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9. ABSTRACT

Part V of the Agricultural Sector Planning Report discusses general requirements for the successful transfer of the general system simulation approach technology and the constraints to institutionalization typically encountered in LDCs. It expands on the manpower requirements for institutionalization and describes educational programs designed to relieve constraints of human capacity. The experiences in implementing these institutional and training principles in Korea are reported, and implications for future directions for the general system simulation approach are discussed. The general system simulation approach illustrated in this document can provide the conceptual framework for establishing the basis for a more integrated and complementary set of disciplinary, subject-matter, and problem solving work. Interactions between decision makers, analysts, modelers, and affected persons in government, the universities, and the private sector can be more purposeful and better understood within the framework of the approach in both LDCs and developed countries.

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A GENERAL SYSTEM SIMULATION APPROACH

edited by GEORGE E. ROSSMILLER

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PREFACE

For as long as governments have existed, public sector decision makers have searched for better methods of planning and monitoring the performance of national economies and their subcomponents. In recent years, interest in many countries has focused on comprehensive and integrated sectoral planning and performance monitoring. Government officials in these countries are searching for better tools and techniques to assure more consistent and higher quality analytic input into their decisions. Some have turned to computer-based models as a partial answer to their needs. Many, however, are reluctant to make the sizable investment required for large and complex computer-based modeling efforts.

The arguments against computer-based modeling largely follow the line that the techniques and methodologies employed are generally not understood by decision makers, often do not include all the information necessary to a comprehensive analysis of the problem under consideration, and sometimes lead to unworkable prescriptions for action. Such arguments, in too many cases, have been justified.

The authors contributing to this book argue that it is possible, and in many cases highly desirable, to develop decision-making systems that include an investigative capacity to carry out analytical and monitoring functions with computer-based models as an integral part of the system. The authors, with widely varying backgrounds and experiences, through a series of fortuitous events became involved in working together on a project funded by the U.S. Agency for International Development (USAID) and carried out by Michigan State University in cooperation with the Ministry of Agriculture and Fisheries, Republic of Korea. This book is about the set of experiences and the lessons learned from this project. As such, it is as much about people and institutions as it is about models. The book should be useful to a wide range of scholars, students, administrators, policy analysts, planners, and decision makers interested in better approaches to more effective public sector decision making.

Although the work in Korea is depicted in some detail, the authors intend these descriptions to be viewed by the reader as a case example of the application of the general system simulation approach toward providing investigative input into the decision process. The Korea example focuses on national-level decision making with respect to agricultural sector development. But the lessons learned from this experience and the conceptual framework of the approach are applicable in a variety of decision-making contexts, subject matter foci, and geographic locations.

We wish to acknowledge the contributions and support provided by Francis C. Jones, both as project monitor during his tenure as Food and Agriculture Officer, USAID/Korea, and as one of the authors of this book after his retirement from USAID. His death in the spring of 1977 saddened us all.

It is impossible to individually acknowledge the contributions by the many people and institutions who have been a part of the projects upon which this book is based. To them the authors of this book owe a heartfelt debt of gratitude. Special acknowledgment and appreciation are due the institutions with which the authors are affiliated for providing them the opportunity to participate. We also specifically acknowledge the Government of the Republic of Korea for its contributions and cooperation, and the U.S. Agency for International Development for the funding which made both the projects and the book possible.

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Finally special thanks go to Bert Pulaski, project administrative officer, who released us from untold logistic and administrative details and kept us solvent; to Kathleen Schoonmaker, who edited and managed the manuscript through the publication process; to Larry Senger, who assisted in the many steps from draft manuscript to published book; and to our secretarial staff — Judy (Pardee) Duncan, Edith Nosow, Kyong Soo Kim, and Sonia Brundage — for a difficult job well done.

George E. Rossmiller
Editor for the Team

Michigan State University
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INTRODUCTION

The purpose of this volume is to explain the general system simulation approach as a viable basis for providing input to planning and policy decision making in agricultural sector development. We do this through discussion of the philosophic orientation of the approach, its eclecticism with respect to modeling techniques and types and sources of data, its relationship to the decision-making process, and the establishment of its credibility with decision makers. We also discuss the prerequisites for institutionalization and use of the general system simulation approach for agricultural sector development planning and policy analysis within the agricultural decision structure of a national government. The development and institutionalization of the approach in Korea is detailed and conclusions are drawn about its transferability and preconditions for its use in other developing (or developed) countries.

A wide and varied audience for this volume is anticipated. It should be of particular interest to:

1. Agricultural sector development decision makers at the national level interested in improving the quality of their planning, policy formulation, program development, and project design, implementation, and evaluation
2. Agricultural sector development staff and policy analysts searching for more useful and comprehensive approaches to problem-solving analysis
3. Students of the systems approach interested in methodology and application of systems analysis to socioeconomic problem areas

4. Students of economic development within and outside the academic community who are interested in alternative methodological approaches to agricultural sector development problem solving
5. Students of political and institutional development interested in the problems, requirements, and process of integrating the use of quantitative analysis into the decision-making structure of developing (or developed) countries

In writing for such a diverse audience, we run the risk of probing too deeply in some areas and not deeply enough in others to satisfy any given reader. For those of you who are quantitatively oriented and are interested in a more in-depth mathematical treatment of the models, we can only refer you to the technical documentation by the project team [1, 2, 8, 30, 40, 115]. We urge those who find some of the concepts and the occasional mathematical exposition to be laborious simply to skip over those sections or equations. In doing so, most readers will find the general meaning still apparent.

The book is organized into five parts. Part I, "The Case Study Projects," consists of chapter 1 and covers the development of the projects and the experience upon which this book is based. Part II, "The General System Simulation Approach," consists of three chapters. The first, chapter 2, presents the conceptual framework of the general system simulation approach to improved decision making. The description focuses on a national decision structure concerned with agricultural sector development. The second, chapter 3, develops the public policy environment within which the agricultural sector operates and the policy choices available to the agricultural decision maker as influenced by the prevailing value system imposed by the socioeconomic, technical, and political environment. The third, chapter 4, covers a wide spectrum of model types and techniques, describes how they are used in decision analysis, and indicates their strengths and weaknesses.

Part III, "The Korean Agricultural Sector Models," consists of 9 chapters. The first, chapter 5, describes the process of sector model conceptualization in Korea. The next five, chapters 6 through 10, describe component models that constitute the Korean agricultural sector model system and give illustrations of their application for planning and policy analysis purposes. The five component models in the Korean agricultural sector model system are population, national economy, technology change, resource allocation and production, and demand-price-trade. The next, chapter 11, discusses data and parameter estimate requirements for the model and how they were obtained. The final two chapters in this part indicate the process by which the models can be used by decision makers (chapter 12) and a specific application of the models in long-term planning for land and water development (chapter 13).

Part IV, "The Korean Grain Subsector Models," illustrates the two subsector models built to focus specifically on short- and medium-term problems associated with the Korean government's grain management program. The first, chapter 14, discusses the grain management program model, developed for use as an on-line management tool for government decisions regarding the price, stock, storage, and trade of grain. The second, chapter 15, illustrates a small, static model used to analyze the consequences of grain pricing decisions on production, consumption, inflation, foreign exchange, and government grain management accounts.

Part V, "Technology Transfer," consists of four chapters that cover the problems, requirements, and process of integrating the use of quantitative analysis into the decision-making structure of developing countries. The first, chapter 16, discusses the requirements and prerequisites for institutionalization of the general system simulation approach into a national agricultural decision framework, and the second, chapter 17, indicates the amount and kind of training for indigenous personnel necessary to institutionalize the approach effectively. The third, chapter 18, illustrates the generalizations indicated in the previous two chapters through the experience in Korea, and the last, chapter 19, discusses the future directions necessary to further develop the approach in Korea, as well as to transfer the general approach to other developing (or developed) countries, subject matter areas, and problems.

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PART FIVE

TECHNOLOGY TRANSFER

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16

INSTITUTIONALIZATION OF INVESTIGATIVE CAPACITY

Francis C. Jones
George E. Rossmiller

INTRODUCTION

This chapter discusses the general requirements for successful transfer of the general system simulation approach technology and constraints to institutionalization typically encountered in developing countries. The next chapter expands on the manpower requirements for institutionalization and describes educational programs designed to relieve constraints of human capacity. Our experiences in implementing these general institutional and training principles in Korea are reported in chapter 18, and the concluding chapter discusses implications for future directions for the general system simulation approach.

Development of a problem-solving investigative capacity includes institutionalizing that capacity as an integral part of the decision structure. Little, if any, contribution is made toward developing an indigenous investigative capacity when the World Bank sends a short-term team into a country to conduct one of its periodic economy surveys, when a consulting team is called in to do a feasibility study, or when a specialist is brought in to consult on a specific technical problem. In each of these cases the parameters of the problem are prescribed a priori and the objective is to move in quickly, gather the secondary data and information necessary to the required analysis, draft the report, and leave. Although these activities are important in their own right, they are not of concern here.

We are interested in the institutionalization of an investigative capacity composed of a core of professionals capable of amassing, analyzing, and synthesizing data and information within a problem-oriented logical framework in such a way as to provide decision makers with an understanding of the likely consequences of possible alternative courses of action. The information and data, and much of the analysis and synthesis, must include knowledge from a variety of disciplinary and subject-matter areas. Disciplinary knowledge is drawn from the social, biological and physical sciences as well as from mathematics, systems science, statistics, and engineering. Subject-matter knowledge includes information about the structure, state, and relationships of the economic, social, and political systems as they affect the agricultural sector, how the agricultural sector is structured and how it operates, and the state of human, technical, and institutional change. Thus, the investigative unit must have the capacity of drawing upon knowledge and abilities from a variety of sources in government, the university community, and the private sector.

INSTITUTIONALIZATION

Institutionalization is the process through which the investigative capacity, in this case including simulation models and their attendant trained manpower, is installed within the agricultural decision-making structure in such a way that optimum interaction with decision makers will take place, thus guaranteeing functional continuity of the capacity. In other words, this section does not deal with model building per se (see chapter 4) nor in a detailed way with training to build the professional indigenous capacity to operate the models (see chapter 17). Rather, it deals with the organization, interactions, and linkages we feel are necessary for continuing optimum usage of an investigative capacity by decision makers. It also deals with improving the capacity of indigenous researchers, analysts, and policy makers to use the models in designing, analyzing, and evaluating policies, programs, and projects. As indicated in Figure 56, the investigative linkages are to decision makers on the one side, and on the other to support and service agencies, including data and information acquisition systems, computer services, technical agricultural research units, universities, and other research institutions.

Each unique configuration of institutions and complex of investigative and decision-making responsibilities will dictate to some extent the latitude and scope of linkages and functions delegated to an investigative unit, but some basic principles generally apply. Figure 56 indicates a conceptualization of the functional linkages necessary to integrate an investigative unit into the decision structure.

The investigative unit is shown in the middle, with the units providing support and services indicated in the lower part of the figure and the functional units or agencies being served by the analytical unit shown in

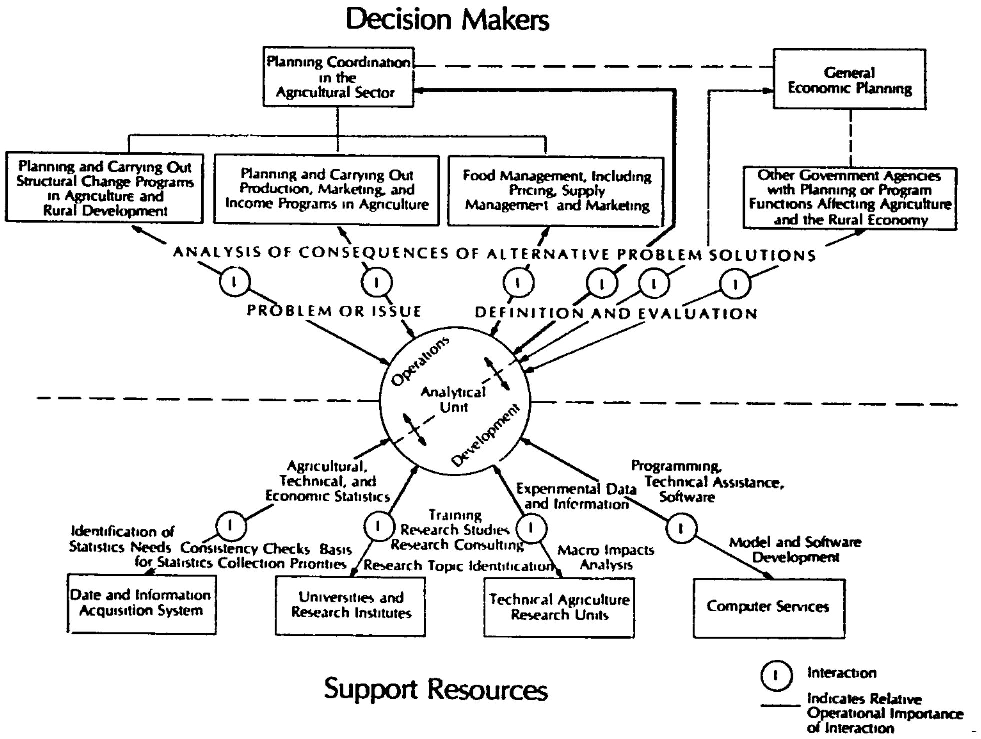

FIG. 56. The analytical unit in the decision structure.

the upper part. The importance of interaction between the analytical unit and *all* other units with which it is linked is indicated by the circled *I*s on the arrows depicting linkages. The heaviness of the arrows indicates the likely relative operational importance of the linkage. Finally, the investigative unit is shown to have two subunits — one concerned with further development, adaptation, and testing of the models, techniques, and methodologies used by the unit, and the other concerned with operational use of the investigative tools in analysis of problems defined in interaction with the decision makers.

Linkages to Decision Makers

The relationships of the investigative unit to decision makers consist of two-way information flows as problem definition, data collection, and analysis take place. At both the general economy and the agricultural planning levels, the analyses will focus on long-term consequences of broad planning and policy strategies. At the agricultural production and food-management levels, the analyses will focus on intermediate and short-run consequences of policy implementation and program alternatives. Problems at each level must be defined in interaction with relevant decision makers and within the realm of authority of the particular decision maker.

A caveat is necessary with respect to Figure 56. The only part of the decision-making system shown is that which impinges directly on the investigative unit. Input to the decision process by the investigative unit is only one of many inputs from a variety of sources. The inputs available from all sources are weighed and sorted, accepted or rejected by the appropriate decision maker for any given decision. The relative strength of the input by the investigative unit depends upon the nature of the problem concerned, the relative value placed upon the input from the investigative unit by the decision maker, and the relative importance of information and implications not within the purview of the investigative unit; the decision maker is always attempting to satisfy multiple objectives within an arena of multiple constraints — political, institutional, technical, and human, as well as socioeconomic.

Linkages to Support Resources

The resources required for effective institutionalization and use of an investigative capacity within an existing decision-making structure can be categorized into (1) a data and information acquisition system, (2) other research units, (3) a computer support system, (4) trained personnel, and (5) organization and administration for planning and policy determination.

Data and Information Acquisition System. An extremely important supporting service is the data and information acquisition system, which provides the important function of measuring the structure, performance, and behavior of the agricultural sector and relevant parts of the general economy. The statistics collected should be processed and disseminated in a form most helpful to the users, in this case the investigative unit and the planning and policy decision makers. Close interaction between the investigative unit and the acquisition system can provide the basis for data improvement. The investigative unit, through the use of its models, can provide information on consistency and data sensitivity that can be helpful to the acquisition system in determining what statistics to collect and how they should be processed and in establishing guidelines for priorities in data refinement for greater accuracy. The quality of the data and information generated by the acquisition system is vital to the quality of the output going to decision makers from the investigative unit. To be of most use in the decision process, the flow of data and information from the acquisition system must be relevant, accurate, timely, and consistent (both over time and across series). It is against these criteria that an agricultural statistics collection and data system should be evaluated.

Other Research Units. The supporting linkages with universities, technical agricultural research units, and other research and analysis institutions are also vital. Through these linkages a continuous flow of information, research and analytical results, and trained personnel from relevant disciplines can be maintained. Since much of the trained intellectual capacity of a country normally resides in these types of institutions, much can be gained through establishment of close working relationships with them. One means of facilitating a working linkage is through governmental support to these institutions (funding for special studies, grants, contracts, consulting) to carry out research and analytical efforts of mutual interest and of use to the government.

Computer Support. Computer service support is also critical. Computer installations will vary substantially from one country to another with respect to hardware capacity and configuration, software availability, administration, and cost. Development and institutionalization of the general system simulation approach to sector planning and policy decision making require access to adequate computer facilities by the investigative group responsible for development and use of the models — adequate in terms of the size and capacity of the computer, availability of the right kind of software, and the "operational mode" of the computer installation.

The size of most agricultural sector models requires large-scale computers. The large model size results from the variety of different policies that decision makers would like to explore; the levels of disaggregation in terms of number of commodities, regions, etc.; and the number of model components and the types of analytical techniques employed — particularly those involving matrix manipulation. Computers in the class of the CDC Cyber Series, the IBM 370 Series, and the Univac 1100 Series, or their equivalents, usually have sufficient capacity to run these models.

The "operational mode" of the computer installation can greatly affect the time it takes to develop and use a system simulation model. Computer installations vary greatly in terms of their management and operational style. They can be grouped into those that are oriented toward production work (e.g., preparation of payrolls, budgets, and general data processing) and those that are oriented to research, analysis, and development of new software systems. Usually, a research-oriented computer is managed by a more highly trained and technically sophisticated staff. Whereas the production computer will likely use a central-site batch mode of operation, the research computer will likely provide, in addition, remote batch job entry and interactive remote access to the computer. After a model is developed and stabilized in its development through use of a research-oriented computer, it can then be easily run in a production mode on a production-oriented computer.

The investigative group responsible for developing and making operational policy-planning models should be given access to adequate, research-oriented computer facilities. The investigative unit should be provided with a budget to purchase computer time from commercial facilities if the government facilities, which are often provided cost free, are not adequate to do the job because of their production orientation.

Trained Personnel. Development and institutionalization of investigative capacity based on a computer model system require highly trained people for model development, capable administrators who have high levels of organizational skills, and well-trained agricultural economists who understand the system simulation approach to sector analysis. Such people should be located at various strategic points within the governmental agencies dealing with the agricultural sector. The latter perform the essential function of establishing, within the action/decision-making agencies, a climate favorable to the use of the models in solving agricultural development problems.

Model development requires highly trained people in the fields of systems science, computer science, agricultural economics, econometrics, technical agriculture, and statistics. The following chapter discusses the composition and training requirements of the system simulation team in detail.

Organization and Administration. Since institutionalization and use of the investigative capacity are complex operations and in many countries will require a considerable reorganization of the planning and decision-making apparatus, people with high levels of administrative and organizational skills are required. The administrative and decision-making organizational structure should provide an environment in which access, coordination, and information flows among decision-making units and between them and the analytical units are facilitated. Unless the involved government agencies are organized for effective vertical and horizontal coordination at all levels, administrators and decision makers have little incentive and, in some cases, little opportunity to develop a capacity to absorb and use centralized investigative input into the planning and policy process.

CONSTRAINTS TO INSTITUTIONALIZATION IN DEVELOPING COUNTRIES

The overall process of institutionalizing an investigative capacity in which organizational, technical, and human change are required is an extremely complicated venture at best. The process must begin within the context of a given political ideology, human resource base, technological level, and configuration of institutions and their linkages with each other.

Certain prerequisites must be present before any attempt is initiated to build this capacity. There must be a recognition by key decision makers that policy and planning objectives are not being fully realized and that this is due in part to the lack of information and reliable analysis upon which decisions are based. There must be a demonstrated intent and will to improve the agricultural decision-making process with a more scientific and analytical approach. There must be the will and the ability among the appropriate decision makers to commit the manpower and financial resources necessary to such an endeavor. Finally, appropriate decision makers must be willing and able to make necessary organizational changes in their planning and policy determination system in order that the new investigative capacity may be properly institutionalized and effectively used in improving policies, programs, and projects. Available resources for institutionalization and use of the investigative capacity in most developing countries fall considerably short of the resources delineated in the previous section in terms of both quantity and quality.

Data and information acquisition systems in most countries grew and became institutionalized piecemeal, as needs were identified and as resources were made available. As a result, statistics are often inadequate, inaccurate, and inconsistent and thus fall short of the quality needed for sound research, analysis, and planning. The publication process is often very slow, and the greater the delay in publication or dissemination the greater the loss in usefulness — in many cases a total loss. Often, too, there is inadequate interaction between the collectors and users relative to the users' needs and what the collectors can provide.

Many developing countries have procured or are procuring the computer systems required. Consideration cannot be given to building the type of investigative capacity described here unless adequate hardware systems are present and appropriate software is available.

The system simulation approach to planning and policy decision making for agricultural sector development involves a conceptual framework and quantitative methods that are not part of the background of most professionals in developing countries. Further, in many if not most countries these concepts and methods are either not taught or not taught appropriately. Thus, development of an indigenous capacity to apply the system approach and its various quantitative methods requires a substantial investment in education. Initially, the bulk of this training will have to be in the developed countries.

In many if not most of the developing countries, planning flows vertically from minister to bureau to division and vice versa. Often there is no meaningful exchange of ideas or views horizontally between bureaus or divisions. Planning functions tend to be scattered throughout the bureaus and divisions, resulting in inconsistencies and a large degree of autonomy for individual bureau activities that are not well coordinated, even though so-called "coordinating offices" may exist at the top of the organizational structure. Further, although capable administrators usually exist, very seldom have they been trained in the organizational skills required to put together a modern planning system that uses sophisticated analytical tools; this requires new concepts of organization and management.

Probably only a few developing countries now have all the prerequisites necessary for the development and institutionalization of a relevant set of agricultural sector simulation models as a part of a comprehensive investigative capacity. A long-term well-planned program of building human capacity, developing the institutional environment, and installing the technical capability in a way that will achieve over time a comprehensive investigative capacity is possible for any country with the will to do so. Through well-planned efforts and given enough time, an indigenous investigative capacity can be institutionalized within the decision structure of a developing country and effectively used for planning and policy decisions.

17

EDUCATION TO BUILD HUMAN CAPACITY

Thomas J. Manetsch

INTRODUCTION

As we emphasized in the last chapter, by its very nature a system approach to planning agricultural sector development involves a conceptual framework and quantitative methods that are not part of the background of most professionals in developing countries working in this area. Further, in many cases these areas are not taught in the developing countries. It follows, then, that development of indigenous capacity to apply this approach and its various quantitative methods requires a substantial investment in education — formal and informal. It also follows that at least part of this education must be acquired abroad. In this chapter we will analyze in some detail the types of people required to carry out the functions essential for effective model development and application. We will then discuss educational programs for producing the requisite manpower. The chapter concludes with an examination of some problems and obstacles to the development and operation of a viable system simulation team and some means of addressing these problems. We assume that a system simulation team is to be developed within a government decision research unit serving agricultural sector decision makers at various levels.

HUMAN RESOURCE NEEDS OF A VIABLE SYSTEM SIMULATION TEAM

The development and application of models at the project, subsector, and sector levels in developing countries involve a number of essential *functions* that must all be carried out effectively in order for the models to contribute usefully to agricultural sector development. These functions include:

1. Data acquisition, storage, and updating
2. Model development
3. Estimation of model parameters
4. Model testing
5. Use of models in decision and analysis
6. Model refinement and updating
7. Model documentation

Experience has shown that carrying out these functions effectively requires not only the integration of many disciplines but also unique kinds of people who perform well as members of multidisciplinary teams.

Data Acquisition, Storage, and Updating

The primary disciplinary inputs required for the acquisition, storage, and updating of data are statistics and computer programming, along with substantial knowledge of the economy and its data. A trained statistician is needed to supervise data acquisition and processing and to coordinate team activities with government statistics units; however, other experienced people who know the economy and its data will play a vital role in selecting among data sources and in "massaging" data if the statistician does not have this background himself. The carrying out of this function effectively depends heavily upon the rest of the simulation team for guidance in the determination of *what data* are required to support the overall analytical effort and in *what forms* they should be stored in order to be compatible with model applications.

Model Development

The model development function is probably the most demanding in terms of disciplinary depth, as well as breadth. In most cases experienced system analysts and agricultural economists at the Ph.D. level are needed to organize and carry out a viable system modeling enterprise. A common pattern is several key people working together with backgrounds that in part overlap and in part complement one another. These people must have strong backgrounds in mathematics and statistics and operational competence in system dynamics, control theory, system optimization (including linear programming), computer programming, and estimation techniques (including methods of econometrics). Further, they must have a demonstrated ability to relate creatively mathematical abstractions to real-world phenomena in a way that captures the essence of the problems under study without becoming bogged down with excessive detail. They must be steeped in the system approach as a problem-solving methodology. In order to be effective model builders, they must also have good basic grounding in economics, an ability to assimilate rapidly other disciplinary knowledge relating to the real world being modeled, and a good grasp of how the world being modeled "works." All this is, of course, a tall order; but it is a realistic assessment of what is needed to develop the broad range of models needed in agricultural sector analysis. Development of these people is not an easy matter, but comfort can be taken in the fact that it has been done and that some of these people *do* exist.

The above discussion is not to imply that systems analysts and agricultural economists can carry out model development functions alone. A number of other people also must play key roles in providing informational inputs needed for model development. These inputs include biological and other knowledge relating to technical agriculture and a mass of information describing how the system being managed behaves. Of particular importance is interaction with decision makers to ensure that the model-building objectives are consistent with the real-world problems being addressed. A key requirement in all model development is competent computer programming.

Estimation of Model Parameters

Numerical values are estimated for model parameters using data that have been acquired from the real world. The two main approaches available for estimation of model parameters are classical econometrics and a set of system identification techniques that has grown out of systems science. A viable system simulation team needs the skills to use both of these approaches. Although well-prepared system analysts and agricultural economists will be able to do a considerable amount of parameter estimation using econometric methods, they may not have the expertise required to handle some of the more difficult issues that sometimes arise. Someone on the simulation team, perhaps an agricultural economist or statistician, should have in-depth preparation in econometrics. A well-prepared system analyst can be expected to have the background necessary to use system identification techniques from systems science in parameter estimation. Of key importance is a set of optimization techniques from nonlinear programming that make it possible in certain cases to estimate unknown parameters in large simulation models.

Model Validation and Verification

The validation and verification of a model are very much a team effort and are closely related to the model-building process in that they often indicate shortcomings that lead to further model refinements. System analysts and agricultural economists are therefore heavily involved in this function; however, others who understand how the model "should work" play key roles. It is sometimes possible to get decision makers involved at this point as consultants and critics. This can be very important in further developing decision makers' familiarity with the model and appreciation of its capabilities and limitations.

Use of Models in Decision Analysis

The central figures in decision analysis are the decision makers. It is, however, necessary for them to interact effectively with economists, system analysts, computer programmers, and perhaps others who know the model and how to use it creatively. In the early stages of model application the model builders themselves are often the only people capable of interacting with decision makers. In the longer run, however, policy analysts will likely be required to provide a liaison function between the model builders and the decision makers. Interaction with decision makers in addressing policy questions often will indicate areas of the models that need modification or extension to provide a needed capability. Interaction among decision makers, policy analysts, and model builders is also needed to define precisely the model changes that are required to focus on specific problems most effectively.

Model Refinement and Updating

Refining and updating the model, like model development, are very demanding in terms of disciplinary breadth and depth. Ideally the team responsible for model development should implement this function as well, and it is very important to keep a productive team working together on a more-or-less permanent basis. If new people must be recruited, great care must go into their selection. Experience has shown that the wrong people at this point, e.g. those unable or unwilling to work as part of a multidisciplinary problem-oriented team, can easily set a modeling effort back substantially.

Model Documentation

The purposes of good model documentation are twofold: (1) to provide a clear technical description of the model that can lead to refinements and extensions, and (2) to provide information needed to use the model intelligently in problem solving. The technical documentation is best written by the model builders and computer programmers who originally constructed the model. The user-oriented documentation is best developed by those on the simulation team most familiar with model applications to decision making. A computer programmer familiar with model operation in decision analysis should prepare a special section of the user's documentation for other programmers who may be responsible for model operation during analytical applications.

PROFILE OF A TEAM CAPABLE OF IMPLEMENTING SUCCESSFUL MODELS

The seven basic functions described above are all necessary for successful institutionalization of agricultural sector models. Other necessary conditions for institutionalization, outside the scope of this discussion, were detailed in the previous chapter. As we have seen, each of the functions requires a somewhat different mix of professional talent. The carrying out of each function requires people who are well prepared in at least one discipline and who, at the same time, have varying degrees of knowledge and experience in other relevant disciplines. These overlapping backgrounds among key team members are *essential* to the operation of a team that is attacking multidisciplinary problems. We can gain insight into the spectrum of personnel requirements for implementation of the approach by looking carefully at each of these seven functions and asking:

1. What *levels of knowledge and experience* in what *disciplines* are required to implement successfully the seven functions?
2. Assuming that each disciplinary specialist on the team must be able to contribute to each of the seven functions, what mix of disciplinary competencies must *each specialist* have in order for him to be a productive member of a team carrying out the seven functions?

Table 27 is a profile of the disciplinary and personnel requirements of a system simulation team based on the above analysis and on experiences to date in Nigeria and Korea. The profile assumes that all personnel are specialists in one discipline and have varying degrees of expertise in other relevant disciplines. The various *participants* (not necessarily one per discipline) are listed in the left column of the table. Across the top of the table are listed the various disciplines necessary for carrying out the various functions. The right column tabulates the level of involvement required of each disciplinary participant to carry out responsibilities effectively. Level of involvement may range from "consultant" through 100 per cent.

Six levels of *disciplinary* competence have been identified:

1: Ph.D.[1] plus experience
2: Master's[1] level plus experience
3: Bachelor's[1] level plus experience
4: Intensive professional course or strong minor plus experience
5: "Short course" or equivalent experience (perhaps acquired in service)
6: None

TABLE 27
Participant/Discipline Profile and Levels of Preparation Required for an Effective System Simulation Team

Participants	Disciplines								Level of Involvement
	Various Areas of Technical Agriculture, as Appropriate*	Computer Science	Agricultural Economics and Related Economic Theory	Econometrics	Public Administration and Policy	Sociology†	Systems Science	Statistics	
Agriculturalists	1–3	6	5	6	5–6	5–6	5	5–6	Consultant
Computer Scientist (senior programmer)	5	3	5	5	5	6	4	4	100%
Agricultural Economist	3–4	4–5	1	1–2	4	4–5	4	4	100%
Public Administrator	5	5	4	5–6	2–3	5	5	5	Consultant–25%
Sociologist	4–5	6	5	6	5	1–2	5	4–5	Consultant
Statistician	4–5	4	4	2	5	5	4	2	100%
Systems Scientist	4–5	4	4	4	4–5	5	1	4	100%

*That is, crop science, soil science, animal science, etc.
†Areas relevant to rural development.

The numbers in the table denote the approximate levels of competence required of each team participant by discipline. Reading across the table, then, we get an educational profile for each team participant. The table indicates the kinds of professionals that experience in Nigeria and Korea has shown are necessary to implement the seven basic functions effectively at the sector level. For example, the table shows that experienced agricultural economists at the doctoral level are needed and that they must have varying lesser strengths in systems science, agriculture, computer science, econometrics, public administration, sociology, and statistics. The systems scientist(s) must have varying levels of preparation in economics, technical agriculture, and so forth.

The main conclusion we draw from this table is that a variety of educational programs must be available that will provide various levels of preparation for specialists from many fields. Many of these needs can be satisfied by appropriate degree programs at the bachelor's, master's, and doctoral levels. *Appropriate* here includes the flexibility to put together course work in necessary related disciplines as part of a degree program in a major field. In many cases degree programs at U.S. universities have this flexibility.

It is also clear that the spectrum of educational needs cannot be met by degree programs alone. There are many qualified and experienced professionals in developing countries (economists, administrators, agriculturalists, etc.) who could become productive members of a quantitative sector analysis team, given well-designed short courses or training programs in key areas. In the following section we discuss in more detail the structure of educational programs needed for equipping various members of a system simulation team. Following the pattern established in Table 27, we discuss educational programs for systems scientists, agricultural economists, administrators, computer programmers, statisticians, and the lesser-involved specialists noted in the table.

EDUCATION OF SYSTEM SIMULATION TEAM MEMBERS

Systems Scientists

As indicated in Table 27, systems scientists should be prepared through the doctoral level. Experience has shown that these people should have an undergraduate degree in a strong quantitative field, such as engineering, mathematics, or statistics. If the undergraduate background is in mathematics or statistics, it is very important that the person be interested and skilled in the application of quantitative methods to *practical problem solving.* The course work preparation for systems science team members should include:

Systems Science

1. System approach as a problem-solving methodology
2. Linear system theory
3. System modeling
4. System simulation (heavy emphasis on nonlinear continuous systems described by differential and/or difference equations)
5. Classical and modern feedback control theory
6. Optimization methods (including linear programming, nonlinear programming methods compatible with large simulation models, and at least an introduction to optimal control theory)
7. System identification techniques (including those compatible with large simulation models)

Economics and Econometrics

1. One year or more of micro- and macro-economic theory (at senior or first-year graduate level)
2. At least one course in econometrics emphasizing practical estimation techniques
3. Two or more "practical" economics courses emphasizing topics such as benefit/cost analysis, public program analysis, market behavior, economic development, trade, or agricultural policy

Computer Science

1. Courses that deal with advanced FORTRAN programming and a simulation language, such as DYNAMO or CSMP

In a number of universities, though by no means all, it is possible for a Ph.D. candidate in systems science to include the range of collateral material above as minors of his program. It is imperative that the systems scientist undertake an economic system analysis (involving modeling and simulation) as a doctoral dissertation.

Agricultural Economists

Agricultural economists also should be trained through the Ph.D. Such people should be generalists in their field and have substantial background in economic theory, production economics, marketing, development, trade, technical agriculture, and agricultural policy. The background in policy is of particular importance, because agricultural economists are likely to be primary linkages with the decision makers, who are ultimately the clients of the system team. To be most effective as part of a system simulation team, the agricultural economists should have a quantitative bent and background in mathematical programming (including linear programming) and econometrics.

In addition to this rather substantial background in the major area, agricultural economists should build the following material into the minors of their Ph.D. programs:

Systems Science

1. A working knowledge of the system approach as a problem-solving methodology
2. An introduction to linear system theory and system simulation
3. An introduction to the techniques of system simulation (again with emphasis on systems described by differential and/or difference equations)

Mathematics and Statistics

1. Mathematics through (at least) introductory calculus and matrix algebra
2. A year of probability and statistics, including regression analysis

Computer Science

1. A working knowledge of FORTRAN computer programming

Technical Agriculture

1. Crop science
2. Soil science
3. Animal science

Sociology, Communications, Public Administration

1. One or more selected courses from these areas related to rural development

Ideally, the dissertation in agricultural economics should involve policy analysis for agriculture development.

Administrators/Decision Makers

Whereas systems scientists and agricultural economists require a great deal of formal education, the training needed by administrators/decision makers for effective interaction with a system simulation team is likely to be more informal. A short course or seminar of perhaps two weeks' duration dealing with applications of system methods and models can be very useful, though it is certainly possible for these people to pick up needed orientation by informal interaction with the system simulation team. Important content for such a short course or seminar would include:

1. A systematic presentation of the system approach to decision making *laced with practical examples*
2. A thorough discussion of the capabilities, limitations, and applications of the most important quantitative tools including:
   a. Benefit-cost analysis
   b. Linear and nonlinear programming
   c. Regression analysis and econometrics
   d. Dynamic simulation models

3. "Hands on" experience in the application of models to practical decision making, using well-designed case studies and associated models

This kind of formal training can be very useful, but there is also an ongoing need for informal training as decision makers interact with the system team in problem definition, model evaluation, and model use as part of the decision-making process.

Computer Programmers

Good preparation for computer programmers for system simulation teams is a bachelor's degree in computer science. Emphasis in this degree should be on programming (advanced FORTRAN and other selected languages, such as COBOL, DYNAMO, or CSMP), data processing, and application of specialized software, such as statistical analysis and linear programming packages. The bachelor's program should also include basic economics, calculus, differential equations, matrix algebra, numerical analysis, basic probability theory and statistics, and an introduction to systems science.

Statisticians

Education through the master's is appropriate for a team statistician. Emphasis in the major field should include probability and statistics with a strong application orientation in agriculture and economics, survey design and implementation, and advanced work in econometrics. Education in minor fields should include technical agriculture, economics, computer programming and data processing, and an introduction to systems science.

USE OF SPECIAL NONDEGREE TRAINING PROGRAM

The educational programs discussed above are for the most part formal baccalaureate or graduate programs. This appears to be a viable means of satisfying most of the educational needs of system simulation team members, *if the universities are carefully chosen.* In each case team members require substantial strength in essential areas which relate to the major field of study. Universities chosen should (1) be able to offer strong programs in the minor as well as major areas, and (2) allow flexibility in the design of degree programs which include strength in the necessary minor areas.

Although regular degree programs can satisfy most of the educational needs of a system simulation team, experience has shown that there are special needs that are best served by special, nondegree training programs. A case in point is the special short-term training for decision makers and administrators cited above. Such training, perhaps in the form of short courses or workshop-seminars, can be offered directly in the developing countries. This was done to a limited extent during the course of the Korean projects. A week-long seminar was held in the summer of 1973 for government officials from the Ministry of Agriculture, staff from the College of Agriculture at Seoul National University, and a smattering of personnel from other governmental agencies. Although the event was generally regarded as successful in introducing the system simulation approach and its capabilities, lessons were learned that can lead to improvement in the quality of such an experience:

1. More time is needed for such a seminar — two weeks is probably a minimum.
2. More needs to be said about the practical applications of a wider range of quantitative methods (benefit/cost analysis, linear programming, perhaps PERT, etc.).
3. More "hands on" experience in the *use* of quantitative methods in decision making is needed.
4. A revised format is needed that eases the problem of busy people being called away by the demands of their jobs.

There is also a need for longer-term nondegree training for economists, researchers, and certain other professionals who need a more in-depth understanding of the system simulation approach and related techniques. Such people usually will be working closely with, if not as a part of, a system simulation team. Special nondegree training programs are necessary for individuals who either do not need a regular degree program or find it impossible to spend the time required to complete an appropriate degree program. As part of the Korean projects, a one-year nondegree training program was designed to address these needs. This program was offered three successive years at Michigan State University — primarily for Korean agricultural economists associated with the MSU Korean project but including both U.S. students and students from other countries. The program included basic courses in systems science and computer science and allowed participants to elect a range of courses needed to enhance quantitative skills and broaden their background for work as part of a multidisciplinary team. The program also included a relatively intensive emphasis on practical projects that applied the methods learned.

In retrospect, this one-year training program appears to have been more or less successful in providing understanding of the system simulation approach and its capabilities and limitations as a means of addressing practical development problems. It was less successful, however, in producing a substantial level of expertise in the development of models for use in decision analysis. About half of the participants acquired significant model-building skills and half did not. In part, the mixed success enjoyed was due to the candidate selection process. Other difficulties with this kind of program are the additional costs required to provide special instruction not available through regular university courses and "low status" for participants relative to regular degree programs. In short, regular degree programs are to be preferred as means of developing system simulation team members, but special nondegree programs can be an important complement for carefully selected participants.

CRITERIA FOR SELECTING TEAM MEMBERS AND/OR TRAINEES

Selecting members of a system simulation team is an extremely important task that must be done with care. In many cases people are selected to be trained for specific team positions. Important general criteria that apply to all team members are first discussed, followed by a discussion of specific criteria for selecting team systems scientists (since these people are normally the most difficult to acquire in developing countries).

Following is a set of general characteristics that our experience has shown are important for members of system simulation teams:

1. Good basic education
2. Above-average intelligence
3. An interest in solving practical problems and, in particular, an interest in the problems of rural development — *problem* focus as opposed to discipline focus
4. A willingness to learn and work outside one's own discipline
5. A willingness to work with other people toward common goals
6. Effectiveness in interpersonal communication, including a propensity to *initiate* communication when necessary
7. Command of the English language, if education in the U.S. is indicated

Clearly, selection of team members is not an easy task and, unfortunately, experience has shown that the effectiveness of multidisciplinary efforts can suffer severely if these basic requirements are not substantially met. A questionnaire was developed as part of the Korean projects to aid in identifying people with these general characteristics. It is designed to be used in conjunction with interviews, personal references, and specialized aptitude tests in an integrated selection process developed by Mehrens and Downing.[2]

Some specific, special criteria for selecting team systems scientists or, more likely, candidates to be trained at the Ph.D. level for this position include:

1. Distinguished completion of quantitative bachelor's and master's degree programs, such as in engineering or mathematics

2. Demonstrated ability to use mathematics in problem solving and good basic education in mathematics
3. An ability to relate creatively mathematical abstractions to the variety of real-world phenomena significant in agricultural decision analysis
4. An ability to capture the essence of a complex, real-world problem and reject extraneous considerations
5. Persistence in the solution of complex, long-term problems
6. An ability to break a complex problem into meaningful subproblems
7. Organizational ability to coordinate a complex whole, delegating responsibility appropriately
8. Related skills in personnel management

Management-oriented skills are important because model development often requires coordinated teamwork to accomplish a variety of interrelated tasks. The questionnaire referred to above also can aid in the selection of team systems scientists. In addition, personal interviews, references, and specialized aptitude tests can be helpful in selecting team systems scientists. Mehrens and Downing discuss this selection process in depth.

SOME PROBLEMS AND POSSIBLE SOLUTIONS

Some problems have become apparent in the MSU Korean projects' attempts to develop host-country system simulation capability. One basic problem encountered is the scarcity of appropriate people to train for system simulation teams. Policy-oriented research organizations in developing countries are often staffed by people with limited or weak backgrounds in quantitative areas. Although some of these people can be trained to function as useful team members, it can be very difficult to locate people (within the policy research organization) who can effectively take leadership in model development. Recruitment of trainees with requisite qualifications from *outside* the policy research organization is clearly called for in these cases. There are, however, administrative obstacles that vary from country to country. These must be dealt with if a viable, indigenous team is to develop.

Another fundamental problem that has emerged is that of retaining team members. An effective system simulation team is a valuable asset that will be sought by other government agencies and the private sector. It follows that there must be strong personal incentives on the part of key team members to remain with the team. Competitive salaries are important; but, again, creative administration will probably be required to make this possible within the civil service structures of many developing countries. Another important factor that can enhance retention is personal interest in, and dedication to, the solution of the agricultural and rural problems of the society. Experience has shown that team members from strong rural backgrounds are much more likely than others to make long-term professional commitments to the goals of an agricultural policy research organization.

These problems of recruitment and retention also indicate that in many cases foreign consultants will be needed for some time as countries develop internal human resources. These foreign consultants must perform two important functions: they must ensure that the system simulation team is functioning effectively as part of the host country's decision-making process, and they must enhance movement toward the self-sufficiency of the indigenous team.

CONCLUSION

The personnel requirements of a system simulation team have been developed by analyzing the functions that must be carried out to involve quantitative methods effectively in the decision making that guides agricultural sector development. These requirements obviously are very demanding. Unique people from various disciplines are required who can work together effectively. These requirements are so demanding that for countries with few educated professionals, it may not be feasible to develop a fully viable system simulation team in the foreseeable future. In other countries the development of such teams is feasible, given careful selection of team members and equally careful planning of education and training programs for individual team members. Guidelines have been provided for designing degree and nondegree programs for individual team members. In most cases educational needs can be met by carefully designed degree programs; however, special nondegree programs can be important in certain cases.

In many countries foreign consultants will be needed in the short run to guide the development of the indigenous team and the contribution of the team to the host country's decision-making process. Unusual and creative administration is needed to ensure appropriate selection of team members and to build an environment that will encourage retention of key personnel.

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THE INSTITUTION-BUILDING EXPERIENCE IN KOREA

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INTRODUCTION

From their beginning, a major objective of Michigan State University's (MSU) projects in Korea was to institutionalize the general system simulation approach within the indigenous investigative capacity for public decision making related to agricultural sector development. The sector analysis and simulation contract, of which the Korean Agricultural Sector Study (KASS) was a field activity, stated in Article II. A that

> . . . emphasis will be placed on first establishing linkages with indigenous institutions and second on establishing their capacity to use computerized simulation models to design, analyze and evaluate their own policies, programs and projects.

In Article II.E, MSU was further obligated to

> [t]rain personnel from host country . . . agencies in the use, adaptation and further development of computer simulation models. . . . This training activity will be important in establishing the international and national linkages and capacities to use computer simulation in designing, analyzing and evaluating developmental policies, programs and projects.

The Korean Agricultural Planning Project (KAPP) contract called for even greater institution-building involvement.

> The general objective of KAPP is to increase the capacity of the Ministry of Agriculture and Fisheries and through them the government of the Republic of Korea for sound planning, agricultural policy formulation, program development, and project design and execution toward more rapid and effective development of the agricultural sector. General project working objectives include:

1. To understand the organizational structure and the operational processes presently used by MAF [the Korean Ministry of Agriculture and Fisheries] in planning and developmental activities and to identify the constraints in these systems leading to ineffective, inefficient and operationally unsound outcomes.
2. To advise on organizational and functional means to eradicate the constraints identified in (1) above.
3. To do substantive work on current issues, within the scope of the project, to relieve current problems and to provide on-the-job training in the use of modern analytical techniques and processes for Korean personnel of the Ministry of Agriculture and Fisheries.

In this chapter, we report on MSU's institution-building experience in Korea. If we view institutionalization of the general system simulation approach as a process of adopting innovation, requirements for successful adoption include motivational factors and institutional infrastructure. Under motivation, we discuss felt needs and perceptions of the innovation of the approach. Infrastructure considerations include institutional linkages, trained manpower, data acquisition, and computer facilities.

MOTIVATION

If we view the general system simulation approach as an innovation from the perspective of agricultural policy makers and analysts in Korea, then we can discuss the process and requirements of institutionalization in terms of the adoption of an innovation [148]. The motivation to adopt is based primarily on felt needs of the potential adopters and their perceptions of the innovation as having the potential to satisfy those needs.

MSU's initial sector study work in Korea in 1971–72 was an expression of the need felt by MAF decision makers for a comprehensive, integrated analysis of the agricultural sector. Such an analysis gained increased importance in Korea as a result of the greater emphasis placed on development of the rural economy in the Third Five-Year Plan (1972–76) after ten years of relative neglect during the first two plan periods. Naturally, the responsibility for designing and implementing programs and projects to achieve many of the new plan's policy targets fell to MAF. Concomitantly, there was a need to train personnel in modern planning and policy analysis methods and techniques.

Potential adopters — MAF decision makers and analysts — perceived and evaluated the general system simulation approach with respect to: (1) its relative advantage over other approaches; (2) its compatibility with their own values and experiences; (3) how easily it could be tried on an experimental basis; and (4) how easily it could be understood and used given its complexity.

One of the most important concerns of decision makers in evaluating the general system simulation approach is its *economic and political* *relative advantage*. In economic terms, one can consider the ratio of cost to quality of effort. When MSU initiated its work in Korea in 1971, the host government was only interested in the agricultural sector study, the first phase of the project. The results of that study, which had the full support and participation of Korean officials and researchers, demonstrated unequivocally how the general system simulation approach could reduce the cost-quality ratio in sector analysis. A well-received sector study [151] was completed in the allotted nine months, a schedule which could not have been met without use of the simple, preliminary simulation model. Furthermore, the computer model released the analysts' time from the drudgery of computing projections by hand, enabling them to do more in-depth analysis while also permitting projections based on more complex relationships. These results generated an interest on the part of the Korean government officials to proceed with further model development and to commit manpower resources to the training component of the project.

Political advantage can be viewed as an increased ability to influence decisions. In many instances, MAF must negotiate policy decisions with other ministries, particularly the Economic Planning Board (EPB). In the past, MAF officials have been at a disadvantage in such negotiations because of a lack of hard analysis backing up their positions. With a small, static model (the annual grain price policy analyzer — AGPPA) designed to help analyze annual government grain price decisions (see chapter 15), the National Agricultural Economics Research Institute (NAERI) has been able to provide MAF with the information it needs to support its position in negotiations with EPB on the reoccuring grains pricing issue. At the same time this activity has demonstrated the political advantage to be gained from analysis in general and the general system simulation approach in particular.

For example, in spring 1977 NAERI performed an analysis, at the request of MAF's Food Bureau, of the then-upcoming government barley purchase price decision. NAERI analysts defined 18 alternative runs of AGPPA that were based on different assumptions about inflation, production cost, and farm income considerations. In addition, supply responses were estimated, and the effects of that spring's barley crop failure due to an extremely cold and dry winter (estimates of which ranged up to a loss of 50 per cent) and how the government's purchase price could serve as a compensatory measure were considered.

The results indicated that a quite substantial price increase would be desirable from the standpoint of farm income, production cost, and supply response. We may never know how or even whether MAF directly used these results in negotiating the purchase price with other ministries, but the price increase finally agreed upon was almost twice that initially proposed by the Economic Planning Board, which is primarily concerned with the inflationary effects of high grain prices and government grain management deficits. This leads us to believe that the analyses provided MAF with the evidence necessary to argue effectively the case for a higher price increase to partially compensate farmers for their production losses.

The *compatibility* of the general system simulation approach with the values and experiences of MAF decision makers further enhances the prospects for its institutionalization. Three pieces of evidence of this compatibility can be cited. First, formal models are already used by other government agencies to provide analytical input to decision making — one reason for the political disadvantage MAF has heretofore faced. Secondly, the Livestock Bureau of MAF has been using a single hand-calculation model for several years to make projections of the supply and demand of livestock products. In fact, it is the Livestock Bureau that made the first heavy use of the sector model for policy projections. Finally, many young people have returned and are returning from abroad with postgraduate degrees and are rapidly moving into responsible positions in MAF. These people, trained in economic research and analysis, are able to appreciate the role of analysis in decision making and to make effective application of the approach.

An important characteristic of an innovation that increases its chances for adoption is its *triability*, i.e., how easily it can be tried on a small scale before a major commitment of resources is made to adopt it. The major expense of initial model development was borne primarily by the U.S. Agency for International Development (AID) under its contracts with MSU. Each occasion of model use has been a trial in the adoption decision process. In addition to the examples mentioned above, various combinations of sector model components have been used — by MSU and NAERI analysts working closely with MAF officials — for population, consumption, foreign trade, and livestock analyses for the Fourth Five-Year Plan (chapter 12), for land and water development analyses (chapter 13), and for long-run marketing and price policy analyses [128, 150].

A major constraint to the adoption of the general system simulation approach is its *complexity*, or perceived complexity, with regard both to understanding the models and the results. Although MAF decision makers strongly feel the need for more comprehensive and systematic policy analyses than have been traditionally used, officials are reluctant to use any analytical results to back up their proposals and recommendations unless they can fully explain to their superiors the basis for those results — the models, the assumptions, the data, etc. In short, complex simulation models, small scale as well as large scale, are not easy for a nontechnically trained ministry employee to understand well enough to explain.

Nor are the models always easy to use and interpret. Policy input options are often numerous and complicated, making experimental design a difficult task. The policy analysis process is iterative, requiring insights into the models themselves as well as the real world in order to interpret the results and to use them in designing additional runs. Another complicating factor can be the volume of information output from a run or sequence of runs. Therefore, a great deal of responsibility is placed on the analysts to work closely with the decision makers so the latter understand the models, the experiments, and the results well enough to respond confidently to questions from superiors.

INSTITUTIONAL INFRASTRUCTURE

In addition to motivation, successful institutionalization of the general system simulation approach requires an institutional infrastructure to support it. Key ingredients include institutional linkages, trained manpower, data acquisition, and computer facilities.

Institutional Linkages

The contract between MSU and AID for the initial nine-month agricultural sector study provided for a separate report on the organization of the Ministry of Agriculture and Fisheries and the organizational and functional constraints to effective planning and policy development in MAF. This study was included because both MAF and AID recognized that the then-present MAF planning and administrative organizational structure might serve as a deterrent to the effective implementation of recommendations on policy, program, and project changes coming out of the sector study. At the same time, the organization study was designed to recommend ways of improving the MAF planning system, including data collection and processing, statistical and economic analysis, and policy, program, and project formulation.

The sector study (KASS) team found that the then-current MAF organization provided little incentive and, in some cases, little opportunity for MAF decision makers to absorb and use centralized investigative input to the planning and policy process. Little horizontal or vertical coordination was found between MAF agencies as planning decisions were made. Bureau directors had considerable autonomy from higher administrative authority. MAF was organized totally along commodity lines, with no concession to function; thus, systematic planning was difficult. Decision makers often had short tenure in their positions, which created a lack of institutional memory and experience. NAERI was more often used by top-level policy makers than by the bureaus that do much of the preliminary planning for MAF.

These findings led to recommendations, in the organization report submitted to MAF in June 1972 [65], for organizational changes in the MAF planning system toward an increased planning and policy development capacity in agricultural policy analysis, agricultural outlook, agricultural program and project evaluation, and agricultural statistics (including the collection, processing, and use of data). The following specific recommendations were made:

1. That a plans coordination unit be established with staff responsibilities administratively under the planning coordinator.
2. That the planning units located in the various bureaus and divisions remain under the administrative control of their respective units but be physically consolidated and housed near the office of the responsible assistant vice minister.
3. That an economic research unit be established for which the primary function would be basic long-run analysis of the Korean agricultural economy. The research unit should be either an independent institute, like the Korean Development Institute (KDI), or a major section of KDI. It should not be expected to spend its time doing short-run analysis for MAF officials for planning and program review purposes. Its structural analyses — e.g., micro production economic studies of farm, marketing, and input firms; price and demand analysis; and macro supply and demand studies — would furnish the basic material upon which both effective outlook and sector analysis could be built.
4. That a single coordinated economic outlook unit be established having the responsibility for all such work formerly scattered throughout MAF and its affiliated agencies.
5. That a policy analysis unit be established as a separate unit, but closely related to the economic outlook unit, to provide the minister and vice minister with economic analysis of various policy proposals and to evaluate economic implications of plans made by the various bureaus and divisions.
6. That a statistical unit be established under a coordinator of statistics and be put under the same administrative direction as the policy analysis and outlook units.
7. That the Agricultural Economics Research Institute (now NAERI) be renamed the Institute for Agricultural Economics and Statistics (IAES) and be headed by a director at the assistant vice minister level. The policy analysis unit, outlook unit, and statistical unit would come under his administrative control.

MAF, in fall 1972, attempted to gain government approval from the Republic of Korea for implementing recommendations 4, 5, 6, and 7 above but was unable to do so because the proposal would have added one assistant vice minister and two bureaus to the MAF structure. This would have placed the number of assistant vice ministers and bureaus in MAF above the maximum permitted for government ministries. The only solution at the time would have been to downgrade the director of the proposed Institute for Agricultural Economics and Statistics to bureau-level status and the coordinators of the economic and statistics units to division-level status, which would have caused unacceptable inequities within the system.

Following this adverse decision, MAF decided to wait until after MSU's KAPP team had been in Korea long enough to familiarize themselves with the problem and to prepare their own recommendations on MAF organization. In the words of a high-level MAF official at the time, "Foreign advisers should go through a painstaking orientation. And only after having familiarized themselves with the different culture and situation can they make suitable recommendations." This is particularly true of recommendations dealing with institutional change affecting the distribution of resources or power.

In fall 1972, it was expected that the KAPP team would be functional by mid-1973. Unforeseen delays were encountered in project approval and funding, and the team did not begin to arrive until summer 1974. After going through the period of "painstaking orientation," the team was expected to prepare the MAF reorganization plan. However, as reorganization considerations progressed, the team and MAF decided that the plan should be a product of interaction and seminars with MAF and other government officials and that it should be an ongoing activity for at least the duration of the KAPP contract. Meanwhile, some reorganization along the general lines indicated above was accomplished.

It is difficult to estimate what influence KASS/KAPP recommendations and activities had on these changes. In general, for policy as well as organizational decisions, the MSU team would interact and work with Korean analysts and decision makers to come up with recommendations. After some delay and over a period of time, decisions would be made and implemented piecemeal that, when viewed together, appeared to be related to the recommendations, although obviously incorporating other considerations important to the decision maker but overlooked by, or outside the competency of, the analysts. Although this is a normal characteristic of the decision-making process, it makes it difficult for the analysts to evaluate their direct effect.

Following the completion of the initial sector study in the summer of 1972, attention of the KASS team turned mainly to model development until spring 1974. During this period some efforts were made to strengthen linkages with relevant indigenous institutions, and interactions with decision makers on model conceptualization took place,[1] but major institutionalization questions were not addressed to any significant degree. Two changes, however, took place in December 1973 that improved the internal organizational environment of the KASS team. First, the Agricultural Economics Research Institute was reorganized into the National Agricultural Economics Research Institute (NAERI). This change in name recognized the broader role being carried out by NAERI after its removal from the Office of Rural Development in 1970 and its increasing involvement in the planning and policy analysis functions in MAF. Second, during this reorganization a new division, the Agricultural Sector Analysis Division, was created in NAERI with responsibility for carrying out the KASS team activities. Thus, the KASS activity was upgraded in status to a permanent division from its earlier temporary existence as a task force.

During the past few years concentrated efforts by KASS personnel have strengthened and made more firm the crucial linkages with other Korean governmental and nongovernmental institutions. Informal working relationships with action agencies in MAF and other government units, research institutes, and universities were being improved and extended through the establishment of problem-oriented task forces. A grain policy task force was created in summer 1974 to work initially on very short-term grain policy issues confronted by the Korean government. Pleased with the results of this work, MAF requested that the task force remain intact for work on additional short-term and longer-term grain policy issues. Later a task force was constituted to provide MAF with analysis and input into the development of the Fourth Five-Year Economic Development Plan. Thus, the task force concept has been introduced and appears viable as an institutional construct for problem solving in the Korean environment.

Perhaps one of the most difficult remaining problems is the location, both within the MAF organization and physically, of NAERI and its KASS analytical unit. NAERI is an institute of the Ministry of Agriculture and Fisheries and as such is not considered a part of MAF proper. This reduces its direct role with MAF action agencies in providing analytical input into the decision-making process. It is physically located outside of the ministry building, which also tends to add to its isolation.

In spring 1975, during a visit by high-level, MSU-based project officers, the opportunity arose through AID auspices to brief the deputy prime minister (who is also minister of the Economic Planning Board) and the minister of agriculture and fisheries on progress in model development and use, future potentials of the models in helping decision makers, and problems of institutionalizing the models and breaking the government salary barriers in order to attract and hold qualified scientists. In addition, a seminar was held for senior MAF officials on the use and development of the models. This seminar stressed that successful institutionalization of the NAERI/KASS activity (i.e., the general system simulation approach) would depend on NAERI and MAF decision makers working together so closely that the models would eventually belong more to the rest of MAF than to NAERI. It was further stressed that although the work of making a model is complex and requires highly specialized skills, it is not true that decision and policy makers and other civil servants cannot understand, use, contribute to, and, indeed, control the use and development of the models. Agricultural economists and systems scientists should be forced to explain their models. Decision makers should insist that the models be capable of dealing with Korea's problems and that they pass the tests for credibility (coherence, correspondence, clarity, workability) discussed in chapter 2.

These briefings and seminars generated a great deal of interest and discussion at the highest levels of the Korean government on the future of NAERI and its KASS models. However, a difference of opinion developed, and at this writing the matter has not been resolved. One group felt that NAERI should be incorporated into the Korean Development Institute (KDI), which carries out long-term economic and social research and policy analysis for the government of Korea. This merger would utilize research resources more effectively through joint use of facilities and research materials and through better coordination among sectoral economists. This would also solve the salary problem, since KDI is authorized to pay salaries competitive with, or higher than, university salaries. A second group, which included most of the agriculturalists, felt that successful short-term economic and policy analysis of agricultural problems requires close interaction between the analysts and the decision makers in MAF and ready access to MAF data by the analysts. In their view, interaction and access to data would be seriously curtailed if NAERI were a part of KDI and thus more remote from MAF. There also would be a tendency for KDI-NAERI to emphasize long-term research at the expense of the short-term analyses needed by MAF decision makers.

It is difficult to predict the exact way in which the investigative capacity of KASS, utilizing the general system simulation approach, will ultimately become institutionalized into the Korean governmental structure. One possibility would be to make the models available to both KDI and MAF and transfer part of the NAERI/KASS personnel to a properly institutionalized unit in MAF and part to KDI. This transfer would enhance both the communication between KASS and the decision makers and the use of the models for problem solving in MAF, as well as increase the capacity of KDI for agricultural related long-term research of a subject-matter and disciplinary nature.

These and other experiences, including many formal and informal discussions with Korean government officials, led to KAPP's reorganization recommendations of December 1976 [34]:

1. That a small policy analysis staff unit be added to the office of the minister or vice minister

2. That the Planning Bureau's authority and responsibilities be expanded to (a) take leadership in the development of plans, including the coordination of planning activities among bureaus and other units of the ministry, and (b) evaluate proposed programs and projects and monitor performances or progress of those underway
3. That one or two staff persons serve as planning coordinators for each assistant vice minister to interpret planning guidelines issued by the Planning Bureau and to advise the assistant vice minister on application of these in developing detailed plans, programs, and projects under his jurisdiction
4. That NAERI, with its economic research and situation and outlook functions, be tied in more closely to the rest of MAF through its reconstitution as a new Bureau of Economic and Rural Research
5. That all major activities in the collection, processing and release of agricultural statistics in Korea be centralized within the Statistics Bureau

The ultimate solution must of necessity be uniquely Korean. Whatever form it takes, it must permit close interaction between the investigators and the decision makers in MAF and ready access to MAF data. The increased commitment to the kind of output provided by the KASS unit, the increased training activity, and the increasing demands being placed upon the unit by a wide array of government decision makers are certainly encouraging signs. It is obvious that NAERI must remain flexible in its staffing and organizational structure in order to be able to respond to the wide array of requests from decision makers for analytical input to the planning and implementation of agricultural sector development.

Manpower

In 1971, at the inception of the MSU project in Korea, NAERI had a strong orientation to farm management and had not yet established itself as a capable, creditable policy analysis unit within the ministry. In fact, NAERI had only four people with advanced degrees in agricultural economics and none with degrees in systems science. The single holder of an advanced degree at the Ph.D. level was the director. His duties were primarily research management and administration. Thus, KASS began within a relatively new, untested policy analysis unit in a ministry that only recently had recognized its need for improvement in the planning and policy formulation arena.

Another serious difficulty faced by NAERI, then and now, is the fact that it is under Civil Service regulations for personnel salaries. Government salaries are approximately one-half those which can be expected in business. Further, individual opportunities and rewards are greater in governmental administration than in governmental agency research. Thus, there is always pressure on NAERI personnel to move out of the institute for personal advantage. In addition, it is extremely difficult to recruit and retain new, highly trained personnel.

It was apparent from the beginning of the project that either substantial numbers of the NAERI staff needed additional training or that NAERI would need to recruit qualified personnel (1) to be able to take over further model development and to use the models effectively as analytical tools and (2) to become a useful investigative unit for MAF and other agencies of government charged with agricultural sector development. It is not enough to have a team of experts come into a country, build a model, and then turn it over to less-skilled indigenous personnel to operate. Models must undergo continuous development as new uses are found for them and as the country's agricultural sector and its problems change. This requires recombinations of existing components and the development of new components, which in turn require highly trained people. Because finding qualified and willing candidates for the critical positions was difficult and because of constraints imposed on recruitment by the Korean Civil Service system, the only choice for NAERI at that time was to train its own people; and MSU joined with AID in extensive training of NAERI personnel.

The long-range plan developed by NAERI for staffing NAERI/KASS with the critical systems scientists, agricultural economists, technical agriculturalists, and computer programmers capable of developing and using models is shown in Table 28.

The table indicates the ideal staffing plan to be achieved at some point in the future, the staffing status as of August 1977, and the planned status as of June 1978. Although the planned staff size by June 1978 is only three professionals short of the ideal, the training level falls considerably short. For example, only one systems scientist was on the staff as of August 1977; two more were scheduled to complete training by June 1978. This is still two short of the ideal staffing plan. Eight agricultural economists were on the staff as of August 1977, with one addition expected by June 1978. This will be one more than the ideal but includes personnel trained at a much lower level than shown in the ideal plan. A similar situation is projected for the technical agriculture and computer programming staffs. Technical agricultural help is available on contract from the universities and from the Office of Rural Development. NAERI recognizes the importance of input from a variety of other disciplines, such as sociology and public administration, to model development and plans to obtain help in these areas through cooperative arrangements with appropriate Korean universities.

With one exception, training began in 1973,[2] and by 1977 a total of 45 Koreans had been trained in the following areas under the AID participant training program related to the AID/Korean Agricultural Planning Project:

Area	Number of People Trained
Agricultural, project, program, and policy planning and resource allocation	17
Marketing	11
Outlook	7
Systems science	5
Agricultural administration	3
Statistics	2

Observation tours lasting about four weeks each have also been conducted for top- and middle-level administrators from MAF so that they could see firsthand how modern planning systems and analytical capabilities are institutionalized and used in the United States.

Of the 45 Koreans trained in the listed areas, 17 received training in areas directly related to model development and operation. Not all of the

TABLE 28
Long-Range NAERI/KASS Staffing Plan

Fields*		Ideal	Present Staff (August 1977)	Planned Staff (June 1978)
Systems science	Ph.D.	3 (1)†	0	1 (1)
	M.S.	2	1	2§
	B.S.	0	0	0
	Subtotal	5 (1)	1	3 (1)
Agricultural economics	Ph.D.	5 (2)	2 (1)‡	3 (1)
	M.S.	3	3‡	3
	B.S.	0	3	3
	Subtotal	8 (2)	8 (1)	9 (1)
Technical agriculture	Ph.D.	2 (2)	0	0
	M.S.	0	0	0
	B.S.	1	1	1
	Subtotal	3 (2)	1	1
Computer programming	M.S.	2	0	0
	B.S.	1	3	3
	Subtotal	3	3	3
Subtotal	Ph.D.	10 (5)	2 (1)	4 (2)
	M.S.	7	4	5
	B.S.	2	7	7
TOTAL		19 (5)	13 (1)	16 (2)

*Additional inputs will be necessary from such fields as technical agriculture, sociology, or public administration through cooperative arrangements with the Office of Rural Development, the Ministry of Agriculture and Fisheries, universities, etc.

†Parentheses denote part-time positions included in total.

‡One has participated in the Development Analysis Study Program at MSU.

§Both will have participated in the Development Analysis Study Program at MSU.

17 have returned to the NAERI/KASS unit; some have been placed within the ministry proper. This training program has been, and will be, increasingly beneficial to the project because those trained are changing the "climate" within MAF towards more sophisticated analytical work and planning.

During the period 1972–74, a constant one-fourth to one-third of NAERI's professional staff was in training[3] without any adjustment in the work load of the remaining staff. Model development and use and training of personnel were conflicting activities.

Systems Science. It was initially thought that people with a good basic training in agricultural economics and statistics could be trained during a period of 9 to 12 months in systems science and then, after several months of in-service training with the MSU systems scientists in Korea, would be capable of taking over model development work. Thus, in July 1972 a Korean was sent to the Asian Institute of Technology (AIT) in Bangkok for a 9-month diploma course in systems science, and in September 1973 MSU initiated a 12-month training program oriented toward systems science, computer science, and economics (the Development Analysis Study Program described in chapters 17 and 19) to produce professionals who could develop and apply decision-making models at project, program, and policy levels. The project scheduled six Koreans to complete this program, either as nondegree training or as part of a graduate degree. However, experience has shown that neither the AIT program nor the MSU Development Analysis Study Program by itself produces people who can carry out model development work on their own.

When this became evident in early 1974, a search was begun for one or more MAF or NAERI employees with the basic training, capability, and desire to complete a Ph.D. program in systems science. Although no one was found who seemed certain to complete the Ph.D., two of the candidates appeared to have potential. AID agreed to finance both of these candidates for the one-year MSU Development Analysis Study Program, with the possibility of their continuing in a Ph.D. program in systems science, provided they proved capable. Unfortunately, although one student completed a systems science M.S. program, neither student continued in the Ph.D. program.

In spring 1975 a search was begun for a possible candidate outside of MAF and NAERI. This was a course of last resort, since it could not be guaranteed that an "outsider" would eventually return to NAERI and work as a full-time member of the KASS team. A person was located at the Korean Institute of Science and Technology (KIST) who had the proper qualifications. A leave of absence from KIST was arranged for him to complete the requirements for a Ph.D. in systems science at MSU. He would return to Korea (and KIST) to work for NAERI/KASS half time. MSU systems science support to NAERI/KASS was extended until December 1977 to maintain continuity.

NAERI will not meet the staffing goal for two full-time Ph.D. systems scientists in the foreseeable future. It is clear, however, that it will have two systems scientists trained at the M.S. level working full time and one at the Ph.D. level part time.

Agricultural Economics. Four Ph.D. agricultural economists, two having systems science training, are serving with NAERI on a part-time basis. One of them is working with NAERI/KASS. An additional Ph.D. agricultural economist is a full-time NAERI staff member directing the KASS team. Another returned from training to NAERI in late 1977 and serves as the KASS team econometrician.

Three full-time members of the NAERI/KASS team earned agricultural economics M.S. degrees, and are serving with NAERI full time. Three people with B.S. degrees in agricultural economics are serving with NAERI full time. Of the nine planned KASS/NAERI agricultural economists, three have attended the MSU Development Analysis Study Program. Three others have gone through MSU's training program but have left the NAERI/KASS team since their return to Korea.

Computer Programmers. Three programmers are working full time, as planned. Additional efforts need to be made, however, in recruiting programmers with experience in programming various kinds of agricultural sector models and quantitative techniques (such as simulation models, linear programming models, and regression analysis). Recruitment of qualified programmers into government is difficult at best because of the sharply increasing demand for programmers from the higher-salaried private business sector. In the meantime, NAERI has supplemented its computer programmer capacity from time to time by contracting for well-trained, experienced programmers from KIST for specific assignments.

Data Acquisition

Korea has the advantage of a well-established statistical reporting system with time series estimates over a relatively long period of time, and positive steps are continually being taken to improve the quality of data. The request by MAF to add an agricultural statistician under the KAPP contract is an indication of their concern. This statistician functioned within the MAF Statistics Bureau to suggest needed changes for obtaining, processing, and publishing reliable agricultural statistics in as timely a fashion as possible. Since data acquisition is relatively strong in Korea, the KAPP statistician devoted most of his time to developing and installing computerized packages to improve the efficiency of data processing and dissemination by MAF.

It is important that researchers/analysts responsible for policy analysis have strong, two-way linkages with statistical units. The ties between NAERI and the MAF Statistics Bureau (BAS) have been relatively weak. Part of the problem has been NAERI's weak links with line bureaus of MAF in general, but a large part has also been BAS's preoccupation with meeting its regular publication schedules to the detriment of its serving its users. The computer program packages introduced by the KAPP statistician were designed to improve the latter problem, and the KASS/KAPP reorganization proposals (discussed above) addressed the former problem.

NAERI conducts some of its own statistical work in addition to relying on secondary sources from BAS and other Korean government statistical units. Such work includes mainly informal field surveys and interviews with farmers and operation of its own computerized data bank of county-level agricultural statistics. The latter in particular offers the potential of facilitating (1) updating of the data in the simulation models and (2) estimating the parameters of the models for regional analysis.

Computer Facilities

Appropriate computer services in Korea were difficult for the KASS project to obtain. The first attempt was to use the UNIVAC 1106 computer services provided by the Government Computer Center, an installation operated by the government to provide services free to government agencies. This computer installation was (and is) administered as a data processing center, priority being given to large data processing jobs, such as survey tabulation or census data processing. The needs of model developers and researchers cannot be met with such a system. At times, the job turnaround time was once a week, when a minimum of three times a day would have been more appropriate. This "free" service resulted in ineffective use of KASS team time and in inefficient model development and operation. It was finally arranged for the KASS team to use the CDC CYBER computer installation at the Korean Institute of Science and Technology (KIST), AID and NAERI sharing the cost of the service. The agreement specified that Korean resources be used for operational activities and AID resources be provided for model development activities. Over time, as the emphasis on model development declined and as operations increased, the Korean government provided an increasing share of the computer service cost. Indeed, in 1977 NAERI was making plans and budget proposals to acquire a batch terminal for its own use.

CONCLUSION

It is unfortunate that the main perspective of the Korean projects tended to center on the KASS models. The written objectives of the MSU-AID contract focused on model development, testing, and application. The attention of interested people, both inside and outside of Korea, tended to focus on the models. Project staff tended to emphasize the models in their discussions. Admittedly, the models were an important component of the project. However, when viewed from an institution-building perspective, the truly critical aspect was the development of the investigative unit with a cadre of trained personnel capable of using, adapting, and further developing the models as a tool in analyzing a wide variety of planning and policy problems. The most complex and challenging dimension of this process was the institutionalization of the investigative unit into the decision-making structure, with appropriate linkages to decision makers and to support and service agencies.

The amount of time required for successful institutionalization of an investigative capacity was seriously underestimated at the beginning of the Korean projects. The amount and phasing of training, the conflict between training and operational work, the time required for model development to the point that trained Koreans could take over further development, and the slowness of the process of building linkages with support and service agencies and decision makers were all underestimated. Much time and effort required for institutionalization had to be used for nonmodel analysts to become familiar and experienced with the models, to understand what the models could and could not do, and to learn to use the model output with judgment and with other sources of information to analyze specific problems. Much time was also necessary for interaction and iteration with decision makers on specific problem solutions to ensure that the preconditions to an optimum problem solution were met.

To facilitate institutionalization and to make it effective, changes must be made in organizational structure, and decision makers must understand the simple rudiments of the investigative procedures — in this case the system simulation models — and their uses. Solving the institutional and organizational problems was difficult in Korea because of the rapid turnover of MAF administrators. Frequent personnel changes presented a problem not only in the final institutionalization of the KASS investigative capacity but also in the continuity of its use by decision makers. In many cases, a change in decision makers' attitudes towards the use of sophisticated investigative procedures was required. In the case of Korea, such change had to take place at the highest levels of government, as well as at the subagency levels. In this connection, AID's role was crucial in Korea.

Its stature there was such that it could gain access to high-level officials to present the case for these needed changes in a way not available to either Korean or American project personnel.

Project staff were often asked: "When will the job in Korea be finished?" "When will the model be completed?" "When will you finish the final report and wind up the operation?" The answer to all these questions was, "If we are successful, never." Once the KASS investigative unit is fully institutionalized into the decision structure, it must continue to be relevant and useful to decision makers to remain an effective part of that institutional structure. It must continually adapt, update, and develop its analytical tools and models as the agricultural systems they represent change. It must continue to adjust its abilities to accommodate itself to the changing nature of the problems confronting the decision makers. Thus, the job is never completed and a "final report" is not an objective.

By the time the MSU projects were phased out, a small but important core of Korean personnel (professionals directly associated with the projects) had returned from training in agricultural economics and systems science. It is their task to take over the operation of the investigative unit and to ensure its smooth and effective functioning. However well trained, these professionals are still relatively inexperienced and will most likely need occasional outside support through short-term consultation.

The conviction by the MSU Agricultural Sector Analysis and Simulation Project team that an indigenous analytical capacity that uses the general system simulation approach can be institutionalized within the decision structure of a developing country is on the verge of realization in Korea. This undoubtedly would not have been the case without the establishment of the KAPP activity that provided the crucial link as the mechanism for KASS team interaction with decision makers and their problems. This linkage was firmly established before the MSU contingent totally withdrew in December 1977.

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LESSONS LEARNED AND FUTURE DIRECTIONS

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INTRODUCTION

In earlier chapters a general system simulation approach to agricultural sector development planning and policy investigation was discussed. Development, institutionalization, and use of the approach were detailed, using Korea as the case example. In this chapter we summarize the lessons learned from this experience and indicate the future directions development and application of the approach should take to be widely useful to agricultural and rural sector planners and decision makers in both developing and developed countries. The first section deals with the transfer of the general system simulation approach to other developing countries for national agricultural development planning and policy investigation. The second section suggests other potential users of the approach. The last section deals with the further research and development necessary for even greater usefulness of the general system simulation approach.

TRANSFERABILITY OF THE GENERAL SYSTEM SIMULATION APPROACH TO OTHER DEVELOPING COUNTRIES

Can the general system simulation approach, which has proven effective and useful in two countries, Nigeria and Korea, be transferred successfully and used elsewhere?

Objects of Transfer

By successful transfer, we mean institutionalization of the approach as part of the investigative capacity in a nation's decision structure concerned with agriculture or some other subject-matter area. A main object of transfer of the approach includes establishing the methodology and appropriate linkages between units and elements of the investigative capacity and with the appropriate components of the administrative capacity of a problem-solving decision structure within a nation. A second important object of transfer is model structure.

It is useful to recall the major tenets of the general system simulation approach as we address the important issues of transferability. The approach is a broad and flexible means of enhancing an investigative capacity for decision making. The core ingredients of the approach consist of sets of logical frameworks, or models, both formal and informal, designed to provide information useful in solving sets of interrelated problems within a given subject-matter context. Developed in a building block or modular format, the components and models are adaptable and flexible enough that, through innovative combination and use, they can provide information required for the solution of specific problems. The generality of the approach derives from the eclecticism of its philosophic orientation, its use of modeling techniques, the sources and kinds of data and information it employs, and the dimensions of the subject matter it addresses — most importantly time and space.

It makes use of both normative and positive information in (1) determining appropriate decision rules to use in prescribing actions for problem solution, (2) prescribing problem solutions, and (3) projecting the consequences of alternative courses of action. The approach takes a systematic view in modeling the domain of a problem or the domain of the common parts of problems in a set. It provides for evolutionary adaptation and extension of the models to represent the changing reality they are designed to reflect.

The approach requires that the models be integrated through interaction with administrators, decision makers, and affected people, as part of the problem-solving, decision-making process. It also requires linking and integration with supporting services, such as research institutions, data and information acquisition systems, computer installations, and institutional sources of trained personnel.

The ability to transfer the approach to different geographic locations or different countries, means that it can be institutionalized and used in environments different with respect to physical conditions; resource endowments; human capacities; and socioeconomic, political, and institutional conditions. Countries exist in different stages of agricultural and general economic development. Political philosophies and approaches differ among countries. The physical constraints of climate, topography, soils, water conditions, and bio-mass development vary widely among countries. Resource endowments may differ with respect to land and its improvements, the level of technology, man-land ratios, population distributions, labor capacities and skills, cropping and livestock patterns, level of agricultural sector modernization, state of industrialization in the nonagricultural sectors, capital-generation capacity, and foreign trade potentials.

Finally, and perhaps most important to the transfer potential of the general system simulation approach, great disparities exist among countries in their national capacities for problem-solving decision making, with respect to agricultural sector development in particular and for public administration and management in general. Constraints to informal and enlightened decision making such as organizational structure, institutional gaps and inadequacies, level of human capacities, skills and training, and the level of commitment to improve the planning and decision-making process differ markedly among countries and affect greatly the potential for transfer of the approach. These issues are discussed in more detail in the next section, but first let us turn our attention to the effect of the physical and technical differences among countries on model structure transferability.

At the core of the approach is conceptualization of models necessary to reflect adequately (for the solution of the problems at hand) the processes and linkages within the system under consideration. As we have indicated, the formal part of this modeling process has three parts. The first is the logical framework, or model structure, which, through the use of various methodologies and techniques, incorporates theories of relevant disciplines to depict the physical, biological, and socioeconomic conditions and processes of the real-world system in sufficient detail to be useful in decision making. This model structure can be displayed in a variety of ways, including system block diagrams, mathematical equations, computer programs, or verbal descriptions. The second part of a model is the parameter estimates required to quantify the linkages within the model structure and the rates of change in the key variables over time, through space, and in other dimensions. The final part of a model is the initial condition data and information required to describe the state or condition of the system at a given point in time and space.

By definition, initial condition data and information are time and space specific and, therefore, not amenable to transfer. Parameter estimates are probably somewhat less time and space specific; but nevertheless, since they depend upon unique combinations of physical, biological, and socioeconomic conditions, few, if any, are likely to be transferable. In rare cases, parameter estimates from one time and location may be used as best estimates of parameter estimates in another, if no better data are available. An example of such use is found in Manetsch et al. [123], in which, because of an absence of population data in Nigeria, the parameters of the population component of the Nigerian model were estimated using age-sex population distributions, birth rates, and death rates from Dahomey.

The part of a model with the greatest potential for transferability is its structure. A computerized model is generally composed of a set of routines and components assembled in a meaningful way to reflect a real-world process or system. These routines and components can be generalized in a manner allowing for their use in a variety of applications. For example, in an aggregate agricultural production model, a distributed delay routine can be used to reflect the gestation period for fruit orchards or rubber plantations, as well as for various types of livestock. The same delay model structure can be used to reflect the arrival of grain shipments at a domestic port from foreign sources. Similarly, at the component level, a demographic component, which steps a population through a series of age cohorts, can be used to reflect human, tree, livestock, or machinery populations. The structure of a demand component, which accepts population and income as demand shifters and includes own- and cross-price elasticities to reflect price-quantity relationships, will be the same in a variety of countries, although the actual parameters and initial-condition data will, of course, be different.

At the sector model level, the population dynamics; the physical, biological, and socioeconomic processes in production, marketing, and consumption; and the investment, price, trade, and control policies affecting the system operate in generally similar ways in most countries. Differences in physical conditions, resource endowments, political philosophy, socioeconomic structure, technological levels and rates, and a host of other variables can be reflected with marginal changes in model structure and through the time- and space-specific parameter estimates and initial-condition data.

Since the routines and components that constitute model structure are generalizable, much of the model structure developed under the general system simulation approach in one location or subject-matter area can be applicable to other locations or subject-matter areas and problem contexts, such as health, education, industrialization, transportation, the military, and space.

Prerequisites for Transfer

In order to transfer, adapt, institutionalize, and use the approach in a new geographic location, subject-matter area, or problem context, certain prerequisite conditions must exist. We will concentrate on the transfer of the approach for agricultural sector development planning and policy analysis, while recognizing that the discussion can be generalized from the public to the private sector, as well as to other subject-matter and problem situations.

The first prerequisite is a commitment on the part of national-level government decision makers to an improved national decision-making capacity for agricultural sector development. Such a commitment requires an interest in using information provided by investigative agencies and staff in the decision process and an administrative capacity allowing for use of such information. Further, there must be a willingness on the part of decision makers to interact with their investigative bodies throughout the decision process.

A minimal investigative capacity must already be in place. It must include a cadre of trained professional investigators, who, with further training and experience, can develop and use the models and techniques, interact with decision makers, and analyze and synthesize data and information in ways useful in the decision-making process. Both the decision makers and the investigative staffs must exhibit enough flexibility to be eclectic enough to respond to the eclecticism of the general system simulation approach.

In addition, some form of data base and a data and information acquisition system must be available. This system should include, at a minimum, a capacity to generate a set of national agriculture accounts for farm numbers, inputs, production, prices, marketings, incomes, and population. Willingness and ability to reorganize and commit additional resources to improvement of the data and information system are necessary to sustain the effort. Another necessity is an appropriate computer system that can be used for research and analysis, that is available to the investigative units, and that is staffed by personnel competent to use, maintain, and administer it.

As part of a country's investigative capacity, the university system must also be involved for successful transfer of the approach. The most important contribution by the universities is training — the basis for sustained activity in further development and use of the approach. Disciplinary skills must be available, maintained, and taught to succeeding generations of students, some of whom will become part of the country's investigative capacity on university faculties or as staff in government investigative or administrative agencies. A further contribution of the university system, in conjunction with maintaining and teaching disciplinary skills, is the research within the different disciplines required for expanding the theoretical and methodological knowledge base. A third contribution by the university system is the integration of disciplinary knowledge and its application in increasing the stock of information and knowledge about various subject-matter areas such as agriculture structure, land tenure, energy, water resource development, mechanization, food and nutrition, rural employment, poverty, or marketing. Finally, somewhat less frequently, the university system can provide input to the direct solution of specific problems.

Means of Transfer

Effective transfer of the general system simulation approach and its application in other geographic locations, subject-matter areas, or problem contexts can be accomplished through a variety of means. These means can be classified as either primary or secondary.

There are two *primary* means of transfer of knowledge and experience regarding the general system simulation approach. The first is through direct provision of technical assistance and consultancies, long or short term, by individual professionals who have developed a body of experience in building, institutionalizing, and using the approach in other areas or contexts. The second is through various forms of training. Such training can be formal or informal and consists of classroom instruction, institutes, workshops, seminars, and/or on-the-job training.

In conjunction with the field work in Korea, a training program, the Development Analysis Study Program, was developed at Michigan State University on an experimental basis to contribute toward improving Korea's indigenous human capacity for successful institutionalization of the approach. This training program has two components — a basic study program of approximately one year's duration to strengthen the investigative side of the national decision-making capacity and an administrator and decision-maker orientation study program designed as one- to two-week workshops to strengthen the administrative side of the national capacity.

The basic study program is designed to provide the student with the skills required for limited model development, model maintenance, and use. It consists of regularly scheduled university course work in systems science, agricultural economics, computer science, and economics supplemented by course work in other agricultural or social sciences. In addition to the regular course work, special intensive application-focused seminars are provided. Each student chooses a special project in which he designs and implements a model based on a policy problem from his own country. In carrying out the special project, the student has available to him tutorial help in computer programming and sufficient computer time to carry through his model development and analytical work. Experience with this program in Korea has indicated that, although it does not substitute for graduate degree programs, it can be an extremely important element in supplementing the more highly trained cadre of investigative personnel. Training at this level is inexpensive and quick, relative to degree programs, and if undertaken early in conjunction with projects involving expatriate help, it can provide indigenous personnel with the skills and perceptions required to work most effectively with the expatriate teams while other indigenous personnel are engaged in the longer-term, higher-level training.

The orientation study program consists of one- to two-week workshops designed to provide administrators and decision makers with a basic understanding of the general system simulation approach to planning and management; the capabilities and limitations of quantitative input to the decision process; and the interactive role they must play to make the most effective use of such investigative input. The orientation study program was tested in Korea with approximately 30 administrators and decision makers. The program was well received and appeared to have been useful in subsequent project activity. A major lesson learned, however, was that future workshops should be held far enough away from participants' offices to assure full-time attendance. In addition, one week is probably the maximum amount of time middle- and top-level officials can afford for such an activity and then only if scheduled well in advance. Finally, discussions of models and their problem-solving applications should include specific examples and appropriate case study materials to provide participants with direct involvement and "hands-on" experience.

These direct contacts can and should be supplemented with *secondary* means of transfer. Examples of secondary means include publication of books (such as this one), reports, monographs, and papers describing the approach, its administrative and analytical processes, and specific examples of its use. Another important secondary means of knowledge transfer is through information management systems, information exchanges, and data banks accessible to those in a variety of locations requiring such data and information. For any country with an open economy, it is important to have a wide array of data and information on production, consumption, and economic conditions of other nations around the world and, particularly, in the region of which it is a part.

Still another important secondary source of knowledge and experience transfer is through documentation, classification, and storage for dissemination of computerized models, components, and routines developed and used in a variety of locations and contexts. As part of the work of the Agricultural Sector Analysis and Simulation Projects activity at MSU an experimental mechanism for this type of transfer has been developed. It is known as the Computer Library for Agricultural Systems Simulation (CLASS).

This library is based on the concept pointed out earlier that, whereas parameter estimates and initial condition data are time and space specific, much of the model structure depicting physical, biological, and socioeconomic behavior processes is general. Thus, much of the model structure required for subject-matter and problem-oriented modeling of an agricultural sector for agricultural sector planning and policy analysis has the property of transferability. Model structure reflecting institutional, technical, and human processes is general in two dimensions. First, a model may be of a generalized process. For example, a model of a demographic process may be used for human, tree, livestock, or capital equipment populations; or a processing model may be suitable for the processing of cocoa, oil palm products, rubber, or tobacco. Second, a model may be generalized with respect to applications. A population model, a demand model, or a production model may be applicable to analyses of food production problems in Tanzania, cattle industry problems in Venezuela or Colombia, or agricultural sector problems in Nigeria or Korea. With this in mind, the software library concept was developed to capture past model structure development as *capital stock,* to be used in a variety of contexts other than those for which it was originally developed.

The Computer Library for Agricultural Systems Simulation (CLASS) acquires, catalogs, maintains, and distributes computer programs and associated documentation. These computer programs are of generalized simulation models and routines designed specifically for the analysis of agricultural development problems and processes. In particular, the library catalogs and indexes programs and documentation so as to facilitate their retrieval by users seeking a set of programs to be used in a specific problem analysis and distributes programs and documentation to users.

To enhance the effectiveness of the library, its functions should include identifying and soliciting needed models, actively bringing programs and documentation up to the library's standards, and providing limited consultation in identifying and implementing appropriate library programs for a particular application. A subsidiary function of the library, in conjunction with the identification and solicitation of models, should be to survey and catalog ongoing research in agricultural systems modeling and simulation [4].

To carry out the functions indicated, the library must be an institutional entity capable of performing activities in three areas: (1) acquisition and development of routines, components, and models, with associated software and documentation; (2) storage and maintenance of these software elements; and (3) provision of user-related services, such as software retrieval, consulting, and training. Acquisition of elements for inclusion in the experimental software library, as developed at Michigan State University, has been limited to the routines, components, and models developed (1) by the Agricultural Sector Analysis and Simulation Projects from their work in Nigeria and Korea, (2) as part of the related training activity under the Development Analysis Study Program, and (3) through dissertation research in conjunction with regular graduate degree programs.

Documentation has been based upon the standards set forth in the *Software Standards Manual* [36], developed as part of the library activity. This manual sets out documentation standards that will (1) maintain a consistent programming style, (2) maintain compatibility among computer programs, (3) ensure and facilitate adequate error checking, (4) facilitate further development, (5) enhance readability, and (6) ensure as much machine independence as possible.

Software library offerings are stored on computer tape, with documentation of each routine, component, or model published in the CLASS document series. User-related services have been provided primarily internally in graduate research projects[1] as a partial test of the library concept. From these test examples, CLASS appears to be a sound and potentially valuable concept for preservation and use of model structure capital stock.

The concept of model structure software as capital stock is relatively new and, obviously, not held widely by modelers and analysts. Most modelers tend to prefer the creativity of their own modeling to borrowing and reassembling from that which has gone before. This is in part a reflection of historical training, which places a higher reward on individual creativity; in part because of inadequate documentation and a proliferation of computer programming languages, which makes models difficult to use by anyone other than those who created them; and in part because of the notion that model development is a means to a limited objective, which normally ends with the publication of a report and with the attitude that the model will not continue to be used as the subject-matter emphasis changes and as new problems arise within that subject area. Modelers and analysts should recognize that redoing what has been done before is a shameful waste of scarce resources. New and unique contributions to software repositories should be judged worthy contributions in peer group reviews. Mechanisms allowing for ease of access and use of modeling software from such repositories could substantially enhance the capacity and capability of all modelers and analysts.

Although the concept of a software library has been developed to a stage of limited use at Michigan State University, it is clear that it should not remain at that location. At a minimum, it should be institutionalized in one or more international agencies dealing with the subject matter and problems in a variety of locations and contexts for which the content of the library can be of use. Possible repositories for the library with the capacity to build appropriate institutional structures to maintain and service such an entity are few. Noncommercial institutions with the potential of integrating the library concept into their operations include the U.S. Agency for International Development (AID), the U.S. Department of Agriculture (USDA), the International Institute for Applied Systems Analysis (IIASA), the Food and Agriculture Organization of the United Nations (FAO), the International Bank for Reconstruction and Development (IBRD), and the International Food Policy Research Institute (IFPRI).

Other national and international agencies may be appropriate repositories for software libraries with either a general or special focus. Further developing, testing, and use of the library concept on an experimental basis are necessary to determine the most appropriate organizational structure, operational processes, and institutional homes for long-term viability.

Agents of Transfer

The main agents of transfer of the approach to other developing countries include both external aid and technical assistance agencies and personnel and the agencies, institutions, and personnel within a specific developing country concerned with integrating the approach into their decision structure. Many diverse entities must be brought together and their activities coordinated over a sustained period of time to institutionalize a comprehensive investigative capacity for planning and policy analysis, such as the general system simulation approach.

External aid and technical assistance agencies can play a major role in transferring knowledge and experience gained in development and application of the approach to other developing countries through funding projects for that purpose. The aid-granting agencies — such as the U.S. Agency for International Development, the Food and Agriculture Organization of the United Nations, the United Nations Development Program — and the major foundations involved in international development activities — such as Ford and Rockefeller — all include as part of their objectives assistance to developing countries in building improved investigative capacity for agricultural sector development decision making. Such agencies and institutions can contribute to the satisfaction of this objective through support of a variety of interrelated activities.

Most of these organizations have subunits charged with the responsibility of supporting and/or collecting relevant disciplinary and subject-matter research which can be useful in a variety of programmatic contexts. All of these organizations have subunits that are geographically oriented. Most include field offices in developing countries. These subunits often support user-oriented subject-matter research and problem-solving activity focused toward and in conjunction with specific host countries. In connection with these research and operational activities some of the aid-granting agencies support training programs for the development of human capacity, conferences for dissemination of the results of research and operational activities, and institutional development projects contributing to improved institutional, organizational, and administrative structures and processes that allow fuller and more efficient use and increased availability of decision-making resources. Systematic and comprehensive development and institutionalization of investigative capacity for agriculture sector decision making, whether through the general system simulation approach or through other similar means, require coordination of many of these activities of assistance agencies. New and innovative ways of carrying out existing activities and even additions to present types of programs and projects can be greatly beneficial.

Unfortunately, aid-granting agencies have several general constraints that also affect their specific capacity to support successfully the set of activities necessary for comprehensive transfer of the general system simulation approach. Such agencies generally have little or no professional capacity within their own institutions to provide the depth and intensity of technical assistance, consulting, and training over the sustained time period required to effect transfer. Even though these agencies have the critical administrative and programmatic links with the developing countries, they must, in the final analysis, rely upon professionals from universities in developed countries, government agencies, and consulting firms to carry out the work prescribed in specific project statements. Project development, administration, and execution within this international assistance system have often been extremely costly, have been subject to the whims of assistance agency administration or even more remote governing bodies, and are much less relevant and successful than they might have been.

With relatively rapid rotation of personnel, assistance agencies tend to have little memory and short planning horizons for any given program goals. The result is often development of project substance and design without the benefit of past experience and without consistent direction and support throughout the course of the program. Finally, programmatic support for many of the international assistance agencies is based on an annual budget cycle that usually limits planning to not more than three years, when the planning horizon for projects of the type required for successful improvement and institutionalization of investigative capacity for planning and policy decision making should be of substantially longer duration.

Universities in developed countries and their faculties are often called upon to assist universities and government agencies in developing countries in many of the aspects of building and institutionalizing an indigenous investigative capacity. This necessarily involves technical assistance and consulting with the developing country's university system and government on organization, administration, development, institutionalization, and utilization of various components of such a capacity, as well as the training of developing-country personnel in the developed country's universities in graduate and/or nondegree programs.

Such involvement can be extremely useful to individual faculty members and to universities as a basis for relevant disciplinary and subject-matter research and a source of practical problem-solving experience. Such international projects provide a rare opportunity for universities and their faculties to produce multidisciplinary analysis focused on real-world problems and issues. These experiences and research opportunities improve the productivity of university faculty and the quality of their classroom teaching. But the vagaries of funding, the timing of projects, and the competing pressures of domestic programs make it difficult to assemble and retain teams of qualified professionals with experience in these kinds of projects. Thus, we can observe a significant amount of slippage in the provision of technical assistance to improve investigative capacity as new projects are developed and new technical assistance teams are formed with little or no benefit from past experience.

Factors within host-country institutions also contribute to the difficulty of carrying out long-term, well-designed projects to improve investigative capacity. A combination of rapid turnover of host-country government and university officials; often an atmosphere of suspicion and distrust of the motivations of technical assistance personnel; inadequate resources, administrative capacity, and institutional structures; a limited cadre of professional personnel; and a lack of clear understanding of program objectives contribute to less-than-satisfactory project outcomes. A clear assessment of the resources available and capacities of personnel in host countries to carry out external assistance programs jointly is necessary. It is well for all parties concerned to recognize that not all developing countries are ready and able to make the commitments necessary to carry out successfully programs to build investigative capacity for agricultural sector development decision making.

Finally, conflicts of interest and perspective often arise among the host-country officials interested in the project for problem-solving reasons; the funding agency personnel, who tend to focus on a subject-matter orientation to build a stock of knowledge that may be useful in a variety of countries in which they have activities; and the university personnel with disciplinary orientations who staff the project. Small wonder that most projects turn out less than perfect.

The projects in Korea suffered from many of these dilemmas. During the six and one-half years of MSU's presence in Korea, the KASS activity never had assurance of more than two years of funding or planning at any given time, while the KAPP activity was planned as a three-year activity. Shifts in orientation of AID away from strong support of sector analysis and quantitative methods during the period of the project required that the MSU project director allocate a major portion of his time to negotiation, meetings, and presentations to AID to ensure survival of the project. Two major and two minor reviews of the projects were conducted by AID during the six-and-one-half-year period that used substantial project as well as nonproject time and resources.

As individual team members completed their assignments, many moved on to other nonrelated professional activity, from where it would be difficult, if not impossible, to use their experience and knowledge in transferring the general system simulation approach to other locations or subject areas. Because of frequent changes in top-level administrative personnel in MAF, project members had to constantly re-explain the project and major shifts in the level of administrative understanding and support occured over time.

The Korean projects were fortunate, however, in that the first phase was highly operational and required the completion of a sector analysis and an investment priorities study within the first year. Through this highly applied work, credibility was established early, which made entrée, interaction, and support much easier to obtain throughout the less operational phases of the project than would otherwise have been the case.

The two most important ingredients in projects designed to develop and institutionalize the general system simulation approach in Korea were (1) the early joint development of clearly defined goals by MAF, MSU, and USAID/Korea with a common commitment to their attainment and (2) time. The six and one-half years of intensive project activity were none too long to arrive at a self-sustaining level of institutionalization of the approach. Even if all other prerequisites are met, clearly defined common goals and time to accomplish them will be imperative for successful transfer of the approach to other locations.

OTHER POTENTIAL USERS OF THE GENERAL SYSTEM SIMULATION APPROACH

The range of decision-making bodies and others who could benefit from general system simulation models and components for agricultural planning and policy analysis is almost endless. Some of the potential beneficiaries need relevant disciplinary models, others need subject-matter models, and many need specific, unique problem-solving models. In addition to the U.S. Agency for International Development, which renders technical assistance to agricultural planning agencies in the less-developed world, many other U.S. governmental agencies need such models and recognize this need by sponsoring and funding such research.

In this connection, the National Academy of Sciences, in its report *African Agricultural Research Capabilities* [137], recognized that it needs system models, both at the firm, subfirm, enterprise, and subenterprise levels and at the sector and subsector levels; the latter models involve the production and marketing of modern inputs and the marketing, distribution, and use of agricultural products, as well as the consequences of alternative agricultural policies, programs, and projects. Another notable example is the National Science Foundation sponsorship of AGRIMOD, a computerized system simulation model of the U.S. agricultural sector designed for policy research and analysis [161]. In addition a recent National Academy of Sciences study on high-priority research areas in world food and nutrition emphasizes the need for both methodological and operational research on food sector analysis and the systems approach. The study report[2] states:

> Methodological research [is needed that] . . . would seek to improve techniques for gathering and analyzing the large amount of information needed to predict how alternative government policies and programs (or other events) might affect the various goals a developing country might have. This would require further development of systems work. . . . Systems research, which has developed useful methodologies and equipment to handle large amounts of information, should be extended to strengthen analysis of food policies in the developing countries.

The U.S. Department of Agriculture (USDA) historically was a developer and user of projection models or system simulation models long before computerization took place. The USDA is now moving forward on computerized general system simulation models for long-range projection and planning, such as the National Interregional Agricultural Projection Model (NIRAP) [147], as well as shorter-term policy analysis and outlook models [24].

At the international level, the International Institute of Applied Systems Analysis (IIASA) supported by the scientific communities of both eastern and western bloc developed countries, is using general system simulation models in such subject-matter areas as energy, interregional development, and food and agriculture.

The International Commodity Research Centers are increasingly recognizing the need for general system simulation models to understand such processes as photosynthesis, photorespiration, the nitrogen cycle, pollution of food chains, multiple cropping systems, and other applications. The International Bank for Reconstruction and Development (IBRD) has also engaged in development of general system simulation models at the sector, program, and project level.

In the United States, various state governments are interested in agricultural systems involving control of water, pesticides, environmental pollution, and land use. Agricultural system simulation models are also of value in modeling and solving problems of individual farmers. At Michigan State University, a number of simple simulation models, which can be operated by push-button telephone from a farmer's home or office, are in use. These models include spraying routines, investment problem analyses, livestock feeding programs, and a host of other aids to specific problem solution.

A major reason for employing the general system simulation approach is to provide relevant and useful information to the decision maker to enhance his ability to solve the problems he encounters. The disciplinary research and subject-matter inquiry and modeling within the general system simulation approach are designed to focus upon the domain of the sets of problems encountered by decision makers toward which the approach is directed. Each specific problem has its own unique domain, and thus constant development, updating, and reorientation of the model must take place to provide the analysis and synthesis required to generate the information of use in solving specific problems.

FURTHER RESEARCH AND DEVELOPMENT OF THE APPROACH

The general system simulation approach applied to planning and policy analysis for agricultural sector development has provided relevant information to decision makers for solving problems. Particularly important examples include the application of the approach in Nigeria and Korea. Although the Nigerian model was not designed for specific use by Nigerian policy makers, results from its use accounted for 60 pages of a Nigerian-produced document entitled *Agricultural Development in Nigeria 1973-1985*, published by the Federal Ministry of Agriculture and Natural Resources Joint Planning Committee [59]. The Korean agricultural sector simulation model has been used extensively by Korean decision makers. The formal models for Nigeria and Korea are categorized by the authors as subject-matter models capable of providing information relevant to the investigation of a fairly well-defined set of problems confronted by agricultural sector development decision makers.

In addition, the approach lends itself to relevant disciplinary research, subject-matter conceptualizations, and problem-solving analyses in the much broader arena of rural development. The discussions in this regard in chapter 3 begin to show the potential for conceptualizing and relating the subject areas and problem domains of health, education, transportation, rural industrialization, environmental quality considerations, and a host of other sector, subsector, regional, program, and project variables affecting the development of rural areas and their relationship to the rest of the economy and the rest of the world.

The substantial progress made in applying this approach to agricultural sector analysis can continue and expand at an accelerated rate. Central to success in further developing the approach is the avoidance of undue specialization by individual disciplines and their analytical techniques. This applies particularly to economics and its specialized quantitative techniques such as linear programming, input-output analysis, simultaneous equations based on probabilistic estimates of parameters from time series data, and the like. It also applies to systems science and its specialized approaches such as control theory or dynamic simulations based on differential and/or difference equations. Progress will also be enhanced by avoiding undue emphasis on special subjects such as land tenure, agricultural marketing, energy, or the role of women in agriculture. Unless these special subject areas are placed in balanced perspective, they can interfere with the development of broader comprehensive sector models. Such comprehensive, balanced models can be constructed from components linked to model the domains of well-defined sets of problems faced by clearly identified decision makers and affecting well-defined groups of people in an economy.

In the process of developing and using models and components for problem-solving decision making in Korea, we found that a number of our subject-matter models and components required further substantial work. To the extent possible, with available resources, the theoretical and methodological shortcomings became the subject of disciplinary inquiry, primarily in dissertation research [17, 26, 68, 118, 176]. Identification of the set of pressing potential problems to be solved in agricultural sector development guided the subject-matter research and model development activity, which in turn provided relevant and useful information for the solving of specific problems within the identified set. The subject-matter research and model development activity identified the theoretical and methodological research necessary to improve and extend the subject-matter work. Successful accomplishment of the disciplinary research in turn improved the basis for the subject-matter work and thus its ability to provide more useful and relevant information for problem-solving activities. For example, the thesis research by Lee [118] became the basis for the crop technology change component (CHANGE) in the Korean agricultural sector model. Thus, a recognizable and complementary blending of relevant disciplinary inquiry, subject-matter research, and problem-solving activity was accomplished. Recognition of the differences and the proper role of each of these three types of research and model development activity allows a balanced allocation of resources and efforts among the three areas of work and prevents overly enthusiastic focusing on any one to the exclusion of the others. It is necessary to keep this perspective in mind while examining further research opportunities in the general system simulation approach.

Needed Subject Matter Research

The job in Korea, and more generally, is not yet done but only well begun. Most developing countries do not have an adequate set of national agricultural accounts. Such accounts are crucial in developing agricultural sector models. The accounting identities on which they are based produce most of the "performance variables" with which decision makers are familiar and which are used by national planners of both the agricultural and nonagricultural sectors of the economy. Most systems could be designed to link data acquisition, processing, storage, and retrieval systems to analytical systems to provide more useful and relevant information for problem-solving decision making. Recognition of the wide range and levels of aggregation required of analytical systems leads to the conclusion that the data systems must be extremely flexible in the types of data included and the levels and combinations of aggregations (or disaggregations) into which the data can be processed for use with the wide array of necessary analytical systems.

Data, like models, are capital stock. They represent one of several forms of archival experience and knowledge which, when placed in the proper logical framework, are valuable to present and future problem solutions. Data systems are required to collect, store, process, and provide data for a variety of unique and different uses within simple to complex analytical systems in one form or another in operational use the world over. Unfortunately, most are barely adequate to inadequate, and a great deal of work is necessary to develop generalized data-analysis-information systems and to institutionalize them as part of national investigative capacities. With such a fully integrated system, a model component used to project the behavior of an agricultural sector through time could, with very little additional effort, be designed to maintain and update its own data files, run its own consistency calculations on the data, process them in a variety of needed forms, and as part of the standard output produce the national agricultural accounts and other data normally found in published agricultural statistics yearbooks.

In both Nigeria and Korea the authors were struck with the difficulty of developing components for dealing with nonmonetary, normative feedbacks from decision makers and affected people to planners, other decision makers, and sector analysts. Perhaps this difficulty originates in the positivistic orientation of many economic analysts, systems scientists, and the cyberneticists from whom the systems scientists have borrowed so much. On the other hand, we are also struck with the necessity and importance of interaction among modelers, analysts, and decision makers required to "model" these feedbacks, at least informally.

Our experience has indicated, both in developing and promoting the use of agricultural sector models, that iteration and interaction are essential. As we and our colleagues have interacted with decision makers and affected persons, the necessity to modify our models iteratively has been clear. These iterations and interactions have been helpful in defining and redefining the domains of both problem-solving and subject-matter models. They have also been sources of information, both normative and positive, and have yielded insight into the decision-making rules appropriately used in (1) modeling systems behavior, and (2) determining prescriptions for solving problems. This experience indicates a substantial need for more formal components to model such iterative interactions.

Needed Disciplinary Research

Disciplinary as well as subject-matter and problem-solving contributions are needed. For example, the output of an agricultural sector, region, or subsector depends not only on nondurable resources used and investments or disinvestments in durables, but also on the rate at which durables are used. John Maynard Keynes recognized this when he considered the "user costs" of varying the rate at which services are extracted from durables. He saw clearly that the output of economies, sectors, and subsectors depends on changes in use rates for durables. User cost theory and the relationships between user costs and investments and disinvestments and, hence, growth and stagnation are not well developed in the discipline of economics. Model components are needed that will handle both user costs and investments and disinvestments if we are to project changes in agricultural production and changes in production capacities.

Economists have long been concerned with both monetized and nonmonetized values in exchange. They have also been concerned with total utility and welfare as well as exchange values. It is however, difficult to deal with nonmonetized values in developing agricultural sector models to be used by decision makers to reach decisions. Contributions are needed from economists that will help model the monetary values and from humanists that will help advance the theory and methodology to model the onmonetary values important in making decisions concerning agriculıre.[3]

In addition, theoretical abstractions and methodological conceptualiations are sorely needed to better understand and project the determiants, the processes, the interactions, and the consequences of technolog:al change, institutional change, and human change. Our understanding bout how technological change takes place could be much improved. .lthough economists have been experiencing some success with "inuced innovation models," such models are too specialized in economics. uch models need to be supplemented by models explaining the origin of :chnical change that are based on the knowledge of the biotechnical isciplines and by models explaining the innovation of technical change ıat are based on the knowledge of humanist and sociological disciplines s well as economics. It will then become possible to develop subjectıatter models dealing with technological change far superior to those 'hich have been created by economists alone.

The same approach is necessary with respect to models of institutional nd human change, although substantial contributions have been made :cently under the rubric of "induced institutional change" and the "forıation of human capital." In these cases, however, the contributing disciplines need to be expanded to include political scientists, education ɔecialists, and psychologists.

eeded Problem-Solving Research

One of the most important uses — in fact the ultimate use — of general 'stem simulation models is to assist in solving practical problems. Since ıch problem requiring solution is unique and specific to a point in time ıd space, it is impossible to generalize about needed contributions for 'oblem solving in the same way it is for needed disciplinary and subjectatter contributions. We can, however, indicate a major constraint in ırrying out problem-solving activity.

Building models of relevance for problem solving involves unique lministrative requirements. Great administrative flexibility is required for 'nthesizing personnel, theories, methodologies, information, and models ɔm a great variety of disciplines. People in charge of building and using ıch models must also have administrative powers to command personnel ıd model contributions from the disciplines germane to the problem at ınd. University departmental structures based largely on disciplinary stinctions are not well organized to supply the administrative flexibility ıd power required in modeling the domains of problems. Typically, :ither the administrative structure nor the administrative power to handle ultidisciplinary problem-solving projects are in place.

On the other hand, governmental agencies, which generally have the appropriate administrative organization and skills, are not likely to possess the range of disciplinary competencies required for such activities. The paradox of the situation is that the universities have the range of disciplinary skills and competencies required but lack the administrative capacity to form them into problem-solving configurations, whereas government does not have the necessary range of competencies at its disposal despite the wide array of pressing problems it confronts and the large numbers of administrators it has on hand. It is this basic paradox that has made it necessary for government and universities to cooperate in doing problem-solving agricultural development work and at the same time has made it almost impossible for government and the universities to succeed in organizing such problem-solving research.

The general system simulation approach as illustrated in the chapters of this book can provide the conceptual framework for resolving this paradox and for establishing the basis for a more integrated and complementary set of disciplinary, subject-matter, and problem-solving work. Interactions between decision makers, analysts, modelers, and affected persons in government, the universities, and the private sector can be more purposeful and better understood within the framework of the approach in both developing and developed countries. Thus, both the investigative and the administrative capacities for informed problem-solving decision making can be improved.

2. The elasticities estimated from regression analysis proved to be sufficiently inconsistent that they could not be used directly. This appears to be the result of various nonprice and nonincome factors not included in the statistical analysis of time series data. Instead, the income elasticities used were obtained from the analysis of the most recent cross-section data; own price elasticities, from the analysis of time series data on the basis of reasonableness and of consistency with other estimates; and cross-price elasticities, from judgments by food grain specialists about how the other two grains substitute for each grain as its own prices change. An important factor considered in making these judgments was the historical tendency for total grain consumption in Korea to remain relatively stable, despite substantial shifts in the consumption of individual grains. See [165], appendix B.

3. The average factory selling price of wheat flour is controlled by the government, rather than by the flow of flour stocks directly.

4. This occurred, in fact, with the yield of rice, where disease and weather factors resulted in a lower-than-expected yield.

5. Average producer prices for farm households and average consumer prices for nonfarm households.

6. The basis for such a model, identified as the "Optimum Prices Submodel — AGPPA 2," is described in [165], appendix C.

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CHAPTER 17

1. Based upon U.S. standards.

2. William A. Mehrens and Steven M. Downing, "Candidate Selection Procedures: Multinational Program of Study in Systems Analysis for Developmental Planning," Training Program Paper (East Lansing: Michigan State University, 16 April 1974).

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CHAPTER 18

1. In May 1973, a KASS Issue Paper [160] explained to decision makers how the then-current KASS model could be used in preliminary planning for the Fourth Five-Year Plan; and in summer 1973 a one-week workshop was held for decision makers and economic analysts in government and private agencies to explore the major methodologies and research findings employed by KASS.

2. After project approval was given by MAF in 1972, it took considerable time to locate the appropriate people, process them through the AID/ROKG training program, and get them accepted in U.S. institutions.

3. Some of these staff members received training grants from other than AID sources.

Prt

CHAPTER 19

1. Examples include Lee [118], who projected technological change in Korean agriculture, with the use of CLASS delay routines for lags in the acceptance of innovation and CLASS table functions for the allocation of resources to education and extension work for the diffusion of innovations; Nweke [139], who, in his model of Nigerian forestry demand, used CLASS distributed delay routines to model the replacement needs for wooden structures, CLASS table functions for

tracing projections of economic variables not amenable to simple algebraic equations, and CLASS demography components for population modeling. In addition, CLASS table routines, demographic components, delay routines, accounting components, and the policy analysis language were used by Watt, first, in developing a Michigan agricultural sector simulation model and, later, in his dissertation research [176] in developing a detailed production component for the Michigan agricultural sector study model. Finally, CLASS delay routines, table functions, and demographic components were used by Jaske in his dissertation work [68] on livestock enterprise decision making. The CLASS policy analysis language has been used in conjunction with two national agricultural models of the U.S. Department of Agriculture economic projections group. The first is a national framework model of the agricultural sector, the second an aggregate farm production model. Additional research projects, using CLASS library components, include a model for commercial fisheries in Michigan and a rubber industry model.

2. For further elaboration of the dimensions of the problems in the important subject matter area of world food and nutrition; specific research recommendations under four major headings of nutrition, food production, food marketing, and policies and organizations; and an agenda for action, see *World Food and Nutrition Study,* National Academy of Sciences, Washington, D.C., 1977. This report resulted from a request from the president to the National Academy of Sciences, after the 1974 World Food Conference, to assess the world food and nutrition issue and to make specific recommendations on how the U.S. research and development capabilities might contribute to the solution of the problems involved.

3. Productive conceptual work has been done in this area although it has not been incorporated well into operational work. For example, see Karl A. Fox, *Social Indicators and Social Theory* (New York: John Wiley and Sons, 1974).

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