation of the economy was proceeding rapidly. The agricultural sector accounted for less than 20 percent of GDP in 1969-71. While more workers were still employed in agriculture than in any other sector, farm employment had declined to 36.5% of total employment by 1970. Rural-urban migration was such that the farm work force was reaching its maximum and could be expected to begin to decline in absolute terms in the late 70's.

The relative decline in the agricultural sector in Panama should be viewed in part as a response to changes in the composition of demand in the economy. As incomes rise, consumers demand more industrial products and services and spend a smaller proportion of their incomes on food. The relatively more rapid growth of the nonagricultural sectors provides the desired mix of goods and services. The transfer of human and financial resources from agriculture to the more rapidly growing sectors had been an essential element in the structural transformation of the Panamanian economy. Similarly, price stability had not been a pressing problem. Rapid growth has proceeded almost continuously under noninflationary conditions. Food price problems appeared to signal poor output performance in agriculture rather than to indicate general price instability.

However, economic growth and price stability had been achieved under conditions of less than full and efficient utilization of resources. Unemployment has been a long-run problem in Panama City; it was estimated to be about 10 percent of the metropolitan work force in 1970. Underemployment is an even more serious problem; its presence is signaled by the large amount of labor in service and agricultural sectors where output per worker is much lower than in other sectors. The amount of underemployed human resources that existed among campesino families because of the small size and low level of technology of their farms was a major problem.

Inefficient utilization of labor is related to the unequal distribution of income. The existing skewed distribution of income was becoming even more unequal as a considerable part of the population was bypassed by economic development. The concern with income inequality was especially relevant in the agricultural sector, considering the high incidence of rural poverty.

Policies designed only to promote the most rapid growth in agricultural output were unlikely to trickle down to the economically marginal campesinos. The lot of the small, subsistence level farmers was likely to improve only if equity and efficiency goals were given priority along with output and stability objectives.

The resultant studies analyzed the present role of and contributions of agriculture to the economic development of Guatemala and Panama and suggested short- and mid-term policies conducive to agricultural and overall economic development. A total of not more than 12 work-months was devoted to each of the studies by Iowa State economists. Possibly another 18 work-months were contributed by Guatemalan technicians assigned to the research group by their agencies. Considerably more work time was utilized in Panama. A full-cost estimate for the complete Guatemala study probably would not exceed $50,000. The study was started in late 1968 and completed within six months of its initiation. The Panama study represented a larger investment of time and human resources.

B. Conceptual Framework and Methods

The basic approach used in the studies was to analyze the agricultural sector as a component of the overall economy. Development was defined in terms of a set of goals, including growth, employment and income distribution. No attempt was made to determine the actual goals of the government nor to specify a feasible set of targets for the economy. The necessity to consider goals other than growth and the possible tradeoffs between growth and employment and income distribution objectives were emphasized. The contributions of the agricultural sector to the full set of national economic and social goals were considered.

The time horizon of the studies was "short and medium term," presumably 5-7 years. For Guatemala, the premise that a major land reform could not be carried out within that time horizon, the present land ownership pattern was taken as given. This approach was not based on a belief that major structural changes in the ownership of land might not be desirable on economic, social and political grounds. Indeed, such changes may be essential in a long-run process of economic and social development of Guatemala. In the next few years, however, a large land redistribution program was not considered potentially possible. Moreover, we rejected the proposition that land reform is necessary for agricultural development in the short-run and that its implementation must precede any development program for the agricultural sector. In Panama, the government's policies and programs in agrarian reform were analyzed.

The framework of the studies included a review and analysis of the macroeconomic structure and performance of the economy, the role of agriculture, the structure of the agricultural sector, the marketing system and government policies and programs; projections of demand and supply for foods; and consideration of alternative policies and programs to improve the performance of the agricultural sector.

No single research method was applied; rather, a variety of methods were utilized when appropriate and feasible. Lack of data was the most serious limitation on the use of quantitative models and analysis, supported where possible by tentative and incomplete assessments of costs and benefits.

C. Main Results of the Guatemala Sector Study

1. Macroeconomic Structure and Performance

The cumulative annual growth rate of GDP amounted to 4.4 percent in real terms between 1950-52 (average) and 1964-66 (average). This rate was only slightly above the population growth of 3.1 percent. Thus, per capita income growth was only just above 1 percent per year during the period.

An econometric model of the Guatemalan economy was used to analyze the overall structure and behavior of the economy. The model consisted of six behavioral relations and five identities. The relationships in the model were used independently to identify major determinants of key macroeconomic variables and, considered as a set of interdependent relationships, were viewed as a model of the economy. While individual relationships provided good evidence on the dependence of strategic variables such as imports and investment on variables exogenous to the model, the model as a whole was not capable of coping with the large discrete changes that had occurred in some exogenous variables. As a result the model was used only for short-run projections of the growth of GDP.

The export sector was the main dynamic sector in the economy identified in the model. Growth in Guatemala appeared to have been export-led. Increases in export receipts or improvements in the terms-of-trade stimulated investment either directly through reinvestment in export industries or indirectly by generating new funds for general investment purposes. On the other side of the trade balance, the import component of investment was high due to the limited domestic production of investment goods.

Export performance during 1956-66 was reasonably good. Cotton exports increased dramatically after 1960. At the same time exports to Central America also grew rapidly. A low investment ratio explains why Guatemala did not enjoy more growth in this period of good export performance.

Since short-term exports prospects did not appear favorable, a low rate of growth in GDP in the future was forecast. In fact, a better than anticipated export performance brought about by higher coffee prices and continued growth in Central American exports led to a higher than forecast growth rate of GDP in the 1967-70 period. The question remains if export earnings in the future will constrain the economy's capacity-to-import and limit the supply of investment goods required for growth.

Guatemala is an excellent example of a dual economy. A large subsistence sector co-exists with a growing commercial sector. Distribution of income between the traditional and modern sectors appeared to be deteriorating. To examine this change eight departments of the economy were identified as a "subsistence" region. Each was characterized by a high proportion of its labor force in agriculture or other subsistence activities. The share of GDP generated in these departments, as measured by official statistics, was shown to have decreased from 16 to 6.4 percent between 1951 and 1966. At the same time, the level of per capita output fell from 97 to 51 quetzales. This and other evidence suggested not only a mere unequal income distribution but an absolute decline in the standard of living in the subsistence region.

A remarkable degree of price stability had existed in Guatemala. The GDP price deflator was at the same level in 1966 as in 1958. Stability was also confirmed by the consumer and wholesale price indices. The quetzal has been on par with the dollar since 1926. It is clear that the government has placed high priority on price and exchange rate stability as a policy objective and has used monetary and fiscal constraints to maintain stability.

2. Role of Agriculture

The share of agriculture in total output between 1950 and 1966 declined from 32.5 to 30.1 percent. Agricultural to total exports was 81 percent in 1966, down from 90 percent in the 1950's. Coffee, cotton and bananas are the most important commodity exports. While some inputs used by the sector are imported, the sector's net contribution to the trade balance has historically made it possible for Guatemala to maintain relative balance of payments equilibrium. It was questionable in 1968 if coffee and cotton could continue to provide the exchange earnings required for growth of the overall economy. Some potential exists for increased exports of vegetables, fruits and meat to Central America and the United States. However, it was difficult to be optimistic about the rate at which the country's agricultural exports are likely to grow.

About two thirds of the labor force was in agriculture. A slight decline from 68.2 to 65.4 percent in agriculture's share of the labor force occurred between 1950 and 1964. But the absolute size of the labor force in agriculture rose from 659,000 to 861,000. Thus, while agriculture was contributing about 30 percent of GDP, it was employing 65 percent of the labor force. Most of these workers were employed in subsistence agriculture, where output was stagnant if not declining.

It appeared that export crops and domestic commercial production had received most attention and resources from the government. This strategy probably reflected high relative weights on objectives such as growth, balance-of-payments equilibrium and price stability, and the belief that payoffs from allocating resources to commercial production was higher than could be obtained in subsistence agriculture. If the relative importance of the government's objectives or the payoffs from alternative allocations of resources were changed, a different strategy would be indicated. At the time of the study, the payoff from additional resources, in terms of growth and balance-of-payments objectives, allocated to coffee and cotton appeared to have fallen. New technologies were increasing payoffs that could be obtained in subsistence agriculture. At the same time, objectives such as a more equal income distribution and employment creation were receiving greater weight in policies and investments. This implied that a stronger case could be made for directing more resources to traditional agriculture. The study emphasized that conclusion and showed some of its implications for policies and programs.

3. Structure of the Agricultural Sector

Guatemalan agriculture is carried on largely within two major farming systems: a large-scale, commercial or plantation-type agriculture and a small-scale subsistence-type agriculture. The commercial sector is oriented toward the production of beef cattle and cash crops for domestic consumption and exports. Many large farms appear to be farmed neither intensively nor efficiently. They encompass much more land than is used regularly for production. Production is largely organized around the use of large numbers of resident laborers and migratory workers. How to insure intensive and efficient utilization of land now contained in large holdings is a policy question of major long-term importance in Guatemala.

Subsistence agriculture while carried out on small plots throughout the country, is concentrated among the Indian population in the highland area. Production is based on hand labor and a low level of technology. All available land is utilized. There is a lack of rotation of crops, leading to widespread depletion of fertility and erosion.

Corn is the basic product of the subsistence sector. It is the most widely cultivated of all crops, and the staple food grain in the diet of the population. Much of the corn is produced from native varieties on land neither fertile nor well-suited to the crop. As a result, yields are low and even declining where population pressure on the land is most intense.

Some products are produced in the traditional sector mainly for the market. Wheat and vegetables are the two best examples. These crops are grown on small farms using highly labor-intensive methods. Thus, output per man remains low and the farmers poor, although yields per unit of land can be high.

An important interrelationship exists between the commercial and traditional subsectors--the provision of resident and seasonal migratory labor by subsistence farmers for export crop. Estimates of the number of migrants who come from small farms in the highlands to work in the coffee and cotton harvests and then return to their "milpas" are as high as 400,000. Much of this labor is drawn from workers who would otherwise be seasonally unemployed; peak demands for labor in coffee and, to a lesser degree, cotton are in the peak demands for production in the highlands. The wages earned represent an important part of the migrant's family income and is a crucial element in their survival.

Poverty prevails in the traditional sector, a condition rooted in the structure of small farms, the use of primitive methods of production, the existence of underemployment, and the pressure of population growth. Farmers working small plots of land with traditional inputs and primitive tools will never produce much per man nor per hectare. New inputs and improved practices that raise yields represent one approach to the productivity problem. Giving more land to small farmers or moving labor out of agriculture and mechanizing production are two others.

The mechanization alternative did not seem consistent with the greater weights attached to income distribution and employment goals. Employment prospects in industrial and urban occupations were shown to be poor. Mechanization would raise output per man for the labor utilized, but would also aggrevate employment and income distribution problems. Possibilities for giving more land to small farmers through colonization or land reform largely were discounted for the time horizon of the study. Previous settlement projects had reached only a relatively few families and suffered from high overhead costs. Prospects for large-scale projects in the sparsely settle Petén region were highly uncertain. The feasibility of extensive land redistribution was doubtful on political and administrative grounds. The alternative of increasing productivity in the subsistence sector was emphasized as the most promising and feasible for near-term implementation.

4. Supply and Demand Projections

Supply and demand projections were developed for basic grains, fruits, vegetables and the main livestock products. These projections served several purposes. First, they provided a rough idea of the magnitude of the food surpluses and deficits that could be expected during the 1970's if the consumption and production trends of the 1950's and 1960's continued. Secondly, they provided some of the basic data needed for the analysis of several government investment programs and price policies.

The development of the supply projection required information on where, how and by whom the crops were produced. This in turn provided some insights as to how various government programs would affect different groups of producers in different parts of the country. In very broad terms, it was found that programs designed to increase grain production would tend to benefit small farmers while programs to increase fruit and livestock production would tend to benefit larger farmers. A vegetable production program would tend to benefit the larger vegetable producers if it centered on warm-season vegetables and to benefit the smaller, highland, producers if it centered on cool-season vegetables. Similarly, programs designed to increase vegetable and grain production would tend to be labor-using, while programs directed towards increased production of fruit and livestock products would tend to be capital-using.

The supply and demand projections indicated that Guatemala would be about 9 percent short of meeting the domestic demand for corn by 1980 unless corn production could be increased. This led to three types of questions. First, what are the alternative production programs that could be used to increase corn production? Second, assuming production could be increased by enough to avoid supply deficits, what investments would be needed for grain storage facilities? Third, what type of government price policies for corn would be feasible? Alternative production programs for corn were considered as a part of a more general discussion of agricultural development policies and programs as discussed below.

5. Marketing of Grains and Other Commodities

The available data on grain storage capacity revealed that Guatemala had less grain storage capacity as a proportion of its total output of rice, beans and corn than any other Central American country. Guatemala's grain storage capacity requirements were estimated using regional supply and demand analysis and the available information on the seasonality of production. The benefit-cost ratio based on the value of corn saved by the new facilities was estimated to be three main reasons for this. First, the government had been unwilling or unable to play a sizable role in the storage and marketing of corn. Second, private grain dealers had been reluctant to construct modern storage facilities because of uncertainty about the government's policies on grain marketing. Third, there had been a shortage of long term capital for the construction of grain storage facilities.

The government's inability to play an important role in grain marketing was closely related to its corn price policy. The government's support price was frequently below the private market price. It's buying procedures and the location of its storage facilities tended to discourage farmers from selling their corn to their government. As a result only a small portion of the government's rural grain storage capacity was used. Even with a more flexible price policy and a cash purchase program the government probably could not have directly altered the average wholesale price of corn by more than about five percent with its existing grain storage capacity. Its ability to indirectly affect corn prices by importing corn was limited to some extent by the Central American Special Protocal on Grains which required that first priority in meeting grain deficits and to be given to imports from other Central American countries. This reduced the government's ability to rapidly import corn at the lower world market prices.

The marketing systems for fruits, vegetables, meat, fish and dairy products were not as easily analyzed as the grain marketing system because of the lack of data on such things as marketing margins, cold storage capacity, and the seasonality of production. The approach taken was to survey all of the recent AID and government reports on food marketing to develop an idea as to what type of marketing problems were considered to be the most important, why they were considered to be important, and the type of action that the government could take to solve the problems or at least reduce their importance. It was found that the lack of sanitary marketing conditions for livestock products and fish were probably the most important problems. Government programs designed to promote the construction of new public markets and the use of cold storage facilities appeared to be the most feasible alternatives for directly solving these problems.

6. Government Policies and Programs

Aggregate public expenditures in the agricultural sector were found to be small in absolute terms and equal to only about 12 percent of total government expenditures in 1968. Nevertheless, the government has been spending in recent years from 2 to 4 dollars in the rural sector for every dollar it collected in taxes from agriculture. Additional taxes on large landowners would provide revenue and encourage these owners to either place land in intensive production or sell it to someone who will. The revenue is needed to support larger public expenditures for agricultural services and infrastructure.

Research and extension programs were found to be inadequate as a base for a development program aimed at the subsistence sector. Little effort has been made to understand the existing production practices of this sector. The impact of new technologies on employment, output, optimum cropping patterns and incomes for different regions and types and sizes of farms has not been evaluated. A research-extension program for this purpose will require a major shift in the philosophy and organization of the agencies involved.

7. Analyzing Alternative Programs for Agricultural Development

One of the questions which developed in the course of the analysis was, "Where should corn production be increased?" More precisely, given limited personnel and financial resources, should precedence be given to increasing corn production on the south coast or in the central highland region? This question was representative of the controversy over the importance to be attached to objectives other than growth in output and the possibilities for payoffs from resources allocated to the subsistence sector.

It was found that rainfall, topography and temperatures are favorable to corn production on the south coast. At least two corn crops a year are possible in coastal zones. There are fewer and larger farms and hence fewer decision makers to be influenced. Financial institutions and input supply systems are fairly well developed. Yields are higher than those in the central highlands and farmers are more familiar with modern production technology.

Several disadvantages associated with a corn production program directed to the central highlands were identified. Topography, climate, depleted soils and traditional farming methods have resulted in low yields in many zones of the region. The large numbers of small farmers would be difficult to reach with yields in many zones of the region. The large numbers of small farmers would be difficult to reach with yields-increasing programs. It is unlikely that a large-scale production program could be implemented as rapidly in the central region as on the south coast because of the difficulty in extending the program over the entire region.

A corn production program focused on commercial farmers in the south coast would reduce corn prices thus benefiting urban and rural deficit areas. At the same time, incomes of all producers not involved in the program would fall, an indirect effect on incomes of small corn producers that would be especially serious and widespread in the highlands region.

A program focused on small highland farmers would also increase marketed output and reduce corn prices. In addition, it would have the following effects:

1) improvement in nutrition from additional home consumption,
2) an increase in cash income, which would be available to purchase consumer goods and additional inputs,
3) absorption of underemployed labor.

It can be argued that the appropriate procedure would be to develop a tax system to transfer income from the coastal to the highland producers. Even if the development of such a system were feasible, it would require time to carry out the transfers. The small highland producer faced with falling corn prices may not have the resources to survive the wait.

A model that incorporated realistic production coefficients at different technology levels in both regions, empirically based estimates of home consumption of corn, income and price elasticities for food and nonfood expenditures, and accurate knowledge of geographic, seasonal, and vertical price relationships, would vastly improve our knowledge of the affects of the alternative production increasing programs. Such a model would not, however, provide a unique answer to the question as to where corn production should be increased. The answer to that question depends on the weights assigned to different goals.

D. Main Results of the Panama Sector Study

1. Macroeconomic Structure and Performance

As was done for Guatemala, an econometric macroeconomic model was constructed for Panama using data for the period 1950-70. The rate of growth for the economy was found to be closely linked to the growth rate of exports; the elasticity of GDP with respect to exports was only slightly less than one.

In 1970, goods and services sold to the Canal Zone (including the wages and salaries paid to Panamanians who work in the Zone) made up about 40 percent of total exports. Bananas accounted for about 13 percent. Tourism, which includes expenditures by tourists, businessmen, visitors on official government business, and passengers in transit accounted for 10 percent. Value added to goods imported then reexported from the Colon Free Zone made up about 9 percent. Other goods and services, which included exports such as petroleum products, sugar, shrimp, and financial services, accounted for 28 percent of total exports. This breakdown also illustrates the importance of the Canal Zone to the overall performance of the Panamanian economy; a one percent increase in the growth rate of exports to the Canal Zone increases the overall growth rate of the economy by about 0.39 percent.

The multiplier for government investment expenditures is only 0.9717. In other words, a B/1 increase in government investment increases total GDP by slightly less than B/1, and there is no multiplier effect of government investment. Although this measurement does not take into account the increase in total production capacity which may result from government investment and may affect future output, it does indicate that government investment expenditures used to stimulate the economy will have only limited short-run impact. The explanation for this apparent paradox was found in the import function which indicated that an increase of B/1 in investment increases imports by B/0.65.

This leakage, resulting from the high-import content of investment, counteracts any multiplier effect that would otherwise result from investment expenditures.

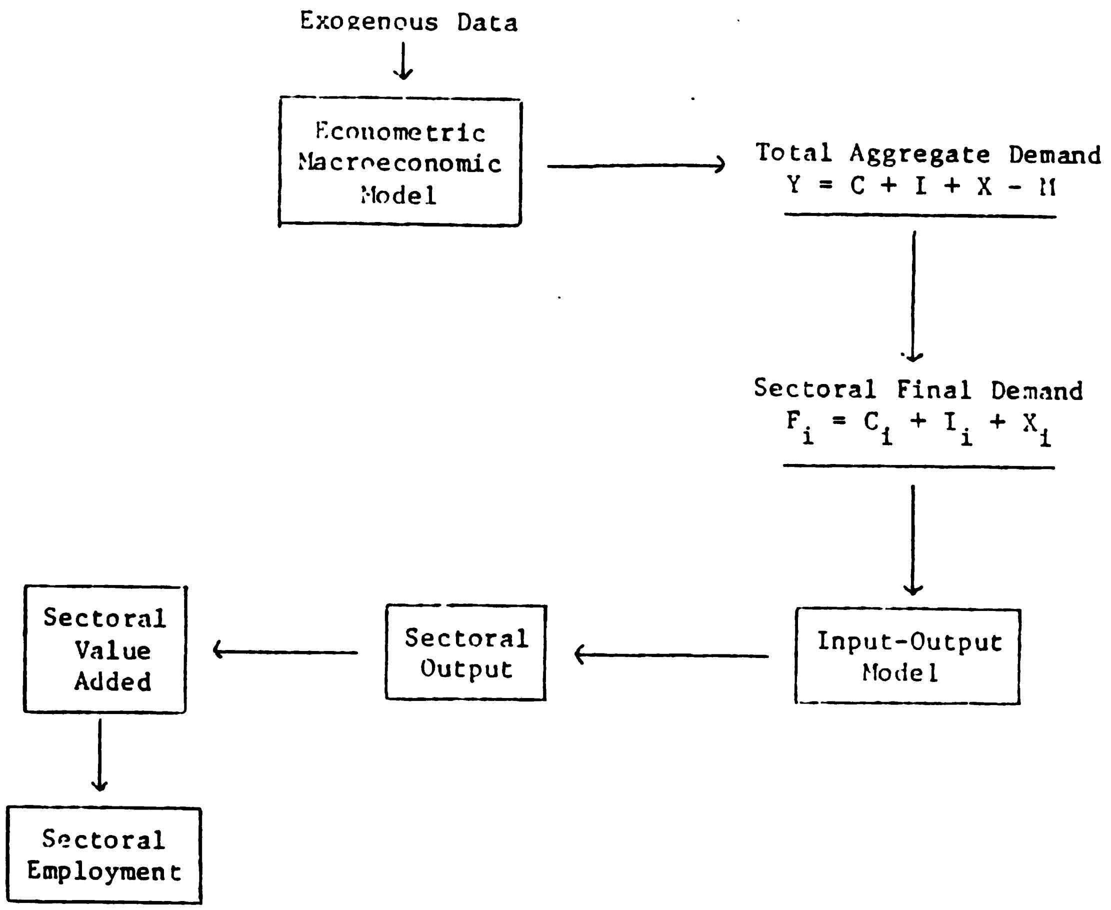
In summary, exports were the most important growth factor in the model. Growth projections from the model, therefore, were highly sensitive to export levels. Alternative export projections were developed and used to forecast growth in the economy for the 1971-75 period.

The macromodel was then combined with an input-output model in a total consistency framework to analyze sectoral growth in output and employment in relation to overall growth.

A schematic representation of the consistency framework is given in Figure 1. The framework is constructed by using the macroeconomic model to generate estimates of total aggregate demand (Y). Exports and government investment were exogenous variables projected outside the model. Total aggregate demand is then allocated among sectors, using weights based on sectoral consumption, investment, and export data to form a final demand vector. Given final derived gross output by sector was calculated using the input-output model. Next, value added by sector was calculated. These projections of value added by sector were tested for consistency by determining if their sum is sufficiently close to the overall GDP generated by the model. The check was not exact due to statistical errors. Nevertheless, if the sum of value added by sector is reasonably close, the entire model is consistent. If the sum is different from projected GDP, the original GDP must be readjusted, which in turn changes the demand components and the estimates of sectoral value added. The process was iterated until a set of consistent estimates was found.

The results showed that an 8 percent real rate of growth in the agricultural sector was consistent with an 8 percent overall growth in GDP. That rate for agriculture was almost double the historical rate, especially since 1965.

FIGURE 1. PANAMA: CONSISTENCY BETWEEN OVERALL ECONOMY AND SECTOR GROWTH RATES



while the projected overall growth rate is about equal to that of the 1960-70 period. If this higher rate of growth in agricultural output cannot be achieved, overall growth in the economy is likely to be constrained in the following ways: (1) pressures on food prices will continue and intensify, leading to overall price instability; (2) exports will be insufficient, and the rate of growth will fall; and (3) other industries will be unable to obtain as large quantities of intermediate goods from the agricultural sector as they need, thus creating bottlenecks elsewhere in the economy. It is in this sense that agriculture in Panama was termed a lagging sector.

If the unemployment rate and the labor force particpation rate for agriculture and nonagriculture are assumed constant, the growth rate of agricultural employment can be related to the growth rate of total employment and that in nonagriculture by the following equation:

$$r_A = \frac{L_T}{L_T - L_N} r_T - \frac{L_N}{L_T - L_N} r_N$$

where

r_A = rate of growth of agricultural employment

r_N = rate of growth of nonagricultural employment

r_T = rate of growth of total employment

L_T = total employment in the economy

L_N = employment in nonagriculture

The rate of growth of employment in agriculture will remain temporarily constant as long as the ratio of total employment to agricultural employment $[L_T/(L_T - L_N)]$ and the ratio of nonagricultural employment to agricultural employment $[L_N/(L_T - L_N)]$ remain constant over time. These ratios remain constant only if $r_T = r_N$. However, if $r_N > r_T$, the rate of growth in agricultural employment will become negative at some point in time. If $L_T = (1 + r_T)^t L_T^0$

and $L_N = (1 + r_N)^t L_N^0$, where L_T^0 and L_N^0 are equal to total employment and nonagricultural employment in the initial time period, respectively, and substituting into the expression for r_A, the rate of growth of agricultural employment can be expressed as a function of time (assuming r_T and r_N are constant over time). Thus

$$r_A(t) = Z(t)r_T - X(t)r_N$$

where

$$Z(t) = \frac{(1 + r_T)^t L_T^0}{(1 + r_T)^t L_T^0 - (1 + r_N)^t L_N^0}$$

and

$$X(t) = \frac{(1 + r_N)^t L_N^0}{(1 + r_T)^t L_T^0 - (1 + r_N)^t L_N^0}$$

Starting with 1970 as the base year, $r_A(t)$ was calculated for succeeding years. The growth rates for total and nonagricultural employment (r_T and r_N) were calculated on the basis of the growth rates implied by alternative A, which was based on the assumption that exports and government expenditure would grow at the same average rate as in the past. The derived values for r_T and r_N were 5.78 percent and 8.31 percent, respectively. The results of this test showed that agricultural employment would reach a peak by 1975. The calculations indicated that the labor force in agriculture would number about 162,000 workers at its peak, compared to 158,000 in 1970.

2. Organization and Resource Utilization in Agriculture

Panama's agricultural sector exhibits an economic structure and characteristics that result in serious underemployment of farm labor and highly unequal distribution of agricultural income. Most of the increase in land in farms between 1960 and 1970 was due to an increase in pastureland. More than three-fourths of the increase in pastureland that took place during this period occurred on farms of 50 hectares or larger; most of these farms employ extensive methods of livestock production. The increase in agricultural output has not been general for all types and sizes of farms. The largest increases have occurred in rice, sugar, bananas, and beef on larger farms that utilize mechanized techniques of production.

The agricultural sector also shows a sharp duality in its structure. Most of the farms are small and produce rice, corn, and beans under traditional technology, largely for home consumption. Little credit and purchased inputs are used, production is based almost entirely on human labor, and family labor is the principal input used for production. A few larger farms are highly mechanized and use modern inputs for production. Most of these farms produce rice and perennial tree crops. The large farms that are not highly mechanized usually produce cattle, using extensive technolgoy.

The poverty of small farmers producing cereal crops by land labor for home consumption is one of the most pressing agricultural problems. These small farms have depleted soils and low yields. The farmers use no credit and receive no technical assistance. Lack of legal title is prevalent among small farmers, leading to insecurity of tenure and an inability to use land as a basis for obtaining credit. Awarding land titles is a prerequisite to any programs designed to reach small farmers, but titles alone will do little to raise productivity and incomes of small subsistence farmers.

Substantial migration from rural areas has occurred. Most of this migration represents small farmers and their families seeking a better life in urban locations. Other small farmers have moved to new agricultural areas seeking more and better land. Many of these migrants have found themselves unemployed or underemployed in minor trades or services in the cities or back in subsistence agriculture.

Migration into the Darien region is expected to increase during the seventies. Commercial development of the Darien region forest is unlikely to take place before the Darien Highway is completed and a system of feeder roads developed. Meanwhile, a national forest policy will be needed to assure that commercially valuable forests are not destroyed as farming in the region increases.

3. Supply and Demand Projections

Supply and demand projections prepared by the SSC in early 1971 indicated that by 1975 the domestic production of nearly all major food products except beef, coffee, and bananas would be less than domestic demand. These projections also suggested that the supply deficits for most major foods would increase further by 1980 unless major efforts were made to increase agricultural production. The short-run implications of these projections are obvious. Panama must increase food imports if food prices are to be maintained, or prices will have to increase if domestic supply and demand are to be equated without increased imports.

Both approaches were used during the 1960s; for some products, imports were increased, while for others, prices were allowed to adjust upward. The alternative of rapidly increasing agricultural production could not be implemented in the late 1960s for several reasons. Investment opportunities outside agriculture were more attractive to large landowners than the opportunities available within agriculture. Secondly, the government did not have enough well-trained technicians or "technology packages" to rapidly increase the productivity of small and medium farmers. The asentamiento program can be viewed as an attempt to concentrate the government's limited resources to assist small farmers through the use of large-farm technology which is feasible for those products where it is significantly more productive than small-farm technology. Rice is a possible example. There is little evidence to suggest that the existing large farms are significantly more efficient than small farms in the production of products such as cattle, corn, beans, or vegetables. If, in fact, they are not more efficient, the formation of asentamientos will not increase production significantly until new technology suited for this form of resource control can be developed and introduced. Time is required for this type of development. Indeed, one might expect any large-scale government-sponsored development programs for agriculture to require at least a year or two to plan and finance and another three to five years or more to implement.

The trend projections of supply in the sector study was not significantly different from SSC projections. The trend projections of demand frequently were somewhat below SSC projections due to differences in the statistical techniques used. Nevertheless, both sets of projections led to basically the same conclusions. Retail food prices and imports are likely to continue to increase more rapidly during the early 1970s than they did during the 1960s. The upward pressures on food prices and imports are expected to continue during the last half of the decade, unless aggressive government actions are taken to increase the productivity of land, labor, and capital presently employed in agriculture; increase the amount of land in farms; and encourage a higher rate of investment in the agricultural sector.

4. Marketing Basic Foods

By Latin American standards, Panama's food marketing system is above average. A considerable proportion of the food supply is handled, processed, and merchandised by companies with modern, capital-intensive facilities, supermarkets account for a relatively high proportion of urban food sales and food price during 1960-72 remained remarkably stable.

The capital-intensive character of food marketing results from several factors. First, interest rates have been relatively low and wages relatively high. Second, seasonal labor scarcity has encouraged capital-intensive technology. Large rice producers, for example, have adopted large-scale machinery since labor has been in short supply during the planting and harvesting seasons. Mechanization and bulk handling of rice on large farms has complemented bulk storage and handling of grain by rice dealers. A third factor has been the dualistic nature of the agricultural sector. Large producers market most of their production and either become large wholesale and processing operations or create them. A few relatively large dairy farmers, for example, specialize in the production of Grade A milk, and most of their output is sold to one milk processor. The milk processing company in turn is able to operate on a large enough scale to justify investment in stainless steel tank trucks, cooling stations, and modern pasteurization equipment. Marketing channels reaching small farmers usually are less capital intensive than those reaching large farmers. Small farmers are more likely to sell their cattle to municipal abattoirs. The marketing system for fresh vegetables has not generated very much investment in packing sheds or cold storage facilities. Small milk producers are more likely to sell their milk to local dealers who distribute unpasteurized milk.

A fourth factor affecting the capital intensity of marketing channels has been the growth of supermarkets in Panama City. This growth is a reflection of the relatively high and increasing average income levels in the Panama City and Colon areas. Supermarkets buy on a large scale and prefer to deal with wholesalers who can consistently supply large quantities of high-quality products. Wholesalers have had to invest in larger storage facilities to assure consistent supplies and in the future may have to purchase additional processing and handling equipment in order to improve product quality. As a result, a capital-intensive retail system (supermarkets) tends to create a more capital-intensive wholesale system.

Most of the marketing channels for the major food products are controlled at some point by a small number of firms. The oligopolistic structure of the marketing channels cannot be altered to any great extent without reducing the operational efficiency of the markets. Existing firms are large relative to the national market, but most are still too small to take full advantage of economies of larger scale operations. The general trend appears to be toward even fewer and larger firms controlling marketing of most food items. Regional abattoirs gradually will replace small, municipal facilities. Supermarkets will continue to capture a larger share of urban food sales. It also seems likely that there will be an increased amount of vertical and horizontal integration in the food marketing industry. Several of the poultry marketing firms already are completely integrated from farm to final consumer, milk processing companies gradually are moving into vegetable processing, and the ability of supermarkets to undertake their own wholesale operations will increase as they become larger.

The oligopolistic nature of food marketing channels should make it easier for the government to control prices and to regulate food quality. Regulatory agencies must deal directly with only a few firms to alter market conduct and performance. While the government may not wish to alter the market structure of the main food marketing channels, it could give greater support to the development of farmer cooperatives in order to increase the market power of small and medium producers. It seems unlikely that there will be any less need for government price controls in the future than in the past, but there will be an increased need to allow seasonal price variations and greater differences in the prices of different qualities of food products. In the past, the government has tended to prevent the price system from providing farmers with information on the type and quantities of food products that consumers want. The prices set may have been fair and equitable when they were established, but they were not adjusted rapidly enough to signal changes in demand, a situation that reflects the importance assigned to price stability. A more sophisticated and flexible approach to price controls will be needed in the future.

5. Toward an Agricultural Development Strategy for Panama

It is possible to accelerate the growth in agricultural output without concurrent attention to the income distribution and rural levels of living. Production can be generated through programs that make little attempt to benefit the majority of the rural populace. This approach simplifies development planning but does little to transform the traditional sector or to promote development in its broadest sense. The literature on economic development is replete with references to a possible conflict between growth in output and improvements in income distribution. Panama's land base, population distribution, and economic situation, however, are such that the goals of increasing agricultural output and improving the welfare of low-income farmers should be reasonably complementary. Productive lands already are owned by the government and can be opened to development by building new roads. Increasing the credit available to small and medium farmers will allow them to increase their incomes but need not result in a reduction of credit available to large landowners. Enlarging seed improvement and soil testing programs may benefit large and medium farmers relatively more than small farmers but certainly would not reduce the real incomes of small farmers. Expanding agricultural education and technical training programs will benefit farmers in all farm size categories.

The possibility of reconciling production with social welfare and equity goals exists if income redistribution is largely brought about by increasing the productivity of the low-income segment of the agricultural labor force. By following this appraoch, underemployed farmers can add to their output a contribution to the overall economy while simultaneously improving their economic status.

Once goals and objectives have been established, it is helpful to identify target groups and to design development programs to meet their needs. A useful approach in Panama's case was to identify the target groups on the basis of farm size. The following major groups (or subsectors) were identified by this method: (1) a small group of relatively large firms producing major export crops, primarily sugar and bananas; (2) a group consisting of roughly 2,000 to 3,000 large commercial farms that market most of their production and hire most of their labor inputs; (3) a group consisting of some 35,000 small and medium farms that use mostly family labor but market a substantial proportion of their output; and (4) a group of almost 53,000 small farms that are basically subsistence operations on 10 hectares or less and use few if any modern production techniques or inputs. These groups have different problems and require different types of government assistance. Even within a given group, the relevant problems may vary with geographical region so that a program that is appropriate in one location may be unworkable in another.

The Export Subsector. Output of the large-firm export subsector grew at a faster rate than total agricultural output during the 1960s. Ouptut of bananas and plantains increased by 75 percent between 1960 and 1970, and exports of bananas increased by over 125 percent during this period. Although the world price of bananas may decline somewhat during the 1970s, banana exports should continue to account for at least 10 percent of the total value of exports of goods and services in 1980.

Production of sugarcane increased by 184 percent during the 1960-70 period with most of the increase taking place after 1962, due primarily to the tenfold increase in sugar exports between 1960 and 1970. Panama has the refining capacity and the land resources needed to continue to increase sugar production rapidly throughout the 1970s. Whether it will be profitable to do so depends primarily on world sugar prices and changes in Panama's U.S. sugar quota. As an active participant in the sugar refining industry, the government should develop a thorough understanding of the industry's problems and alternative solutions.

Part of the fishing industry could be included in the export subsector. This industry has grown rapidly and is expected to continue to do so at least until 1980. The fishing industry's primary needs appear to be larger boats and better port facilities. The large boats are being built, but government assistance will be needed if port facilities are to be improved.

The Large-Farm Subsector. The underutilization of land resources by large farms is closely related to the lack of investments in land improvements. Several interrelated factors have influenced the amount and type of investments made by large landowners. An especially important factor is the scarcity of competent farm managers, in part due to the shortcomings of the agricultural education system. Not enough farm youth have been trained in agricultural sciences. Generally speaking, beef cattle operations require less supervision and less farm labor and involve fewer risks than field crop operations. As a result, large landowners invest in cattle rather than in machinery and equipment for planting and harvesting crops. Over time, cattle increase in value and machinery depreciates; the large, commercial farming subsector develops more and better livestock managers than field crop managers; and the lending activities of banks further promote the growth of extensive livestock operations. This circular chain of events cannot be broken without substantial public investment in agricultural education.

Given the existing size structure of farms, less than 300 skilled farm managers would be required to ensure that the 22 percent of the farmland in farms over 500 hectares was fully and efficiently utilized. If present enrollment levels are maintained, the University of Panama will graduate a total of about 300 persons in agricultural sciences between 1970 and 1985; but many of these graduates will be from and will remain in the Panama City area. Many of them will not be interested in becoming farm managers, and many will be needed by government agencies to help carry out various rural development programs. Obviously, improving the agricultural education system and increasing the number of graduates in agricultural sciences must receive high priority in any program to more fully utilize Panama's land resources.

The investment opportunities outside agriculture are also an important factor influencing the investment decisions of large landowners. Nonagricultural investment opportunities were especially attractive during the 1960s; special tax incentives were available to firms establishing assembly and reexport operations. Urban populations grew rapidly, and average incomes increased by over 80 percent between 1960 and 1970, thereby creating a rapid growth in the demand for consumer goods and services. The economic growth of urban areas reduced the flow of investment capital to the rural sector, directly by lowering the relative profitability of agricultural investments and indirectly by reducing the amount of bank credit available to farmers.

Government controls of food prices, imports, and exports have had mixed effects on investments in the agricultural sector. The prices of many products have been maintained above world price levels by limiting food imports. Price controls on rice, for example, appear to have been an especially important factor accounting for the increased investments of large farmers in rice production during the late 1960s. The emphasis on price stability, on the other hand, gradually reduced farmer profit margins during the late 1960s and early 1970s as the costs of inputs increased more rapidly than agricultural productivity. In general, however, government price and import controls appear to have been used with reasonable effectiveness to promote economic growth without being used to the long-run disadvantage of either the rural or urban sector.

Steps should be taken also to encourage improved utilization of land on large farms. One of the major purposes of the rural cadastre was to provide information for applying the idle lands provision of the agrarian reform law and for implementing a land tax based on potential productivity. Such policies are difficult to administer but when successful can result in efficient utilization of land by existing landowners.

Medium-Sized Farms. Operators of medium-sized farms probably have been affected more by changes in government agricultural policies than either large or small farmers. Large farmers have a wider range of investment opportunities and greater borrowing ability and are able to transfer funds into and out of the agricultural sector more rapidly than medium farmers. Small farmers use few purchased inputs and market a smaller proportion of their production; consequently, their real incomes are affected less by changes in the market prices of either inputs or outputs. Farmers with 5 to 50 hectares accounted for 45 percent of the total farms and nearly one-third of the land area in farms in 1970. Only 22 percent of these farmers held title to their land. Without land titles, there is less incentive to make long-term investments in farm improvements and less opportunity to obtain short-term production loans from banks. The medium farmers would receive considerable benefits from a vigorous program to grant land titles. With land titles to secure short-term loans, these farmers would be in a much better position to utilize new production technology provided by an expanded extension program. The middle-sized farmers are an important and sizable group, yet they seem to have been frequently overlooked in Panama's agricultural development programs. This group of farmers can make a major contribution to output while providing adequate income to hold labor in the agricultural sector.

The Small-Farm Subsector. Farms with 0.5 to 4.9 hectares accounted for 45 percent of the total farms larger than 0.5 hectares in 1970 but contained only 3.7 percent of the land area in farms. Most of the farms in this group are subsistence operations using a slash and burn technology. Programs designed to help the families on these farms are needed and should be considered an important part of Panama's social development efforts. Doubling the production on these farms would double the real incomes of over 41,000 farm families that account for about 225,000 persons, roughly 12 percent of the total population. Since much of the increased production would be consumed on the farm, development programs directed toward farms in this size class probably would have relatively little impact on the total amount of food marketed.

There is no single "best" program for all small farmers. Supervised credit, penetration roads, and land title programs may help some farmers; agricultural cooperatives and asentamientos may be the most effective way to help others. Programs must be designed to meet the needs of the people to be helped.

The total number of small farms in the 0.5 to 4.9 hectare size class declined by about 5 percent between 1960 and 1970. Further declines are expected, but even if the 1960-70 trend continued, there would still be over

34,000 small farms in this size category at the end of the twentieth century. Based on present family sizes and projected population growth rates, about 6 percent of the nation's population will be living on small farms (0.5 to 4.9 hectares) in the year 2000 unless vigorous small-farmer assistance programs are undertaken.

The extent to which the current policy of organizing asentamientos to aid the marginal compesinos will be successful is not yet known. The economic importance of the land area in asentamientos is still quite small. Many years will be required to extend this program to the majority of low-income farmers.

The difficulty of working with small farmers is widely recognized. Asentamientos offer one alternative by which groups can be formed to facilitate credit and technical assistance programs. If efficient means can be found to organize asentamientos and develop them into viable economic units, their economic and social contributions can become substantial. On the other hand, if the asentamientos absorb much of the attention and resources of the Ministry of Agricultural Development (MIDA) without achieving economic viability, the opportunity costs of this program may become excessive.

In the long run, the number of small subsistence farmers should diminish. Every effort should be undertaken to encourage creation of employment in the nonfarm economy and to facilitate the entry of small farmers and landless laborers into other occupations. Resettlement and consolidation can assist other small farmers in moving into the medium farm class. A large part of the inefficient utilization of labor in agriculture can be solved only by growth and employment expansion elsewhere in the economy. Nevertheless, good jobs are not automatically available for rural migrants. Little economic or social gain is achieved by moving underemployed rural workers into low-productivity urban service and trade activities. Emphasis on technical education and vocational training is needed to facilitate entry by farm migrants into higher income nonfarm occupations.

Results of the agricultural sector analysis vividly illustrate the uniqueness of Panama's development situation. Services account for over two-thirds of the nation's export earnings. The value of food imports in 1970 was less than one-third the value of food exports. Food imports as a percentage of GDP were only 2.2 percent in 1970, compared to 3.2 percent in 1960. Panama is hardly a major food importer and in a broad sense is self-sufficient in food production. The supply and demand projections indicated that the total value of food imports probably will continue to increase, but if Panama is able to maintain the overall growth rate of GDP at 7 percent to 8 percent annually, food imports should continue to be less than 4 percent to 5 percent of GDP at most. In this case, the government will continue to have considerable flexibility in regulating food prices. This ability is increased further by the concentrated nature of the food marketing channels. Government price policies thereby become an extremely important tool for promoting (or discouraging) the production of basic foods, perhaps the single most powerful tool presently available. Emphasis on price stability, however, has reduced the government's willingness to use price policy as a development tool.

Panama's orientation toward export of services and its self-sufficiency in food production has resulted, in the past, in a general unconcerned attitude toward agricultural development. Improvements in the road system during the 1950s linked the central and western provinces more closely to Panama City, helped keep food prices low, and encouraged private investment in the agricultural sector. The decline in banana production during the 1950s and the resulting relocation of the banana industry began to increase public interest in agriculture by the early 1960s. The possibilities of increasing sugar production and of becoming self-sufficient in rice production through the introduction of the green-revolution rice varieties, as well as the recovery of the banana industry based on new varieties grown in a new location, resulted in further increases in public interest and private investment in the agricultural sector by the mid-1960s and an agricultural boom in the late 1960s. The formation of MAG as a separate government agency in 1969 reflected both the increased recognition of the importance of the agricultural sector and the increased public concern for the welfare of the majority of the nation's population living in rural areas.

The rapid changes that have taken place in the agricultural sector during 1960-70 have called forth equally rapid changes in government policies and programs. The lack of basic information on the agricultural sector has made it difficult not only for government agencies to anticipate the impact of various programs but also for the general public and international development agencies to fully understand what was happening and why. The shortage of well-trained agricultural technicians, due partly to the earlier unconcerned attitude toward agriculture, has made it difficult for the government to increase its development programs as rapidly, efficiently, and effectively as desired.

The slower rate of growth of the agricultural sector since 1970 is partly due to the world market situation for bananas, to weather conditions, and to an adjustment in priorities, with more emphasis being placed on improving the welfare of low-income farmers and less on short-run increases in food output. The slower rate of growth in food production has resulted in upward pressures on food prices and increased food imports. In a sense, the urban sector is now being asked to return to farmers a few of the benefits of low food prices that urban workers enjoyed during the 1960s. This policy is consistent with the basic conclusion of the agricultural sector analysis that a substantial increase in the productivity of the existing agricultural labor force should be a major public policy objective of 1970-80. This increase should come partly from increasing the area cultivated, especially by small and medium farmers, and partly from yield-increasing technology.

III. Uses of the Sector Studies

The first use of the sector study in Guatemala was to generate discussion between the government and AID as to what the agricultural problems were and how they could be solved. AID presented the study to the Guatemalan government as a starting point in the discussion. The goal was to encourage the Guatemalan government to develop an agricultural development program that was acceptable to the highest decision makers and that could be financially supported by AID. The study was used very effectively as a catalyst to achieve this goal.

The National Planning Council completed a five-year development plan in 1969, which was adopted by the Government in 1970. The plan emphasized the poor performance of the Guatemalan economy in regard to income distribution, employment and social development. The agricultural sector was given high priority for programs designed to aid small farmers in improving their productivity and income. The plan outlines a number of development programs generally consistent with the ideas presented in the sector study. An increase in public-sector investments was called for to accelerate economic and social development.

The Plan outlined in considerable detail a complete reorganization of the government agencies related to agriculture. Most of the recommendations in the sector study were primarily concerned with economic analysis rather than public administration. It was implicitly assumed that some programs could be made to work (and others could not) under a wide range of administrative structures. It was suggested in the sector study that the lack of trained personnel was probably a more serious deterrent to program implementation than the government's organization structure. The implication was that higher priority should be given to training programs than to reorganization plans. The National Planning Council's plan assigned first priority to reorganization.

It is impossible to determine exactly how the sector study influenced the content of the National Plan. It appears that the sector study may have had some influence on the Plan's general philosophy. It had very little direct affect, however, on the form of the programs included in the Plan. The sector study appears to have been fairly widely read. Thus it served to provide many of the key planners with an up-to-date picture of the country's agricultural situation, insights into the relationships between the various sectors of the economy, and a wide variety of projections based on past trends.

AID accepted the National Planning Council's plan as the basis for developing a rural development loan. The sector study was used by AID as a basic supporting document for the loan program. A total of $23 million was requested for four projects to provide training, research and technical assistance, and production and marketing credits to producers of grains, diversified crops, and handicrafts.[3]

The basic grains project consisted of about $4.0 million for supervised credit, $2.5 million for marketing credit to finance private storage facilities, and approximately $1.6 million for technical assistance and research. The general outline of this project was consistent with the suggestions made in

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[3] The figures given are loan funds. The total amount to be spent from the loan and additional government contributions on the four projects is projected to be $44.9 million. Most aspects of the projects are jointly financed by AID loan funds and Guatemalan tax revenues.

the sector study. The details of the government program now being developed, however, call for considerably more direct government intervention in grain marketing than appears to be necessary or advisable.

The diversification project was designed to promote the production of fruits, vegetables, flowers, sesame and plantain. An estimate $7 million if AID loan funds was to be used for production credit and another $1.5 million for research and technical assistance activities.

Approximately $5.6 million in loan funds was allocated to the human resources project. The main elements of this project were the development of cooperatives, training extension agents, expanding the 4-H Club program, provision of scholarships for secondary and higher education, and technical assistance.

The handicrafts project was financed with approximately $0.8 million in loan funds. Its purpose was to encourage the development of artisan's cooperatives.

It seems likely that the loan program placed more emphasis on programs designed to reach small farmers than would have occurred without the sector study. Only time will tell if this emphasis is maintained and successfully implemented. The loan required reorganization of the Ministry of Agriculture and presentation of an agrarian reform policy as conditions precedent. Neither of these was given priority in the sector study.

In Panama, no sector loan nor other specific program resulted from the sector study. This probably resulted in part from the low participation of the government in the final stage of the study. Priorities in the study were generally not the same as those of the government. The AID Mission was largely unsuccessful in developing a comprehensive assistance program based on the strategy recommendations of the sector analysis.

IV. Evaluating and Improving Sector Analyses

The question considered in the previous section was whether or not the sector studies were used. More precisely, would the development program developed by the Guatemalan government have taken a different form if the sector study had not been available? The conclusion was that, as a result of the sector study, the National Plan and the AID sector loan may have placed somewhat more emphasis on programs directed toward small farmers than they would have otherwise. The sector study had very little, if any, direct influence, however, on the form of the particular projects included in the Plan and loan program.

A sector study could also be evaluated on the basis of selection of research technique and the competence with which those techniques are applied. Thus, assumptions underlying projections could be questioned, results of single-equation regression could be challenged, or more use of formal models could be suggested. Evaluation of a study's technical aspects should not abstract from the data, financial, time and personnel constraints under which the study was conducted.

If the goal of sector analysis is to provide a well-supported analysis of a wide range of development programs, a study may be judged to be "technically sound" but yet not "useful." Opinions as to how reliable data must be for use in formal models differ between researchers. Assumptions about a given country seem more acceptable to some observers than others. Thus, researchers may apply advanced techniques to the best data available and amply demonstrate the advantages of certain policies or programs without convincing administrators that their recommendations are workable or administratively acceptable. Nearly all policy and program recommendations in a sector analysis are based to some extent on value judgements. Thus, it is not surprising that policy-makers may feel a study is not "useful" or disagree in their evaluations of policies and programs even if they are in complete agreement that the study is technically sound.

In Guatemala, a new sector study would likely give more attention to the use of micro data to show how choices of different techniques would affect output, employment and income distribution. These results would provide a firmer basis for evaluating the effects of alternative policies and programs on economic and noneconomic goals. It is debatable if this approach could or should have been used in the original study under the given time and resource constraints.

In Panama, the sector study had the potential to:

1) bring to the government's attention the problems and needs of the agricultural sector,
2) provide an analysis of sectoral policy issues,
3) establish priorities for a coherent investment program, and
4) identify institutional constraints and suggest reforms.

Its limited success was due in large part to the external preparation of the final document. There was no one to speak for it within the government and, as a result, there was little demand for the information it contained. The lack of utilization of the Panama study illustrates the need to institutionalize sector analysis within the host government.

Chapter VIII

Modeling for Policy Analysis

Policy analysis is defined as the process of creating and using information for policy decision making, and models provide the necessary means for that creation and use of information. Models are particularly important as essential tools in the analysis and synthesis phase but also are used in and influence other phases of the process. (See Figure I.3.) This is true for policy analysis at whatever stage of agricultural planning -- formulation, implementation, control -- and for whatever area or areas of policy are being analyzed.

This chapter begins with a brief definition of this broad concept of "model" and a classification scheme for models. The remainder of the chapter focuses on mathematical models as a class of model which can contribute greatly to improving the quality of information used in agricultural planning. First, a few mathematical modeling approaches commonly used in agriucltural planning are reviewed, and then the process of mathematical modeling is outlined. The chapter closes with a discussion of the process of using mathematical models for the formulation and analysis of policy options.

DEFINITION AND CLASSIFICATION OF "MODELS"

Abstraction of Reality

It would be impossible for anyone to grasp the totality of the socioeconomic system in all its structural detail and complexity in order to diagnose the socioeconomic situation and analyze policy options to deal with it. Therefore, models are always, of necessity, used in policy analysis, where a model is defined as:

> A system which is an abstraction of another system, called the reference system.

With this definition, the theoretical and operational frameworks of concepts discussed in Chapters I and II are models of the socioeconomic system. That is, they serve as filters abstracting out only the essential elements for agricultural planning purposes, given the values reflected in the government's doctrinal position.

For specific decision problems related to a particular policy area, however, even this model may be more complex and detailed than necessary to evaluate policy options. That is, the problem identification described in Chapter IV will have narrowed the scope to a particular problem or set of problems within the totality of agricultural planning. Based on the problem identification, then, a further abstraction takes place in modeling for the analysis and synthesis of policy options (Figure I.3).

Classification Dimensions

The word "model" evokes different images in the minds of different people. For some, a model is a good-looking woman or man who wears new fashions in shows or magazine photos for advertising purposes. For others, a model is a plastic or wooden airplane or ship which comes in pieces and is put together by a child or aeronautical engineer. Still others see a model as a set of mathematical equations.

The general definition given above captures the essential element common to all these images: they are all abstractions of a reference system. The fashion model represents the potential consumer, the model airplane is a simplification of a real airplane, and the mathematical equations may capture the dynamics of a physical, biological or social process. However, the definition alone is not enough. The human mind seeks order and wonders whether these various models exhibit characteristics which can be used to classify them.

This section presents one such classification scheme (not necessarily the only feasible one) which is useful from a policy analysis perspective. Seven classification dimensions are defined [3, 4, 5], and any given model may then be characterized by locating its position along each dimension.

Informal/Formal: Mathematical Models in Perspective

The form that a model takes can be classified as either informal or formal, as in Figure VI.1. For our purposes, informal models are mental models, that is, models which exist in the mind of the modeler/analysis. Such models tend to be vague, implicit, often subconscious images or concepts of how the world works. Thus, the theoretical framework for agricultural planning (Figure I.3) is a mental model. A decision maker who derives most or all of his information for decision making from his own mental models is said, in colloquial English, to be making "seat-of-the-pants" or "intuitive" or "gut" decisions.

Formal models, on the other hand, exist in concrete, explicit form outside the modeler's mind. Thus, being explicit, they are available for critical scrutiny and evaluation and thus for conscious improvement and modification. There are four ways formal models can be further classified for policy analysis purposes: schematic models, physical models, role-playing models, and symbolic models.

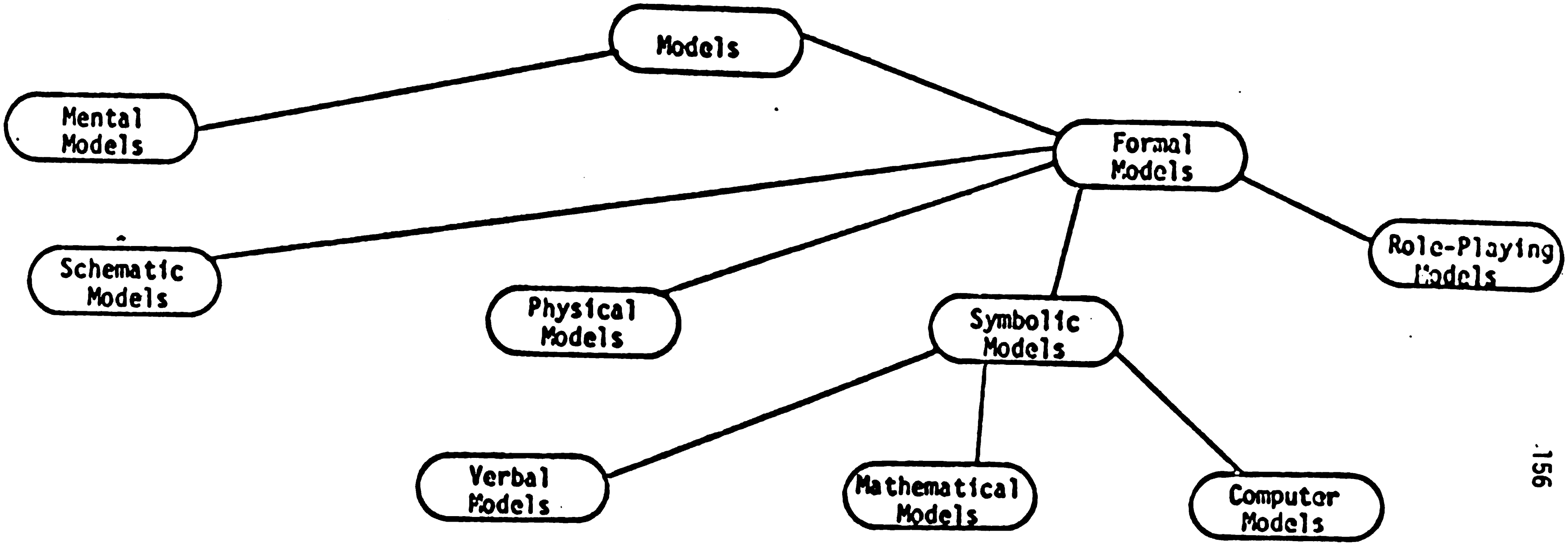


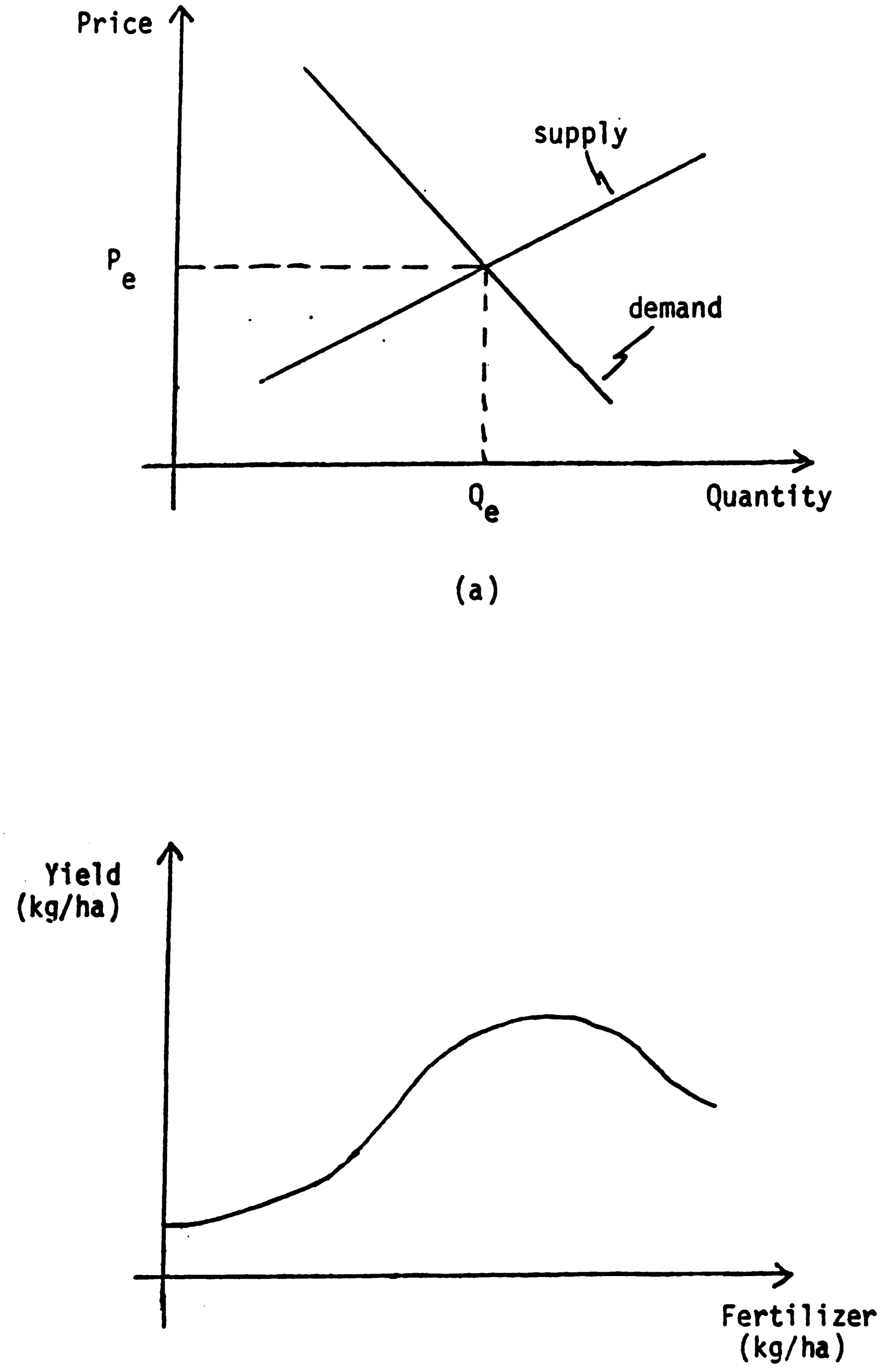
Figure VI.1
CLASSIFICATION OF MODELS BY FORM

Source: Adapted from Martin Greenberger, et al., Models in the Policy Process, New York: Russell Sage Foundation, 1976.

Schematic models are diagrammatic or pictorial representations of the reference system. Thus, a road map is a schematic model of a city's road network or a nation's highway system, an architectural blueprint is a model of a residential or commercial building, and a political cartoon is a caricature of a public officeholder. Figure VI.2 shows schematic models of a supply-demand equilibrium and a hypothetical fertilizer yield response.

The fashion models and scale airplane models mentioned above are examples of physical models, as are wind-tunnel experiments, fertilizer trials on experimental plots, dolls and doll houses, and the statue of Cuauhtemoc in Mexico City. These are all physical models which approximate the actual physical form of their respective reference systems. Other physical models may look nothing like their reference systems, but are physical analogs which behave like them. Common examples are analog computers, which use electrical circuits, and hydraulic systems, which use water, tanks, pipes and valves, to represent the essential forces, flows and storages of physical or economic systems.

Role-playing models (or gaming simulations) provide a means of combining mental and formal models for policy analysis. Decision makers, analysts or experimental subjects are given 1) formal roles to play representing various participants in the reference system (public and private decision makers, affected parties, etc.); 2) a scenario describing the problem context in which to perform those roles; and 3) possibly a computer, to assist in routine computations and bookkeeping. Everyday examples are theater actors in a play, children playing house with dolls, and the game of Monopoly, whose reference system is the real estate industry in Atlantic City, New Jersey, in the 1930s.



(a)

(b)

Figure VI.2. Schematic Models of (a) Supply-Demand Equilibrium, and (b) Fertilizer Yield Response

Symbolic models use symbols related in a linguistic structure to represent essential elements and relationships of the reference system. Three classes of symbolic model can be identified, depending on the nature of the symbols being used: 1) verbal models, 2) mathematical models, and 3) computer models. Other types are conceivable, but these are the most relevant for policy analysis.

The symbols used in verbal models are words, and they are related by the syntactic structure of human languages. The description of the agricultural planning system and its policy analysis process given in Chapter I is a verbal model of that system and process. (Figure 3 is a schematic model of the same reference system.) A recipe is a verbal model of how to bake a cake or cook a stew.

Verbal models are very important in policy analysis because they provide the primary, direct link with the mental models of analysts and decision makers. This link is essential, because it is these mental models, no matter how extensively they are supplemented with complex formal (especially mathematical) models, which are always used to provide the necessary judgemental and prescriptive information for making the ultimate decision.

Verbal models have some severe limitations, however, in policy analysis. Foremost among them is the fact that verbal models are frequently not unambiguous. Semantic problems arise from different interpretations (or connotations) placed not only on word-symbols but also on syntactic structures and vocal inflections. Furthermore, such models are difficult to manipulate and change and to replicate for repeated policy option experiments. Finally, a human language evolves from a particular cultural, social and historical heritage which places limits on the concepts that can be represented by the words and syntax of that language.

Many of these problems can be overcome by the use of mathematical models. The rules and symbols of mathematics are unambiguous, relatively easily manipulable, and culturally neutral. Moreover, a much greater number of variables and complex interactions can be modeled mathematically than can be feasibly handled by verbal or mental models. A shortcoming of mathematical models, however, is that the language of mathematics is not as widely understood as other languages. As a consequence, substantial effort and care are required of analysts using such models to establish an effective communication link, verbally and/or diagrammatically, between mathematical models and the mental models of decision makers and other analysts.

A common criticism of mathematical models is that they cannot incorporate many of the important variables and relationships which must be considered in decision making but which cannot be quantified or precisely defined or for which data do not exist. There are several answers to this criticism.

First and foremost, mathematical models can never pretend to be the sole source of information for complex, socioeconomic decision making. Other informal (i.e., mental) and formal models must always be used in combination with each other and with mathematical models in order to generate all the information needed to support decision making. Nevertheless, mathematical models can increase the quality and quantity of a significant portion of the needed information over that which is attainable with mental or other less formal models. In this sense, quality is measured in terms of consistency and comprehensiveness, while quantity is increased by the ease of analyzing a greater number of more complex policy options.

Secondly, quantification is not necessarily a required feature of mathematical models. Indeed, the symbolic structure of a model -- i.e., the variables included and their qualitative relationships to one another over time -- is frequently more useful as information than the quantitative data used in the model or generated by it. Therefore, nonquantifiable variables may be at least symbolically included in mathematical models as long as their dependence and impacts on other variables can be defined. If such definitions cannot be made, or even hypothesized, then their inclusion in other kinds of models, even mental models, must be precluded as well.

Furthermore, advances are being made in the art of mathematical modeling to facilitate the quantitative use of otherwise nonquantifiable variables. One example is the development of fuzzy set theory [6] which establishes a means of quantifying so-called linguistic measures, such as "big," "adequate," "sufficient," "beautiful," etc.

Finally, it is frequently said that mathematical models tend to require data which either do not exist or are hard to acquire in developing countries and which, even if they do exist, are often of poor reliability. Even for quantitative models, however, the quality of information generated by them is more critically dependent on structure (variables and relationships) than on data. That is, poor data with good structure yield more useful information than good data with poor structure.

While mathematical models can handle more complex structures more consistently than can verbal or mental models, there are, nevertheless, limits on the feasibility of finding general mathematical solutions without the aid of digital computers. Computer models, then, are the final category of symbolic model considered here. Using programming languages interpreted by computers as step-by-step instructions, computer models approximate mathematical models to calculate numerical solutions. Thus, computer models are models of models of models -- abstractions of mathematical models, which are abstractions of verbal or mental models, which are abstractions of reality.

The remaining model classification dimensions discussed in this section apply to any type of model along the informal/formal dimension. That is, verbal models, schematic models, and mental models can also be located along a microscopic/macroscopic dimension and classified as static or dynamic, linear or nonlinear, etc. However, because of the importance of mathematical models and their potential contribution to improving the information generated by the policy analysis process, the focus of the discussion in the remainder of this chapter is on mathematical models.

Microscopic/Macroscopic

A model's abstraction of reality can be classified as microscopic or macroscopic. Actually, this dimension is a continuum. that is, there is no absolute category of microscopic or macroscopic. Rather, one model can only be said to be more or less micro or macro than another model, or to take a relatively micro or macro view of the world. Of course, the appropriate view to take should be dictated by the purposes of the model as specified in the problem identification (Chapter IV).

Microscopic models tend to look at more detail, at individual entities or processes. Macroscopic models, on the other hand, tend to consider more aggregated processes and flows. For example, a population model that considered aggregate, annual average birth and death rates as functions, say, of average nutrition in the population would be more macro than a model which determined instances of births and deaths as they might occur at various points in time as functions of nutrition of individual persons. In turn, however, the former, more macro model, would be more micro than one which modeled population as a simple, exponential growth process.

Static/Dynamic

A model is dynamic if its behavior at any point in time depends on its behavior at earlier points in time, or equivalently if what happens now affects the future. If there are no intertemporal dependencies (time lags and rates of change), the model is static. For example, the yield response model in Figure 5b above is static, because yield at any time depends only on fertilizer application at that same time. However, if the model assumed yield also depended on accumulations of past applications, then it would be dynamic. In another example, a model which assumed crop land allocations in one year depended on prices in the previous years would be dynamic.

Deterministic/Stochastic

Uncertainty is a fact of life in decision making, and models which explicitly consider uncertainty by incorporating random variables are called stochastic models. Otherwise, models which don't include random variables are deterministic models. In our yield response example, Figure 5b is a deterministic model, because, given the fertilizer application, we assume we know the yield. However, to consider possible weather effects, if yield were modeled as a random variable with an assumed probability density function, perhaps with the mean of the distribution depending on fertilizer, this would be a stochastic model.

Whether a model should be stochastic or deterministic again depends on the problem identification. For short-term forecasting purposes, for example, the above yield model might need to consider randomness due to weather. For longer-term analysis of policy options, however, it may be sufficient to assume normal weather with the yield-fertilizer response taking on its average value over time, i.e., a deterministic model. On the other hand, depending on the purposes of the analysis, behavior should be modeled. In general, however, nonlinearities do complicate models and significantly increase the difficulty of parameterizing and solving them.

Optimizing/Nonoptimizing

Optimizing models result in prescriptions for action. Specifically, values for a set of decision variables are determined in order to maximize or minimize a given objective subject to resource, technological, behavioral, logical and other constraints which may be specified. Optimizing models are used in policy analysis either to prescribe optimal policies for the political-administrative system or to describe the optimizing decision behavior of various components of the socioeconomic system (consumers, producers, households, etc.).

Conversely, nonoptimizing models do not seek to maximize or minimize anything. With such a model, alternative decisions (policy options) are assumed and the model executed repetitively to project the likely consequences of each assumption. These projections are then compared with one another by the analyst and/or the decision maker, and a decision may be made based on these comparisons, or additional options may be suggested for further analysis. In this way, the nonoptimizing model is combined with the decision maker's mental model to form a larger, optimizing model.

The applicability of mathematical models themselves as optimizing models for prescriptive policy analysis is limited because of the difficulty of mathematically establishing the four preconditions for optimization. These conditions are:

1. Agreement on a decision rule, i.e., the objective function. In agricultural planning, there are typically a large number

of objectives sought related to income, income distribution, political stability, nutrition, foreign trade, etc. Some of these objectives may not be readily quantifiable, and even if they are there is the problem of combining them in a single objective function, which introduces the second condition.

2. Existence of a normative common denominator enabling aggregation of the "goods" to be attained and the "bads" to be avoided. There may be conceptual difficulties in converting all agricultural planning objectives to units of money or utility in order to combine them in a single objective function, even if a weighting scheme (the first precondition) were agreed upon.

3. Existence of a normative common denominator which has interpersonal validity. That is, even if, for example, all "goods" and "bads" could be expresed in dollars (or pesos or bolivars or cruzeiros), is a dollar's worth of "goods" conferred on one segment of the population equivalent to the dollar's worth of "bads" which may consequently be imposed on another?

4. Establishment of second-order conditions. This is mathematical terminology for the obvious requirement that deviations from the optimum set of decisions should reduce the objective in the case of maximization problems and increase it in the case of minimization. This condition may not be assured in general -- that is, at all points in time and throughout the relevant ranges of the decision variables -- particularly if there are nonlinearities in the problem.

Disciplinary/Subject-Matter/Problem-Solving

This dimension does not describe a system or mathematical property of a model but rather its domain of application with respect to policy analysis.

A disciplinary model is one based on the knowledge of one discipline, such as economics, physics, physiology, sociology, etc. Disciplinary knowledge embodied in models includes the selection of variables, the theories and hypotheses which structure those variables, and frequently types of data, data sources and modeling methodologies traditionally used in the discipline.

Disciplinary models contribute essential information to policy analysis. However, such models alone can rarely, if ever, be sufficient for decision making. Socioeconomic planning requires information from many disciplines for sound decisions, thus disciplinary models cannot be called problem-solving models (see below). For example, the partial and general equilibrium models reviewed in the next section are derived from the discipline of economics. While the information they can provide is necessary for agricultural planning, additional information from other disciplines (animal husbandry, agronomics, soil science, public administration, sociology, etc.), is also necessary.

A subject-matter model is one which can address a well-defined set of problems, where a problem is defined as a specific decision-making situation. For example, the agricultural policy areas outlined in Chapter V represent such sets of problems, called subjects. Of necessity, therefore, subject-matter models are multidisciplinary, using variables, theories, data and methodologies drawn from those disciplines having a bearing on the subject.

Subject-matter models, while closer to the needs of problem solving than disciplinary models, are not in general sufficient for problem solving, either. A specific problem, i.e., decision to be made, may require information from more than one subject area. For example, a decision on an import tariff for, say, maize may require information on the impacts on consumer demand (a subject) and domestic maize production (another subject). System simulation models, as described in the next section, generally tend to be subject-matter models but are not sufficient as problem-solving models.

Problem-solving models, finally, are models used to solve, i.e., prescribe solutions for, specific problems. Being thus prescriptive, and given the preconditions for optimization discussed above, which essentially preclude the use of formal optimizing models alone for policy prescriptions, problem-solving models always include the informal, mental models of the decision makers themselves. Thus, they are combinations of formal and informal models from the disciplines and subjects having a bearing on the decision at hand.

Mathematical Models

As discussed above, mathematical models are explicit and unambiguous and have the ability to consistently project the logical consequences of policy options under a comprehensive set of assumptions regarding socioeconomic relationships. Therefore, their use can greatly improve the quality and quantity of information for agricultural planning. Nevertheless, they are not sufficient for problem solving. As we have seen, they can at best supplement the informal, mental models of decision makers; they can never replace them. The last sections of this chapter focuses on the process of mathematical modeling, and the use of mathematical models in the formulation of policy options.

THE MATHEMATICAL MODELING PROCESS

Earlier chapters have covered the importance of interaction between policy analysts and decision makers in the problem definition phase. To summarize, this phase involves the analysis of needs, specification of values ("good" and "bad") and the specification of relevant policies, performance criteria, and constraints. The problem definition phase is an essential first step before moving into the mathematical modeling phase. It provides the framework for determining the type of model to be selected and the variables and relationships to be included in the model.

Selection of Model Type and Modeling Approach

The first step in the mathematical modeling phase is to select the model type and modeling approach to be used in policy analysis. The different dimensions along which models can be classified were summarized in the first section of this chapter: informal-formal, micro-macro, static-dynamic, deterministic-stochastic, optimizing-non-optimizing, linear-nonlinear, disciplinary/subject-matter/problem-solving. Some general modeling approaches which have been used in agricultural policy analysis are discussed in later chapters: partial and general equilibrium models, optimization models, and system simulation models.

A number of factors will influence the selection of a model type and modeling approach. These include the scope of the analysis, the availability of relevant data, the availability of human and computational resources, and the time and budget available to carry out the analysis.

In considering the scope of the system, the analyst will ask: what is the essential behavior of the system being modeled; what are its boundaries; what are the exogenous inputs to the system from its environment; what are the policy inputs, and what are the important system performance criteria; what is the planning horizon for the analysis; and how many variables and relationships must be included in the model to capture the important behavior of the system? These questions are answered in the problem identification phase (Chapter IV).

Data availability, precision and accuracy may also affect the modeling approach selected. For example, if certain essential data are not available but are needed for a modeling approach, this may affect the time frame in which the analysis can be completed. Data may have to be collected and part of the analysis budget may have to be allocated to data collection rather than to modeling.

Another important factor in deciding the modeling approach is the human and computational resources available to conduct the analysis. Several different modeling approaches have been described above; people skilled in applying these approaches must be available to carry out the analysis. In addition, the computational resources available must be capable of handling the analysis within the bounds of budgeted costs. Size and speed of the computational facilities may constrain the types of models which can be developed.

Finally, the time and budget available for conducting the analysis may be important constraining factors. Some general statements can be made about the cost of running various types of models on computers [4]:

1. Dynamic models are usually more costly to develop than static models. However, they usually provide decision makers with significantly more useful information.

2. Micro models are not necessarily cheaper to build than macro models (even though much more limited in scope) because they often contain elaborate detail.
3. Stochastic models usually are not much more expensive to build than deterministic models, but they are much more expensive to operate.
4. Optimizing models are usually much more expensive to operate than nonoptimizing models.
5. The cost of operating a nonoptimizing model usually goes up directly with the size of the model (as measured by the number of variables contained in the model) -- double the size, double the operating cost.
6. The cost of operating optimizing models tends to go up much faster than the model size -- double the model size, quadruple the operating cost.
7. Model development costs tend to go up much faster than the model size -- double the size, quadruple the cost (perhaps).

The various modeling approaches themselves can be classified along another important dimension "theory-rich" (structural) versus "data-rich" (black box) approaches. In the theory-rich approach most of the emphasis is put on specifying structural relationships between the important variables in the system. Much less emphasis is placed on the precision and accuracy of the data available for parameterizing the relationships in the model. The theory-rich approach seeks rather to understand the broad general behavior and cycling of a real-world system than precise forecasts as to how the system will operate into the immediate future. The theory-rich approach can be considered to be more of a deductive approach to modeling. By contrast the data rich approach is an inductive approach. Much greater emphasis is placed on the gathering of accurate data about the important behavioral variables in the system. A general broad set of structural equations are developed. The methodology then sorts out the important relationships sector system simulation model which was developed to handle the scope of policy instruments, system behavior and performance indicators diagrammed in Figure IV.1 [10, Chapters 5-10]. In this particular application a variety of modeling approaches was used. The national economy component was modeled using a 16-sector input-output model. The population component utilizes a cohort-survival model. The crop technology change component follows a production function approach. The resource allocation component was modeled using a recursive linear programming approach. Finally, the demand/price/trade component operates as a simultaneous-equation, market-clearing model.

Whether the final version of the model is structured as a single component or as several linked components, the basic work of modeling building is the same: the specification of the basic equations which interrelate the variables. Several different forms of equations are worth noting.

The empirical relationship relates a dependent variable to one or more independent variable through a set of parameters. The relationships may be linear or nonlinear. Very often statistical regression techniques are used to determine the values of the parameters of the model. Those parameters are selected which provide the best fit of the structural equations against empirical data.

Equations may also be expressed graphically for the cases in which there is no specific algebraic functional relationship. A graph is usually constructed based on a set of data points connected by a smooth curved line or a series of straight line segments interconnecting the

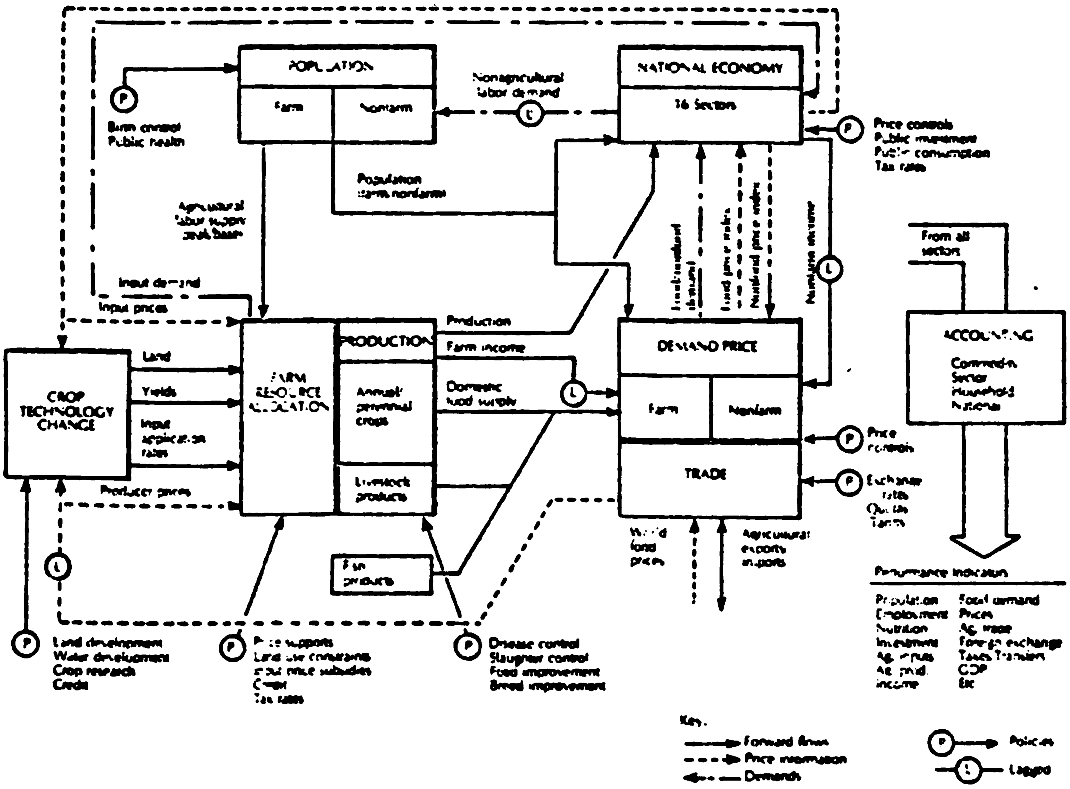


Fig. VI.3. Five-component agricultural sector simulation model.

data points (see Figure VI.4). A two dimensional graph is the most familiar, however, relationships can be expressed in n-dimensional space by the same techniques.

Another basic equation form is the accounting equation. The assumption is that the basic entities in any system, whether agricultural products, energy, people, or tractors must be accounted for at all points in the system. Most dynamic economic models in agriculture model the flow of agricultural inputs, agricultural products, labor services, and money through the system. The differences of flow-in and flow-out at any stage in the system are handled as changes in inventories at that point in the system. For example, in a population model a typical accounting equation might specify that the number of males aged X+1 years in a region of the country at time t+1 years is equal to the number of males aged X at time t plus males aged X who migrated into the region during the year minus males aged X who migrated out of the region during the year minus males aged X who died during the year.

The feedback control equation is a specific type of functional relationship that is useful in cybernetic models. It provides a mechanism for modeling the way various decision-making entities adjust policy variables based on the desired and actual values of some variable in the system.

For example, Figure VI.5 is a schematic of the seasonal price control mechanism of a grain management program model [15]. Point A in the figure represents the seasonal price patterns which decision

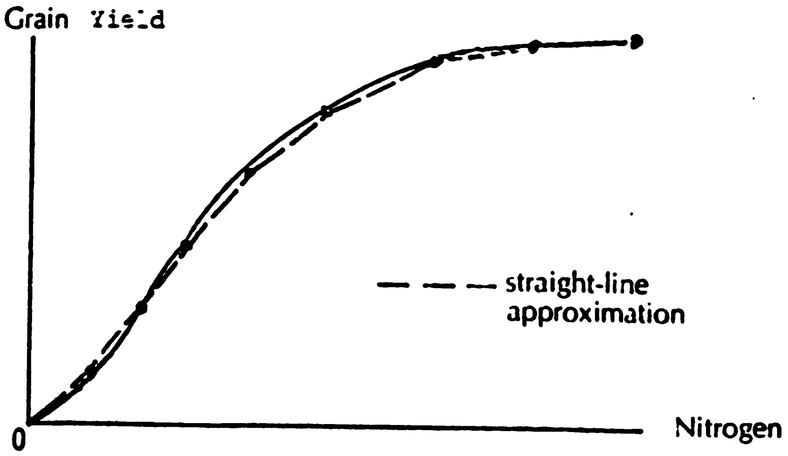


Fig. VI.4. Graphical representation of empirical relationship between two variables.

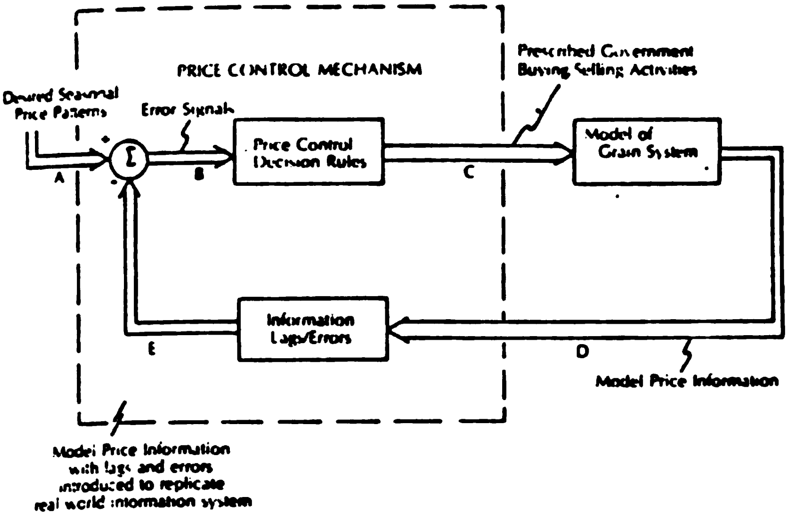


Fig. VI.5. Seasonal price control mechanism of a grain management program model.

akers consider to be the "most desirable" grain system response in meeting the objectives of seasonal price policies. Point B identifies the error signals that are produced by comparing desired price patterns with information on actual price patterns produced by the model. Point C identifies the prescribed government buying and selling activities produced by applying specific decision rules to error signals represented by point B. The decision rules may depend on the magnitude of the error, how fast the error is changing, and how long it has persisted. Point D identifies food grain prices produced by the model with the government undertaking the actions prescribed at point C. These model prices are then fed back into the price control mechanism for comparison with desired price patterns. Note that an attempt is made to replicate information lags and errors in observing market prices (point E). This is done to effect a control design more applicable to the real-world situation.

Having specified the functional relationships which determine the structure of the mathematical model, the analyst will then consider data sources for parameterizing the model.

Data Sources and Requirements

The decision as to where a model falls on the micro-macro continuum very much influences the data requirements, sources, and procedures for estimation. In the model-specification stage decisions have been made on the level of aggregation for the variables to be included in the model. For example, depending on the country and the purposes for the model (as stated in the problem definition) it might be important to treat rice, corn, wheat, beef, milk, pork, chicken, and eggs as separate commodities (even these agricultural products aggregate different varieties with different characteristics), while grouping other commodities such as fruits, vegetables, and industrial crops. In general, the aggregation levels decided upon, whether for commodities, population groups, geographic regions, etc., will heavily influence the data requirements of the model.

One class of data which will be utilized in model specification and testing is time-series data on the variables that are included in the model. Typical such time-series data might include the planted area and production of agricultural commodities by region and wholesale and consumer prices for agricultural commodities. Field surveys and market surveys are commonly used to collect these types of data.

In a dynamic model it is necessary to have values for the initial conditions of the state variables included in the system. A starting year of the model can be specified and data for that year from available time series may be used to initialize those variables.

In the case of parameter estimation, it may be necessary to use data series to estimate indirectly the parameters that are utilized in the model. For example, to estimate own-price and cross-price elasticites it is necessary to have commodity price data which vary either over time or across geographical regions. Income elasticities are usually estimated from household consumer survey data in which consumption of different commodity groups differs as a function of household income. Given these basic data sources, statistical techniques are applied to estimate values of the elasticities.

Finally, data series are utilized in the implementation of the model to input policy measures and environmental influences. For example, in a country which is deciding whether to adjust its fixed prices for certain agricultural commodities over a future period of time, this data series input must be specified over that projected time period and provided to the model. In the case of environmental influences it may be necessary to provide time-series data projected into the future for, for example, relevant world prices for agricultural commodities. In the case of weather influences, it may be necessary to provide either a typical time series of weather fluctuations and their effects on yields in the case of a deterministic model, or a mechanism for randomly generating weather patterns and their affects on yields in the case of a stochastic model.

Particularly in the case where the data may be weak or non-existent, sensitivity testing is a method for determining how sensitive the outputs of the model are to uncertainties about the data incorporated into the model. The technique involves making systematic changes in appropriate data values to reflect the degree of uncertainty in the data and then looking at the effects of those changes on the model's results. A model is considered to be sensitive to a particular data value when small percentage changes of that parameter produce relatively large percentage changes in one or more outputs of the model. Thus, sensitivity testing may direct efforts to improve selectively the estimates of parameters in the model and thus may conserve scarce resources needed for data collection and analysis.

Finally, data values have a roll to play in verification of models against historical empirical data to be discussed later.

Computer Implementation

At the time the analyst is specifying a model type or modeling approach he or she is also usually selecting the method for solving the model. Solving the model refers to the process of determining values for the dependent variables, including the performance variables, given particular initial conditions and values of model inputs (policy variables, world prices, etc.). Various techniques are used to solve models. In the case of simple models it may be possible to apply mathematical techniques of symbol manipulation in order to arrive at a reduced-form solution in which the dependent variables are on the left-hand side of the equations and are expressed as explicit functions of the independent variables on the right-hand side. This approach utilizes techniques of matrix algebra, differential calculus and integral calculus. However, it is often the case that the models which have been formulated are too large and complex and/or involve nonlinearities which make a direct, so-called analytical solution by these techniques impossible. In those cases, it may be necessary to use techniques of numerical analysis which involve iterative solutions. This is the basis of the simulation approach (as discussed above) in which solutions to the model are found by stepping the model through time by small increments.

Except in the case of the very simplest models, the computer will be used to effect a solution in two broad general ways. First, a solution package may have already been programmed on the computer to handle the particular solution method required by the model. An obvious example of this form of computer implementation are large-scale linear programming problems in which the algorithm for solving the problem has already been programmed for the computer and is made available to the user in the form of a documented package. Responsiblity of the user then is to prepare the data in the form required by the program according to the user documentation. In the case of linear programming, the user would input a constraint matrix, right-hand-side values, an objective function, and additional specific information required by the algorithm (e.g. tolerances for determining when a solution has been reached). In these cases the user does not need to know a computer programming language but must understand enough about the computer and the solution package to prepare his data, read the user documentation, enter the data and interpret the results from the output provided.

In other cases, however, a standardized package may not be available to effect a solution to the model. The user must, therefore, program the equations of the model himself, usually in a high-level programming language available on the computer. Examples of general purpose computer languages are FORTRAN, COBOL, PASCAL, AND PL/1. Examples of special purpose computer languages which are useful for simulations are DYNAMO for continuous systems simulations, and GASP or GPSS for discrete-event or mixed continuous-discrete simulations. A general purpose language is more flexible and adaptable to a variety of model types and also usually more economical to run on the computer than a special purpose language. However, a special purpose language may facilitate the programming work for a particular application and may provide better diagnostics to aid the user in correcting errors in the programming. Both general purpose and special purpose programming languages usually have available a set of utility subroutines which facilitate the programming process. These subroutines provide standard algorithms for handling many of the tasks and mathematical manipulations required by subcomponents of models, e.g. optimization algorithms, functional representations, and other solution techniques. Obvious examples are routines which return trigonometric and logorithmic values for variables and perform matrix manipulations.

Model Testing and Refinement

The final step in the modeling process involves model testing and refinement. However, the testing of model credibility actually occurs during model application for policy analysis as well. Credibility testing involves checking i) the coherence of the model's logical structure (called validation); ii) the correspondence of the model's outputs against empirical observations (called verification), iii) the clarity of the model, including its being unambiguous and the ease of its communication to relevant decision makers; and, finally, iv) the workability of the model in terms of its utility in operation and of the policy recommendations which come out of the policy analysis process in which models have been used.

The validity (coherence) of the model should begin to be checked even before computer implementation. Some key questions to ask at the final stages of model specification are: 1) Does the model contain the major variables thought to be relevant in a given application (appropriate policy inputs, criteria for evaluation of performance, etc.)? 2) Is each model variable uniquely defined? 3) Is each equation consistent with accepted theory and constraints that may apply? 4) Is each equation mathematically correct? 5) Have the components of the model been properly linked? A "no" answer at this point will result in further model refinement even before the model is implemented on the computer. During the process of computer implementation programming errors will usually be uncovered. Further, logical errors are often discovered during the early runs of the computer when certain variables move completely out of range of the logically or theoretically possible values. After the most glaring errors are removed from the mathematical structure of the computer implementation, further sensitivity testing may reveal inconsistent behavior in the model. Upon investigation, this may lead to the correction of less easily detected flaws in the model structure.

The next step in model testing involves the verification of the model structure. One important means of doing this is by comparing the outputs of the model solved over a historical period with historical data. The failure of the model to track historical values within some reasonable tolerance range would indicate problems in the structure of the model or in the data supporting it. If a check of the model structure indicates that it is sound, it may be possible to use the historical series to adjust parameters in the model to yield better results.

After the policy analyst is satisfied as to the validity and veracity of the model, the process of interacting with decision makers can usually proceed. At this point it will be the responsibility of the analyst to explain to the decision maker the salient characteristics in the structure of the model and its behavior. The extent to which this process is more or less successful is an indication of the model's clarity.

The clarity of the model and its results will be greatly enhanced by good, user-oriented, clearly written documentation. Very often this is done in the last stages of developing a model and may be hurried or left undone. Good user documentation is particularly important in the case of subject-matter models which may be utilized and modified for a number of different applications.

Finally, the decision makers themselves will make pragmatic judgments about the utility of modeling approaches in terms of the value of the information received as compared to the cost of gaining this information and in terms the workability of the policies which have been implemented partly on the basis of the results of the modeling exercise.

THE FORMULATION OF POLICY OPTIONS

Models are a necessary part of analysis not only as simplifications of reality but also as laboratories for policy experimentation. When formulating policies to guide the socioeconomic system, it typically is not possible or politically or economically feasible to test the various options on the real world in order to determine their relative consequences and choose among them. Therefore, such policy tests (or experiments) are conducted with models in the same way fertilizer trials or feeding trials are designed as controlled experiments with test plots or livestock herds. This section discusses the process of policy experimentation in the formulation of policy options.

Specification of Policy Experiments

Assume that a mathematical model has been developed, implemented and tested which can provide at least some of the information necesary for decision making with respect to some policy problem which has been identified. The use of that model in the formulation of policy options begins with the specification of policy experiments. That is, assumptions are made regarding values of policy measures included in the model--tax rates, quotas, price controls, investments in land and water development projects, land reform, population planning, etc. If the values of a policy measure are determined endogenously in the model over time as a function of conditions of other variables in the model, then alternative assumptions may be made with respect to the decision rules thus modeled.

In either case, each such set of assumptions constitutes a policy experiment. These assumptions may be made on the basis of a formal, factorial or other experimental design procedure. Alternatively, and more commonly for the socioeconomic policy design process, they may be made heuristically, on a case-by-case basis according to what seems reasonable and appropriate for the problem at hand.

Simulation of Relative Consequences

Having thus specified the policy inputs, the model is executed for each experiment to project over time the likely consequences of the policy assumptions for that experiment. In evaluating the results, it is generally true that comparative analyses of the set of experiments is more useful and valid as information for decision making than are the absolute, numerical projections of any one experiment. This is because the accuracy of the absolute projections depends on the accuracy of the data and structural assumptions of the model. Since any model is only an approximation of reality, there will always be errors in its absolute predictions.

Iteration and Interaction

The formulation of policy options, as described here, is a highly iterative process including interaction with the decision makers who will be using the information generated by it. The results of a single set of policy experiments will rarely be sufficient for decision making, especially for the complex socioeconomic problems of agricultural planning. Based on these comparative results, analysts and decision makers will refine and formulate new options to test, and through successive iterations will interact with each other and with the models to converge ultimately on a decision. This process is described in more detail in the next chapter.

Chapter IX

Core Models for Economic Analysis

The use of core models in agricultural policy decision making

The foregoing pages support that the policy analyst should be sensitive to the following aspects:

1) that the development of the agricultural sector must be measured in terms of multiple objectives, and not only in terms of a single criterion.
2) that the desirability and impact of agricultural policies should not be measured in terms of a single criterion, but in terms of multiple performance indicators.
3) that in order to evaluate the desirability of different policies, one must have a fairly precise idea as to how they affect the development of the agricultural sector.
4) that it is not sufficient to study one single policy package, but that one should study alternative policy packages.
5) that the validity of a certain policy is not constant over time. Autonomous and erratic changes, make it necessary to adjust existing policies vis a vis the objectives.
6) that agricultural policy analysis is a continuous activity with important elements of prognosis as to the future expected situation of the sector.
7) that the method of analysis must be capable of identifying and simulating the probable behavior of producers, consumers, workers and the public sector agencies, given the proposed agricultural sector policies.
8) that the method must be of a quantitative nature where possible.
9) that the method must blend traditional economic theory with country-specific conditions, particularly as to types of farms and the distribution of income.

The execution of above mentioned ideas, while conceptually simple and desirable, is nevertheless rarely feasible, given the limited human, financial and informational resources of the typical "Sistema de Planificacion".[1] The problem is compounded by the fact that the policy analyst is usually given very little time to come up with the requested estimate as to policy incidence. Scientific study by nature is not compatible with absolute deadlines. Because of this, policy analysis is often a compromise between what ideally should be done and the dictates of circumstances as to what can be done.

Economists have a long familiarity with this dilemma. It is expressed most fundamentally in the use of partial vs. general equilibrium theory. A rough transliteration of this notion is that in Table 1 we should not concentrate on all possible interdependencies but only those which are socially or politically relevant. A more practical approach, therefore, might be to consider each important objective-instrument pairing separately. It requires the applications of core theoretic ideas as taught in the economics curricula of U.S., Latin American, and European graduate schools.

The approach is not without disadvantages. It enters into uncharted waters. Theoretical writings are available on most, but not all, of the objective-policy pairings indicated in Table 1. The translation of theoretical work into didactically easily understandable material is a major task in itself. Not all of such objective-instrument pairings have been the subject of applied research in the context of IICA countries. The conclusions of applied research cannot readily be transferred between one country and another. The theory needs to be tested anew, with updated data under specific country circumstances.

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[1] For a comprehensive survey of the human, financial and informational resources available to agricultural planning organizations in IICA member countries, the reader should consult PROPLAN Document No. 2, i.e. reference 29.

The limitations on professional manpower and data are particularly noticeable in this respect.

It also raises the question as to whether a core analytical approach can be used in articulating the interdependence between what appears to be at first sight a very heterogeneous collection of policies and objectives. Policy analysis would consist then of adopting a core analytical approach to specific policy analytical contexts. If, furthermore, the core analytical approach is easily understood or accessible to most policy analysts, one would have created one of preconditions for improved policy analysis.

The second condition is that policy analysts be skilled in adopting specific policy analytical contexts to the core analytical approach. Some of the difficulties in this can be anticipated and illustrated by case studies. Nevertheless, the specificity of data and other circumstances are such that in each instance, policy analysts would have to make contributions of their own. Policy analysis, therefore, can never be a purely mechanical or repetitive process.

Policy analysis in support of policy decision making must make explicit choices in relation to the following:

1. the choice of model that reflects the essential behavioral features of the institutions (e.g., consumers and producers) that constitute the private sector.
2. the selection of the essential behavioral features of the institutions that constitute the public sector in terms of policy objectives and policy instruments in place, to be introduced, or to be withdrawn.
3. given 1 and 2, determine the appropriate level of the policy instruments for given levels of objectives.

The quantitative theory of economic policy has traditionally focussed on the third point. It takes the set of admissible objectives and instruments as given as in equation 7. The danger in this approach is that important side effects on the remaining endogenous variables may go undetected. More importantly, however, it overlooks the possibility stressed under point 2 that an alternative set of instruments may be socially more efficient in accomplishing the same objectives.

The choice of model that reflects the essential behavioral features of the institutions that constitute the private sector in principle can be made positivistically. The same observed phenomena, however, may give credence to substantially different models. Consequently, there usually remains some latitude in model selection.

The 191 agricultural policy measures listed in Table 1 can be divided into four large categories:

1. measures that affect the ownership of agriculture-related outputs, inputs and services.
2. measures that affect the production and supply of agriculture-related outputs, inputs and services.
3. measures that affect the allocation of agriculture-related outputs, inputs and services.
4. measures that affect the improvement or preservation of the quality of agriculture-related outputs and services.

This classification suggests the applicability of traditional economic analysis, such as production, consumption and distribution theory at the industry levels. Specifically, it would focus on the determinants of the industry output and factor supply and demand curves.

Basic economic theory, however, does not usually concern itself as to how public policies affect the equilibrium of the industry as to output, factor employment and prices. The initial task for policy analysis is, therefore, to integrate the theory of economic policy with the theory of production, distribution and consumption at the industry level. This integration should yield a class (or classes) of policy models which can be adopted to the needs of the policy analyst.

For that purpose we have developed in detail three classes of policy models. The nature of the models can be put in perspective with reference to Table 3. The assumption is that the markets for agricultural commodities, inputs and services are essentially competitive, i.e. producers as well as consumers are price takers. Each market is characterized by a set of variables that determine the demand or supply of the commodity, input or service in question. Introductory economics texts concentrate on one market at a time, i.e. the (1 x 0) or (0 x 1) configuration, i.e. one analyzes the demand for or supply of a commodity or an input without reference to related outputs or inputs. In this section we assume that the reader has a familiarity with that type of model.

The (0 x 1) and (1 x 0) are called partial equilibrium models. Much of what is useful in economics can be illustrated by these models. They continued to dominate applied economic analysis until the late fifties when it became evident that this type of model has substantial drawbacks for rigorous policy analysis. At the same time it was realized that a Walrasian (m x n) general equilibrium model was also unsatisfactory for policy analysis. The outcome was the construction of three core models.

1) the Hicksian (25) one product-two factor model, i.e. the (1 x 2) configuration in Table 3.
2) the (54) two product-one factor model, i.e. the (2 x 1) configuration in Table 3
3) the Harberger (21) two product-two factor model, i.e. the (2 x 2) configuration in Table 3.

Table 3: Core models for agricultural policy analysis

		number of input markets			
		0	1	2	m
numer of output markets	0	(0 x 0)	(0 x 1)	(0 x 2)	(0 x m)
	1	(1 x 0)	(1 x 1)	(1 x 2)	(1 x m)
	2	(2 x 0)	(2 x 1)	(2 x 2)	(2 x n)
	n	(n x 0)	(n x 1)	(n x 2)	(n x m)

It is these models that currently dominate much of applied economics in public finance, international trade and welfare economics. The essential feature of these models is that they are very compact, yet analytically sound and powerful. Detailed discussions of the theory and applications of these models is available elsewhere (65, 66, 68). In what follows we will simply present convenient expository forms of these models so as to convince the reader that these models are indeed structurally simple and accessible to anyone with basic training in economics.

4.1 The Hicksian one product-two factor model

The structural equations of the one product-two factor model are as follows:[1]

I.1 $x_1 = -k_2\sigma p_1 + k_2\sigma p_2 + 1 \cdot q$

I.2 $x_2 = k_1\sigma p_1 - k_1\sigma p_2 + 1 \cdot q$

I.3 $p = k_1p_1 + k_2p_2 + o \cdot q$

I.4 $x_1 = e_{X_1} \cdot p_1$

1.5 $x_2 = e_{X_2} \cdot p_2$

1.6 $q = e_q \cdot p$

Equations I.1 and I.2 are the factor demand equations for a given level of output. The rate of change in factor demand (x_1 or x_2) depends on the rate of change in the prices (p_1 and p_2) of the factors of production and the rate of change in output (q). The critical parameters are the cost shares k_1, k_2 and the elasticity of substitution σ. Equation I.3 shows how the cost of production (p) changes as determined by the rates of change in factor prices for a given output. Equations I.1, I.2 and I.3 suppose that the firms composing the industry

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[1] The production and distribution theory underlying the derivation of equations I.1 through I.3 is discussed in pages 1 through 6 in (66).

are in long-run equilibrium. Average cost then equals marginal cost. Alternatively, one could assume that the production function for the industry is linear homogeneous in the two factors of production.

Equations I.4 and I.5 are the factor supply functions. Equation I.6 is the demand function for output. The factor supply and commodity demand functions can include arguments other than commodity or factor prices. They are discussed on pages 65 through 90 in (65).

The above linearized model of six equations in six unknowns determines the competitive equilibrium of the industry. Changes in this equilibrium stem from various sources. It is the planned changes in this equilibrium which are our concern. They relate to the introduction, withdrawal or change in selected economic policies. Policies aimed at technological progress within the industry (e.g., agricultural research and extension) will require modification of the factor demand and cost formation functions. Policies aimed at technological progress outside the industry will modify the factor supply equations. Policies aimed at direct control of one or more of previously endogenous variables (e.g., price, output, and factor use controls) will modify the corresponding commodity or factor demand or supply functions. Policies aimed at indirect control of the endogenous variables (e.g., taxes, subsidies, import, and export controls) will modify the appearance of these variables in the above basic model. Policies aimed at creating market clearing mechanisms (e.g., rationing, production certificates) parallel to that of the competitive market clearing mechanism add additional equations to the basic model.

The introduction withdrawal or change in the above policies implies an initial shift in one or more of the commodity and factor supply and demand equations that characterize the initial competitive equilibrium of the industry. An initial shift in one of these relationships causes subsequent adjustments in the remaining functions, resulting in a new competitive equilibrium of the industry.

The impact of selected policies involves a comparison of the old and new equilibria. To carry this out we can use a narrative, graphical or algebraic format. In (65) we stress the latter two. The narrative procedure comes to the foreground once we move from an abstract situation to applications. The algebraic manipulations underlying the comparative statics of the one output-two factors of production model are simple. Yet, even this basic model allows for a very large number of policy model specifications. Those involving direct controls of prices, output or factor employments have been summarized in Tables 3, 4 and 5 in (65). Policies involving indirect controls and autonomous developments outside the industry are discussed in pages 65 through 69 in (65). Policies related to technological progress within the industry are discussed in pages 70 through 85 in (65). Policies that suppress the competitive market clearing mechanism are discussed in pages 85 through 90 in (65).

It follows that in principle a large array of policies can be used to achieve a single or multiple objective. A systematic study of logical candidates of the above categories of policies grafted on a core model such as in equation I.1 through I.6 can help us understand the comparative social and private benefits and costs of different policies. This is an important area for future research, particularly in order to discover qualitative results, whereby one class of policies can be judged to be superior to other classes of policies under a wide range of circumstances.

2.4 The two product-one factor model

The natural counterpart of the one product-two factors model is the two product-one factor model. Much of the economy literature focuses on things which have a common destiny. Hence, the theory of derived demand for factors of production, input-output analysis being its best known special application. But the pricing of things which have a common origin is also of interest. What, for example, are the consequences of controlling the price of bread but not the price of flour? What are the consequences of an export quota on cotton cake on the production of cotton? What are the consequences of subsidizing the price of milk for human consumption on the price of raw milk, butter and cheese?

All of above examples of market intervention can be analyzed in the context of two product-one factor model. Figure 1 contains in initial equilibrium demand-supply configuration in the two commodity markets and the remaining (composite) factor market. In figure 1 S_A and S_B are derived supply relationships, giving rise to a derived demand D_X for the composite factor X. The demand functions D_A and D_B usually can be taken as independent of developments in the factor market. If Q_A and Q_B are close substitutes or complements in consumption, then the position of the demand curves D_A and D_B will be mutually dependent, but they are independent of the derived supply functions S_A and S_B.

Marshall emphasized the symmetry between the theory of derived demand and the theory of derived supply, stating that (39, p. 388)

> "it may be discussed almost in the same words by merely substituting "demand" for "supply" and vice versa."

Corresponding to the four Marshallian rules of derived demand, we can formulate four rules that govern the elasticity of derived supply. These rules can be used to examine the presumably low price responsiveness of food production relative to export production in developing countries. They are also important in demonstrating how food price controls under these circumstances can be used to increase national welfare. Marshall restricted himself to the case where joint products were produced in fixed proportions. Sune Carlson (8, p. 74-102), following Fanno (17), studied joint production with technically variable proportions of the products. We follow that approach in (68), the case of fixed proportions being a special case of this more general approach.

The 2 x 1 model can also be interpreted as a general equilibrium model. As such, it has been used extensively in the theory of international trade and public finance. Its essential characteristic is that developments in the factor market, specifically changes in the level of factor income, directly influence the demand for commodities. All of the relationships in Figure 1 then become endogenous. The analysis of policy measures such as tariffs, quotas and taxes nevertheless remains straightforward.

In previous papers (65, 66) we discussed the one output-two factor model and the two product-two factor model. The two output-one (composite) factor model can be coupled with the foregoing models. For example, a composite factor (e.g. milk) is itself produced by, for example, two factors of production. Consequently, one obtains an augmented [(2 x 1) x (1 x 2)] model. The structural equations of this model are those of the (2 x 1) and (1 x 2) model, in addition to a coupling identity.

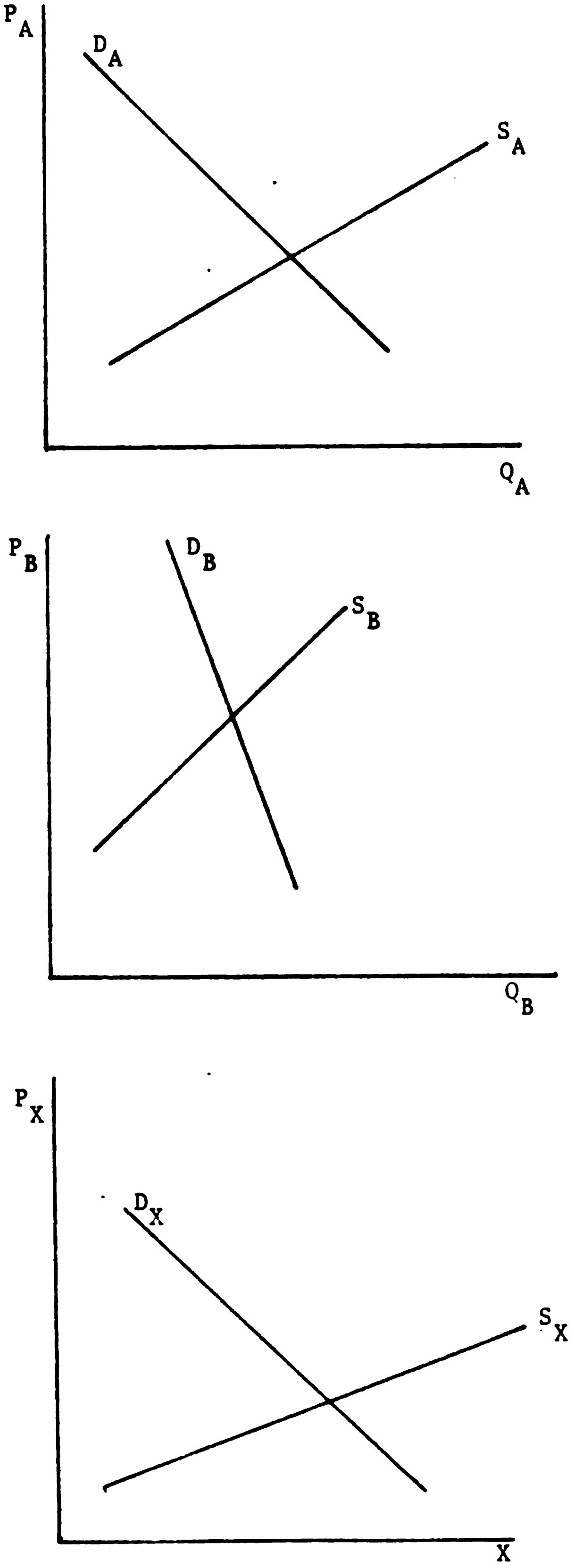
The essential characteristic of augmented models, such as sketched above, is that they simplify the full general equilibrium characteristics of a policy problem by eliminating a priori a large number of possibly insignificant interdependencies between the demand and supply relationship that characterize the several commodity and resource markets. The advantages of above blockwise decomposability of policy problems is considerable for the purposes of analysis and statistical estimation.

There is a fundamental symmetry between the (1 x 2) model and the (2 x 1) model. The six structural equations of the two commodity-one factor model are as follows:[1/]

II.1 $q_A = -k_B\sigma^* p_A + k_B\sigma^* p_B + 1.x$

[1/] For details, see (68) pages 11 through 15.

Figure 1



II.2 $q_B = k_A\sigma^*p_A - k_A\sigma^*p_B + 1.x$

II.3 $p_x = k_Ap_A + k_Bp_B + 0.x$

II.4 $q_A = e_{q_A} \cdot p_A$

II.5 $q_B = e_{q_B} \cdot p_B$

II.6 $x = e_X \cdot p_X$

Equations II.1 and II.2 are the general equilibrium supply functions for commodities Q_A and Q_B respectively. Commodity supplies are determined by relative commodity prices P_A and P_B and factor supply X. The critical parameters are the value shares k_A and k_B of Q_A and Q_B in gross agricultural income and the elasticity of product substitution σ^*. This elasticity measures the degree of curvature of the production possibility curve found in any introductory text on economics. If σ^* is small, then one product is not readily substitutable for another product. If σ^* is large, the production possibility curve will approach a straight line. Equation II.3 shows how the value or shadow price of resources used in the production of commodities is determined by the prices of commodities and available factor supplies. Because we assume joint production to be linear homogeneous, the scale of production or average size of farm does not affect the unit value of the resources used in production. Equation II.4 represents demand for commodity Q_A. We assume it to be influenced only by its own prices, the price elasticity being e_{q_A}. This hypothesis is easily modified and made more comprehensive. It has been explored in (68). Equation II.6 represents the factor supply function of factor X. We assume it to be influenced by its own price only. The supply elasticity e_X has no predetermined sign. If, however, II.6 is interpreted as a factor compensated supply curve, e_X must be positive.

Above model has been applied in (68) to investigate a variety of typical agricultural policy problems in IICA countries, such as the incidence of commodity price controls, export taxes, and tariffs. It is shown under what conditions these policies can be used to increase national welfare. The paper also introduces a system of income compensated commodity demand curves, symmetric to the general equilibrium supply functions. It is this type of model that allows us to measure the real income losses associated with price distortions. It was first used by Hotelling (28) and subsequently by a large number of well-known economists active in the field of public finance, international trade and welfare economics.

4.3 The Harberger two product-two factor model

The (2 x 1) and (1 x 2) models are very useful when the interest as to the incidence of policies is primarily focused on products, but not on factors or vice versa. However, the two product-two factor model is appropriate whenever one needs to consider simultaneously more than one commodity and more than one input as, for example, in the incidence of technological progress.

The 2 x 2 model comes in two versions. Its application in the theory of public finance is built around a general equilibrium framework. Here the sum of factor incomes equals the sum of consumption expenditures, which equals national income. The demand for sector outputs is determined not only by relative prices, but also by the level of national income, measured in some constant numeraire, and the functional distribution of income. Inclusion of the feedback effect of a change in real income on the demand for commodities makes the analysis of the qualitative properties of the 2 x 2 model awkward. Given an undistorted competitive economy, the first order changes in real income can be ignored. This is the approach followed by Harberger [21], Johnson [31, 32] McLure (41) and others. Ballantine and Eris (3) provide an analysis whereby changes in real income are allowed for.

Applications of the 2 x 2 model in international trade theory generally discard the general equilibrium framework in the sense that neither the sum of consumption expenditures nor factor earnings equals national income. No attention needs to be paid to an endogenously generated income effect on the demand for or supply of commodities. It is possible, of course, to introduce exogenously created income effects or similar variables that affect the demand for and supply of commodities. The central concern of the 2 x 2 model in international trade theory, therefore, is with the supply side of two competitive industries seen in isolation for the rest of the economy.

When one deals with the agricultural sector vs. the non-agricultural sector, the general equilibrium framework is often appropriate. When one deals with two competitive agricultural products or industries seen in isolation of the rest of the economy, adaptations of the international trade model are more appropriate. However, the required methodology remains essentially the same for both classes of problems. This indicates that the 2 x 2 model provides a convenient point of departure for agricultural policy analysis whenever a 2-commodity, 2-industry, 2-sector or 2-region differentiation is an essential aspect of the policy problem to be analyzed.

The two product-two factor model comprises the twelve basic variables listed below:

$$\begin{array}{cccccc} P_A & Q_A & X_{1A} & X_{2A} & X_1 & P_1 \\ P_B & Q_B & X_{1B} & X_{2B} & X_2 & P_2 \end{array}$$

In the typical exercise commodity prices (P_A, P_B) and factor supplies (X_1, X_2) are given. Consequently, factor employments (X_{1A}, X_{2A}, X_{1B}, X_{2B}), factor rewards (P_1, P_2) and production (Q_A, Q_B) are retained as endogenous variables. The endogenous variables, separately or in combination, can be expressed in terms of the exogenous variables. A change in a given exogenous variable must induce a change in one or more endogenous variables. In order to make this procedure analytically tractable, elegant or determinate, two key assumptions are made, i.e. linear homogeneous production functions and perfect competition. The latter assures full employment of resources for an appropriate range of the exogenously given commodity price ratio. Linear homogeneity of the production function gives this relationships convenient qualitative properties when differentiated or transformed. Coupled with the assumption of perfect competition, it assures that the sum of the factor earnings in each industry exhausts the value of the output produced by each industry.

The standard treatment of the 2 x 2 model transforms absolute levels of variables into expressions containing exclusively ratios of variables as below

3.1 $(Q_A/X_{1A}) = f_A(X_{2A}/X_{1A})$

3.2 $(Q_B/X_{1B}) = f_B(X_{2B}/X_{1B})$

3.3 $(P_1/P_A) = [f_A - (X_{2A}/X_{1A})f'_A]$

3.4 $(P_1/P_B) = [f_B - (X_{2B}/X_{1B})f'_B]$

3.5 $(P_2/P_A) = f'_A$

3.6 $(P_2/P_A) = f'_B$

3.7 $(X_{1A}/X_1).(X_{2A}/X_{1A}) + (X_{1B}/X_1).(X_{2B}/X_{1B}) = X_2/X_1$

Elimination of the factor rewards P_1 and P_2 in equations 3 through 6 yields the basic relationships between factor intensities and the exogenous commodity price ratio.

3.8 $[f_A - (X_{2A}/X_{1A})f'_A] = (P_B/P_A).[f_B - (X_{2B}/X_{1B})f'_B]$

3.9 $f'_A = (P_B/P_A)f'_B$

Differentiation of above equation with respect to the exogenous commodity price ratio (P_B/P_A) yields the direction of change in the factor intensities (X_{2A}/X_{1A}) and (X_{2B}/X_{1B}). For a constant endowment ratio (X_2/X_1), we can then determine the reallocation of X_1 and X_2 among the two industries. The nature of the changes in the other variables can also be derived by substitution in the remaining equations of the model (38, 63).

Above approach while commonly used in the literature will not be used in this paper. In its place we will use log-linear transformations of the structural relationships that characterize the 2 x 2 model. This is the same approach used in the analysis of the one product-two factors of production equilibrium model of the competitive industry (65).

The essential equations of that model can be summarized as follows:

3.10 $x_1 = -k_2\sigma p_1 + k_2\sigma p_2 + 1 \cdot q$

3.11 $x_2 = k_1\sigma p_1 - k_1\sigma p_2 + 1 \cdot q$

3.12 $p = k_1p_1 + k_2p_2 + o \cdot q$

3.13 $x_1 = e_{X_1} \cdot p_1$

3.14 $x_2 = e_{X_2} \cdot p_2$

3.15 $q = e_q \cdot p$

Equations 10 and 11 are the factor demand equations for a given level of output. The rate of change in factor demand (x_1 or x_2) depends on the rate of change in the prices (p_1 and p_2) of the factors of production and the rate of change in output (q). The critical parameters are the cost shares k_1, k_2 and the elasticity of substitution σ. Equation 12 shows how the cost of production (p) changes as determined by the rates of change in factor prices for a given output. Equations 10, 11, and 12 suppose that the firms composing the industry are in long-run equilibrium. Average cost then equals marginal cost. Alternatively, one could assume that the production function for the industry is linear homogeneous in the two factors of production. Equations 13 and 14 are the factor supply functions. Equation 15 is the demand function for output. The demand for output Q is not explicitly related to industry factor incomes.

A natural extension of the 1 x 2 model to the 2 x 2 model is obtained by attaching appropriate commodity subscripts to the variables appearing in equations 3.10 through 3.15. Consequently, we obtain the following pairs of factor employment equations:

$$3.10.A \quad x_{1A} = -k_{2A}\sigma_A p_1 + k_{2A}\sigma_A p_2 + q_A$$

$$3.11.A \quad x_{2A} = k_{1A}\sigma_A p_1 - k_{1A}\sigma_A p_2 + q_A$$

$$3.10.B \quad x_{1B} = -k_{2B}\sigma_B p_1 + k_{2B}\sigma_B p_2 + q_B$$

$$3.11.B \quad x_{2B} = k_{1B}\sigma_B p_1 - k_{1B}\sigma_B p_2 + q_B$$

Given competitive equilibrium in both industries, we have

$$3.12.A \quad p_A = k_{1A}p_1 + k_{2A}p_2 + 0 \cdot q_A$$

$$3.12.B \quad p_B = k_{1B}p_1 + k_{2B}p_2 + 0 \cdot q_B$$

The factor supply equations 3.13 and 3.14 will not be modified, although a more complex relationship incorporating an income feedback effect on factor supply has been explored in detail [2]. In equilibrium the demand for factors must equal factor supplies. Hence,

$$3.16 \quad \frac{X_{1A}}{X_1} \cdot x_{1A} + \frac{X_{1B}}{X_1} \cdot x_{1B} = x_1$$

$$3.17 \quad \frac{X_{2A}}{X_2} \cdot x_{2A} + \frac{X_{2B}}{X_2} \cdot x_{2B} = x_2$$

The demand for outputs must equal the supply of outputs. With endogenous commodity prices, the model can be closed on the demand side by a complete scheme of price and income elasticities.

$$3.18 \quad q_A = e_{11}p_A + e_{12}p_B + E_A y$$

$$3.19 \quad q_B = e_{21}p_A + e_{22}p_B + E_B y$$

In a general equilibrium setting, the rate of change in income is dependent on the rates of change in commodity volumes and prices

$$3.20 \quad y = \rho[p_A + q_A] + (1 - \rho)[p_B + q_B]$$

where ρ is in the initial share of national income spent on commodity A. Also, the weighted sum of income elasticities must equal unity

$$3.21 \quad 1 = \rho E_A + (1 - \rho)E_B$$

Substitution for y and E_A in above equations reveals the well-known result that the absolute changes in values cannot be uniquely expressed in terms of the absolute changes in commodity prices, because the determinant of q_A and q_B in the matrix equation below is singular.

$$3.22 \quad \begin{array}{cc|cc} q_A & q_B & p_A & p_B \\ \hline (1 - E_A\rho) & -E_A(1 - \rho) & e_{11} + E_A \cdot \rho & [e_{12} + E_A(1 - \rho)] \\ -E_B \cdot \rho & [1 - E_B(1 - \rho)] & e_{21} + E_B \cdot \rho & [e_{22} + E_B(1 - \rho)] \\ \hline \end{array}$$

We, therefore, must adopt a factor or commodity price as numeraire. Given an initially undistorted competitive economy, the first order income effects can be ignored.[1/] This is the assumption made by Harberger [21] Johnson [31, 32], McLure [41] and others. Harberger shows that given this condition $e_{11} = -e_{12}$

[1/] Ballantine and Eris [3] show that when this assumption is not justified, the numerical values of the solutions may change drastically.

and $e_{22} = -e_{21}$. Consequently, the complete scheme of demand equations can then be summarized as follows:

$$3.23 \quad q_A = e_{11}(p_A - p_B)$$

$$3.24 \quad q_B = -e_{22}(p_A - p_B)$$

If the sum of factor earnings equals the sum of industry incomes, then equilibrium in the factor markets and one commodity market implies equilibrium in the remaining commodity market. The direct price elasticity of the second commodity therefore does not have to be estimated independently but is determined residually so as to ensure local consistency on the demand side.

McLure and Thirsk [41] assume the existence of a linear expenditure system. Hence, $-e_{ii} = E_i = 1$ and $e_{ij} = 0$. If, furthermore, national income is taken as a constant numeraire, then $q_A = -p_A$ and $q_B = -p_B$.

In what follows, we do not always assign a general equilibrium connotation to the 2 x 2 model. In such instances we do not need to consider endogenous income effects. In such exercises we also assume that the two industries are competitive in production but not in consumption. This allows us to ignore cross price elasticity effects on the demand side. Incorporation of such effects does not present computational problems, but it preempts to a large extent an accessible qualitative analysis of the 2 x 2 model. In (66) we use the (2 x 2) model to answer the following problems.

1) The incidence of the corporate income tax
2) The incidence of a commodity tax
3) The incidence of a general factor tax
4) Incidence of an expansion in factor supplies (Rybczynski's second and third theorem)
5) Incidence of factor employment quotas
6) Incidence of factor augmenting technological progress, given

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6.1 Constant commodity prices and fixed factor supplies

6.2 Endogenous commodity prices and fixed factor supplies

6.3 Endogenous commodity prices and infinitely price elastic factor supplies

6.4 One price sensitive commodity demand and one variable factor supply

The performance variables analyzed are factor rewards, factor intensities, factor employments, output effects, income effects and welfare effects. The above range of variables show that the 2 x 2 model is very useful in analyzing the income distributional implications of agricultural policies. In particular, it can play a very important role in assessing ex-ante the benefits of agricultural research and extension.

A study of the structural equations of the (1 x 2), (2 x 1) and (2 x 2) core model reveals that extensions to large-scale (1 x m), (m x 1) and (m x n) models are possible, as for example in (15). The advantage of the core models is their theoretically solid foundation, their modest informational needs, and their adaptability to specific problems and policies. In policy analysis, time is often the most limiting constraint. The core models outlined above help us think on our feet. They lead to a very rapid diagnosis of policy incidence in the qualitative sense. With additional judgements as to numerical estimates of the parameters involved, a reasonably good quantitative estimate can be produced in a very short time. It is often more important to be approximately on target in the short run than totally on target in the long run, simply because the nature of the problem may change over time.

5. Types of relationships that appear in policy models

Policy models contain four types of relationships:

1) technical

2) behavioral

3) accounting

4) institutional

Let us illustrate this with respect to the one product-two factor model on p. 27. For convenience, we repeat the equations given there.

I.1 $x_1 = -k_2\sigma p_1 + k_2\sigma p_2 + 1.q$

I.2 $x_2 = k_1\sigma p_1 - k_1\sigma p_2 + 1.q$

I.3 $p = k_1 p_1 + k_2 p_2 + 0.q$

I.4 $x_1 = e_{X_1} \cdot p_1$

I.5 $x_2 = e_{X_2} \cdot p_2$

I.6 $q = e_q \cdot p$

Equations I.1 and I.2 reflect two assumptions as to the technical relationships in agricultural productions

1) the absence of economics of scale

2) the possibility of factor substitution

It can be seen that in equations I.1 and I.2 a one percent expansion in output Q leads to a one percent expansion, for given factor prices P_1 and P_2, in the demands for factors X_1 and X_2. This is a feature uniquely associated with linear homogeneous production functions. Linear homogeneity implies that if X_1 and X_2 expand at an equal rate, then output Q will expand at that same rate.

Equations II.1 and II.2 indicate that if the price P_1 of factor X_1 increases relative to the price P_2 of factor X_2, given constant output Q, then less of X_1 and more of X_2 will be demanded. The only exception is when $\sigma = 0$. In that case, changes in relative factor prices cannot influence the technology or mix of factors of production, factors X_1 and X_2 are said to be complementary.

The easier X_1 and X_2 can be substituted for each other, the larger the elasticity of substitution σ. The latter is the degree of curvature of the unit-isoquant, a technical production relationship discussed in detail in introductory economics textbooks.

Whereas equations I.1 and I.2 reflect the technical assumptions underlying production, they themselves are nevertheless behaviorial relationships, i.e. factor demand functions. Equation I.1, for example, shows how the demand for factor X_1 is related to changes in its own price (P_1), the price of its substitute (P_2), and the level of output (Q_2). Since I.1 and I.2 are behaviorial equations, they must implicitly reflect a behavioral assumption. In this case, the assumption that for any given level of output producers will minimize production costs.

The commodity demand equation I.6 reflects the assumption that consumers will maximize their satisfaction from given money incomes. Because of this, an increase in P leads to a decrease in the quantity demanded Q, i.e. the price elasticity e_q is negative. The factor supply equations I.4 and I.5 are also behaviorial relationships. If X_1 is labor, then the supply elasticity of labor e_{X_1} is of indeterminate sign. Its sign can be shown to depend on the preference mapping of the representative worker between income and leisure. Again, the assumption is that the worker will choose that combination of work of leisure which maximizes his well-being.

The model contains three additional behaviorial relationships, i.e. the assumptions that the demands for and supplies of output Q and factors X_1 and X_2 are in equilibrium. These three demand-supply equalities are also ex-post accounting identities. However, for the purposes of analysis, no ex-ante equality needs to exist. By assuming that producers and consumers are price takers, i.e. by assuming the existence of price competition, we may be sure that such ex-ante inequalities must disappear and translate themselves into ex-post equalities.

Relationship I.3 is an accounting relationship. It states that when producers are price takers in both factor and output markets, the average price of the output will equal the average cost of production. Above equality holds only if the industry is in equilibrium and if the industry is competitive. Agriculture comes sufficiently close to meeting these assumptions to give them a priori validity for policy analyses based on those assumptions.

The one product-two factor model does not contain any explicit institutional relationships, except that our framework of analysis is that of a competitive economy. Often the public sector will impose certain restrictions on the behavior of the private sector. For example, if X_1 is labor, it might specify that the price of labor P_1 be above a certain minimum. It might specify that the price P of output Q be below a certain maximum. In the interest of employment absorption, it might specify that for each unit of capital X_2 at least X_1 units of labor be employed. It might specify that output Q should be at least at a level $\bar{Q}$, and so forth. It follows that policy objectives are often synonymous with institutional relationsihps.

Chapter X

Models for Policy Optimization

Economic policy and concepts of optimality

There is a proverb which states that "beauty is in the eye of the beholder." So it is with optimality. There often are sharp disagrements as to what concept or variables are to be optimized. Is it the rate of growth in GNP, is it the distribution of income, or is it the rate of employment absorption? Such criteria are competitive in the sense that the attainment of one objective may have to be partially or wholly at the expense of some other objective. For example, it is known that policies which optimize growth may have undesirable consequences for income distribution, and so forth.

What is to be optimized is resolved continuously by two types of voting mechanisms. The first one is constituted by the free exchange in the markets of goods and services. The implication is that market prices are also measures of social value. Faced with any given price of a commodity, the rational individual (producer or consumer), in seeking to advance his state of well being as much as possible, will purchase a number of units of that commodity so that, at the margin, his willingness to pay for that commodity is just equal to its price. There are exceptions to this fundamental proposition of microeconomics. In some instances market prices exist, but they do not reflect social values because of privately or publicly caused market distortions. Also, when income is distributed very unequally, most people would deny the proposition that the marginal utility of income can be assumed to be equal for all income recipients. If so, market prices do not reflect social values. External economies or diseconomies also invalidate the presumed identity of market prices with social values.

For the large category of public goods and services, market prices do not exist, and means must be found to assess their opportunity cost in terms of privately-produced goods and services through the political process. The variety of needs to be satisfied through the political process coalesces around such well-known concepts as "full employment", "price stability", "equity" and "economic growth". In Table 1 we give a similar list of eight major and 44 subobjectives, which emerge as discernible proxy objectives in agricultural policy analysis. The continuous interaction between the "sistema administrativo", the "ambiente economico-social" and the "sistema de planificacion" reflects the political process by means of which the objectives and means of agricultural policy are established. It implies that the performance of the agricultural sector would be sub-optimal if left alone, i.e. if not made subject to policy intervention. If one were to make the hypothesis that system performance is optimal without policy intervention, there would be no point in publishing this volume.

Nevertheless, the laissez faire philosophy, which holds that in the interest of social welfare the number of policy interventions should be kept to a minimum, cannot be rejected out of hand. One may agree as to the need and legitimacy of establishing goals for the agricultural sector which would not normally be achieved in the absence of public policies. Yet, it does not follow that the public sector will achieve such goals. The ex-ante analysis of policy incidence has an important role in assessing the probability with which the objectives of the public sector will be achieved. Policy analysis, formulation and implementation is much more difficult and risky than policy makers and planners are willing to admit.

In the foregoing subsections we stressed that the optimal policy cannot be determined independently of other policies. We emphasized the element of uncertainty in policy response. We brought to bear the element of real time in the sense that delays in policy response make it more difficult to determine the optimal policy. We also emphasized that in the case of decentralized decision making the assignment of appropriate organizational responsibilities is a matter of some importance. In all of the above we stressed the paramount importance of the correct specification of the policy environment, i.e. its underlying technical, behavioral, accounting and institutional relatinoship. All of these pose formidable obstacles with the end result that no policy is often the best policy.

These technical difficulties are compounded by the administrative aspects of policy formulation and implementation. There is no a priori guarantee that a given political system and its component decision processes represent national welfare any better than a laissez-faire Pareto optimum represents national welfare. Policy implementation is often a muddle, reflecting little of the required synchronization and readjustments of policies in place consistent with an efficient pursuit of optimal economic policies.

Small wonder then that many economists hold that optimal economic policies are an abstraction and that actual policies only by chance coincide with optimal economic policies. This phenomenon is not new to economics. Actual prices for goods and services differ from their Marshallian normal prices.[1/] The latter play an important part in the economist's approach towards the determination of social welfare. It is actual prices, and not normal prices, that spur politicians and planners into action. It must be admitted that the divergence between actual and normal prices is often such to give a sophistical tinge to the argument of non-intervention. At the same type, it is precisely established principles of exchange behavior that must guide the politician in a longer-run perspective. The reconciliation of both approaches is not easy. It is as much an art as it is a science. It implies that an economist must deal with day to day realities and become a planner. The theory of economic policy is in part an enabling vehicle for the economist to play such a role.

A question of principle nevertheless remains, i.e. to what extent the attainment of the proxy objectives which play such an important role in this volume truly represent a contribution to national welfare. This is illustrated, perhaps most convincingly, by the increasing realization that Gross National Product, a money aggregate, is, under many circumstances, a poor indicator of social welfare. This also applies to other money aggregates derived from the 1 x 2 and 2 x 2 model, such as industry earnings and factor incomes. It is

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[1/] For a discussion of Marshall's concept of normal price and its implications, see [67].

therefore a matter of concern to economists to find money measures which can serve as true indicators of welfare.

Whether such money measures can be found is a controversial question. The resurgence of the tools of the old welfare economies in such diverse fields as benefit-cost analysis, public finance and international trade is nevertheless indicative that decision makers want economists to give serious attention to this possibility. Perhaps the causality is the reverse. Applied welfare economics provides the economist with a decision criterion which does not require him to solicit or accept proxy policy objectives from the decision makers. It provides a basis for "sound" policy advice without having to interact with policy makers. Interaction with policy makers at any time is limited at best. But it is well to remember Keynes' observation as to the cumulative effects of economic doctrine.[1/]

The old welfare economics provides such a doctrine. Basic to it is the notion of unearned economic surplus in the form of rent, consumer's surplus or producer's surplus (or producer's rents). Removal of these surpluses through, for example, taxation, should not affect resource allocation and hence the efficiency aspects of a competitive economy. For this to be true, the demand and supply curves that characterize the equilibrium in the commodity and factor markets of a competitive economy must possess special characteristics. Much effort has been expended on the proper specification of the demand curve for a commodity, so as to yield a meaningful money measure for consumer's surplus. The reader is referred to Currie et. al. [14], who in 1971 published an excellent survey of the concept of economic surplus and its use in economic analysis.

[1/] "the ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else." J. M. Keynes, the General Theory, MacMillan, New York, 1936, p. 383.

The measurement of producer's surplus (or producer's rents) and its interpretation as a money measure of welfare has received much less attention. Marshall [39], Shove [52], Robinson [47], and Mishan [42, 43] made important contributions. Recent contributions by Schmalensee [50, 51], Wisecarver [70], Anderson [1, 2] and Just et. al. [36, 37] pay particular attention to the interdependence of commodity and factor markets, as exemplified by the 1 x 2, 2 x 1 and 2 x 2 models of the competitive industry. An important conclusion is that consumer's surplus and/or producer's surplus can be measured in either the commodity or factor markets.

An important drawback of these contributions is the assumption that factors or production are homogeneous in all uses, and either fixed (giving rise exclusively to quasi-rents) or available at constant cost (no factor is scarce). Marshall, on the other hand, emphasized the heterogeneity of factors to firms in the industry. Robinson emphasized the possible scarcity and heterogeneity of factors to firms outside the industry in which the factors are currently employed. Shove formulated a general definition of rent, which allowed for pecuniary and nonpecuniary aspects, which underlie resource allocation in the competitive economy. The inclusion of nonpecuniary aspects in rents poses an important methodological problem for the measurements of rent and its welfare interpretation as shown by Mishan.

The recent contributions mentioned earlier, including the contributions by Mishan, do not allow for the simultaneous occurrence of these complicating circumstances in the demand and supply curves of the 1 x 2, 2 x 1 or 2 x 2 model. There is nothing unusual in this, since theory must approach reality by means of successive approximations. It raises, however, a serious question about the findings of econometric studies. This is because the large number of assumptions,[1] which must be made to give producer's surplus significance as a measure of welfare, are glossed over in statistical investigations or cannot be factored out.

The measurement of producer's rent, and their interpretations as a money measure of welfare, is slippery, both on theoretical and statistical grounds. Economists, therefore, under most circumstances, might as well accept the use of the proxy variables referred to in Table 1.

10. Optimality and optimization techniques

A policy can be said to be optimal if it is the most favorable or most conducive to a given and end under specified conditions. Optimization is the search for the optimal policy. An optimization technique is a method which facilitates the systematic search for the optimal policy. An algorithm is a repeating sequence of steps involving numerical calculations such that an initial chosen policy is rejected in favor of a better policy until the optimal policy is determined. There is a natural progression between these concepts. It is the concept of optimality that determines the appropriate optimization technique, it is the optimization technique that determines the algorithm. It follows that no single algorithm or optimization technique will prove to be appropriate for all optimality concepts.

The solution of the policy coordination problem involves the use of matrix algebra. The solution of optimal policies under uncertainty involves the use of matrix algebra, differential calculus and elementary statistics [11]. The solution of optimal policies involving dates variables involves matrix algebra

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[1] i.e., perfect competition in commodity and factor markets, no internal or external economies of production, zero transfer costs, indifference to non-pecuniary aspects of employment, homogeneity of factors to all firms inside and outside the industry, nonscarcity of factors of production, except for those factors held constant for each firm in the industry, constancy and equality of the marginal utility of income among factor income recipients.

and differential equations [4]. Similar disciplines must be called upon when solving the assignment problem. The solution of optimal policies that maxmize the sum of producer's and consumer's surplus involves the calculus of line integrals [53]. If the variables are dated in above problem, then we must use the calculus of variations [20]. If target and instrument variables are bounded, we must use optimization techniques associated with control theory [12, 30]. All of above problems can be solved by successive numerical approximation, i.e. by using specially adapted algorithms.[1/] Large-scale models cannot be solved without the use of computer oriented algorithms.

There are circumstances under which large-scale models are required for policy analysis. This will be so whenever disaggregation of the technical, behavioral, accounting and institutional relationships is a required aspect of the policy problem analyzed. Table 1 stressed the need for disaggregation of objectives into major objectives and minor objectives. Similarly, the instruments of agricultural policy are disaggregated by family and by type. On the other hand, we did not stress the need to disaggregate the technical, behavioral and accounting relationships that appear in policy models. The models presented there are national, sectoral or industry relationships. Often, however, one needs to go beyond two sectors, two commodities, two factors, two regimes, or one time period. Jointly considered, the dimensions of the problem are then (m x n x j x k x l). Even for small m, n, k, l, j, the problem is then no longer manageable without access to electronic data processing.

The size of the problem is such that the behavioral relationships of producers and consumers can no longer be solved for explicitly as is possible with

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[1/] Space does not permit a discussion of algorithms such as matrix inversion techniques, the literative solution of systems of differential equations, the the simplex method, Bellman's equation, the conjugate gradient method, etc. The above cited references contain elementary expositions of these algorithms. The writing of algorithms is best left to specialists in applied mathematics and computer science.

compact macro or micro models. Nor is it possible to derive a relationship such as equation 7, which expresses the optimal policy in terms of the objectives of the sector itself, the objectives of the other sectors, and the projected development of autonomous variables of the agricultural and nonagricultural sector. Only if the model is linear and contains no inequaliites can equation 7 be solved for relatively large models (15). If, however, the model contains nonlinear technical or behavioral relationships or if the model contains inequalities as on page 45, no explicit solution, such as equation 7, can be obtained.

Nonlinear relationships can often be approximated by means of linear approximations for stated intervals. The boundary conditions for such segments add additional inequalities to the specification of the model. In ultimate instance, it is inequality constraints that frustrate a direct derivation of the basic policy equation 7.[1/] Linear programming and quadratic programming are optimization techniques which were especially developed to derive optimal solutions for problems characterized by inequalities.

Such inequalities arise quite naturally if we impose upper or lower constraints on targets or instruments, or if we try to approximate a nonlinear function in terms of bounded linear segments. This, however, is not the usual nature of the inequalities in linear or quadratic programming models. Equilibrium in commodity or factor markets supposes an equality of the quantities demanded and supplied in each market. Inequalities, i.e. excess demands or supplies arise if one or more prices or quantities are held constant. Assumptions must then be made as to whether the quantity demanded or the

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[1/] We do not discuss the use of control theory (12) or variational methods (20) in economic policy. Dynamic optimization of large-scale linear models is possible [9, 10]. On the other hand, dynamic optimization of nonlinear models subject to inequality constraints exceed electronic data processing capacity even when the models are relatively small (59, 60).

quantity supplied is binding for the solution. The usual assumption is to rule out excess demands as well as excess supplies of commodities, i.e. commodity markets are assumed to reach equilibrium. Excess demands for factors of production are also ruled out, but excess supplies of these are admissible. Consequently, we may have one or more resources partially or wholly unemployed. The usual assumption is that factors or resources are offered without regard to their rate of renumeration, i.e. the supply curves of factors are vertical. Consequently, if a factor is less than fully employed, its renumeration or shadow price will equal zero.

This poses a major validation problem, because in practice no resource is available at zero price. The problem is compounded when, in spatial programming models, all resources of comparatively disadvantaged regions are declared to be without value, whereas in such regions land, labor and capital are all exchanged at nonzero prices. Above anomaly is inconsistent with the workings of a competitive economy where all reosurces tend to be fully employed at nonzero prices. On the other hand, it may be argued that in practice selected prices or quantities are fixed by custom or by decree and that because of this the appearance of structural unemployment of resources as part and parcel of an optimal economic policy cannot be ruled out. What is to be avoided, of course, is assumptions that do not accord with reality, e.g. to assume that selected prices are fixed when in reality they are variable or vice versa.

Such assumptions are also important as to the mobility of resources between uses within the firm, between firms in a given industry, between industries and between regions.[1/] The assumption of perfect immobility is as unsatisfactory as that of perfect mobility. The ad-hoc assumptions of large-scale models in this matter reflect our ignorance as to the determinants of factor mobility.

[1/] Land, of course, is not mobile between regions.

Commodities, in contrast with resources, are virtually always perfectly mobile, i.e. they can be stripped from any arbitrarily selected production point to any arbitrarily selected consumption point, at home or abroad. Physical mobility, however, does not imply economic mobility. As to whether a commodity will be transshipped depends on its profitability. The latter is part of the optimal solution.

The demand for factors is a derived demand. But this notion does not appear explicitly in large-scale models. In its place, use is made of the unit-isoquant, which allows one to construct alternative combinations of resources which yield equal amounts of production. Often a theoretically rigorous connection with the concept of technically efficient production is avoided. In its place one uses raw or processed cost of production data. Collection of reliable and relevant cost of production data is a major aspect of the construction of large-scale linear and quadratic programming models to be used for agricultural policy analysis.

Such models usually analyze one policy at a time. Its effectiveness as dependent on target variables, other policies and autonomous variables as in equation 7, is rarely allowed for. Nor is there necessarily a need for this. Most large-scale models have just one target variable, i.e. the maximization of consumer's surplus, the maximization of producer's surplus, or the sum of these concepts. Such models, therefore, do not use the proxy objectives in Table 1 but the concepts central to the old welfare economics discussed in the previous subsection. Consumer's surplus or producer's surplus do not appear directly in the objective functions of large-scale linear programming or quadratic programming models. In its place appear their equivalent notions of minimizing the cost of a given consumption basket, or maximizing the value of a given aggregate of resources, or both.

The number of parameters that appear in large models is also correspondingly large. Because of this, it becomes difficult to assign critical importance to any one, or combination of parameters, such as an elasticity of substitution, the supply elasticity of a given factor, the rate of population growth, the desired target level of a commodity price and so forth. It is that aspect which makes compact macro and micro models attractive. In contrast, the solutions of large models are expressed in abundant numerical detail. Yet, it is often difficult to provide a meaningful summary of such solutions, because we do not know which set of parametric conditions separates one solution qualitatively from another.

In principle, all of the foregoing objections can be overcome through the use of sensitivity analysis. This technique, however, is rarely used. The change of one parameter at a time, along traditional caterls paribus lines, is often not very appealing in a model that may contain thousands of parameters. Consequently, changing sets of parameters at a time, along mutatis mutandis lines, is in principle more attractive. But there are many ways in which such sets can be chosen, thereby defeating the purpose of obtaining clear-cut results through sensitivity analysis.

11. Linear programming models: an example

Heady [22], Heady and Candler [23], Bishay [5] and Blitzer [6] contain excellent surveys of the theory and applications of large-scale linear and quadratic programming models in developed and developing countries, and in capitalist, socialist and mixed economies. The work of the World Bank in Mexico [19] and in Central America (45) also merits mention.

11.1 The Salaverry model

To give the reader a sense of the structure of such models within an IICA country context, we will quote from Chapter 1 of Dr. Salaverry's doctoral thesis, "An interregional linear programming model for the analysis of agricultural development policies in Peru" [48].

The main purpose of the study was to develop and apply an interregional activity linear programming model for the analysis of long-run agricultural development policies to increase agricultural output and productivity. The model applications include in their specifications the regional characteristics of the agricultural economy of Peru.

Two main domestic agricultural production alternatives were considered: 1) increases in agricultural production through increases in total cultivated agricultural area (increases in the land base and improvements in the existing land base) and/or 2) increases in agricultural production through productivity increases. The first alternative was linked implicitly to public expenditures on land development activities. The second alternative was explicitly linked in the model to productivity coefficients of public expenditures on research, promotion and extension services.

The model allows one to

1) find the optimal land use pattern (the cropping pattern) that mazimizes the objective function for each region, and therefore at the national level, that is consistent with the resource supplies and other limitations and satisfies the given levels of domestic demand.
2) obtain the optimal allocation of regional and national semi-mobile and mobile resources and the returns which these resources would earn under competitive economic conditions. This is done through a comparison of accounting prices that accrue to limiting resources to the optimal solution of the interregional programming model.
3) obtain the intermediate demand of labor and capital factors of production which are required to produce the optimal production activity

levels and to find the direction that these resources would follow in an optimal allocation framework.

4) test the production responses (net product, employment and income) of the agricultural activities included in the model and the effects on the objective function and resource use of different land expansion policies and/or productivity increase policies as alternative formulations to increase domestic production. Also, alternatively, policies of domestic production and export-import policies under different foreign exchange circumstances.

5) use the formulation of the model and development of the basic input data as a unique systematic methodology - a learning device - for the study of the main regional characteristics, conditions and factors of the agricultural economy of Peru.

6) find ways in which existing research organizations and institutions in charge of policy formulation and action implementation can improve research and the subsequent needed information in terms of the problems and alternative policies for their solution.

11.1.2. Model specification

Linear programming techniques involve the optimization of a linear function subject to a set of linear inequalities of the form, i.e., in the Primal problem:

$$\text{Max } f(s) = c' X$$

$$\text{Subject to } AX \leq B$$

$$\text{and} \qquad X \geq 0$$

where,

c' = the transposed column vector of the pricing (choice criteria) corresponding to each structural activity of the formulated problem.

X = the activities levels to be obtained in the solution of the optimum problem.

A = the input-output matrix relating each level of activity to the resource use and related cost structure.

B = the fixed resource supply constraints and other limitations given in the problem formulation.

A1. General assumptions of linear programming

The basic assumptions of linear programming techniques as applied to interregional activity analysis are as follows:

a) The objective function (choice criteria) is linear and separable, each of its components depending only on one corresponding activity level. This assumption indicates the possibility of introducing into the problem formulation separable objective functions for each region (or groups of individual units of production within each region) expressing different assumptions about the behavioral response of individual units of production or groups of them to existing structural and economic conditions in each region.

b) Linearity of the production functions. This assumption arises from the facts that 1) the input-output coefficients of each activity are assumed to be constant within a relevant range and 2) the prices paid for resources (and received for products) are assumed to remain constant. The assumption of homogenous production functions with constant coefficients precludes the adjustments due to economies of scale: input-output and related cost structures for each process remain in the same ratio whether the process is used at unit level or million unit level. Also, in the solution, the same production pattern is assumed to exist for a small unit of production or for a giant unit; there is no scale criteria for identifying or isolating the activities of the individual unit of production in accordance with its size. However, there exists the possibility of including into the problem formulation different production processes specified for several possible combinations of factors in the production of each commodity, obtaining a segmented transformation curve. This segmented transformation curve may well approximate, in certain problems, a desired choice between different production models or techniques or technological levels available in the production of each commodity. However, there still remains the problem of defining and specifying a shift coefficient in terms of the cost required to increase from one technique to the next higher level.

c) Additivity of production processes. This assumption states that two or more processes can be used simultaneously, within resource constraints, and that the resulting output and inputs used are the arithmetic sum of the initial individual processes. This assumption indicates that no external economies or diseconomies of scale are allowed in any of the individual production processes.

d) Divisibility. It is assumed that factors can be used and commodities can be produced in quantities which are fractional units.

e) Fixed supplies of resources and other limitations. The linear programming techniques apply to situations where resources are assumed to be in fixed supply for each region, such that any adjustment in resources, incomes or demands must be made externally to the linear programming framework.

A2. Specific assumptions of the regional model

a) A competitive economic system is assumed in the sense the decisions on the type of production, resource use and intensity of resource use (levels of technology and techniques) are determined in a market concurrence where prices of products and of inputs production are relative to the prevailing economic and social conditions. The specification of the regional conditions corresponding to a competitive system constitute a strong limitation of the empirical uses of the model. The main problem in this respect rests on the specification of the components of the model in terms of the available data, particularly with respect to the main interdependences between the production activities, the transfer activities (marketing activities) and "realistic" determination of the regional resource constraints and other limitations.

b) The maximization of value added is assumed to characterize the behavior of the average producer in each of the programming regions under the existence of limitative factors of production - other than labor - imposing upon the agricultural production functions special structures. The maximization of value added, quantity that includes salaries, rents, interest and profits, and not only profits, is assumed to represent the behavior of the average producer. For small units of agricultural production, it represents the family farm income from direct agricultural undertakings at the opportunity cost of labor elsewhere in the economy. The seasonal components of agricultural employment have, in these circumstances, a heavy weight in determining agricultural production activities in the subsistence subsector. It is in this sense that this subsector could properly be referred to as the residual sector to the external conditions of production within the agricultural sector and to the conditions of growth in the rest of the economy.

c) Regions are assumed to have a concentration point in production. The average cost structures for each production activity at different technological levels are assumed to be uniform within each region but different between regions. Output value per unit of area is defined in terms of the average price received by producers. The profitability of each activity in the regional framework assumes constant marketing margin costs of commodities shipped within and between regions.

d) Only production of final commodities is assumed. The final demands are given in terms of domestic apparent demand, including direct human consumption plus seed and losses. In the case of certian commodities, the final demand is a derived demand, for example, the demand for corn animal feed is derived from the demand for livestock meat.

e) Each production activity is intended to include at least three technological levels. Each technological level is specified in terms of the input-output coefficients and respective cost profiles. The technological levels for each production activity in each region represent the production possibilities at a given point in time. Further, a productivity coefficieint is intended to be attached to each production activity. This coefficient is expressed in terms of the expected public cost in agricultural research and extension services required to increase productivity from one yield level to a higher one. The main empirical problem in this respect is the specification of the productivity coefficients in terms of the total cost of research and extension services required to increase one unit of output yield level. Another problem is related to the cost variations with the regional distribution of public funds, particularly due to overhead administrative costs. These and other considerations are important in determining the efficiency conditions in the empirical solutions of the model when used for projection purposes. However, they are exogenously determined in this model. No attempt is made in changing these productivity coefficients while it is recognized that they are of the upmost importance on the regional "optimal" solutions. They constitute an additional strong limitation to empirical findings.

f) A further assumption is the perfect mobility of labor and intermediate capital factors of production. The input supplies of these factors, including technical knowledge and skills and commercial credit, may be binding constraints in the model. This can be actually specified in the resource constraints for labor and capital factors of production by groups of units of production stratified according to certain criterion, for example, distribution of area by technologies of agricultural production. Specifically, for certain activities, bounding constraints are used. The introduction of commercial and promotional agricultural credit policies is also made possible by these constraints.

11.1.3 The Direct Problem

B1. Notation

The following notation was used consistently in the interregional program-model and its applications:

$h = i, 2, \ldots, n$ natural regions (ecological or socioeconomic main regions)

$i = 1, 2, \ldots, s$ programming or producing regions (shipping regions in the transport matrix)

$h_1 = 1, 2, \ldots, s_1$ natural region 1

$h_2 = s_1+1, \ldots, s_2$ natural region 2

$h_3 = s_2+1, \ldots, s_3$ natural region 3, et cetera

$j = 1, 2, \ldots, r$ consuming regions (receiving regions in the transport matrix)

$k = 1, 2, \ldots, m$ final commodities

$t = 1, 2, \ldots, l$ technological levels or output-yield levels

X_{kit} = level of land use (hectares to produce the k^{th} commodity in the i^{th} region at the t^{th} technological levels

V_{kit} = value added (soles per hectare)

y_{kit} = output yield (kilos per hectare)

p_{kit} = price per unit of output (soles per kilo) received by farmers

l_{kit} = per unit land requirement (hectare)

g_{kit} = productivity coefficient of public expenditures on agricultural research, promotion and extension in terms of soles per hectare required to increase the output yield from the (t) technological level to the (t+1), (t+2) technological levels of production

n_{kit} = per hectare labor requirements in labor days to produce the y_{kit}^{th} output yield level

w_{kit} = imputed wage rate for labor day use (soles per day)

c_{kit} = per hectare intermediate capital expenditures on traction, seeds, fertilizers and chemicals and tools required to produce the y_{kit}^{th} output yield level (soles per hectare)

R^h, R_i^h, R_{it}^h = value added (wage bill plus gross profits)

L, L^h, L_i^h, L_{it}^h = supplies of total cultivated lands

P, P^h, P_i^h, P_{it}^h = supply of public expenditure funds for productivity programs

N, N^h, N_i^h, N_{it}^h = intermediate capital supplies (operating capital)

W, W^h, W_i^h, W_{it}^h = total wage bill

Y, Y^h, Y_i^h, Y_{it}^h = total output value

D_{kj} = adjusted apparent domestic demand requirements for the k^{th} products in the j^{th} demand region

FED = foreign exchange condition

PEG = public expenditures availability condition

T_{kij} = quantities transferred of the k^{th} product produced in the i^{th} region and shipped to the j^{th} receiving region

E_{ki} = exports of the k^{th} product produced in the i^{th} region to the rest of the world

M_{ki} = imports of the k^{th} commodity from the rest of the world to the i^{th} region

f_{ki}^e, f_{ki}^m = foreign exchange coefficient - generation and depletion coefficients - in dollars per metric ton exported and imported

t_{ki}^e, t_{ki}^m = ad valorem tax coefficient on exports and imports

B2. The model

The purposes and objectives of this study can be met by the following formulation of the problem:

The objective function is

$$\text{B.2.1} \quad \text{Max } f(s) = \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} V_{kit} \cdot X_{kit}$$

maximize total value added over m commodities produced in s regions at 1 output-yield levels within each region. Value added is defined

$$\text{B.2.2} \quad V_{kit} = (y.p)_{kit} - K_{kit}$$

The first term in the right-hand side is the farm output value per hectare, and the second term corresponds to the intermediate capital expenditures per hectare required to produce the y_{kit}^{th} output yield level, for the k^{th} crop activity produced in the i^{th} region at the t^{th} output-yield level.

Two alternative formulations of the objective function may be considered: (1A) maximization of gross profits and (1B) maximization of labor use. These alternative formulations have as objectives to compare the patterns of production and resource use in the optimal solutions to changing conditions and parameters.

Alternative 1A Maximization of gross profits.

The objective function is:

$$\text{B.2.3} \quad \text{Max } f(x) = \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} \pi_{kit} \cdot X_{kit}$$

where

$$\text{B.2.4} \quad \pi_{kit} = (y.p)_{kit} - (TVC)_{kit}$$

and

$$\text{B.2.5} \quad (TVC)_{kit} = N_{kit} + K_{kit}$$

(profit equations)

The first term in the right-hand side of the profit equation is on-the-farm output value per hectare. The second is the total variable cost of production composed of total labor expentures at imputed wage rates plus total intermediate capital expenditures, for the k^{th} crop activity produced in the i^{th} region at the t^{th} technological level.

Alternative 1B Maximization of labor use.

$$\text{B.2.6} \quad \text{Max } f(x) = \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} N_{kit} \cdot X_{kit}$$

This alternative will require some modification in the constraints and limitations of the model

The model is subject to the following constraints and limitations:

National land constraint

$$\text{B.2.7} \quad \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} X_{kit} \leq 1$$

Natural regions land constraints for each of the n natural regions

$$\text{B.2.8} \quad \sum_{k}^{m} \sum_{i}^{s_1} \sum_{t}^{1} X_{kit} \leq L^{h}$$

Programming regions land constraints for each of the s regions

$$\text{B.2.9} \quad \sum_{k}^{m} \sum_{t}^{1} X_{kit} \leq L_{i}^{h} \text{ (max)}$$

$$\text{B.2.10} \quad \sum_{k}^{m} \sum_{t}^{1} X_{kit} \geq L_{i}^{h} \text{ (min)}$$

such that

$$\text{B.2.11} \quad L \geq \sum_{h}^{n} L^{h} \geq \sum_{h}^{n} \sum_{i=1}^{sh} L_{i}^{h}$$

Land constraints by groups of units of production or forms of organization of production for each of the 1 groups in the s regions

$$\text{B.2.12} \quad \sum_{k}^{m} X_{kiy} \leq L_{it}^{h}$$

such that

$$\text{B.2.13} \quad \sum_{t}^{1} L_{it}^{h} \leq L_{i}^{h}$$

Programming regions labor supplies for each of the s regions

$$\text{B.2.14} \quad \sum_{k}^{m} \sum_{i}^{s_h} N_{kit} X_{kit} \leq N_i^h$$

Labor supplies by groups of units of production or forms of organization of production for each of the s regions

$$\text{B.2.15} \quad \sum_{k}^{m} N_{kit} \cdot X_{kit} \leq N_{it}^h$$

such that

$$\text{B.2.16} \quad \sum_{t}^{1} N_{it}^h \leq N_1^h$$

Programming regions intermediate capital supplies for s regions

$$\text{B.2.17} \quad \sum_{k}^{m} \sum_{t}^{1} c_{kit} X_{kit} \leq K_i^h$$

Intermediate capital supplies by groups of agricultural units of production stratified by different criteria (i.e. distribution by technological levels) for 1 groups

$$\text{B.2.18} \quad \sum_{k}^{m} c_{kit} \cdot X_{kit} \leq K_{it}^h$$

such that

$$\text{B.2.19} \quad \sum_{t}^{1} K_{it}^h \leq K_i^h$$

Public expenditure funds available for agricultural research, promotion and extension programs at the national level

$$\text{B.2.20} \quad \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} g_{kit} \cdot X_{kit} - FT = 0$$

where,

the first term in the left-hand side is the total expenditures over m production activities in the s regions required for the productionof the X_{kit} hectares at the y_{kit} output-yield levels, made possible through the financial transfer activity (FT) of public funds available for productivity programs plus those funds generated internally in the optimal program through export-import ad valorem taxes as explained in the public expenditures - generation restraint (PEG).

Public expenditures funds available for agricultural productivity programs at the natural regions levels for n natural regions

$$\text{B.2.21} \quad \sum_{k}^{m} \sum_{i}^{s} \sum_{t}^{1} g_{kit} X_{kit} - \eta_h FT = P^h$$

such that

$$\text{B.2.22} \quad \sum_{h} \eta_h = 1$$

where

η_h = the relative share of FT in each natural region

The first term in the left-hand side has the same meaning as explained in Equation 2.16. The second term $\eta_h FT$ allows for the distribution of available financial funds (FT) between natural regions according to differential distribution policies on the allocation of research, promotion and extension programs or regional social transfer policies.

Public expenditure funds for programming regions for all s regions

$$\text{B.2.23} \quad \sum_{k}^{m} \sum_{t}^{1} g_{kit} \cdot X_{kit} \leq P_i^h$$

under the following condition:

$$\text{B.2.24} \quad \sum_{i=1}^{s_1} P_i^h \leq \eta_1 \ FT$$

$$\sum_{i=s1+1}^{s_2} p_i^h \leq n_2 \text{ FT}$$

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$$\sum_{i}^{s} p_i^h \leq \text{FT}$$

Public expenditure funds for groups of units of production within a region

$$\text{B.2.25} \quad \sum_{t}^{1} g_{kit} \cdot X_{kit} \leq p_{it}^h$$

Distribution identities for the production of the k^th product in the i^th region transferred within and between regions

$$\text{B.2.26} \quad \sum_{t}^{1} Y_{kit} \cdot X_{kit} - \underset{(i=j)}{T_{kij}} - \sum_{i \neq j} T_{kij} = 0$$

for all the (k = 1,2,...,m) commodities produced in the (i = 1,2,...,s) regions and transferred within regions and between regions to satisfy the given levels of final demands as predetermined in the supply-demand and transport matrices.

Total domestic apparent demand requirements

$$\text{B.2.27} \quad \sum_{i=j} T_{kij} + \sum_{i \neq j} T_{kij} + E_k - M_k \geq D_{kj}$$

for all m products in the s regions and r receiving regions considered in the supply-demand and transport matrices. This condition states that the total final apparent demand (D_{kj}^*) for the k^th product in j^th receiving region must be at least equal to the production in i=j region, plus the total transfers of the k^th commodity from the i^th producing regions to the j^th receiving region, where i ≠ j, plus exports to, minus imports from, the rest of the world.

Foreign exchange condition

B.2.28 $\sum_{k}^{m} \sum_{i}^{s} f_{ki}^{e} \cdot E_{ki} - \sum_{k}^{m} \sum_{i}^{s} f_{ki}^{m} \cdot M_{ki} \geq FEG$

This condition allows for the creation of foreign exchange funds through exports and its depletion through imports given the foreign exchange generation requirements of the economy (FEG).

Public expenditures funds supply-generation condition

B.2.29 $\sum_{k}^{m} \sum_{i}^{s} (t_{ki}^{e} \cdot E_{ki} - t_{ki}^{m} M_{ki}) - FT \leq PFG$

This condition allows for the generation of public funds through agricultural export taxes (t_{ki}^{e}) and import duties (t_{ki}^{m}), which are added to the given supply of public funds for productivity programs (PFG) and transferred through a final transfer activity (FT) to satisfy the public expenditure funds contributions at the national level (P) and natural regions levels (P^{h}) according with predetermined proportional distributions, as explained in conditions 2.20 to 2.22, and B,2.30 $X_{kit} \geq 0$.

11.1.4 Application[1]: land saving vs. land increasing policies

At the time the study was undertaken[2] the optimal distribution of public expenditures between land saving policies (research, fomento and extension) and

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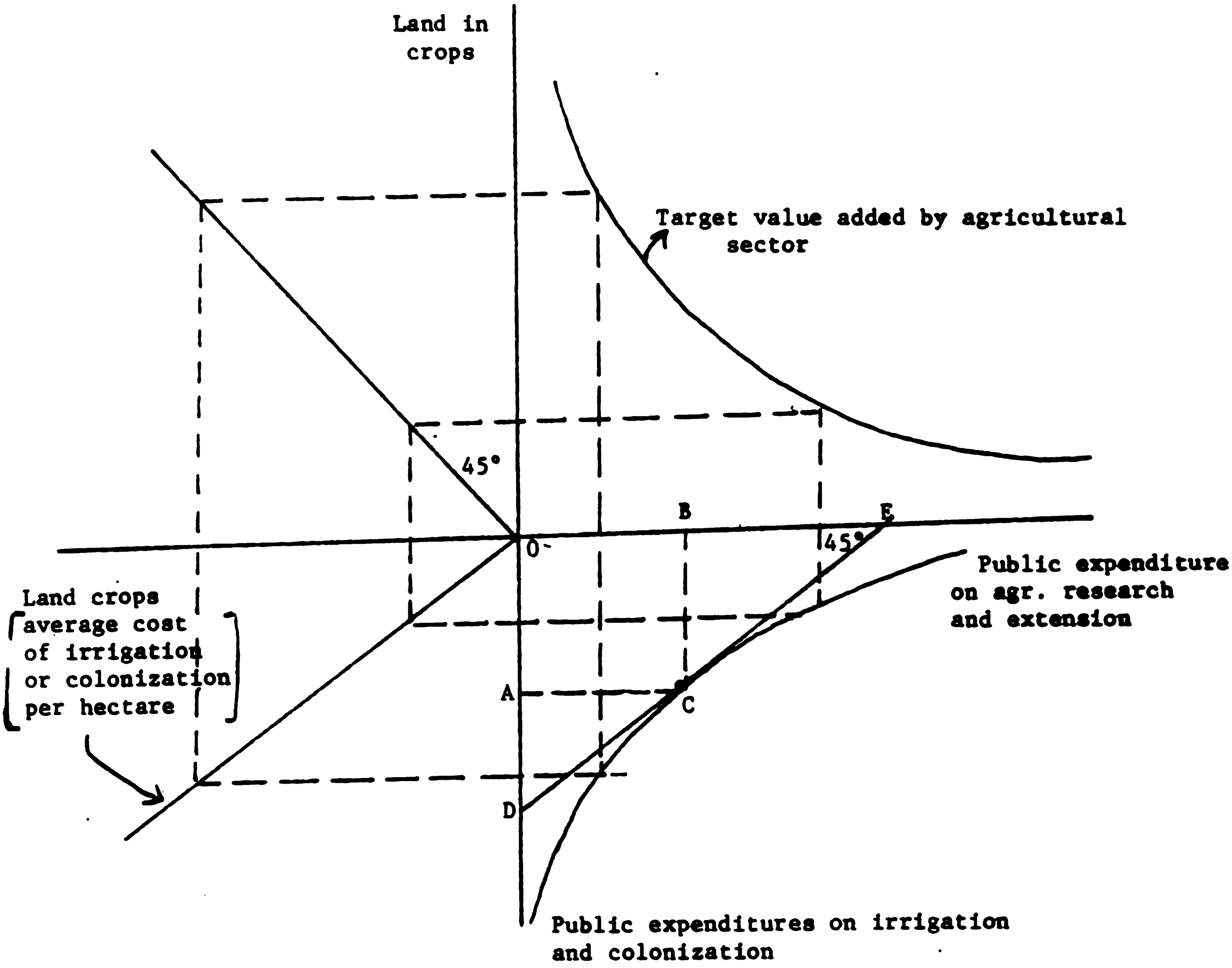
[1] Salaverry's study contains several applications; we have chosen one which continues to be of interest to a majority of IICA countries.

[2] Work on the study began in 1966. It was completed in 1969, i.e. coincident with the initiation of Peru's comprehensive agrarian reform program. The gestation lag in the construction of large models is often more than three years. By the time the study is completed, the major focus of agricultural policy may have changed, as happened in this case. Time, not data or personnel, is the limiting factor in policy analysis. It is for that reason that this section of Chap. IV stresses the need for compact, yet analytically rigorous, models which go directly to the core of the problem. Large-scale models, to be useful, must be nurtured carefully through birth, infancy and maturity. Instability of the institutional environment often cuts short the maturation of large-scale models.

land increasing policies (irrigation, and colonization) was a key issue with obvious implications for regional development, the balance of payments, employment absorption and the composition of food and industrial crop production. Figure 3 focuses on the optimal choice between land saving and land increasing policies. The target increase in value added was set by the National Planning System. Salaverry, in Figure 35 of his thesis, derived the precise quantification of the required iso-value added curve. A previous study contained calculations as to the present discounted cost of irrigation or colonization of hitherto uncultivated land. Using this information, it is possible to construct the curve in the lower right-hand diagram. This curve specifies, for a given combination of land saving and land expansion policies, the present discounted expenditure to be made by the public sector if the target value added specified by the Planning System is to be met. The optimal strategy calls for a mixture of land saving and land expansion policies as indicated by point D. At that point, total public expenditure, indicated by DE, is the minimum possible for a given increase in value added by the sector. It also illustrates the principle that at the margin, a unit of public expenditure on alternative policies should make an equal contribution to the policy objective.

Figure 3: The optimal choice of land saving and land increasing policies



Chapter XI

System Simulation Models

This short overview of system simulation models begins with a statement of the kinds of decision-making problems arising in development planning which make system simulation a useful approach. Next, the basic principles and mode of operation of the system simulation approach are discussed, and then it is illustrated with brief descriptions of a few applications and uses of system simulation models.

The Development Planning Context

The problems of planning for economic development arise from the interplay of physical, political, social, and economic processes of a developing country. Major issues challenging policymakers include, for instance, the relationships among population growth, nutrition, and economic development; the problems of accelerating technical change; the two-way relationship between the environment and agricultural production; and the effect on the national system of major perturbations in the international scene. Public decision makers face problems characterized by their increasing complexity and interdependencies, derived on the one hand from the large number of sometimes conflicting objectives the public sector is required to pursue in a modern society, and on the other hand by the uncertainty arising from both the quantity and quality of available data and information and from the difficulty of forecasting how a large-scale system of complex interactive and feedback relationships will respond to various policy options.

The problem becomes even more complicated if we include the time dimension in the analysis. That is, policies may have different short- and long-run effects. Also, various policies usually have different time lags between the time they are implemented and the time they begin to have an impact. Parallel to this temporal dynamics with respect to the set of policies there is another with respect to the socioeconomic situation. that is, the socioeconomic situation is not static. It evolves, worsening in some ways and getting better in others as time goes by and in response to past policy actions. Thus, the timing with which a set of policies is implemented has an important influence on the effectiveness and costs of those policies.

The System Simulation Approach

The system simulation approach offers a broad and flexible means of facing this challenge. The core of the system simulation conceptual framework is a model or set of models of the structure and processes constituting a system within which a specific set of problems is encountered and related sets of objectives have to be attained. Thus, system simulation models tend to be subject-matter models, as defined earlier. The approach typically includes problem formulation, mathematical modeling, model testing and refinement, and simulation, which is the application stage, all in interaction with the analysts and decision makers who are users of the policy analysis information.

The system simulation approach can be characterized as a general, flexible, integrative, adaptive, and problem-investigating process. It is general with respect to philosophies, techniques, and kinds and sources of data and information. Its flexibility rests in the building-block organization of its models, allowing for the development and incorporation of new components and the substitution of simpler components by more disaggregated ones as necessary for particular analyses. It also allows for the use of a wide range of modeling techniques from different disciplines. The iterative process traces the likely consequences of specific decisions and polocies across a wide variety of dimensions of interest to decision makers, such as time, space, income class, etc. Through interaction with analysts and decision makers, then, additional policy options may be defined for testing and modification in the models themselves. It is an adaptative approach in that improved knowledge about data, parameters, and structural relations can be progressively incorporated into the models. Finally, the approach focuses in the investigation of and search for solutions to actual problems. Positive and normative knowledge is required for this, and the approach is especially useful whenever an objective function encompassing the various goals of the decision makers cannot be defined, which is usually the case in development planning.

We can conceptualize a formal system simulation model in the following general way:

$$\begin{aligned} \psi\,(t+1) &= F[\psi(t), \alpha(t), \beta(t), \gamma(t)] \\ \pi\,(t) &= G[\psi(t), \alpha(t), \beta(t), \gamma(t)] \end{aligned}$$

Where:

ψ (t): a set of variables defining the state of the simulated system at any given time,

π (t): a set of output variables indicating system performance and reflecting the concerns of the decision makers,

α (t): a set of parameters defining the structure and behavioral patterns of the system.

β (t): a set of environmental variables (physical, social, political, economic) which influence the system from outside,

γ (t): a set of policy instruments.

A distinctive, though not exclusive, feature of system simulation models is their "simulation" mode of operation. Simulation consists of a process of conducting policy experiments on models instead of on real-world systems. Although not necessary for simulation, simulation is increasingly being identified with computerized mathematical models.

According to the conceptualization given above, we can describe the operational mode of simulation in the following way. Values for a set of environmental variables β* and a set of policy instruments γ* are fed to the model. The computer executes the model tracing out time paths for the corresponding sets of state variables ψ* and output variables (performance criteria) π*. For each different policy strategy γ_i, the model gives a different set of consequences π_i. These sets of performance variables for various strategies are the output of the simulation stage and constitute the basis for the selection of the "optimum" strategy. As pointed out above, a great deal of interaction with decision makers during the simulation stage is required in order to determine the relevant policy strategies to be assessed.

In addition to their primary contribution to policy assessment and design, system simulation models can make three other noteworthy contributions which are sometimes considered to be of more lasting importance than the primary one. First, during the modeling stage, a deeper understanding is gained by analysts and decision makers alike of the structure and behavior of the socioeconomic system. Second, simulation analysis provides important insights about research priorities in three ways: (1) via the indication of data collection priorities (through sensitivity analysis), (2) via the identification of structural relationships and behavior patterns about which theoretical disciplinary knowledge is lacking, and (3) via the identification of technical and scientific research areas with high potential investment payoffs. Third, a system simulation model can work as a sort of laboratory in which new knowledge and hypotheses about parameters and structural relationships can be tested.

Illustrative Applications

The system simulation approach has been widely used during the last decade in modeling and analyzing food and agricultural systems. As a result, a fairly good body of experience is available to evaluate the operational utility of the approach. System simulation models have been constructed at many levels of aggregation, but this brief survey of applications considers only a few long-run national, sectoral, and subsectoral models, and one international model which focuses on the interplay of the environment and the socioeconomic system.

Representative of the more comprehensive type of model are the Nigerian and Korean agricultural sector models developed by Michigan

State University in collaboration with Nigerian and Korean researchers and decision makers [9, 10]. The Korean model, which was actually used in policy assessment in Korea, is described here. The model's objectives were to evaluate the impacts of alternative policies on three broad policy goals of Korean decision makers: (1) achieving improved food supplies, preferably from domestic sources, (2) realizing a higher quality of life in rural Korea, and (3) enhancing and improving the contributions of the agricultural sector to overall national development. The model was designed in order to allow flexibility in using its individual components singly for exploring narrowly defined policy issues as well as in combination for general sector analysis over a planning horizon of 15 to 25 years. Its six components are: (1) population and migration, (2) national economy, (3) crop technology change, (4) demand/price/trade, (5) farm resource allocation and production, and (6) accounting, which summarizes the behavior of various performance indicators under different policy sets. The Korean model was used in assessing land and water development investment alternatives, and in helping in the design of the Fourth Five-Year Plan in such areas as livestock planning, population projections, price policy analysis, and foreign trade impacts.

A second national socioeconomic model is the Bachue-Philippines model constructed by an ILO team [11]. It simulates the behavior of the demographic-economic system of the country based on three subsystems: (1) economic, (2) labor market and income distribution, and (3) demographic. It is a projection model, and its main use has been for sensitivity analysis with a time horizon of 40 years, starting from 1972.

The A. C. Picardi, W. W. Seifert Sahel model [12] focuses on the very relevant issue of the interplay between the natural environment and the socioeconomic system. It models the dynamics of pastoralism in the Sahel zone of Africa and evaluates the ultimate impacts of certain aid programs, such as the provision of veterinary services, first on the environment, via overstocking and overgrazing, and then on the socioeconomic system. A combined technical-economic-cultural package resulting in the stabilization of livestock birth rates is prescribed.

At the subsector level is a system simulation model which analyzes a program for modernizing cotton production in northeast Brazil [13]. A modernization process, in which resources shift from a traditional subsector to a modern one resulting in increased average yields, is simulated, and alternative policy packages, consisting of coordinated extension-credit-research programs are assessed.

Also at the subsector level, Halter and Miller applied the cattle component of the Michigan State University Nigerian model [9] to the Venezuelan cattle industry to test alternative policies directed towards the modernization of that subsector [14]. For this purpose, modernization involves (1) increasing resource productivity in order to meet rising demand through internal supply, hence reducing imports, and (2) offsetting environmental problems due to overstocking and overgrazing in many areas of the country. The model includes two components -- a traditional and a modern subsystem -- between which shifts of resources (land, animals, etc.) occur. The policy packages considered include (1) various kinds of price policies, (2) a pasture improvement program, (3) a herd management campaign, (4) a new land development program, and (5) an extension campaign promoting shifts to modern methods of production.

Chapter XII

Communication of Results

Interpreting and Presenting Results

In a simple world, decision-makers would be faced with choosing one alternative from a limited and explicit choice set based on a single criterion. In those circumstances, analysts could easily rank the alternatives according to the agreed-upon objective. The approach of constrained optimization would be applicable. This could involve either fixing the level of goal achievement and ranking alternatives according to their cost or fixing a level of cost and ranking them by their degree of attainment.

Benefit/cost analysis can be viewed as an example of this approach. The use of monetary values provides a unit for quantifying benefits and costs. The comparability of benefits and costs makes it possible to trade off one benefit for another and look for the "best" alternative. The main difficulty, of course, is in capturing the relevant costs and benefits in monetary terms.

Even where benefits and costs can be successfully quantified, the ranking of the alternatives may not be straightforward. Assume that the benefit/cost comparisons for two alternative policies are as shown in Fig. 1. In this example, point A cannot be attained and point D is inefficient in benefit/cost terms. Which policy is "best?" That depends on other considerations. If B_2 is specified as the minimum acceptable level of benefits, then Policy II is the only feasible choice. Similarly, if C_2 represents a fixed budget, then Policy II will provide more benefits for this expenditure than Policy I. However, if the objective is to maximize the ratio of benefits to costs, then Policy I is preferred (point E).

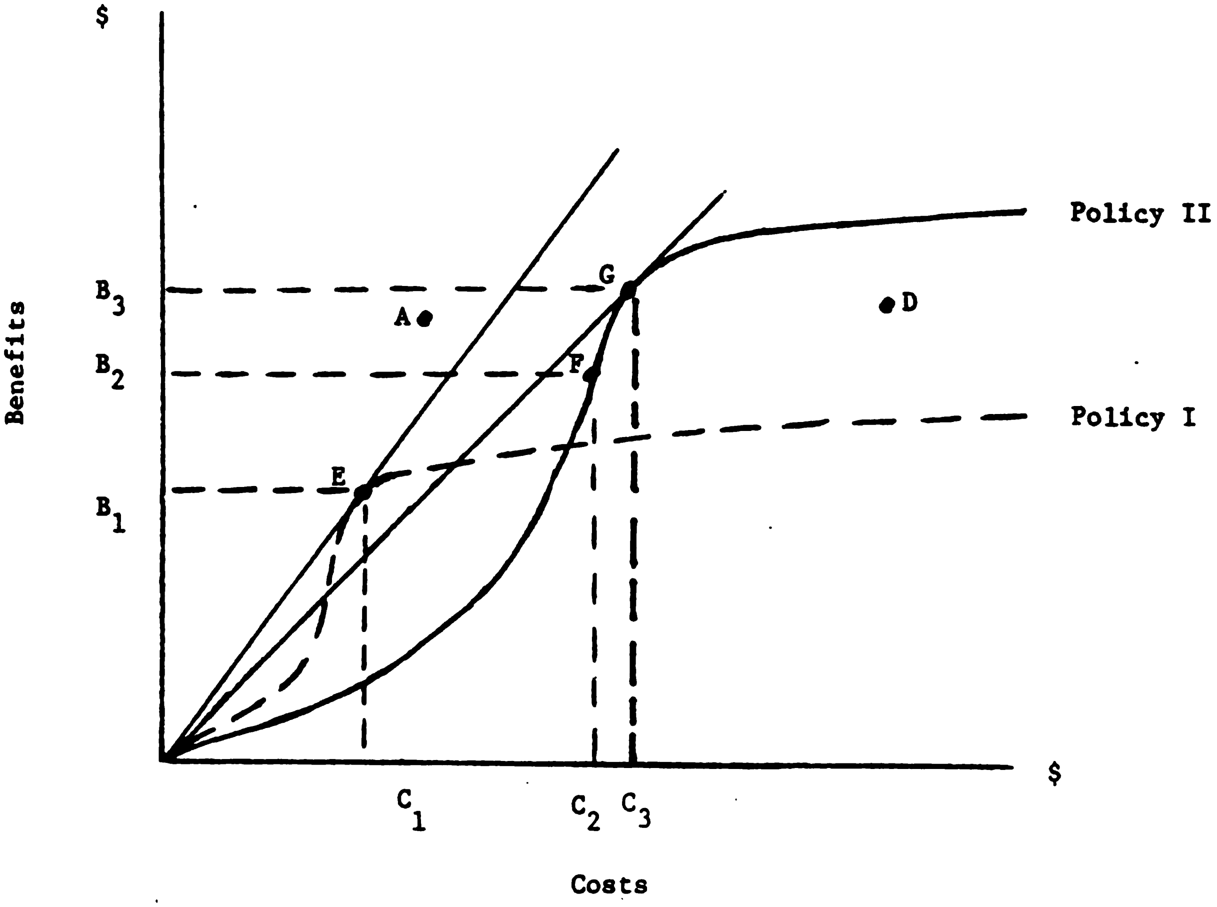


Fig. 1. A Benefit-Cost Comparison of Policy Alternatives

In practice, however, goals are usually multiple and not all costs and benefits can be expressed in dollars values. Moreover, as the analysis becomes more comprehensive, more decision-makers, executor agencies, and socioeconomic groups become aware that they have an interest in the decision to be made.

For this reason, and also to guard against recommendations that are biased by what the analyst feels should be done, the best scheme may be to present a "scorecard" of the impacts of the alternatives and leave the ranking problem to the decision-makers. A matrix like the following could be utilized for this purpose.

	Policy Choices			
Impacts	No Change	Alternative I	Alternative II	Alternative III
Production				
Imports/exports				
Consumer prices				
Producer prices				
Government expenditures				
Producer income				
Consumer expenditure				
% change expenditure of low-income consumers				
% change income of small farmers				
Government costs				
Ease of implementation				
Employment				
Nutrition of low-income strata				

This approach places the emphasis on a display of the full consequences of the policy alternatives—costs, benefits and their distribution, qualitative as well as quantitative. It should be accompanied by a frank indication of how uncertainties could affect the various impacts. This will permit decision-makers to ask "what if" questions which, when answered by the analysts, may lead to the design of other alternatives for analysis.

Uncertainty is an aspect of policy analysis that is both pervasive and hard to handle. It is usual to distinguish between uncertain events that are stochastic, for which all possible outcomes are known together with the probability that each will occur, and those for which the probability distributions are unknown. In the latter case, even the full set of possible outcomes may not be known.

Another useful distinction is between environmental uncertainties--those under the control of nature--and strategic uncertainties--those due to ignorance about the actions of decision-makers. (Quade, pp. 214-7)

Formal techniques for decisions under uncertainty are described in an extensive literature. For purposes of this manuel three admonitions are offered:

1) Make extensive use of sensitivity testing to examine the effects of ignorance about response parameters, environmental factors, and preferences.
2) Provide information from a "maxim~~um~~in" perspective; that is, what will happen under the assumption that the least favorable outcome occurs in every case; and
3) Look for alternatives that have a clear advantage over a range of uncertainties and strategic considerations rather than concentrating extensively on how much better one alternative is than another.

Given the limitations of the models, data problems, and the many uncertainties, there are important interpretations that must be made after solutions are obtained before results have information value for decision-makers. Analysts must make these interpretations in terms such as, "This is what the model predicts will happen if this policy is adopted, and this is why. On this basis, these are my conclusions about the alternative policy choices."

Decision-makers bring their own judgment and experience, their responsibilities, their institutional perspectives, and other information available to them, to their evaluation of their decision alternatives. If they desire accurate information on the likely effects of policy changes, how will they decide whether or not to accept the information provided by their analysts?

Generally, decision-makers cannot be expected to have a technical understanding of the structure of a model, the theory and assumptions on which its structure is based, or the methods by which predictions are made. Consequently, the policy-maker is more likely to evaluate the analyst than the analysis. It is for this reason that a careful interpretation of the results of the analysis is required. Since policy-makers are likely to rely on sources that have proven reliable before, analysts who want their results accepted should avoid acknowledging unrealistic assumptions, unreliable data, and untested results only in footnotes, thereby passing the responsibility of validating the results to the users.

Implementation

Even when the alternatives have been compared and a decision made to adopt one, considerable analysis may be needed in readying the chosen alternative for implementation.

For example, once a decision to implement a price guarantee-purchase program has been made, questions about the level of the minimum price guarantee, how purchase will be made, availability and cost of storage, and many other factors, will arise. For some of these questions, further analytical work will be required. Moreover, careful thought ahould be given before implementation to collecting baseline data that can be used later for evaluation of the policy.

Analysts may also be called upon to assist the decision-maker in inter-institutional negotiations required for getting his policy choice accepted. In this context, information may be used by a decision-maker more to strengthen his bargaining power with higher authorities or related agencies than as a basis for deciding which policy to choose.

Implementation does not follow automatically once a policy has been formulated. Indeed, problems with policy implementation are widespread. In many countries, for example, price guarantees are announced but actions to implement the required purchases are insufficient. As a result, prices at harvest fall well below the announced level. Or, retail price controls are placed on a food commodity. If implementation is inadequate, actual prices may go up when they are controlled.

How and to what extent should policy analysts consider likely difficulties in gaining acceptance for, or implementing, a given alternative?

Clearly, some policies have a better chance than others of acceptance and implementation, another important category of uncertainty to take into account in evaluating alternatives. Analysts may not be in the best position to assess that uncertainty. But as a minimum, if the analyst believes that a policy will encounter trouble in being accepted and successfully implemented, he should point that out.

Evaluation

The purpose of evaluation is to measure the extent to which an existing policy is fulfilling the objectives for which it was chosen. However, the concern is less with a purely ex post assessment than to suggest changes in implementation or that a new policy be formulated.

The ideal evaluation is to be able to say what happened that would not have happened if the policy had not been implemented. A "before vs. after" comparison is a common way to approximate the policy impacts. However, to establish cause-effect relationships, it is necessary to compare what actually happened to what would have happened had the policy not been implemented. If a model was developed for the ex ante policy analysis, then actual ex post data can be compared to estimated data predicted by the model run without the policy change. A major problem with this method is how the influences of changes in other factors than the particular policy choice can be taken into account.

Analysts may encounter resistance from executor agencies in the evaluation process. Most administrators will agree that the principle of evaluation is good but many feel threatened when their own operations are evaluated. Even when the stated purpose is to improve policy formulation and implementation, the mere mention of evaluation can cause difficulties in obtaining access to data. This, plus the perception of many administrators that evaluation uses scarce resources that are needed for implementation, may well explain why evaluation activities are almost always behind schedule and frequently superficial. They often amount to little more than a comparison of planned vs. actual performance. Such evaluations describe the policy implementation process but reveal little about the impacts of the policy—the extent to which it is attaining its goals and what other spillover effects are occurring.

Chapter XIII

Resource Requirements, Development and Management

Increasing Capacity for Policy Analysis

This paper argues that there is a wide variety of kinds of questions about agricultural and rural development that all countries need to be able to explore analytically--using effective tools and reliable data. Country policy-makers need to know, for example, how best to allocate resources among different crops. They need to know whether their land, labor, and capital resources are being used efficiently in pursuit of their multiple goals. They need to know the implications of technological and policy choices on output, input, employment, and income distribution objectives. They need to better understand how agricultural change affects the total economy and how the agricultural sector is affected by growth and change in other sectors of the economy. At present, most LDCs are unable to obtain useful answers to these questions due to a lack of analytical capability and a poor data base. Nevertheless, in a number of countries, policy-makers are beginning to recognize the significance of the questions and the importance of the analytical capability needed to answer them, and to make provisions for policy analysis in their staffing and budget plans as a crucial component of their overall sector planning system.

The critical questions facing LDCs require many types of analysis involving different degrees of methodological sophistication, different time spans, and different levels of aggregation. Analysis can range from short-term sector assessments and related project identification and evaluation activities through medium-term subsector studies of commodities or regions to the preparation of a sector-wide plan involving a substantial effort to model the entire agricultural and rural sectors and their interaction with the rest of the economy.

The expected benefits from better policy analysis can be thought of as a potential for various cost savings from improved policy choices:

--By definition, identification of more efficient alternative programs means lower costs to achieve a given goal.

--Even where the predictive reliability of sector models is not yet high regarding specific effects of alternative actions, policy analysis can forestall the waste of investment that occurs from pursuit of program choices that are mutually inconsistent. This is very common in LDCs, and often very costly. Even simple models with low predictive reliability can make it clear that A, B, and C cannot be done together.

--An appraisal of available policy options increases the prospects for decreasing management and operational costs of particular programs because it calls for detailed specification of the nature and timing of the inputs required for each program output, and of the dependence of one action upon others. By analyzing these interrelationships within the framework of an internally consistent system, costly omissions and errors in implementation may be forestalled. If program A generates demand for inputs that must be provided by other means, identification of this dependence can indicate possible shortages and bottlenecks in the supply of essential inputs. If the success of A depends upon doing B as well, discovery of this dependence can forestall disappointment in the implementation of A alone.

--Another major saving potential is in the cost of data collection and processing. LDCs already spend large sums for this purpose, often encouraged by international agencies and other donors as well as by internal needs. Costs for large-scale data collection are rising rapidly. Unfortunately, much of the data collected is not very useful for the pursuit of development goals. The elaboration of an analytical framework that indicates the specific kinds of data that are needed to produce the analyses required to support decision making permits LDCs to pinpoint more precisely their data requirements. This could increase the actual yield from expenditures on data.

--Comparable to the data case, LDCs (and aid agencies) utilize surprisingly large amounts of money in a discrete series of poorly related, low quality, one-shot, start-and-stop analysis and planning efforts. Policy-makers tend to demand quick answers to policy and program option questions, which is often necessary but which almost as often produces inadequate answers due to a lack of a systematic analysis of the pertinent factors by personnel trained to do it well. Usually this analytical capacity cannot be created quickly, or even in several years, so that highly subjective methods are applied by inadequately technically prepared LDC personnel. This description too often applies to much of the analysis done for project selection as well as other policy work. The reliability and usefulness of the results are often comparatively low, even when professionally competent foreign advisors are involved. As a result, the support for policy analysis, and sector planning in general, is damaged so that it becomes more difficult to obtain resources for the longer term and the more systematic analytical approach that is needed. By gradually building up, keeping current, and improving a suitable array of data sets and models of agricultural sector and rural development processes, the costs of responding to short-term analytical requirements of policy-makers and planners can be reduced and the quality and consistency of responses much improved. Costs are reduced because duplication of efforts to build the content of each analysis is avoided, the analysts themselves are better prepared for their task, and the results are not left aside after their immediate use but contribute to later analysis in a cumulative fashion.

The inelegant term "institutionalization" expresses the extent to which an analytical and planning capability is actually created in a country, possibly assisted by a donor agency. If achieved, this capability will hopefully continue, expand, improve, and be increasingly utilized after the termination of any technical assistance. For successful institutionalization, the following conditions appear essential:

1. Organization--a formal organizational structure that places the economic policy analysis unit in an effective working relationship with policy-makers and executor agencies.
2. Environment--recognition by policy-makers of the role analysis can play in policy formulation and credibility of the capacity of the policy analysis unit to generate timely, relevant, and accurate information.
3. Staff-a sufficient number of adequately trained personnel to do the necessary tasks of model development, analysis, interpretation, and communication of results to policy-makers; salaries and working conditions sufficiently attractive to retain qualified staff.

4. Support services--data systems, access to computers, travel and data collection funds, and other required services.

A planning and policy analysis capability requires an investment of scarce manpower and budgetary resources. Once a capability is to be developed in one country, the question of its transfer from another country arises. The direct transfer of results, conclusions, and policy recommendations is usually not possible; there is no real alternative but to develop the analytical capacity in each country. Transfer possibilities, therefore, are limited to concepts, methods, software, people, and lessons of experience.

Some transfer of model components and software is probably possible. But this potential is limited by the need to adapt existing models to local conditions. This leads to the conclusion that the transfer of experienced personnel familiar with the model components and software to collaborate with technicians in another country in developing local capability is more important than the transfer of existing models and software.

Possibly the most promising transfer possibilities involve principles and lessons of experience. Review of experience in several countries has led to the following guidelines:

1. Start with small, simple models directed to important and immediate policy and investment projects.
2. Look for early utilization possibilities that will help to convince policy-makers of the usefulness of the activity and build support for longer-term efforts.
3. Develop models in close cooperation with executor agencies and technicians to promote acceptability of the results.

4. Do not get model development too far ahead of data availability and reliability and local staff capability.
5. Emphasize training and transfer of responsibility to local staff from the very beginning.

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