7-1977

Singapore Symposium: Agricultural Sector Analysis in Thailand

Division of Agricultural Economics, Ministry of Agriculture and Cooperatives, Royal Thai Government

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Singapore Symposium: Agricultural Sector Analysis in Thailand

DAE-CARD Sector Analysis Series: No. 7
July 1977

SINGAPORE SYMPOSIUM: AGRICULTURAL SECTOR ANALYSIS IN THAILAND

The Division of Agricultural Economics
Office of the Under Secretary of State for Agriculture
Ministry of Agriculture and Cooperatives
Royal Thai Government, Bangkok, Thailand

in cooperation with

The Center for Agricultural and Rural Development
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This work was completed under
Contract AID/CM/SA-C-73-19 and
Grant AID/CSD-2824

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July 1977

PREFACE

The papers included in this volume were presented by DAE-CARD staff members involved in sector planning at the Singapore seminar. The seminar on sector planning models was sponsored by the Agricultural Development Council in November, 1976.

The DAE-CARD sector planning activity is conducted in the Division of Agricultural Economics, Royal Thai Ministry of Agriculture. The models and analyses reported here represents a small part of the research work conducted in the Division of Agricultural Economics. Also, those reported represent only part of the model development and application work being conducted under the DAE-CARD program. This program is conducted cooperatively by the Division of Agricultural Economics, the Royal Thai Government and Iowa State University through a grant by the Agency for International Development.

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Introduction

The goal of the agriculture sector analysis project in Thailand is to develop a meaningful modeling capacity for use in policy analysis to provide strategies for agricultural development. An attempt also is made to narrow the gap between nonlinked planning approaches, microeconomic analyses, ad hoc projects, and macro-sector models with a systematic linkage of variables and models to simulate an economy under alternate conditions.

In Thailand, where the agricultural sector accounts for a large part of the national income and an even higher proportion of total employment, efforts to construct linked sector models as the basis for sound agricultural development planning have been minimal. The related uneven growth of the economy has brought about serious economic and social struggles among disparite income groups.

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The authors are indebted to Somporn Hanpongpan, Koset Manowalailao, Supot Dechadesh of DAE, and ISU Team members: Keith Rogers, Western Illinois University; Herbert Fullerton, Utah State University; Charles Framingham, University of Manitoba; Lee Blakeslee, Washington State University; and James Stephenson, Iowa State University; for valuable assistance and recommendations in the preparation of this paper.

Past planning processes have been pursued as a collection of independent projects proposed by various concerned departments. Every department has tried to maintain its projects and has paid minimal planning attention to identification of economic problems and how to cope with those problems. Therefore, high levels of achievement from those practices could hardly be expected.

Although agricultural sector analysis varies widely in scope and problem orientation, the effort in Thailand includes problem identification for policy analysis. It also explicitly considers model construction and linkages to search for a meaningful set of strategies for agricultural development planning.

The Development of the National LP Crop Model and the Macroeconomic Model of Thai Economy

Since 1973, the DAE/ISU team has been employing a variety of analytical tools to arrive at relevant solutions concerning agricultural development problems of Thailand. The very first mechanism on trial (and one which is still used to cope with several categories of agricultural economic problems at present) is linear programming. The core of the agricultural sector analysis so far has been the national model of agricultural crop production and transportation. The policy variables include policies on land and water use, export and import taxes and subsidies, farm credit, farm price policies, farm income, employment, etc. The economic modeling process is such that each item in the policy set must be formulated in the model so that the policy set affects the model in the same way the implemented policy affects the economy. Nevertheless, the policy analysis need not begin at the national level. For specific regional study, it is considered more efficient to begin the analysis at the regional or agroeconomic zone level. For planning purposes, 19 agroeconomic zones were delineated as aggregates of the 17 Changwads of Thailand. Criteria for delineation were based on homogeneity of climate and economic variables, namely, soil, rainfall and temperature, economic crops, livestock, etc. First, the production component of the agroeconomic zone model was defined consistent with the anticipated national crop model. Linear programming models with monthly detail on land, labor, and capital were then constructed for every agroeconomic zone. Results from the regional model of the Northeast and from the agroeconomic zone models in the Central Plain have been discussed in published documents and public meetings. The agroeconomic zone was then used as the building block for the national model of agricultural production and transportation with spatial linkage between producing and consuming regions.

The size of the national model includes some 400 equations and more than 1,000 variables. A set of optimal solutions consistent with specific policy alternatives has been obtained from the national crop model. To illustrate, one alternative solution B2, in addition to assuming a medium rate of population growth and a medium level of exports, includes a set of income constraints requiring a minimum level of income to be produced from upland crops and a set of bounds placing upper limits on production of specified crops in the Northeast (NE), where per capita income is below average. The results show, among other things, fairly extensive use of fertilizer and new rice varieties in addition to implying that more extension and educational efforts related to upland crops would be required to meet such income constraints in the NE. They also show national crop income from solution B2 lower than that assuming no minimum income restriction.

So far the fixed point demand projections employed in the national model have been estimated from simple cross sectional and time series studies. Potential agricultural processing enterprises to be included in the models have been identified and coefficients for these enterprises are being estimated but these have yet to be incorporated in our models. At a later stage a range of livestock activities will be incorporated in the national crop model. The LP models provide a number of optimal solutions relating to resource allocation from the national level to zone levels. The solutions obtained from the LP models so far have been used to analyze the economic problems in the agricultural sector while other sectors have been given only aggregate treatment.

Construction of the macroeconometric models was introduced some time after the LP modeling began. The broader view of the relationship among all major sectors of the economy will be obtained from that model. The macro model attempts to specify the functional relationship among the jointly dependent variables (JDV) and the predetermined variables (PDV) under a system of national income accounting identities. Given data on JDV and PDV, a set of structural parameters was estimated through a system of simultaneous equations to describe the existing structure of the economy. Next, the reduced form of the structural model, expressing each of the JDV as a function of all the PDV, was derived for forecasting purposes.

So far, two macroeconometric models have been developed. Model I is a 45-equation model with 36 behavioral equations and 9 identities, linear in both parameters and variables. It is designed for linking to the national linear programming model so that policy goals of interest (namely, increasing farm production and income) could be efficiently drawn. The behavioral equations encompass several groups of equations, namely, private personal consumption, government expenditure, exports, imports, gross fixed capital formation, and output and income distribution equations. Model II is a 55-equation model, linear in its parameters but allowing for nonlinearity in the variables. Some modifications of Model I are made in Model II, namely, disaggregation of equations and changes in the form of equations that incorporate a simple monetary and price sector to capture the effects of change in prices on the real sectors of model. Results of Models I and II have been obtained both in terms of structural equations and the reduced forms. The macroeconometric model, itself, offers valuable suggestions to planners in terms of positive economics, "what is." However, the ultimate goal of the consolidated MACRO/LP model as a tool for normative policy purposes is yet to be realized.

Future Plans for the Integration of I-O/Macro/LP Model for Agricultural Development Planning in Thailand

Fortunately, a 75 x 75 I-O matrix of the Thai economy has been developed by the National Economic and Social Development Board (NESDB) during the recent past.

A meeting arranged between concerned officials from DAE and NESDB led to an agreement to cooperate and exchange data and information. DAE develops coefficients from the agricultural sector while NESDB is responsible for supplying coefficients for nonfarm sectors. However, the data processing and compiling will be conducted jointly using DAE computer facilities. The coefficients for a regional I-O (input-output) model will be collected by joint field enumerators in November 1976 for the Northeast region. Coefficients for the other regions will be subsequently determined. The resulting interindustry relationship of I-O analysis will provide a consistency check between the producing and purchasing sectors of the economy. Although national policy interests concerning employment, level of income, and income distribution could be drawn from this analysis, the principal purposes will be the national consistency check and provision of regional impact analysis models. The first national 75 x 75 I-O matrix of the Thai economy constructed by NESDB also provides a basis for further extension to achieve a more disaggregated national analysis.

Thus linear programming, macroeconometric, and I-O models have been identified and to varying degrees applied in Thailand's Agricultural Sector Analysis Project. The following discussion and schematic illustration explains how the component models and intermodel linkages are used to research and analyze agricultural policies (Figure 1).

Stepwise Operation of Thailand's Agricultural Development Policy Models

At the national level

1) Problem identification from the conventional economic situation and formulation of national policy alternatives for testing and analysis.

2) Linear programming model of agricultural production, marketing, and transportation considering agricultural policy variables and/or related constraints from which employment, income, exports,

and imports from agricultural production, processing, transportation, and marketing are obtained.

3) Building of a macroeconometric model with equations for aggregate sectors relationships between production and final demands expressed as a function of predetermined agricultural and nonagricultural policy variables.

4) An LP/Macro linkage through incorporation of macro variables into the LP system such that total output, income, and employment from all sectors as well as policy indicators like gross domestic product (GDY), national income (NY), personal disposable income (PDY), income distribution among sectors and net investment can be derived.[1]

5) Identification of economic subsectors in the more aggregate farm and nonfarm sectors of a national I-O model.

6) An LP/Macro/I-O linkage to a national I-O transaction table with coefficients derived and obtained from the LP/Macro model and outside sources. This consolidated model is formed in such a way that it provides a consistency check concerning the national policy objectives and related national I-O model description of the economy.

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[1]The linkage between the agricultural model and the macro model is recursive. The outputs and results from consistency checks are used to make projections for the next time period. The linkage generates estimates of total output, employment, income from all sectors, GDP, NY, PDY, income distribution, industry and sub-industry consistency and feasibility checks, multipliers analysis, etc.

7) Performing of sub-sector consistency and feasibility checks prior to the computation of multipliers for output, income, and employment from the consolidated I-O model.

8) Macro projections of domestic and export demands from the macroeconometric model and the feeding of these projected demands back into the system starting from step one through seven.

9) Revised and/or newly proposed policies not yet encountered can be incorporated into the models from which further simulations and new solutions can be obtained.

<u>At the regional level</u>

1) Regional policy identification that is consistent with the national goals.

2) Regional breakdown of agricultural domestic demand and of non-agricultural export and domestic demand from the controlled totals obtained in the macro projections at the national level.

3) Interregional flow (regional exports and imports) of agricultural commodities taken as breakdowns of the national LP model.

4) Incorporation of 2 and 3 in regional LP models of agricultural production, processing, marketing, and transportation.

5) Forming of regional From-To models and a regional I-O model with consideration of policy identification in 1 and incorporation of demand breakdowns in 2.

6) Consolidation of 4 and 5 in regional LP/IO linkages.

7) Establishment and evaluation of regional programs concerning crop and livestock production, land, and labor use. Estimation of

capital requirements, direct and indirect impacts on total income and employment, etc. (Agricultural production, processing, transportation, income and resource use is zone-specific.)

8) Consistency and feasibility checks of flows between the regional LP model and that of the national level, and between the regional I-O and the national I-O models.

Farm-level modeling

1) Farm-level modeling specific to soil type, agro-climatic cropping pattern, and type of farm. Identification of farm-level extension program requirements, coefficients from updating planning and predicting farmer response to policy within agroeconomic zones.

2) Consistency and feasibility checks between farm level LP models and regional LP models as well as the agricultural sector coefficients of regional I-O models.

Special studies

Specific models (including econometric commodity models for demand analysis, transportation, processing and storage, livestock production, and polyperiod models) are used to develop model coefficients at the national, regional, and farm level.

Farm-level modeling. Farm-level modeling is a relatively new project activity introduced in order to extend our analyses to the farm level. Its addition permits us to refine our national, regional, and zone level analyses and will enable us to make program recommendations specific to types of farms.

The national or regional model outcomes can be used to identify income distribution problems within the agricultural sector and between farm and nonfarm sectors. However, such model solutions best serve as broad policy guidelines to planners. The national and regional models do not always cover all detailed information on what an individual farmer should do to attain certain specified objectives. Thus, farm-level modeling consistent with national and regional outcome must be conducted to yield actual farm-level, detailed information concerning farm-level program requirements.

Detailed information of typical farms by commodity produced, resource availability, etc., and those typical farms in each region consistent with the national and regional models will yield at least two kinds of information. First, such LP solutions at the farm level tell typical farmers what, where, when, and how to produce. Secondly, the solutions tell what the government should do in order to provide a program consistent with national and regional objectives.

To illustrate the linkage between national, regional, and farm-level modeling, assume that an equity problem exists among and between farm and nonfarm sectors. Some corrective measures could be taken at the national and regional levels. However, the kind of recommendation in terms of detailed information to particular types of farmers is rather vague. In terms of action programs for the government and relevant agencies, it provides at best general recommendations in accordance with national and regional conditions. Typical farm-level modeling can encompass a broader range of local farm enterprises with respect to crop variety, technology and timing, multiple cropping, and availability of farm inputs such as water, fertilizer, and credit. Various specific government programs can then be drawn from LP farm-level modeling consistent with national and regional level outcomes. These might include the optimum size of farms for the land reform program, the amount of new variety seeds for the seeds program, and the right amount and timing of credit for credit extension programs. Thus, the whole set of action programs at the typical farm level could be formulated in a more detailed manner. This is critical because the current interregional- or regional-level models contain only the average type of farm in each zone which is far from realistic in terms of drawing detailed conclusions at the individual farm level.

At the same time, useful information obtained from farm level modeling can be fed back to regional and national level models to facilitate refinement and updating. Valuable knowledge such as critical enterprise constraints could be determined for use in upper level modeling so that farm, regional, and national models can be further harmonized. Through the feeding back and forth of information the objectives of the nation can be more effectively modeled at both aggregated and disaggregated levels and represent both national and farm-level conditions more effectively.

Supporting Programs

Without strong supporting programs, our sector analysis activities could not be realized.

Basic data provision

The Division of Agricultural Economics can be divided into two broad lines of activities, one of which deals with agricultural statistics and the other with economic analysis. The economic work depends very much on the services of the agricultural statistics group. Although the economic analysis group collects certain data on market prices of both farm products and inputs, it depends heavily on the Agricultural Statistics Center for data on area planted, farm receipts and expenses, farm population, land use, etc. Futhermore, data on production costs of crops and livestock used in model building are surveyed by the Center.

The primary data base for the National Agricultural Model was a 1971-72 general farm survey with 20,000 respondents and a 7,000 farm detailed enumeration subset. The Center is scheduled to undertake one general survey each year including a detailed enumeration subset as requested by the economic analysis group. In addition, the Center has several surveys on crop production and area planted by season during the year. At the end of the crop year a more comprehensive survey is conducted.

The size of the questionnaire is one of the factors limiting the detail of our economic data subset. How often it is changed depends on how quickly data requirements change. Supplementary surveys to provide detailed data supplementing that contained in the general survey are conducted periodically. Two such surveys were conducted to secure detailed economic data for the LP model after the 1971-72 general survey.

The Farm Management Economics and Agricultural Business Branch in cooperation with the Regional Economic Branch has also undertaken nationwide farm record keeping. This farm account project has been expanding the number of farmer cooperators each year in order to include all types of farms in the country and to collect local price and local market information. This information is regularly reported to our Bangkok headquarters for use in updating and improving technical coefficients employed in our models and for other purposes.

There are two other projects that are relevant and very important to our work. One is the Data Bank Project, which classifies, compiles, and stores time series data. The user can easily utilize those data directly from computer disks with the help of a library file.

The other project is a cost-of-production indexing project. The component costs of production of each crop and livestock enterprise at various locations have been disaggregated and any changes in the crop production technologies are to be identified by each new general survey. From survey information concerning changes, adjustment factors will be derived. Prices of each resource utilized in production are also recorded chronologically. On the basis of the above information set, the cost coefficients to be used in modeling can be updated regularly and model costs kept current.

We hope that all of the data and coefficients used in our models will be updated in a similar manner in the near future.

Staff training

With the desire for the Division of Agricultural Economics staff to better understand the economic problems and upgrade their economic and statistical analysis capability, two types of higher education training programs--an inservice training program and on-the-job training--have been pursued.

Higher Education Program

The Higher Education Program is divided into two categories. The first category involves sending staff to continue their education abroad. The second category enables staff to continue higher education in domestic institutions.

For the first category, the Division of Agricultural Economics has been greatly assisted by AID since 1962. The total number of masters graduates to complete degrees under AID scholarships is 42. Two Ph.D. candidates have now returned to do research work for their dissertations. Eleven persons are still in the United States studying for masters degrees. Ten persons are currently abroad studying toward Ph.D. degrees.[1] Under this category ADC also participated; one of the staff members went abroad for a Ph.D. program under an ADC scholarship. The Thai government also sent one student to study agricultural economics at the Ph.D. level some time ago and another is currently studying at the Ph.D. level in Germany. FAO also participated in this program. One masters degree graduate received grant support from FAO.

Under the second category, the Division staff study at the masters degree level in Thai universities. This type of project was started in 1971 under sponsorship of the Ford Foundation. Now two persons have graduated and another 13 are working on masters theses. Others are still taking courses.

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[1]The Division of Agricultural Economics would like to express its gratitude to Dr. Orlin J. Scoville and Dr. Fletcher Riggs, who were Chiefs of AID's Agricultural Division in Bangkok. Both of them were energetic supporters of the Division of Agricultural Economics not only in respect of the higher education program, but also economic research programs. Fletcher Riggs initiated the AID sector analysis in Thailand in harmony with the needs of the Division of Agricultural Economics.

In-service training

In 1971, ADC, jointly with the Division offered in-service training programs for the staff members of the Division. Three two-month training program sessions have been offered to some 20-30 staff members each year. The courses offered are mathematics for economists, economic theory, statistics, linear programming, computer programming, econometrics, and simulation. Special and short courses are also offered periodically in order to develop particular technical skills. The courses have enhanced work efficiency of the participants who gain a better understanding of work objectives and improve their analytical capability. Fortunately for the Division of Agricultural Economics, the ISU Team has participated as faculty for the In-Service Training Program along with some capable staff members from the Division of Agricultural Economics.

On-the-job training

Any models constructed in the Division of Agricultural Economics involve participation both by the people primarily responsible for model construction and the DAE technical staff who assist them closely. The members of the ISU Team engage in two jobs, one as model builders and the other as professors. This practice is followed so that the technical staff in the Division can learn research methods and techniques to improve their ability to conduct independent research after the AID project is terminated.

Day-to-day service activity

The analysis and development of potential policy choices are currently being done somewhat independently of the major modeling effort with a limited amount of essential cooperation with the modeling groups. If the modeling groups become too heavily involved in current policy analysis, perhaps development of the quantitative models would be unnecessarily delayed. It would be desirable for the modeling groups to be fully engaged in current policy formulation but the modeling effort is still in the early stages and must be moved along rapidly. Therefore, many of the short-term projects and related economic analysis are currently conducted by the Branches of Agricultural Marketing, Agricultural Production, and certain sections of the Branches of the Agricultural Development Planning and Farm Management Economics. Usually the policy choices are referred, through modeling staff working on long-term projects, to the higher ministry management for decision making. In addition to specific policy analysis, these branches have organized work systems so that a number of staff regularly analyze the economic issues and the impact of changes in the economy.

Conclusion

The success of the agricultural sector analysis work is attributed to such factors as:

1) A carefully planned Agricultural Sector Analysis Project requested by the Ministry which has continued to receive strong administrative leadership and support from the Ministry and Department of Technical and Economic Cooperation of the Royal Thai Government.

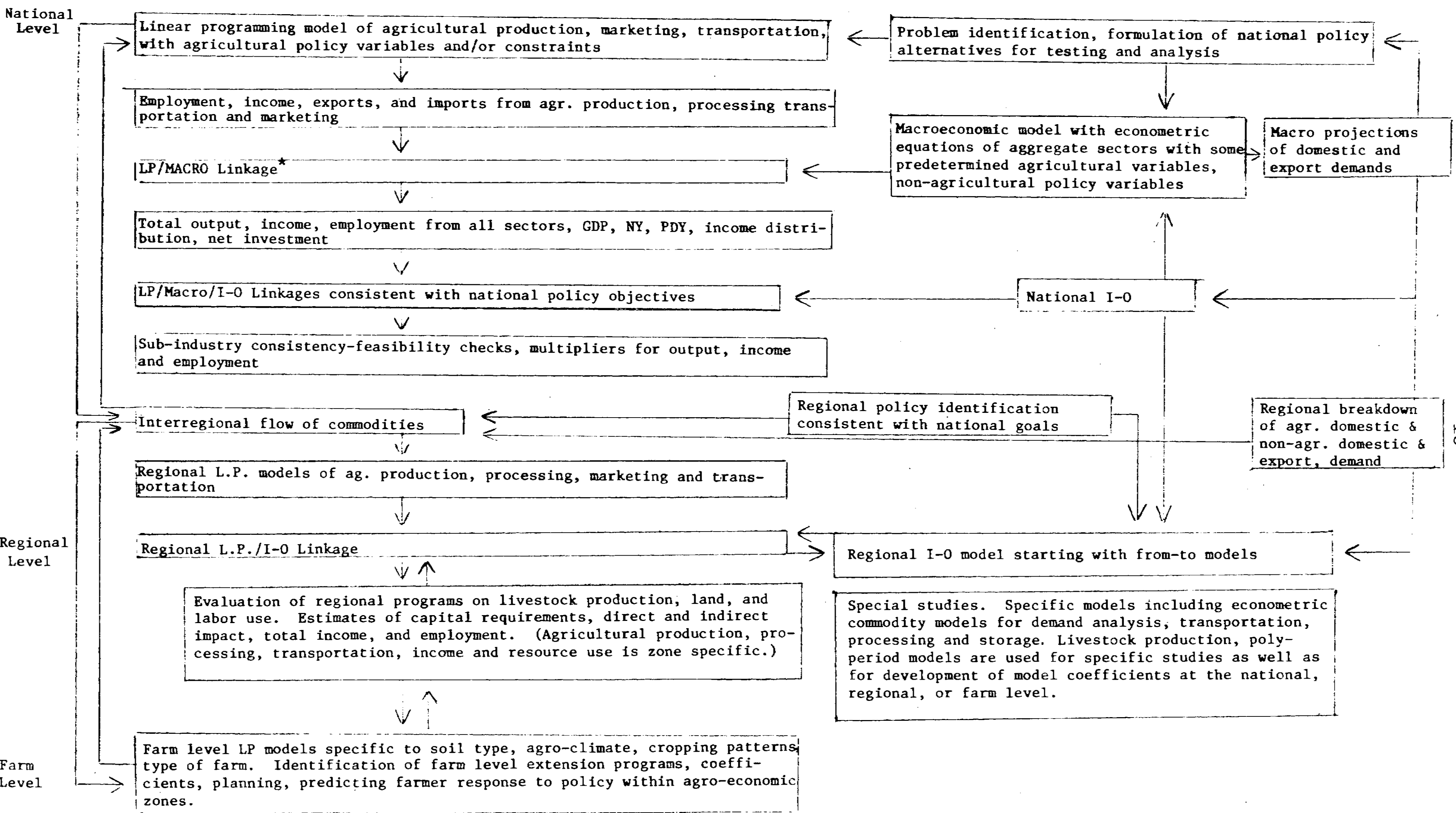
2) Good cooperation among the ISU and Thai staff members, who work together continually to improve understanding and communication.

3) Supporting services of the present statistical base, which though at present not complete, are continuously being improved.

4) Availability of a computer facility capable of handling the work load.

5) The Thai staff, who understand and enjoy what they are doing and are highly motivated workers.

Figure 1. Schematic Presentation of Thailand Agricultural Development Policy Models



*The linkage between the agricultural model and the macro model is recursive. The outputs and results from consistency checks are used to make projections for the next time period. The linkage generates estimates of total output, employment and income from all sectors, GDP, PDY, NY, income distribution, industry and sub-industry consistency and feasibility checks, multiplier analysis, etc.

II. INTERACTION BETWEEN THE ANALYST AND THE POLICY MAKER IN AGRICULTURAL SECTOR ANALYSIS: ART AND SCIENCE

Charles F. Framingham and Somnuk Sriplung*

Introduction

We view the task of interacting with policy makers as both an art and a science. Gaining and maintaining the confidence of first a conservative laissez-faire Minister of Agriculture and later his socialist successor, who opposed and defeated him, requires no small amount of artful diplomacy. At the same time the most carefully thought through modeling approaches developed on the basis of full understanding of the scientific concepts of economics are essential for sound policy-making research. Mastery of the art and science of interacting with policy makers and conducting research on their behalf is very difficult business.

Although interacting with policy makers is indeed difficult, we feel (a) there is a rather universally applicable context within which policy analysts function, (b) there are specific types of participants in the policy formulation process with identifiable roles and needs, and (c) there

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The authors wish to acknowledge the valuable comments offered by colleagues Arthur Stoecker and Herbert Fullerton during development of this paper.

are some principles that can be employed to facilitate development of more productive interaction between policy makers and policy analysts. The central purpose of this paper is to discuss that context, the actors and their specific roles and needs, and the principles we find applicable. The first portion of the paper is devoted to that discussion. The discussion is followed by presentation of two examples of policy interaction to illustrate the ideas presented and emphasize the importance of selected elements. A summary of the entire treatise completes the paper.

The Functional Context

The purpose of policy research is to provide analytical support and decision-making information to the government. That purpose can be accomplished best and communicated most easily through research planned and conducted in terms of and parallel with the environment in which governments function. It must have as its focal points those dimensions on which attention is focused, where questions are asked, and where answers are required.

Figure 2 provides a schematic illustration of the environment in which governments function. Six principal or focal points are identified in the functional environment. They are: 1) a set of all feasible policy objective alternatives, a subset of which are the actual policy objectives at any given time; 2) government policy and functioning programs; 3) a functioning economic system; 4) the level of actual policy objective achievement; 5) alternative programs; and 6) the relationship between desired and actual levels of objective achievement.[1]

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[1]This is only one possible ordering of the components and linkages between dimensions of the functional environment. As described by Fox, Sengupta and Thorbecke (1973), Tinbergen suggests other terms and another ordering of the dimensions. The reader is referred to this book for an intensive, in-depth discussion of models for development planning and policy analysis.

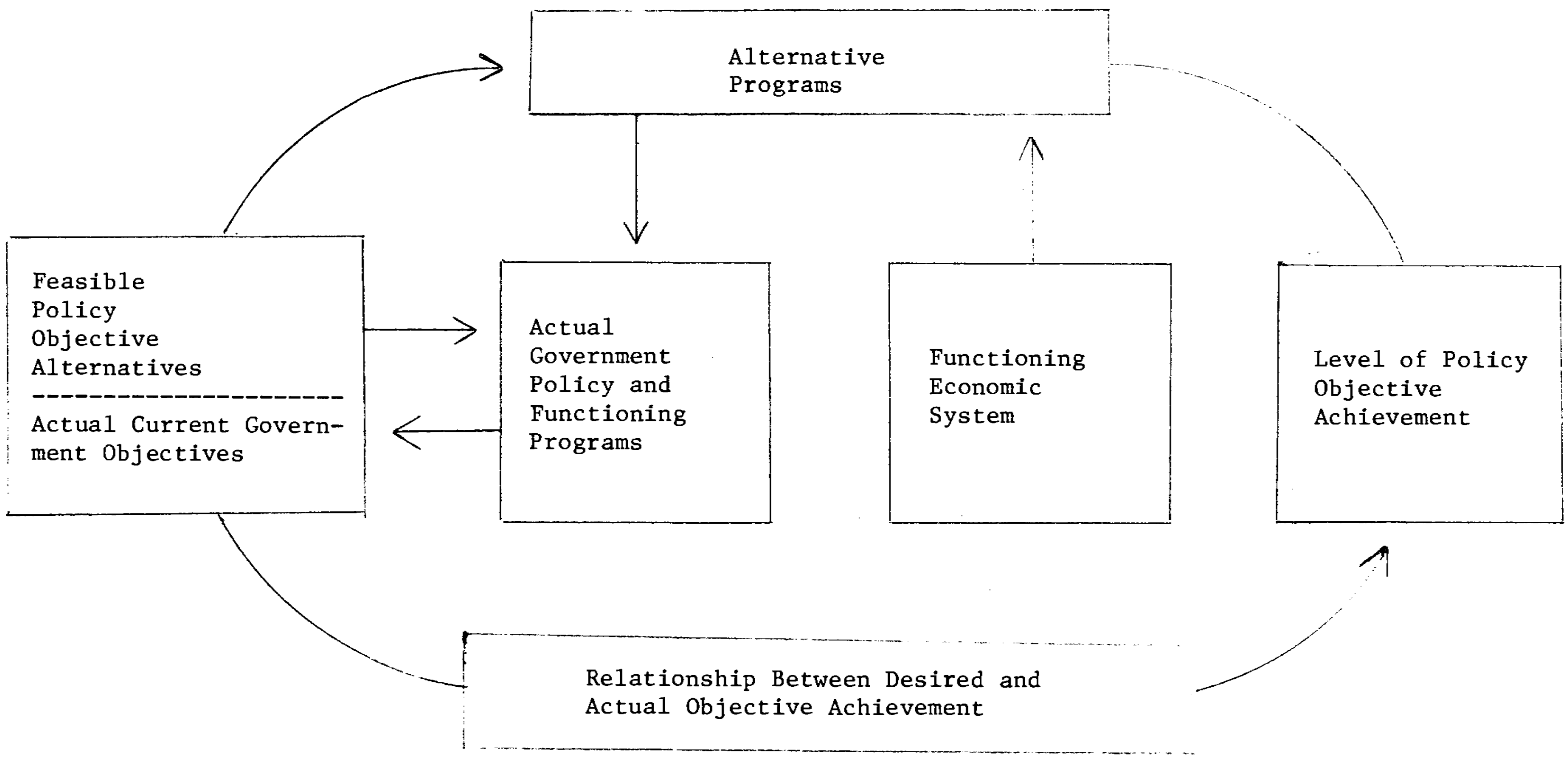

Figure 2. Government's functional environment

Policy Objectives

The set of feasible policy objectives is the entire set of objectives from among which the actual current government policy objectives, those important to the society and hence its government, are chosen. Elements of the feasible set range from objectives related to protection of the environment and individual freedom to provision of employment for everyone seeking work.

Government policy is that set of societal objectives actually chosen as those to be emphasized and pursued. Functioning programs[1] are the means identified as appropriate for pursuit of the government's policy objectives.

The ability to achieve the specified objectives is dependent on the country's functioning economic system and government programs implemented to modify it. The economic system encompasses all individual and group economic activity. This includes all sectors, agricultural and nonagricultural, and both private and public agencies and individuals within these sectors. The economic system is the machine employed to pursue society's objectives.

The levels of objective achievement or goal attainment indicate the success of society, through its government, in achieveing its policy objectives. How satisfied individuals and groups are with income levels and the employment situation, that is, their "standard of living," is the basis on which governments are judged.

The relationship of actual to desired conditions determines the extent of the need for more and/or different programs. The actual levels

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[1]These programs include both retained past programs and new programs.

of objective achievement and state of the economic system imply the kind of alternative programs that may be feasible.

Identification of the key actors functioning in the decision-making environment, understanding their roles, knowing their needs and knowing which of the actors to interact with and how, is necessary for success in developing and maintaining desired interactions between policy makers working in the environment just described and policy analysts. First, we will identify the actors and their roles and needs. Then we will discuss which actors the policy analyst should interact with and how; that is, the principles on which to base the interaction. The discussion is divided between the other actors in the system and the policy analyst as an actor.

The Other Actors: Their Roles and Needs

The "actors" is the functional environment within which policy decisions are made. Groupings according to the type of role actors perform are as follows:

1) Political Actors

- Private individuals and groups as political actors
- Members of the government in office and members of the opposition party or parties
- Politically appointed government staff (those who change with changes in government)

2) Managing Actors

- Senior civil service executives who interact with politicians (the senior government executives who don't always change when governments change)

- Private individuals and groups as executives and managers of the Functioning Economic System

3) Operations Actors
   - Civil servants and technical professionals (physical scientists) throughout the public service responsible for the operation of government programs and expenditures

4) Policy Research Actors
   - Academic professionals
   - Government policy analysts

5) Unclassified
   - Other country interests and philanthropic organizations

The sphere of interaction of each of the four types of actors is illustrated in Figure 3.

The role of the group referred to as political actors is, as the name suggests, political. The role of those who are, formally speaking, politicians (the government and the opposition where one exists) is to act on behalf of the people to achieve what society wants and/or what the politicians judge society ought to want and have. To carry out their role they interact with private individuals and groups on a political basis and with political appointees and civil service executives responsible for management of government programs and expenditures. Their needs include the need for means by which to communicate with society, knowledge of how well the economic system and current government programs are achieving their policy objectives, and information on potential program alternatives and how they affect the economic system and hence objective achievement.

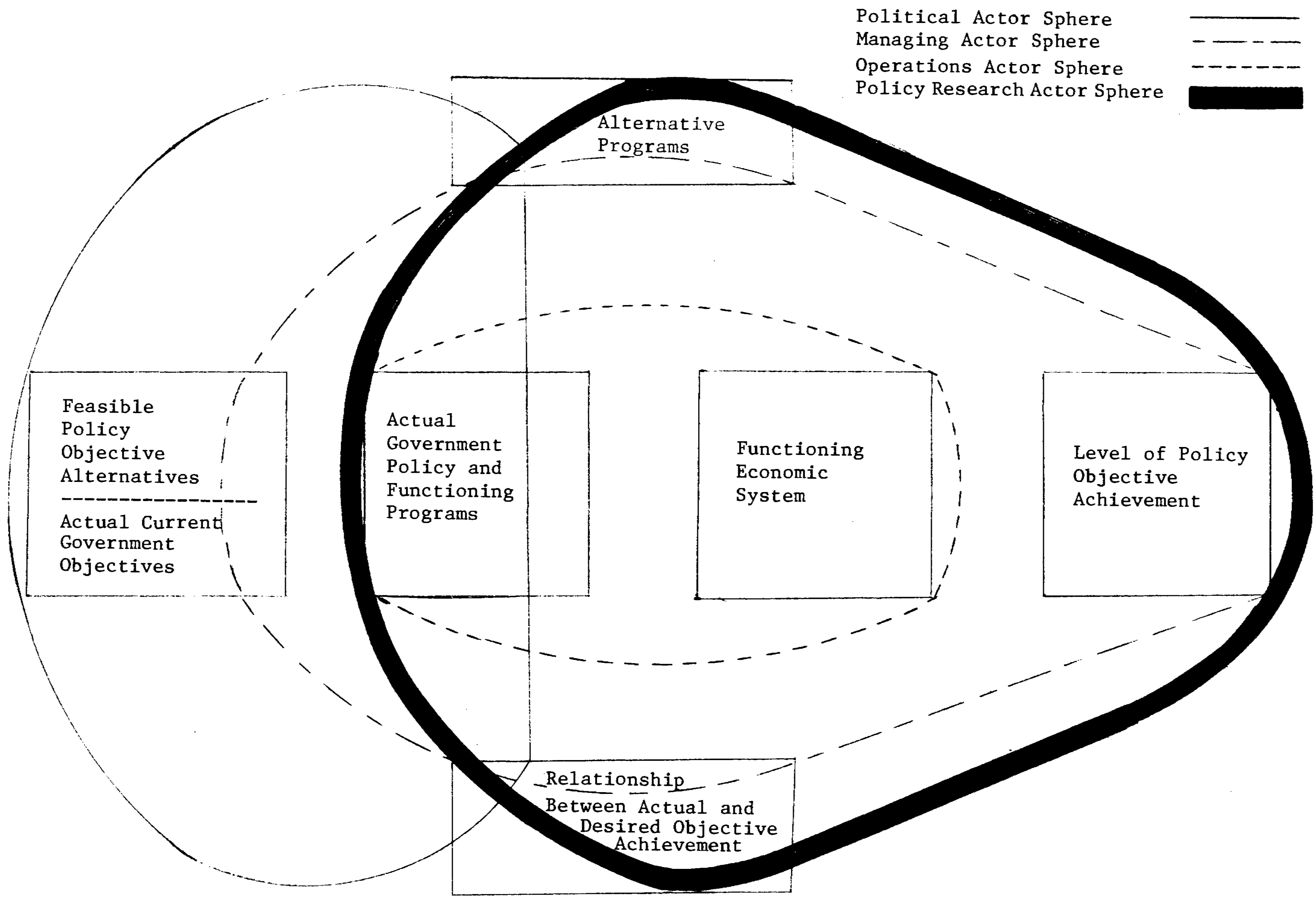

Figure 3. Spheres of actor involvement and interaction

The political role of private individuals and groups as members of society is to select and/or judge their government.[1] To fulfill their role well they require good information concerning the operations of government and their effect on societal objectives.

The role of political appointees (in some cases) and civil service executives, that is, the managing actors, is to keep the politicians informed and to answer their many questions, to manage government operations in a manner consistent with government policy, and to propose and implement programs to achieve government objectives. In fulfilling their role, they, as indicated by their sphere of operation, interact with individuals throughout the functional environment. To fulfill their role well they must know how well the system is achieving government policy objectives, must know how proposed program changes would affect objective achievement, and must have new program alternatives to suggest in response to government requests for ideas as to how to pursue any given policy direction.

The operations actors, that is, the public service at large, operate government programs. They receive instructions and carry them out. They are expected to know whether the programs for which they are responsible are successful or not. If the programs are not successful, the actors are expected to know why and what to do about it. To accomplish these tasks, they need analyses of their programs and their impacts and relationship to the functioning economic system.

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[1]In countries where the government is appointed rather than elected this role becomes that of accepting the government or revolting against it--an indeed difficult judgement but one not uncommon in history.

Two types of policy research actors are identified. They are academic professionals and government policy analysts. The role of the government policy analyst is the topic of the next section. The role of academic professionals is to conduct research for the purpose of refining and expending the theoretical basis for policy research and analysis, to constructively criticize applied policy research, and to train new professionals. Their needs include sources of statistical data and theoretical hypotheses, support for the importance of their role, and continuing demands for their services.

The remaining actors are those referred to as unclassified. They are other countries and philanthropic organizations who usually have one of two roles. They may function as humanitarian influences intent on improving the ability of a country to achieve its objectives or they may have the futherance of their own country's objectives as their role. Alternatively, their role may be some combination of humanitarian and home country objectives pursuit. Whatever the case may be, their need is a link with policy makers in the country or countries with which they wish to interact.

The Policy Analyst Actor: His Role and Needs

Effective policy analysts who provide support for government decision making concerning the agricultural sector are those who can 1) adequately describe the functioning economic system and explain why conditions in and related to the agricultural sector are, at any point in time, like they are; 2) simulate what future conditions would be like if specific changes were introduced; and 3) perform roles (1) and (2) in terms of current and/or contemplated government policy and programs.

To successfully carry out these roles the policy analyst needs to 1) have continual communication links with the policy makers, political staff, civil service executives, the operational government staff and the academic professionals; 2) have a modeling and analytical research capacity that enables him to respond to crisis issues and long-term planning questions; 3) have descriptive statistical and nonstatistical data concerning government operations and the functioning economic system; and 4) have analytical results indicating the current state of the functioning economic system and its status under alternative states which have high potential to become considerations in future policy and program development.

There are two general types of activities that the policy analyst must perform if he is to succeed. They are information seeking or questioning activities and modeling and analysis activities conducted to provide answers through the analysis of alternatives. The particular activities, identified by dimension of the functioning economic system to which they relate, are indicated in Figure 4.

The questioning type activities are those required to insure that the research deals with the real and potentially real issues. That is, the objectives measured and estimated in alternate simulations must be those that are or have a high probability of becoming policy objectives. Furthermore, program changes analyzed must be changes anticipated by government and/or changes identified as changes with good potential to stimulate achievement of government policy objectives.

The second type of activity is the modeling and analyzing of the economic system. It must be based on sound economic theory focused on the key components of and relationships in the functioning economic system.

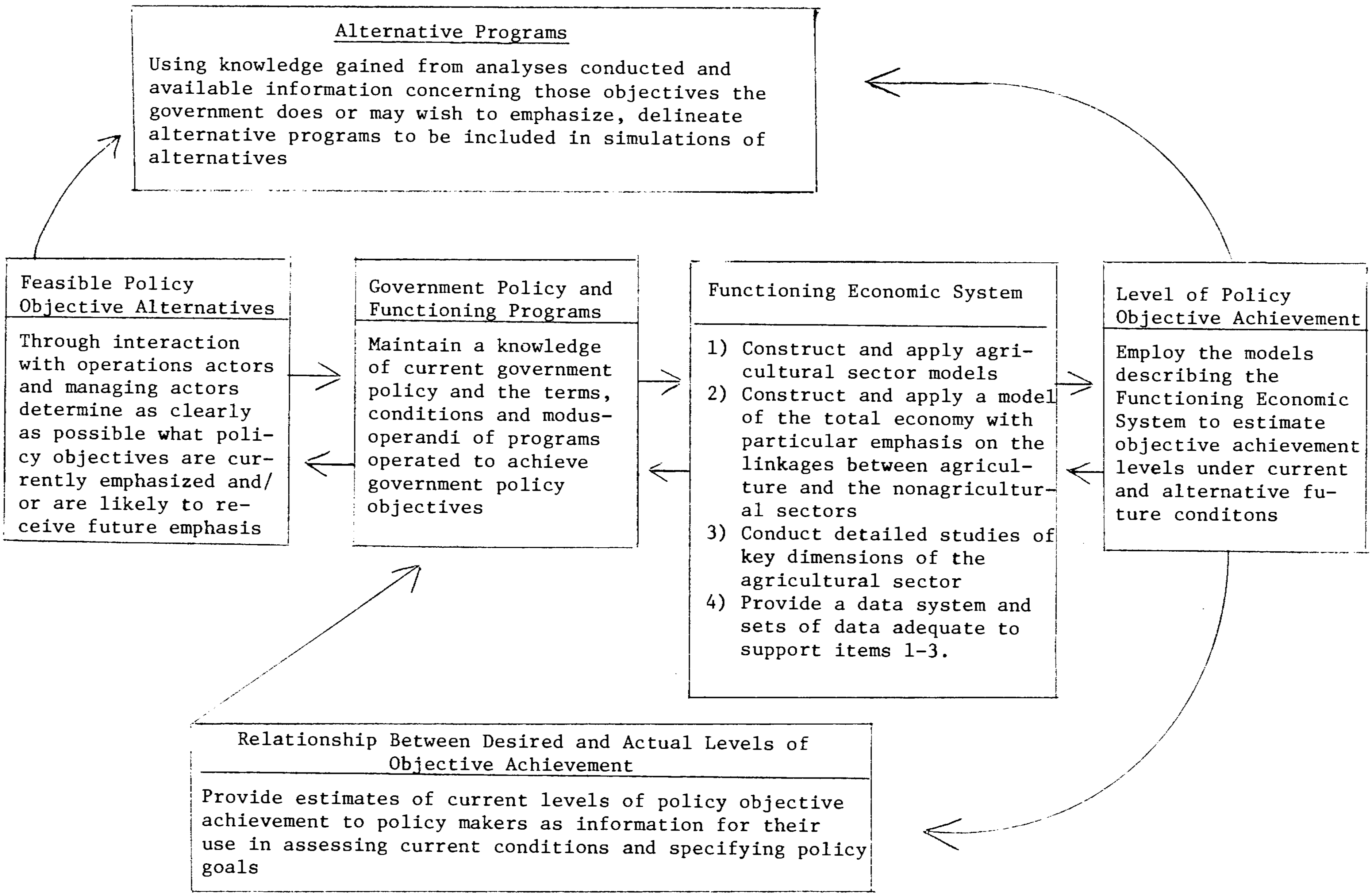

Figure 4. Types of activity conducted by the policy analyst in relation to the dimensions of the government's functional environment

The research models specified in terms of the key components and their intra- and inter-relationships must be applied to analyses designed to identify the key variables affecting the functioning economic system. It is this second type of research activity that typically receives the major time emphasis. However, the first is the most critical. Unless the research deals with the "right" issues, in terms that decision makers understand, the entire effort merely becomes academic exercise.

The activities required to insure that the right issues, objectives, and programs are researched are usually the responsibility of a few individuals. Those individuals who are close to and have the confidence of the government provide the link between the researchers and the government. They must have a mind skilled in discerning the politically real and professionally essential based on training and experience. They must (as shown by their sphere of action, as indicated in Figure 3) interact extensively with managing actors, operations actors, and other policy research actors. There are, we feel, some principles that enhance their potential to succeed. Those principles are the topic of the following section.

Some Operating Principles

The operating principles referred to above are:

1) Maintain an a-political posture and a low profile.
2) Assist those actors, to whom you relate, in filling their roles and satisfying their needs.
3) Involve civil service executive, technical-professional, and operating staff in your research.

4) Respond to government requests for assistance.

5) Don't promise things you cannot deliver.

6) Use carefully constructed models with sound theoretical bases, the best available data, and sound statistical procedures.

7) Know the quality of your results and be perfectly candid about it.

8) Present your results in a manner readily understandable by laymen.

9) Structure research capacity development so that useful results are produced at various stages of development.

10) Make all assumptions employed and their implications for the interpretation and use of results explicit.

11) Give others the spotlight.

12) Be realistic.

The following elaboration on each principle indicates why each is identified as important and how it can be expected to contribute to the success of the policy analyst in fulfilling his role.

Perhaps the most difficult task of the policy analyst is remembering that he or she is not a politician but rather a professional. However, to do so is essential in order to have any degree of assurance that the time required to establish and demonstrate the utility of a policy research capacity will be given. Politics "poles" and "groups" people as the government and the opposition--those for and those against. Policy makers of every government need analytical support and policy analysis. However, a government will not trust and have confidence in analysts who carry the political placard of the former government. Therefore, to maintain a policy analysis capability through changes in government the policy analyst must be a professional with a reputation for good objective research and not a professional-come-politician who holds press conferences and enters the political process regularly.

Remaining a-political requires that the analyst listen attentively to the interchange between the public (society) and the politicians but not become involved. Let the political decision makers establish policy. The analyst's role should stop at the point of demonstrating the implications of alternate policy choices. The alternate choices should include those ranging from (a) objectives reflecting the very selfish interests of a few individuals, perhaps even an individual minister to (b) objectives of the majority of individuals and having very real costs for perhaps that same minister. The analyst should clearly present the pros and cons of alternatives in both extremes. However, he should not argue which is "right" and which is "wrong." Deciding what is "right" and what is "wrong" are decisions to be made by politicians and courts of law.[1]

The second principle may be summarized in two words: "be helpful." The surest way to gain the support of the decision makers and the people in the system is to provide them with information that helps them during times of crisis. If you can provide critical information when they need it they will be much more willing to support you patiently. If you don't,

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[1]One characteristic of economic analysis makes choosing between an economic policy analyst's choices complex to the point where what is "right" may be "wrong" or vice versa. Economic analysts measure choices empirically and some objectives don't lend themselves to empirical measurement. The value of a museum of natural history to a society is certainly not a solely empirical question. The so-called "immeasurable" objectives requiring subjective decisions are areas where the analyst should proceed with extreme care.

you will soon find yourself ignored and/or looking for a new job. The same is true of all the other actors: political staff, civil service executives, government operating staff and agencies, academic professionals, and outside countries and agencies. If you are helpful, they will help and support you.

If you involve civil service executives and operating staff and technical scientists in your research related to their specific areas and needs, several things will happen. You will receive firsthand information concerning conditions in and surrounding the topic under study and have a better research program as a result. The operating and technical-professional staff and civil service executives will know and understand your research and the meaning of the results. Also, you will understand their work and how you can help each other.

Working with technical scientists has been traditionally difficult for policy analysts, but is is no more difficult for the policy analyst than for the technical professionals (plant scientists, etc.). There seems to be several reasons for the difficulty. First, each feels the other is trying to meddle in his affairs. Second, the technical people often feel threatened by the policy analyst. The only solution to this problem is the development of interactions through which both parties benefit. Once such interactions exist the problem disappears. In fact, a good problem of a different kind may well appear. Requests for analyses and consultation may exceed the capacity of your research staff.

The fourth principle, "Respond to government requests for assistance!" is really a restatement to emphasize the importance of being useful to the principal actors, the political decision makers. What this implies is maintenance of a capacity to respond to short-term issues and crises while working to develop a good continuing modeling and analytical capacity. In short, you need analysts responsible for day-to-day issues and others protected from such decisions. Such an approach is possible if the ability to respond to crises increases as the long-term modeling and research capacity evolves because effective response generates increased financial support, confidence, and patience.

Don't promise things you can't deliver. Nothing destroys mutual trust, confidence, and respect faster than failure to deliver the information requested for a policy decision which the policy analyst promised on a given day and the politician told the local labor union would be available by that day. It's better to indicate that it is not possible to provide such information by that time. Then alternative approaches to a decision can be selected or the decision delayed.

Good results and useful information are the product of sound theoretical models based on appropriately employed concepts. Here the policy analyst should interact with other policy analysts, his academic colleagues, and professionals from the technical sciences. Even professionals make errors of fact, omission, and interpretation. Interaction with colleagues will reduce the incidence of these and result in better models and correspondingly better results.

Economics, unlike the physical sciences, is a study of human actions that do not lend themselves to precise measurement. Quantitative results often have high standard errors or indeed only indicate orders of magnitude and direction of change. It's much better to be candid about the statistical properties of such results. We're sure some of you can envision the wrath of a politician who based his political future on guaranteed income increases of $200 per farm because the policy analyst's model said that his new program would have that effect when in fact the actual effect was only $20.

One earlier principle recommended involvement of civil service executives and operating staff in research, the purpose being more effective communication and understanding. It is not possible to involve politicians in research. Nevertheless, the results of analyses conducted on their behalf in response to questions they ask must be communicated to them in terms they understand. They have limited time to read and they understand graphs and pictures, not equations. It is therefore necessary to get the message on (as we have often heard it said) three pages and some charts that communicate.

The capacity to measure sectoral and intersectoral relationships in a national perspective is a very important part of the package needed to provide good policy analysis. Developing such modeling capacity and the data to support model estimation and application is time consuming and expensive. If governments spend large amounts of money for successive years and see no useful results, they lose faith and become skeptical. However, if construction and application of such models are phased to provide meaningful outputs as the capacity evolves, faith is maintained and the utility of the moneys expended is seen and understood.

Policy analysis research usually requires assumptions either because of data and modeling capability restraints or political restraints imposed by policy makers. For instance, a policy analyst may be asked to analyze alternative ways of increasing income through introduction of selected upland crops and told to assume no outmigration from the region in question. Such constraining assumptions and others should always be made explicit to guard against misinterpretation, misuse and/or accusations of political bias.

The next is a simple but very important principle. Give others the spotlight. Nothing makes supporters more loyal than making them look good.

Finally, be realistic. The approach and principles we propose might lead one to assume that if they are followed everything will happen according to plan. You can be certain it will not. The process of public decision making is as referred to as a process of "disjointed incrementalism" (Braybrooke and Lindblom, 1963). Governments change, most politicians are not professionally trained planners, and politicians have limited time to consider new approaches, ideas and research analyses based on established theory. Therefore, the policy analyst should be encouraged if political decision makers consider the analyst's results and information, continue to solicit his assistance and if, over time, decisions are taken on the basis of more complete information and understanding.

At the outset we indicated that the main thesis of our paper would be followed by several examples illustrating its application. Presentation of illustrative examples of application of the entire approach and set of principles suggested is beyond the scope of this paper. However, the following selected examples are given to demonstrate the importance of the approach and principles as means to facilitate interaction between policy analysts and decision makers.

A Successful Failure

Our first example of the proposed approach is drawn from the experience of a policy analysis group in a North American context. Under a conservative government with a right-wing philosophy, a committee responsible for planning research to support and improve government decision making was established. One component of the committee was a policy analysis group. The other was a small group of civil service executives whose role was to be managing actors. The legislation that was enacted provided for establishment of the group explicitly identified as the committee responsible for interaction with the various government departments. The principal purpose of this action was to classify existing programs in relation to government policy and evalute their effectiveness. Conceptually, and in fact, the approach was functional. It was patterned like the approach suggested here.

Some six to eight months after the committee became operational the conservative government fell and was replaced by a socialist government with a more leftist philosophy and in theory committed to a planned approach. Initially this new government relied heavily on the committee and its very experienced managing actors supported by the policy analysis group, but only initially.

After the new government had been in office long enough to familiarize itself with its role and the existing system, some members of the newly elected government and their political advisors suggested that the managing actors, who were long-time advisors of the former government, must surely be politically biased by their long association with the philosophy of the previous government. They insisted their commitment to the new government could only be demonstrated by their joining the political party of the new government. They refused and left for other positions. They failed for real or imagined reasons to remain a-political, the principal essential in order to survive changes of government.

The policy analysts within the committee succeeded in remaining a-political but also resigned because of an unwillingness to present their research results in a politically biased manner. They chose rather to maintain their professional objectivity and a-political approach and did so by accepting university positions.

One could conclude the approach had failed but not entirely. The committee continued to exist, thus demonstrating the need for such research and a planned approach. Furthermore, the new government subsequently contracted with their former director of policy analysis to provide further policy analysis. Their action is evidence of the value of adhering strictly to the principle of doing quality research based on sound theoretical principles of economics and statistics. Did the approach fail? Not completely, the policy analysts survived as policy analysts recognized as having a reputation for useful objective research conducted in an a-political manner.

A Success to Date

Our second example is based on the experiences of the Division of Agricultural Economics (DAE) as an evolving agricultural planning analysis agency for the Ministry of Agriculture and Cooperatives of the Royal Thai Government. It is presented to illustrate that:

1) By maintaining an a-political posture planning analysts can serve successive governments.
2) Responding to government requests for assistance is important.
3) Use of carefully constructed models based on sound theory and improved data sources produces results accepted in continuously widening circles as useful for planning.
4) Presenting your results in a manner readily understood by laymen increases the ability of the policy analyst to interact and support policy decision making.
5) Structuring research capacity development to produce useful results at various stages of capacity development increases support for the policy analyst.

More than a decade ago it was decided that a structured sector modeling approach to policy analysis in the DAE, supported by improved data sources, was essential for development of an effective policy analysis capability. Effective policy analyst-policy maker interaction was judged to require it.

To develop a sector modeling approach, steps were taken to establish data sets needed for implementation of such an approach. Financial support for staff training and model development also was sought out and secured. Over time, a modeling capability evolved.

During the entire period of model evolution, government requests for short-term crisis research were responded to. Those requests ranged from consideration of the reasonableness of prices quoted for government grain bin purchases to writing ministerial speeches on behalf of the managing actors. Extreme care was taken to prevent widespread knowledge of this speech-writing activity in the interests of remaining a-political.

When development of an agricultural sector model for Thailand reached the stage where it could be used for meaningful policy analysis, it was applied. The initial application was an analysis of the implications of alternate land availability constraints on crop production in Thailand. This analysis (based on the national crop model prior to the addition of livestock production) was based on the principle of providing useful results at various stages of model development.

About the time the crop model results became available the Minister of Agriculture questioned the productivity of the DAE as structured and proposed redistribution of its capacity. In response, the results of the crop model analysis were translated into a graphical presentation and shown to the Minister as indicative of policy analysis capability developing in the DAE. They communicated and demonstrated the capacity of the DAE to estimate the income and exployment impact of government programs such as alternate land development strategies. As a result, the Division survived. In fact, the Minister proposed an elevation of its status. Presenting research results in a readily understandable manner is indeed important.

A further effect of the analysis of the impact of alternate land constraints on crop production in Thailand was a request for further impact analyses and planning research. The initial impact analysis results, presented in layman's terms, were discussed with the National Economic and Social Development Board, which is responsible for national planning development. As a result, it requested that the DAE conduct research to serve as guidelines for development of the Fourth Five-Year Plan for Agriculture. Slight modification of the then current model made such analysis possible. As a result, specific impact analysis guiding plans for expansion of irrigated area, improved rice variety use, expanded fertilizer use, and controlled expansion of upland cultivation were provided as inputs for national planning. The sector analysis approach was applied and interaction increased. It was a definite step in the right direction.

The role of the policy analyst in Thailand is evolving. How important it will ultimately become is unknown and much remains to be done. Only minor inroads of interaction with operational departments in the Ministry of Agriculture have been developed and interaction with other ministeries is still very infrequent. Steps to improve both types of interaction are being initiated. The level of success cannot yet be determined but to date success has been achieved. That success is, we feel, directly related to adherence to application of the approach and principles presented and discussed in this paper.

Concluding Comments

Perhaps the most appropriate summary for this paper is a reiteration of its basic ideas. First, always approach the task of policy interaction in terms of the environment and the actors in which a government functions. Given that approach, apply the following principles:

1) Maintain an a-political posture and a low profile.
2) Assist those actors, to whom you relate, in filling their roles and satisfying their needs.
3) Involve civil service executive, technical, professional, and operating staff in your research.
4) Respond to government requests for assistance.

5) Don't promise things you cannot deliver.

6) Use carefully constructed models with sound theoretical bases, the best available data, and sound statistical procedures.

7) Know the quality of your results and be perfectly candid about it.

8) Present your results in a manner readily understandable by laymen.

9) Structure research capacity development so that useful results are produced at various stages of development.

10) Make all assumptions employed and their implications for the interpretation and use of results explicit.

11) Give others the spotlight.

12) Be realistic.

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III. NATIONAL CROP MODEL OF THAILAND: APPLICATION, STRUCTURE, DATA REQUIREMENTS, AND RESULTS

Arthur Stoecker and Kanok Khatikarn

Introduction

One of the group of interrelated models being developed within Thailand's Agricultural Sector Analysis project is the National Crop Model of Thai agriculture. Its purpose is to provide a basis for analysis of alternative crop production levels and technologies in relation to livestock production and production in nonagricultural sectors. Although the livestock model has not been completed and the linkage to the nonagricultural sectors is very preliminary at present, the National Crop Model has been applied to analyze a set of crop production alternatives.

The purpose of this chapter is to indicate the nature of the applications made employing the current crop model, the structure of the model, the data requirements, and the results of its application.

In the first part of the chapter, the nature of the policy issues will be presented, followed by a description of the model. Discussion of model data requirements and a brief summary of the main results and implications completes the chapter.

The Policy Issues and the Modeling Effort

The DAE was asked by the National Economic and Social Development Board to develop a series of guidelines for the agricultural part of the Fourth Five-Year Plan for Thailand. After the dialogue between the policy and the modeling staff was completed, the principle issues which could be addressed by the programming model of crop production were summarized as follows:

1) The adequacy of the productive capacity of Thai agriculture to meet expanding export markets and increased domestic consumption needs over the next five-year period if the policy of limiting the area in farms to current levels was enforced
2) The effect of the completion over the next five years of irrigation projects in progress on 12 million rai on agricultural income, employment, and productive capacity
3) The effect of and the incentive for increased rates of adoption of new varieties of rice and fertilizers
4) The expected levels of future farm income and employment
5) The effects of alternative rates of population growth
6) The future requirements for agricultural credit

Planners face several types of uncertainty. In the present situation two of the major uncertainties include world conditions which influence export markets outside Thailand and the degree of success of programs for agriculture from alternative programs and the levels of program attainment were made by obtaining seven solutions from a national linear programming model of crop production. Each of the solutions showed the effects of achievement or nonachievement in programs for population control, irrigation, crop promotion, and fertilizer use in combination with possible levels of exports.

The crop model was designed to represent conditions in BE 2524 (1981), which will be the end of the Fourth Five-Year Plan period. The national parameters for the following seven solutions are summarized in Table 1.

The main assumptions for each solution were:

A. Solution A represented an optimistic view of program success and export market potential. It assumed that all program targets specified in Table 1 were obtained and that Thai exports reached high levels. The high levels are shown in Table A.7.

B1. Alternative B1 represented conditions for a medium level of success in all areas. The export levels were assumed to be medium. It was assumed that population growth rate slowed to a medium level (2.5%) by 1981. The levels of irrigation project completion were assumed to be medium. Similarly, it was assumed that fewer farmers adopted RD varieties and smaller amounts of fertilizer were applied to each rai of paddy land receiving fertilizer than in solution A. With alternative B1, planners assumed a higher level of domestic consumption, a lower level of export demand, and a smaller productive capacity than for alternative A.

B2. The parameters for alternative B2 were the same as for B1 except that it was assumed that a policy to increase annual incomes in the Northeast by approximately $50 U.S. per household through expansion of upland crops had been adopted. Alternative B2 was added to the solution set after solutions to the remaining alternatives showed that strictly economic efficiency criterion would shift production out of the Northeast thus creating high levels of unemployment and potential for mass outmigration.

Table 1. Principal and illustrative alternatives analyzed

Planning Factors	Principal Alternatives			Illustrative Alternatives			
Demand Factors:	A	B1	B2	C	D	E	F
1) Population: Growth Rate (Percent)	2.1	2.5	2.5	2.8	2.1	2.1	2.1
2) Income: Growth Rate (Percent)[a]	2.2	2.2	2.2	2.2	2.2	2.2	2.2
3) Exports	High	Medium	Medium	High	Low	High	High
4) Commodity Prices	BE 2516 - BE 2518 Average Level or Government Controls						
Supply Factor Maximum Use Levels							
1) Land Available: (1,000 rai)							
Total	111,547	111,547	111,547	111,547	111,547	111,547	111,547
Type I	2,927	2,927	2,927	2,927	2,927	2,927	2,927
Type II	19,805	13,649	13,649	19,805	19,805	10,241	10,241
Type III	48,637	54,794	54,794	48,637	48,637	58,202	58,202
Type III Total Usable	32,237	35,544	35,544	32,237	32,237	37,614	37,614
Type IV	40,073	40,073	40,073	40,073	40,073	40,073	40,073
Type V	104	104	104	104	104	104	104
2) Irrigated Land: (1,000 rai)							
Total	24,582	16,992	16,992	24,582	24,582	12,205	12,205
Wet Season	19,805	13,665	13,665	19,805	19,805	10,241	10,241
Dry Season	4,900	3,228	3,228	4,900	4,900	1,964	1,964
3) Technology Adoption: (Percent or 1,000 rai)							
RD Variety Use:							
Max. Percent of Land II for RD in Wet Season[b]	62.7	49.9	49.9	62.7	62.7	62.9	31.5
Max. RD Area on Land II	12,420	6,407	6,407	12,420	12,420	6,446	3,223
Max. Percent Land III	27.2	21.5	21.5	27.2	27.2	22.3	14.3
Max. RD Area on Land III	8,788	7,659	7,659	8,798	8,798	8,535	5,470

Table 1 (continued)

Planning Factors	Principal Alternatives			Illustrative Alternatives			
Demand Factors:	A	B1	B2	C	D	E	F
4) Max. Fertilizer Use: (Kgs. per rai)							
On Native Varieties	25	25	25	25	25	25	25
On RD Varieties	80	60	60	80	80	80	Levels
Area Fertilized (1,000 rai)	20,567	19,300	19,300	20,567	20,567	18,758	14,974

[a]This growth rate is based on past trends and assumes their continuation.

[b]The maximum dry season rice area was assumed to be 80 percent of irrigable land.

SOURCE: Thailand's Fourth Five-Year Agricultural Development Plan, B.E. 2524 - Guidelines, Prepared by Division of Agricultural Economics, Ministry of Agriculture and Cooperatives on behalf of The National Economic and Social Development Board, Office of the Prime Minister, Royal Thai Government.

C. The model assumptions for solution C were the same as for solution A except that population growth was assumed to continue at a high rate of 2.8 percent per year through 1981. All other program levels except the population targets were assumed to be reached. High export levels were assumed.

D. The model parameters for alternative D were the same as for Alternative A except that only "low" levels of commodity exports were assumed possible. All other development targets were assumed to be obtained.

E. Alternative E represented a situation where export potentials were high and the population growth rate low, but the areas receiving irrigation water and planted to RD varieties were assumed to remain at current levels.

F. Alternative F represented a situation with no increase in technology or productive capacity over current levels. The population growth rate was assumed low and export levels were assumed to be high as in solution A.

National L.P. Model of Crop Production

In this section the general structure of the programming model of crop production is presented together with a brief description of the changes made to the basic model between solutions.

The linear programming model of crop production is composed of 19 agroeconomic zone submodels. The 19 agroeconomic zone production submodels are grouped into four regional consumption areas. The four consumption regions are spatially linked by a commodity specific interregional transportation network. The delineation of the 71 changwats into the 19 agroeconomic zones and the grouping of the zones into the four major consuming regions is shown in Figure 1.

Structure of the model

The structure of the national crop model is shown schematically in Figures 2 and 3. The model contains between 350 and 450 equations depending on the particular policy set being analyzed.

The current model of crop production does not contain price-dependent demand relationships. The fixed point demand projections used in the current model are based on per capita demands, income elasticities, assumed income, and population growth rates. Fixed point demands were also used for all agricultural exports except rice and maize. For rice and maize, exports were allowed to vary up to a specified maximum at a constant price.

Variables and the objective function. The model shown in Figure 7 may be formally stated as

$$(1)\ \text{maximize} \sum_i E_i P_i - \sum_z \sum_j C_{zj} X_{zjts} - \sum_z \sum_k b_{zks} K_{zks} - \sum_{\substack{c \\ c \neq d}} \sum_i S_{cdi} T_{cdi} - \sum_d \sum_i S_{dci} T_{dci}$$

where E_i is the amount of product i exported at price P_i

X_{zjts} is the level of production process j in zone z on land type t in season s

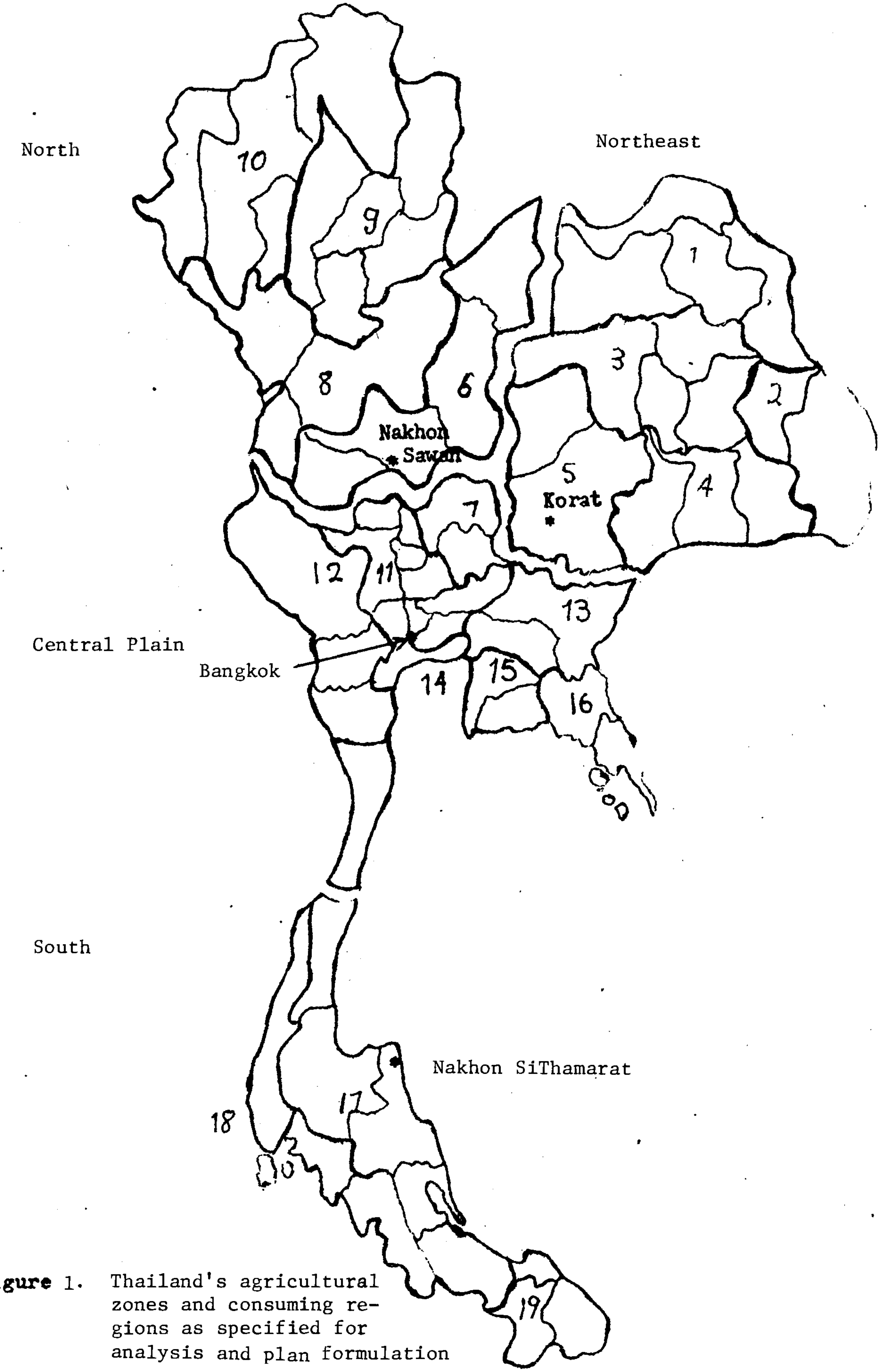

Figure 1. Thailand's agricultural zones and consuming regions as specified for analysis and plan formulation

Restraints	Activities for production and capital use in zone 1									Activities for zones 2,3,4 and 5			
	Rice	Rice	Rice	GNut	Rice	GNut	GNut	BOic	BOic	ACT2	ACT3	ACT4	ACT5
Bounds	B	B	B	B	B	B	B			B	B	B	B
Objective	-c	-c	-c	-c	-c	-c	-c	-i	-i	-c	-c	-c	-c
Land 1 W	1												
Land 2 W		1											
Land 3 D			1	1									
Land 3 W					1								
Land 4 W						1							
Land 4 D							1						
Labor W 1	a	a			a	a							
Labor W 2	a	a			a	a							
Labor D			a	a			a						
Cap W	a	a			a	a		-1					
Cap D			a	a			a		-1				
Bor. cap								1	1				
Sub Dem	-y	-y	-y		-y								
Res 2										A			
Res 3											A		
Res 4												A	
Res 5													A
NE rice dem	-y	-y	-y		-y								
NE g. nut dem				-y		-y	-y						
RD max L 2W		a											
RD max L 2D			a										
RD max L 3					a								
FERN	a	a	a		a								
FERP	A	a	a		a								

[a]The Northeast region of the model is linked to the North, Central, and South regions by transportation activities as shown in Figure 7.

Figure 2. Schematic presentation of the Northeast[a] section of the National Crop Production Model (The illustration uses two crops to show detail by land type in zone 1 while matrix notation is used for zones 2, 3, 4 and 5.)

	Production activities in each zone																			Interregional transportion								Export
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	T	T	T	T	T	T	T	T	E
Bounds	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B									
Objective	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	-c	Pe
Resource Z1	A																											
" Z2		A																										
" Z3			A																									
" Z4				A																								
" Z5					A																							
Demand N.E.	-Y	-Y	-Y	-Y	-Y															I	-I					-I	I	
Resource Z6						A																						
" Z8							A																					
" Z9								A																				
" Z10									A																			
Demand North						-Y	-Y	-Y	-Y													I	-I			I	-I	
Resource Z7										A																		
" Z11											A																	
" Z12												A																
" Z13													A															
" Z14														A														
" Z15															A													
" Z16																A												
Demand Central										-Y	-Y	-Y	-Y	-Y	-Y	-Y				-I	I	-I	I	I	-I			I
Resource Z17																	A											
" Z18																		A										
" Z19																			A									
Demand South																	-Y	-Y	-Y					-I	I			

Figure 3. Schematic diagram of national crop model with four consuming regions and 19 agroeconomic producing areas

C_{zjts} is the variable cost associated with production process j in zone z on land type t in season a. The variable cost includes farmer purchased inputs and processing plus assembly and shipment to the region shipment point

K_{zks} is the amount of capital borrowed from source k, in zone z in season s (k = 1, 3; s = 1, 2)

B_{zks} is the interest charge on money borrowed from source k, in zone z for the duration of season s

T_{cdi} is the amount of commodity i shipped from consuming region c to consuming region d (c, d - 1, 4; c ≠ d)

S_{cdi} is the line haul cost of shipping one unit of commodity i from consuming region c to consuming region d

Subject to:

Land constraints:

(2) $\sum_{i} X_{zjts} LD_{tsz}$ t = 1, 5; s = 1, 2; z = 1, 19

where LD_{tsz} is the quantity of land type t in season s and zone z which is available for production of the crops in the model

Labor supplies:

(3) $\sum a_{zjts} X_{zjts} \leq LB_{zs}$ s = 1, 3

where a_{zjts} is the number of hours of labor required per unit of process X_{zjts}

LB_{zs} is the supply of labor available for crop production in zone z, season s

Capital supplies:

(4) $\Sigma\, a_{zjts}X_{zjts} - K_{zks} - FC_{zs} \leq = 0$

where a_{zjts} is the amount of short term capital required for production process j in zone z on land type t in season s

K_{zks} is the amount of capital borrowed from source k, zone z in season s

FC_{zs} is the amount of farm capital on hand at the beginning of season s, zone z

Regional food balance equations:

(5) $\sum_{z}\sum_{j} Y_{jzi}X_{jz} + \sum_{\substack{c \\ c\neq d}} T_{cdi} - \sum_{\substack{d \\ d\neq c}} T_{dci} \geq D_{ic}$

where Y_{jzi} is the amount of product i produced by production process j, in zone z

T_{cdi} is the amount of outshipment of product i from region c to region d

T_{dci} is the amount of inshipment of product i from consuming region d to consuming region c

D_{ci} is the amount of total demand for product i in consuming regions c

Requirements for subsistence demand:

(6) $\sum_{j} Y_{jz}X_{jz} \geq SD_{iz}$ $\quad$ i = 1, 2

(7) $X_{jz} \geq LB_{jz}$ $\quad$ i = 3, n

where SD_{iz} is the amount of commodity i consumed on farms where produced in zone z

LB_{jz} is a lower bound on production such that $LB_{jz} = SD_{iz}/Y_{jz}$

Export targets:

(8) $E_i \leq E_{mi}$ $\quad i = 1, 3$

(9) $E_i = E_{mi}$ $\quad i = 4, n$

where E_i is the amount of commodity i exported

E_{mi} is the maximum export assumed possible for commodity i

Maximum levels of technical change assumed feasible:

(10) $\sum_x \sum_j X_{jzr} \leq MT_{rc}$

where M_{trc} is the maximum land area assumed feasible for adoption of technology r in consuming region c

Income constraints:

(11) $\sum_x \sum_j X_{zjt}\ nr_{zjt} \leq INC_{tc}$

where nr_{zjt} is the net revenue expected with production process X_{jzt}

INC_{tc} is the target level of income required from land type t in consuming region c

Objective function. The motivation contained in the objective function as stated in equation (1) along with the fixed demand requirements is analogous to the motivation of a subsistence farmer who wants to maximize his off-farm cash sales after first insuring that there will be sufficient production to meet family consumption needs. In equation (1) the export earnings are similar to the cash sales of the subsistence farmer.

Fixed demand requirements are equivalent to the assumption that the demand for a product is perfectly inelastic. The cost minimizing solution to a linear programming model with fixed levels of demand does generate a set of prices which, if implemented in an economy with decentralized decision making, would guide production decisions so that final demand targets could be met within certain limits.

If a feasible solution exists to a linear programming model such as shown in Figure 8, the equilibrium price Pe represents the minimum price necessary to cause production of output level qd. The step-type supply curve generated by an L.P. model (shown in Figure 4) shows that when the price is exactly Pe the output level will be indeterminate between q1 and q2. That is, if the equilibrium price Pe were put into a profit maximizing model, the output level would fall between q1 and q2. The amount of indeterminancy is reduced as the number of constraints are increased.

If the demand for the final product is not perfectly inelastic, the assumption of fixed levels of demand will result in an error in estimating both the final level of demand and the equilibrium price. The amount of error depends on the elasticity or slope of the demand function with respect to its own price and the amount of influence from the prices of other products. If the effect of the own product price on consumption is small, then the assumption of fixed levels of demand will cause no real problem. If the price effect on consumption is significant, price-dependent demand relationships should be incorporated into the model.

Crops in the model. Part of the planned development policy was concerned with increased introduction rates of new rice varieties and the use of more fertilizer on both new and old rice varieties.

The basic set of crops and crop production techniques defined in the model by land type and agroeconomic zone are shown in

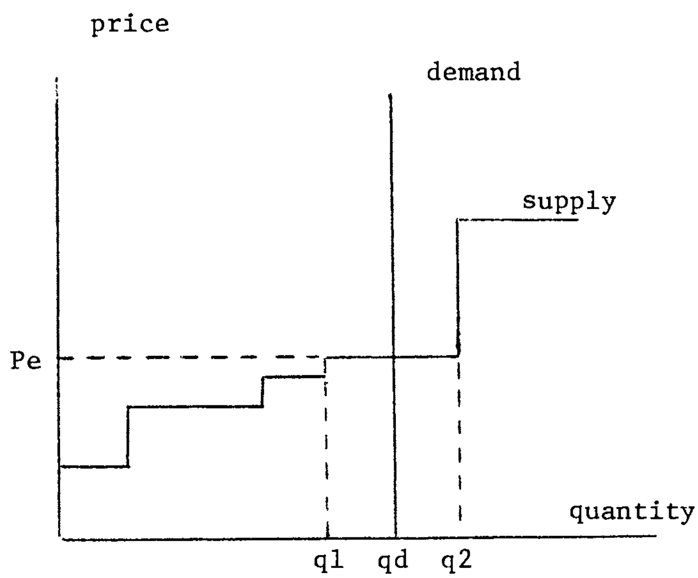

Figure 4. Cost minimizing solution to linear program with fixed point demand

Table 2.[1] Each activity in the model is a specific production process. For example, the production of native variety nonglutinous rice on land type 3 in the wet season in zone 5 is one activity. The production of that same crop with an RD (Rice Department) variety required an additional activity.

The use of new varieties and/or new production techniques by farmers is modeled by defining additional activities. Figure 5 shows two hypothetical fertilizer response functions--one for a native variety and one for an RD variety. When the effects of fertilizer and higher yielding varieties are considered together, the model must contain at least two activities for each variety. There are four activities outlined in Figure 5. Activity OVO with yield YOVO represents production of native variety rice without fertilizer. Activity OVf1 with yield YOVf1 represents production of native variety rice with fertilizer level f1. Similarly, activities RDO and RDf2 with respective yields YRDO and YRDf2 describe production of an RD rice with zero and f2 levels of fertilizer. The solution gives the optimal area planted to each variety along with the optimal use of fertilizer for each variety. Accuracy is increased by defining additional activities with more levels of fertilizer for variety. Constraints were added to reflect reasonable rates of adoption for both fertilizer use and for changing from a native variety to a new variety. These constraints are discussed in a later section.

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[1]The definition of alternative varieties and production techniques similar to those shown for rice are currently being developed for other crops.

Table 2. Major crops and crop production techniques specified by land class and agroeconomic zone analyzed in the National Crop Model for Thailand

Non-glutinous rice (tp, ov,f)	Cotton
Non-glutinous rice (tp, nv,f)	Castor seed
Non-glutinous rice (bc, ov,f)	Cassava
Non-glutinous rice (bc, nv,f)	Sugar cane (fresh)
Glutinous rice (tp, ov, f)	Sugar cane (manufacturing)
Glutinous rice (tp, nv, f)	Tobacco (native)
Glutinous rice (bc, ov, f)	Tobacco (Virginia)
Glutinous rice (bc, nv, f)	Tobacco (Burley)
Maize for livestock	Tobacco (Turkish)
Maize for human food	Coconut
Sorghum	Mulberry with native and Hybrid types of sericulture
Mung bean	Upland non-glutinous rice
Soybean SJ1	Upland glutinous rice
Soybean SJ2	Watermelon
Soybean native	White sesame
Black bean	Kenaf
Kak bean	Jute
Ground nut	Rubber (ov)
Black sesame	Rubber (nv)
	Intercropping on replanted rubber

Abbreviations used: tp = transplanted; bc = broadcast; nv = new variety; ov = old variety; f = yield variable with fertilizer

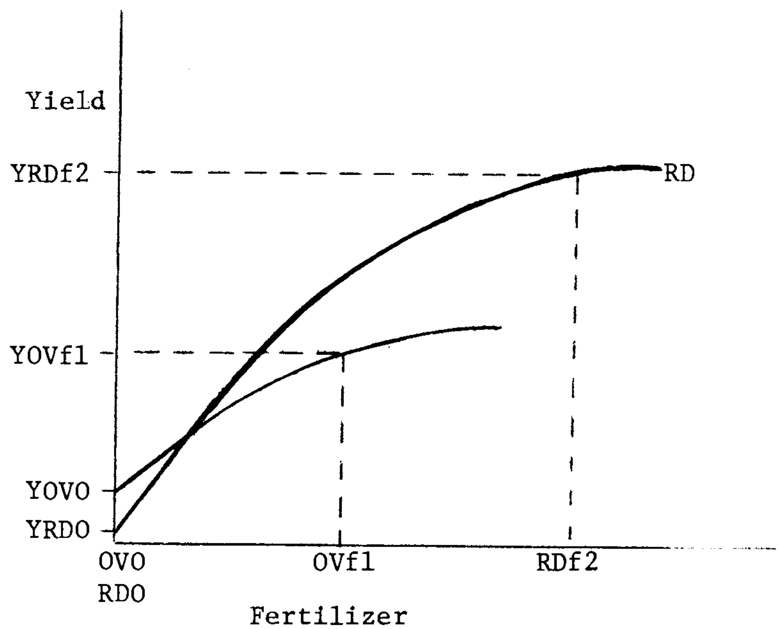

Figure 5. Hypothetical fertilizer response for native and new varieties of rice and defination of activities which allow farmer choice between varieties and fertilizer levels

Variable cost

The total costs included in the objective function of the model describe the production of the crops on the farm, assembly through local markets, processing, and transportation from each zone to the regional shipment point. Interregional transportation activities model the shipment of each agricultural commodity between consuming regions.

The farm-level component of variable cost for each producing activity is the sum of purchased inputs from the nonfarm sector plus the value of nonlabor nonland farmer-supplied inputs. The latter include charges on the value of animal power, farm manure, etc.

More specifically, farm level variable costs included:

fertilizer	depreciation
pesticide	value of animal inputs
fuel, oil, repairs	manure
hired machinery	food for workers
	miscellaneous

Only the total value of the above inputs is included in the objective function but the value of requirements of separate items is calculated in post-solution analysis.

The cost of assembling the product in the local area and shipment from the zone to the regional shipment point also has to be added to farm level production costs. The effect is to predetermine an intra-regional transportation flow within each consuming region. The "gateway" cities[1] in each consuming region were chosen as shipment points. The purpose was to reduce the number of constraints and activities required

[1]The regional shipment centers chosen were Korat in the Northeast, Nakon Sawan in the North, Bangkok in the Central Plain and Nakon Sithammarat in the South.

to specify the transportation system. The bias is minimized under an export orientation. The "gateway" cities are shown on the map in Figure 1.

<u>Resource constraints</u>

The policy questions regarding changes in population growth, export demand, completion of new irrigation projects, and maximum adoption rates of fertilizer and new varieties of rice were addressed by changing the set of constraints used in each solution.

The cropping area within each of the 19 agroeconomic zones consists of five land types. They are:

Land I Deep flooding paddy area suitable for only one crop of broadcast rice per year

Land II Irrigated paddy land. This land may be used for either broadcast or transplanted rice. The amount of multiple cropping possible on this type of land is limited by seasonal water supplies.

Land III Ordinary paddy land which is leveled and diked but where the water source is rainfall or river flooding. Production is limited to one crop per year.

Land IV Area for upland crops. The land may be used for multiple crops depending on rainfall or used for perennial tree crops such as mulberries, coconuts, and rubber.

Land V Sandy island land. This land is located in one zone in the South and is suitable for rubber and coconuts.

The individual zone models contain monthly constraints on the use of each class of land, labor, and capital. An individual zone model may contain 70 to 80 contraints. If all such constraints were retained for the 19 zones, the model would contain more than 1,500 equations. The solutions were to be obtained on an 8K IBM 1130 computer. Experience had shown the practical limit for problems on this computer to be 350-400 rows or equations. Therefore, the monthly constraints on land, labor, and capital were aggregated into wet-season planting, wet-season harvest, and dry-season constraints. The aggregation procedure used here will be relaxed as L.P. algorithms become available on larger computers in Thailand.

The resulting land constraints are shown in equation (2) and in Table 3.

$$(2)\ \sum_j x_{zjts} \leq LD_{tsz} \qquad t = 1, 5;\ s = 1, 2;\ z = 1, 19$$

Equation (2) states the sum of the area used by the x production processes in zone z, in season s, on land type t cannot exceed the zone supply of that land type.

The regional locations of projection changes in irrigation area in wet and dry season periods analyzed in the seven solutions are shown in Figure 6. The regional locations of increases in upland area in production due to increased cultivation of forest areas already in farms also are shown in Figure 10. The major increases in irrigation development are located in the North and Central plain. The area of rain-fed paddy was decreased as the irrigated area increased. In Alternative A it was assumed all of the irrigation area would be completed by 1981

Table 3. Resource constraints defined for each agroeconomic zone in the National Crop Production Model

Constraints specified in each agroeconomic zone	
Land I (deep flooding paddy)	Wet season constraint
Land II (paddy in irrigation area)	Wet season constraint, Dry season constraint equal to area receiving water.
Land III (ordinary paddy area)	Wet season constraint equal to area receiving sufficient water for planting
Land IV (upland)	Wet season constraint. Dry season constraint.
Land V (sandy land)	Wet season constraint. Dry season constraint.
Farm labor	Wet season planting constraint. Wet season harvesting constraint, Dry season constraint.
Farm capital	Wet season constraint. Dry season constraint.
Borrowed capital	Institutional loan constraint. Merchant loan constraint. Friends and relatives loan capacity.
Subsistence demand	Lower bounds on all production activities except rice which require that subsistence needs are met. For rice row constraints which insure that production is greater than or equal to subsistance need in each zone.
Constraints specified at the region level	
Constraints on areas planted to RD Rice	1. Wet season Land 2 2. Dry season Land 2 3. Rainfed paddy
Constraints on fertilizer use on native varieties	Constrained to trend level projection
Fertilizer application per rai fertilized	Additional production activities are defined using specified levels of fertilizer

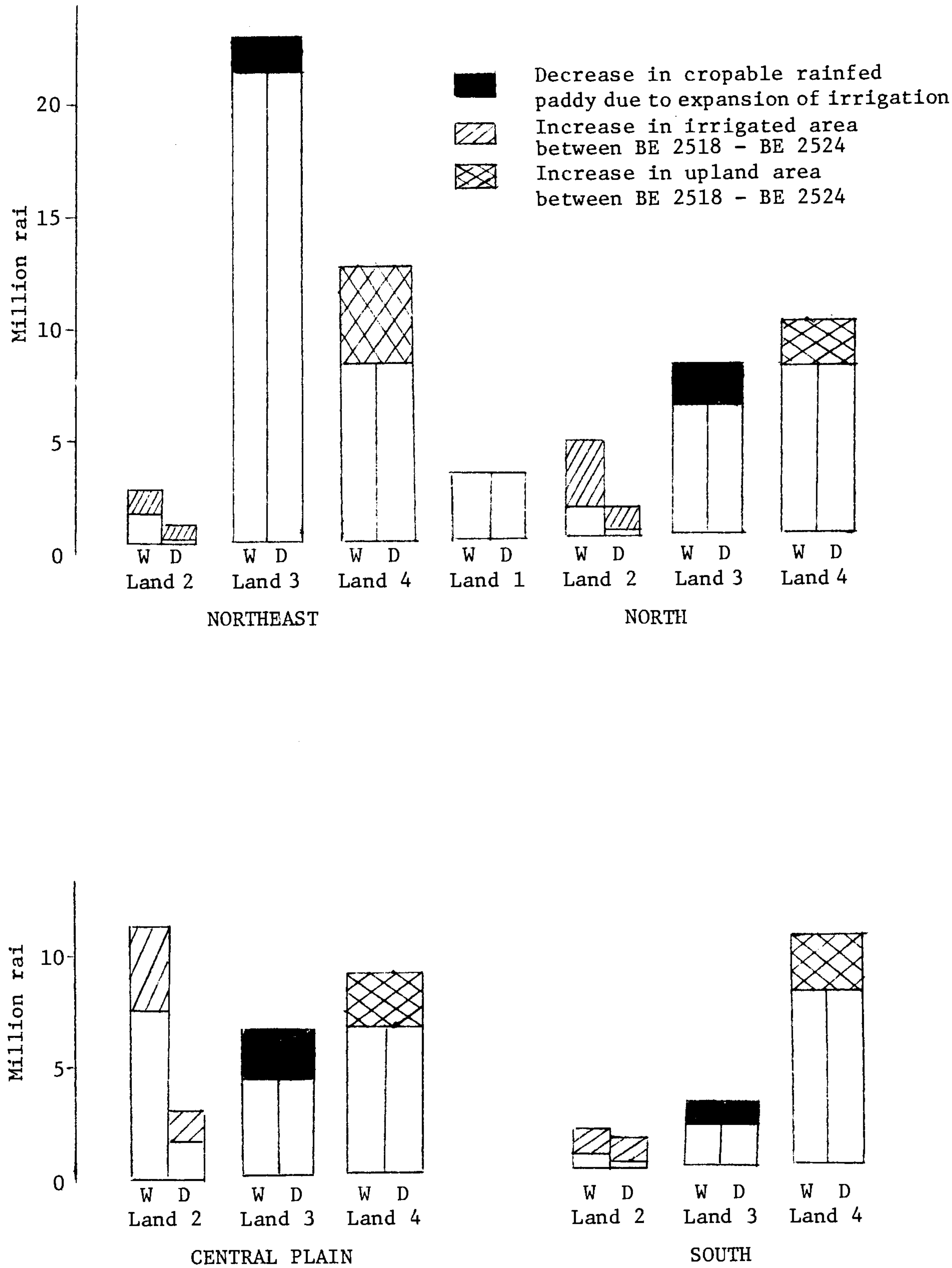

Figure 6. Changes in land classification between BE 2518 and the levels assumed for Alternative A in BE 2524

and in cultivation. In Solution F it was assumed none of the increased irrigation area is operational while in Solution B2 it was assumed part of the projects would be completed.

The specific land constraints in each agroeconomic zone for the seven solutions are contained in Tables A.2, A.3, and A.4.

Equation (3) requires the seasonal demand for labor not to exceed the seasonal supply of labor for crop production.

$$(3) \sum_j a_{zjs} X_{zj} \leq LB_{zs} \qquad s = 1, 3$$

where a_{ajs} is the number of hours of labor in zone z for activity j in season s

The supply of labor for crop production was net of labor requirements for fishing, forestry, livestock production, and crops exogenous to the model.

The labor force in the model was based on the expected number of workers between 15 and 64 years of age.[1] Conceptually, the supply of workers available for crop production should be adjusted for changes in production levels of exogenous commodities. Such changes were ignored in this study. The crop labor supply used in all solutions is shown in Table A.6.

Equation (4) requires the onfarm supply of capital at the beginning of each season plus borrowings during the season to be not less than the use of capital in that season.

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[1]The population available for the labor force in 1981 has already been born and thus is independent of the present and future population planning programs.

(4) $\sum_j a_{zjs}X_{zj} - K_{zks} - FC_{zs} \leq 0$

where a_{zjs} is the amount of short-term capital required for production process j

K_{zks} is the amount of capital borrowed from source k, zone z, in season s

FC_{zs} is the amount of farmer capital on hand at the beginning of season s

Demand for agricultural products. At the present time the programming model contains fixed point demands. Total demand is the sum of domestic consumption plus net exports. Domestic demand is a function of the population growth rate, a projected income growth rate of 2.2 percent and an income elasticity. Stated algebraically,

$D_{ic} = pop_{1981_c} * Co\ [1 + u\ ln(Y_t/Y_o)]$

where pop_{1981} is the estimated population in 1981 in consuming region c

u is the income elasticity of demand

Y_t is projected per capita income in 1981

Y_o is per capita income in the base period

The demand restraints used in the model for a particular solution must be consistent with the rate of population growth and level of exports assumed for that solution. The Kingdom level domestic demands for high, medium, and low rates of population growth are shown in Table A.8. The export levels for high, medium, and low levels of exports are shown in Table A.7.

Total domestic food balance equations were specified at the region level rather than at the zone level in order to further reduce the number of equations. Equation (5)

$$(5)\quad \sum_{z}\sum_{j} Y_{jzi}X_{jz} + \sum_{\substack{c\\c\neq d}} T_{dci} - \sum_{\substack{d\\d\neq c}} T_{dci} \geq D_{ic}$$

requires that total production from all the zones in consuming region c plus in-shipments less out-shipments equal or exceed total demand. Y_{jzi} is the amount of product i produced by production process j in zone z. The total demand includes consumer demand (subsistence + commercial) plus foreign exports or imports if a port of entry is located in this consuming region. Subsistence demands are defined as consumption occurring on the same farm where it is produced. Subsistence demand thus represents production which does not enter the market. Restrictions that force production in each zone to meet subsistence demand in that zone were applied in two ways. The more conventional approach in equation (6) was used for glutinous and non-glutinous rice.

$$(6)\quad \sum_{j} Y_{jz}X_{jz} \geq SD_{iz} \qquad i = 1,\ 2$$

Lower bounds on production activities were used to force production to meet subsistence demand for the remaining crops.

$$(7)\quad X_{jz} \geq LB_{jz}$$

where $LB_{jz} = \dfrac{SD_{iz}}{Y_{jz}}$

SD_{iz} is the amount of commodity i consumed on farms where produced in zone z

Y_{jz} is the yield per rai of production process j in zone a

Export demands were variable up to specified limits for rice and maize. The export price of these crops was assumed to be constant at a level equivalent to a 2,500 Baht per ton farm-level price for paddy. The current export price of maize was used.

(8) $E_i \geq EM_i$ $\quad i = 1, 3$

The maximum level of exports, EM_i, used for each solution varied according to the assumption about the export market. The export targets of the remaining crops were fixed according to equation (9).

(9) $E_i = EM_i$ $\quad i = 4, n$

Restraints on adoption of new technology. The approach used in this study was to compare the changes between a solution representing conditions in BE 2524 given alternative combinations of Thai policy and conditions external to Thailand. Since 1981 is only five years from the present, it would be unreasonable to expect 100 percent of the farmers to adopt any new production technique over the planning period. Except for the current sample period, there were insufficient data available on the adoption rates of specific practices to make a thorough study of this process. Trend level projections of the proportion of the total area planted to new varieties of rice by land and the total rice area fertilized were obtained from the simple relationship

$$\hat{\text{Prop}}\ 1981 = e^{-b/T}$$

where $b = -T \ln$ (proportion base period)

$T = 1$ in the first period the technology was available

The actual values used were double the trend values, 1.5 times the trend values or the trend values depending on the degree of optimism and promotion or extension effort assumed in association with a particular policy set. The restraints were placed at a regional level in accordance with the form shown in equation 10. The actual values are contained in Table 4.

$$(10) \quad \sum_z \sum_j X_{zji} \leq \text{Prop.}_{1981} * FC_k * \sum_z LS_{iz}$$

where X_{zji} is the jth rice activity in zone z on land type i

LS_{iz} is the supply of land type i in zone z

FC_k is the factor of optimism specified for solution k

Table 4. Current and projected trend rates of adoption of RD rice varieties and fertilizer use

	RD Rice[a]						Use fertilizer[b]		
	irrigation area			rain fed paddy			all rice areas		
Region	% 1975	$\hat{B}$	est.% 1981	% 1973	$\hat{B}$	est % 1981	% 1974	$\hat{B}$	est % 1981
NE	.15	26.01	11.4	.09	28.05	9.7	30.0	28.90	39.4
ND	6.02	11.24	39.2	.43	21.0	16.3	12.0	50.89	19.4
CPall	-	-	-	-	-	-	42.0	20.82	51.1
CP 7-11	5.82	11.37	38.8	5.60	11.53	38.3	-	-	-
CP12-16	1.62	16.49	25.3	.72	19.74	19.3	-	-	-
SO	.90	18.84	20.8	.66	20.08	18.8	32.6	26.90	42.0

[a] T = 1 in 1966

[b] T = 1 in 1950

<u>Income constraints</u>. Constraints requiring a minimum level of income for a particular group may be included in a programming matrix. The exact implementable policy applied in a decentralized system which generates such a solution is not always clear. The decision to include the constraints in this study was made after it became clear that not all

farmers in all regions could be expected to obtain positive sum gains from the development policies. Preliminary analysis revealed that development policies would encourage income shifts away from the Northeast region into the North and Central regions. The income constraints were included for Class IV land by region.

The goal was to determine what crops at what levels could be promoted to increase farm crop income by 1,000 Baht per household in the Northeast while not reducing farm crop income in other regions below the levels earned in BE 2514-15.

The constraints added were:

$$\text{NE;}\quad \sum_{z=1}^{5} \sum_{j=1}^{n_z} X_{zj} nr_{zj} \geq 4,052,000$$

$$\text{NO;}\quad \sum_{z=6}^{10} \sum_{j=1}^{n_z} X_{zj} nr_{zj} \geq 2,729,504$$

$$\text{CP;}\quad \sum_{z=11}^{16} \sum_{j=1}^{n_z} X_{zj} nr_{zj} + \sum_{j=1}^{n_z} P_{zj} nr_{zj} \geq 6,143,360$$

$$\text{SO;}\quad \sum_{z=17}^{19} \sum_{j=1}^{n_z} X_{zj} nr_{zj} \geq 3,550,372$$

where X_{zj} is the level of the jth upland crop activity in zone z

nr_{zj} is the net revenue obtainable from the jth production activity in zone z

n_z is the number of production processes defined in zone z

Per household, the constraints required the minimum level of income from upland crops in the Northeast, North, Central Plain, and South to be 2,000, 2,441, 9,539, and 5,513 Baht per year, respectively.

In order to prevent unrealistic levels of production of maize, cassava, and kenaf in the Northeast, a series of trend level upper bounds were imposed on area that could be planted to these crops. The bound does not force production of the above crops but prevents the planted area from exceeding trend projections in each zone. The areas planted to maize, cassava, and kenaf in the five zones of the Northeast along with the upper bounds and B2 solution activity levels are shown in Table A.1.

Data system

This section of the chapter is to discuss the data system used to support a programming model with spatial delineation of the type presented.

The structural detail included in a model is determined by an interaction of policy needs, data availability, the urgency in which the results are desired, previous research efforts, and computational capacity. Computational capacity here includes both human and mechanical elements. The items of data or population characteristics which must be known to carry out policy analysis vary with the structural detail of the model. The model is a means of summarizing relevant available data so the implications of the policy set for the most important dependent variables of the economic system can be measured. The first step in a research effort is one of problem identification. Supposedly, policies are formulated to resolve problems and the analysis is to evaluate the ability of the proposed policy to solve the previously identified problems and to measure expected impact on the variables of the system.

Model specification. The structure of the model evolves through the identification and specification of the following:

1) The spatial definition of large geographic areas into meaningful recognized subareas suitable for purposes of planning and

implementation of development policy. The subareas should be homogenous with respect to important production coefficients. The subareas should be basic units for data collection, reporting, and dissemination of economic intelligence. This is the concept used in defining the 19 agroeconomic zones used for agricultural development planning in Thailand (completed prior to this project).

2) The precise form in which the policy set would be implemented if adopted must be specified for incorporation into the model. In the current analysis this has been done with respect to irrigation, rice varieties, fertilizer, and upland crop income.

3) The major population groups such as urban households and rural households who are affected by a proposed policy must be identified.

4) The major production activities or enterprises along with the major resources or factors of production whose scarcity has or is expected to limit production and income must be specified. The enterprises included in the current model are rice and upland crops. The limiting resources are the seasonal supplies of labor, capital, and land by type. Other constraints reflect rates of technology adoption.

Data requirements. Conceptually, the number of coefficients required for a programming model is the product obtained by multiplying the number of equations or constraints by the number of variables or activities. In practice the density of such models is low. The crop model here contains only 11,000 of a possible 400,000 coefficients.

Model constraints. The supply of each land resource by season and by type specified in item 4 above must be known. The sources of the principle constraints used in this study listed by item and source are:

Item	Source
Land use	General Farm Survey (GFS)
Irrigation area	Royal Irrigation Department
Farm credit	General Farm Survey
Crop labor	G.F.S., Population census, Growth rates approved for planning
Area fertilized	G.F.S., Specific Rice Survey
R.D. varieties	G.F.S., Specific Rice Survey
Domestic demand	Income elasticity studies, population growth rate
Export demand	Time series projections, DAE - NESDB agreement
Subsistence demand	G.F.S., Special Surveys

Coefficient estimation. The total set of coefficients required for a programming model is equivalent to the set of coefficients required for enterprise budgets with the same resource detail. In both the programming model and the budgeting procedure the use of each input and each output by each enterprise must be accounted for. In the budgeting procedure, both the price and quantity of each input and output is specified in advance. In a programming model, the inputs and outputs where price and quantity are prespecified may be included in the objective function. Those items (both inputs and outputs) where either the quantity or the price is a variable to be determined by the model solution make up the tableau of the programming model.

Selected coefficients in the model have been estimated from the following data sources:

Rice yields	G.F.S. for 1971-72, 1974-75 specific Rice Survey 1973, 1974
Rice fertilizer response	G.F.S., Fertilizer trials by DAE, Rice Department, and other agencies between 1971-1974
Upland crop yields	G.F.S. for 1971-72 and 1974-75
Labor requirements	G.F.S. for 1971-72, Farm Records
Capital requirements and variable costs	G.F.S. for 1971-72, Farm Records, all values updated to 1975 price levels
Transportation costs	Transportation survey, transportation study

The major portion of the model presented has been constructed from primary cross-section survey data while supplementary information has been obtained from secondary sources.

The general problems of defining a sample frame and designing a questionnaire are well known. However, there are two specific problems of which model builders using cross-section surveys should be aware. The model described here can be and was constructed first by hand calculation from a single cross-section survey. One objective of a programming model is to allocate production according to the principle of comparative advantage. The first problem is that with a single year's data, the inherent comparative advantage of one zone over another zone in producing a crop cannot be separated from the influence of weather, insects, disease, and other random factors in that year.

The second problem is related to uneven survey coverage. In a traditional rice culture the survey will contain many observations on the traditional variety. There may be only a few farmers who are using a new variety. The standard errors of the respective estimates will reflect the number of observations for each variety. However, when the activities are included in the model, both are assumed to be equally reliable.

Both problems can be diminished by data pooling techniques and by repeating the survey annually. In some cases, the second problem is further diminished by adjusting survey stratification and sampling rates. Supplementary data sources may also be utilized.

The pragmatic approach followed in this project has been to proceed with the most reliable data and methodology which it has been practical to use. As surveys have been repeated and software for more complex calculation procedures completed, the more volatile parts of the model have been reestimated. The rice yields were reestimated by pooling data from five surveys in three time periods. The labor and capital data in the model is being reestimated by a similar procedure.

Results for Policy Analysis

Selected results from Solutions A, B2, and F are presented in this section. The results at the Kingdom level will be discussed first followed by results at the region level. Some results from B1 also are used in the regional discussion.

The implications of the major assumptions about population growth, export demand, and total rice area are summarized in Table 5. As shown there, the levels of final demand assumed for Solutions A and F were the same. However, the total value of demand for Solution B2 was less than that of either A or F because the difference between the high export levels assumed in Solutions A and F and the medium levels assumed in B2 was greater than the increase in B2's domestic demand arising from the higher rate of assumed population growth.

Table 5. Resource supplies, demand levels implied by population growth, and technology adoption assumptions for Solutions A, B2, and F.

Item	Unit	Solution				
		A	B2	A-B2	F	A-F
Population	mp	48.2	48.9	-.7	48.2	0
Domestic demand	mb	42,217	42,709	-492	42,217	0
Export demand	mb	28,263	23,141	5122	28,263	0
Irrig paddy WS	mr	19.8	13.6	6.2	10.2	9.6
Irrig paddy DS	mr	4.8	3.2	1.6	1.96	2.8
Rain fed paddy WS	mr	32.2	35.6	-3.4	37.6	-5.4
Max. rice area fert WS	mr	20.5	19.0	1.5	14.9	5.6
Max area RD rice						
Wet Season	mr	20.2	14.1	6.1	8.7	11.5
Dry Season	mr	3.8	2.6	1.2	1.6	2.2
Max. plantable paddy	mr	59.7	55.4	4.4	50.4	9.3
Max. fert. applied RD	kg/r	80	60	20	CL	-
Max. fert applied Native	kg/r	25	25	0	CL	-

Abbreviations mp = million persons, mb = million Baht, mr = million rai, cl = current level

The potential area which could be planted to rice was 9.3 million rai less in Solution F than in Solution A. In addition, potential production per rai was less in Solution F than for either Solutions A or B2. This was due to the lower assumed rates of acceptance of technology involving new rice varieties and fertilizers and lower rates of fertilizer use per rai fertilized. The result was a productive capacity under B2 conditions lying between that of A and F.

Analysis of results at the Kingdom level

Results at the Kingdom level are summarized in Table 6 and Figures 7 and 8. Income calculations in Table 6 are all based on the price set shown in Table A10. Given the fixed set of market prices, the highest level of farm crop income was obtained under Alternative A and the lowest under F. The values shown for 1971-72 were calculated using the same set of market prices, the actual areas planted, and the crop yields and other coefficients in the programming model.

The changes in net crop income shown in Table 6 are consistent with annual compound growth rates of crop income of 4.6 percent, 3.8 percent, and 3.4 percent for Solutions A, B2, and F, respectively.

Rice production

The results indicate that maximum rice production targets associated with Solutions A and B2 could be met if the realized expansion in irrigated area, adoption of new rice varieties, and applications of fertilizer reached the levels shown in Table 6. Results for Solution F indicated the same 16.1 million ton rice target assumed for Solution A could not be met with current land capacity given current trend rates of new rice variety adoption and no further increase in fertilizer application rates.

Table 6. Comparison of total crop income and resource use for Solutions A, B2, F and simulated results for 1971-72

Item	Unit	1971/72	Sol. A	Sol. B2	Sol. F
			Solution		
Other Agricultural Income[1]	mb	9,680	13,010	13,010	13,010
Total Agricultural Income[1]	mb	46,187	69,988	65,928	64,188
Non-Agricultural Income[2]	mb	-	66,450	63,373	64,386
Non-Agricultural Employment[2]	mb	-	2,373	2,263	2,300
Net crop income	mb	36,507	56,978	52,918	51,178
Cost[3]		11,525	18,195	17,654	18,379
			Use of crop land		
Deep Flooding paddy (L1)	tr	2,228	2,927	2,927	2,927
Irrig. paddy WS (L2)	"	9,240	19,510	13,665	10,241
Irrig paddy DS (L3)	"	1,964	3,052	2,493	1,771
Rain Fed paddy (L3)	"	38,801	30,829	35,263	37,852
Total idle paddy	"	2,492	3,731	1,052	390
Upland area WS (L4)	"	19,145	29,706	27,515	29,579
Upland area DS (L4)	"	17,429	20,578	29,825	30,634
			Use of labor, capital incrops		
Labor WS	md	807	1,025	1,047	1,031
Labor DS	"	146	263	243	254
Total annual capital	"	5,581	8,386	8,812	8,797
			Rice		
production	mt	11.6	16.1	15.3	15.3
Net income	mb	25,283	34,458	34,284	30,012
Yield per rai	kg.	245	288	290	309
Area planted	tr	47,288	55,921	54,484	49,314
Labor use	md	612	747	745	736
Area RD varieties	tr	1,054	6,456	8,280	10,948
Area fertilized	"	14,184	17,898	17,511	18,459
Seed, fert., pest. expense	mb	992	1,861	2,137	2,215
Tractor, machine expense	"	457	758	707	687
			Upland crops		
Net crop income	"	11,224	21,974	18,991	21,106
Planted rai	tr	22,996	39,547	37,481	39,596
Seed, fert., pest. expense	mb	1,037	1,658	1,536	1,646
Tractor expense	"	686	1,623	1,449	1,428

Abbreviations used:
mb = million Baht, tr = thousand rai, md = million man days, mt = million metric tons

[1]Source: Thailand's Fourth Five-Year Agricultural Development Plan BE 2524, Guidelines, Table 31.

[2]Source: Ibid. Table 38 as calculated from multipliers generated by macro model of Thailand.

[3]Includes cost of transportation, marketing, and processing.

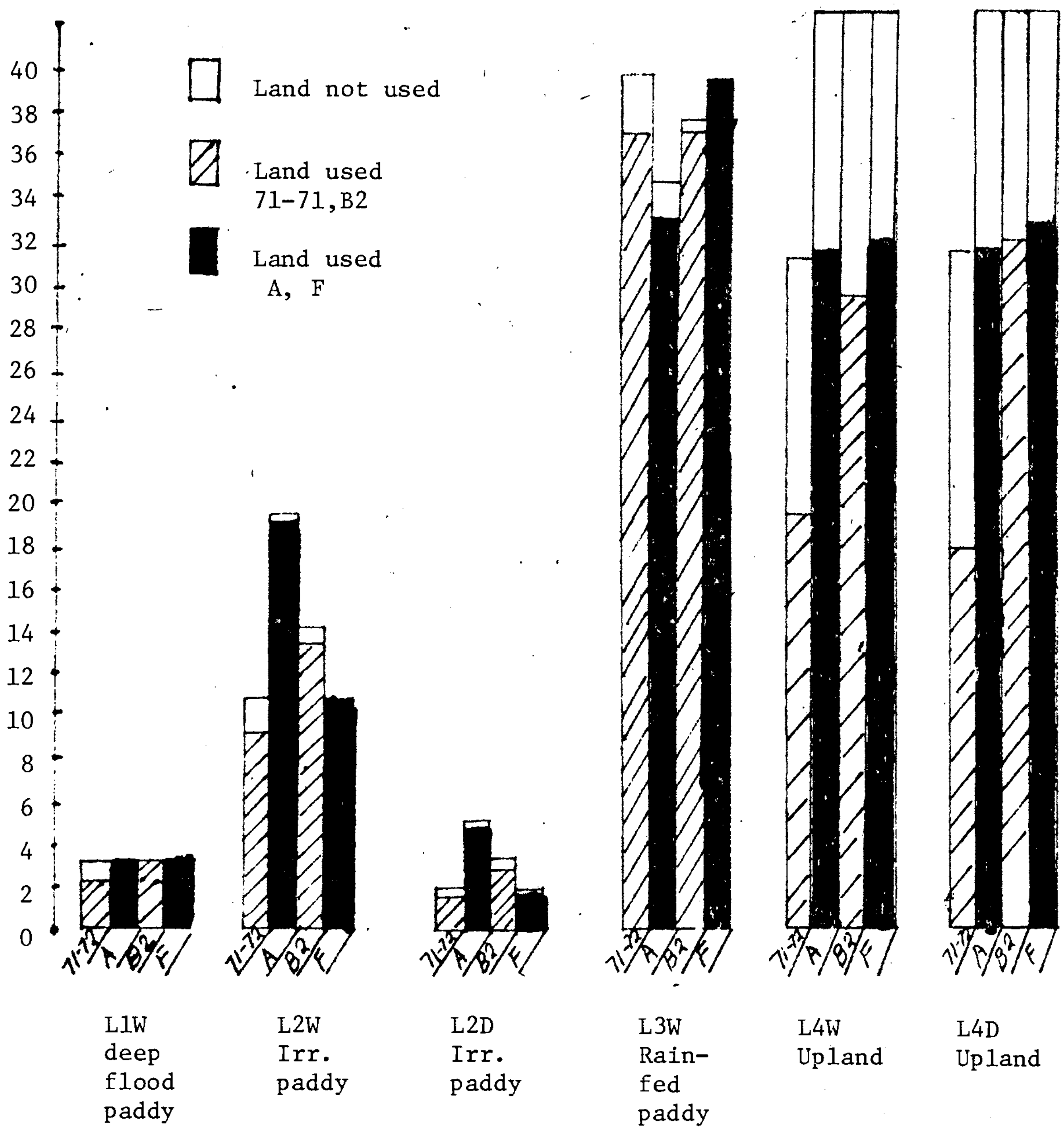

Figure 7. Land use by class in each season for Thailand in 1981 for Solutions A, B2, and F with land use in 1971-72

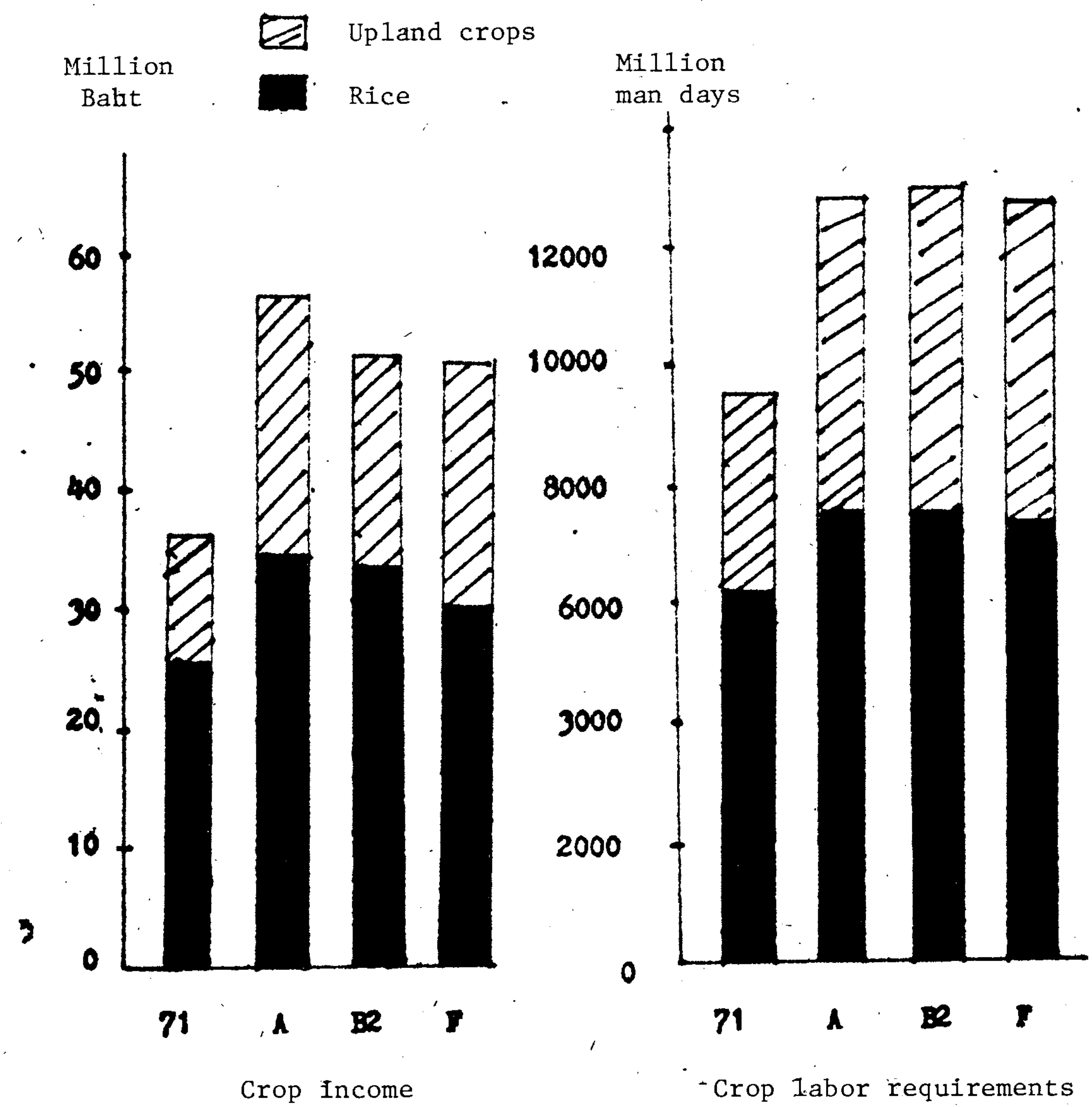

Figure 8. Income and employment from crop production for Thailand in 1981 for Solutions A, B2, and F and for 1971-72

In solution F, only 1.76 million tons of a possible target of 2.56 million tons were exported. The technology for solution F showed an average labor requirement of 20.8 hours per ton and 1965 Baht net income per ton of rice produced. Increasing rice exports by 0.8 million tons would increase employment by 1.2 percent and net farm income farm crops by 3 percent. Expansion of irrigation projects, seed multiplication, and promotion of management techniques lie within the domain of the public sector. Continued progress in this sector will be required if the Thai share of the rice export market is to be maintained.

The growth rates in rice variety adoption required to meet production levels for Solutions A, B2, and F respectively are 20 percent, 23 percent, and 26 percent. The respective growth rates in the area receiving fertilizer are 2 percent, 2 percent, and 3 percent respectively. In Solution A, the rice export target is met and the 16.1 million ton target becomes the factor that limits further increases in farm income and employment. The optimal area planted to RD rice varieties for Solution A was less than for Solutions B2 and F. The reason is simple. Rice land area was greater and hence land less limiting in Solution A than in Solution B2 and F. Land substitutes for capital in the form of fertilizer and/or new varieties that have higher costs.

Upland crops

The upland crop targets for domestic demand and export could be met with current production practices if the forest area already in farms can be utilized as shown in Figure 7. The results in Figure 8 indicate that if the forest area now in farms was not used for crop production, the targets for upland crop production might not be met with current technology. Even when the upland area expansion to include forest area now in farms was allowed, the proportion of upland area cropped for both the wet and dry seasons increased. The final implication is that while a more complete utilization of land with current technology allowed production targets to be met over the next five year period, it will be necessary to have higher levels of technology in the hands of the farmers in the period immediately beyond the current five year plan (Table 7). The annual increase in area planted to meet production targets for upland crops in Solutions A, B2, and F respectively were 6 percent, 5 percent, and 6 percent. Total inputs such as the value of tractor services, seed, fertilizer, and pesticides would need to grow at 7 percent, 6 percent, and 6 percent respectively to meet the targets for Solutions A, B2, and F.

The changes in employment opportunities were measured in terms of the number of days of labor per household as shown in Table 8. If there are no further increases in productivity, the rates of market expansion used in this study alone would not be enough to increase employment rates if the agricultural population increases at the same rate as the general population. Solution F shows the extreme situation where income and employment are limited by the supply of land and the lack of farmer adoption of new technology. On the other extreme, if the land augmentation programs such as increased irrigation area, increased use of fertilizer, and new varieties are successful as assumed for Solution A, then the size of the market is the factor that will limit farm income and and employment.

Table 7. Percentage of total available land and labor used for each of solutions A, B2, F and as calculated for 1971-72

Resource	Est. 71-72	Solution A	Solution B2	Solution F
	Percentage of total supply used			
Deep flooding paddy L1 WS	76	100	100	100
Irrigated paddy L2 WS	91	97	100	0
Irrigated paddy L2 DS	80	64	77	90
Rain fed paddy WS	95	96	99	99
Upland area WS	67	74	69	74
Upland area DS	61	74	74	76
Labor wet season	49	46	47	47
Wet season planting	54	51	50	51
Wet season harvesting	44	41	45	42
Labor December	62	66	68	63
Labor dry Season	12	17	16	16

Table 8. Effects of alternative development policies on regional income and employment per agricultural household

	Region				
	NE	NO	CP	SO	KG
Total Income Baht/year					
A	5955	14264	22860	12958	12016
B2	6551	11293	20645	12306	11235
F	5429	13555	17555	10820	10789
71-72	6129	11155	18619	10142	10344
Employment Days/year					
A	212	262	367	348	272
B2	263	205	336	331	288
F	218	238	324	336	270
71-72	251	201	329	355	287
Capital required Baht/year					
A	1048	1841	3955	1257	1770
B2	1437	1554	3895	787	1858
F	801	1887	4698	985	1855
71-72	846	1545	3841	679	1581
Rice income Baht/year					
A	4533	8743	13661	2700	7164
B2	4557	8806	13199	4236	7230
F	4226	8371	10577	3217	6342
71-72	5259	8126	12208	4132	7106
Rice area planted rai/year					
A	11.3	10.8	18.1	5.7	11.8
B2	11.3	10.6	16.9	5.6	11.5
F	11.0	8.7	14.9	4.2	10.4
71-72	14.3	10.9	19.2	6.7	13.4
Upland crop income Baht/year					
A	965	5351	9101	10259	6573
B2	1994	2463	7446	8070	4005
F	1224	5184	7602	10789	6342
71-72	870	3029	6411	6010	3180
Upland Area Planted rai/year					
A	2.1	12.7	10.5	16.9	8.4
B2	5.5	6.5	8.8	16.5	7.9
F	2.7	11.8	10.2	16.9	8.4
71-72	2.8	6.7	8.1	15.4	6.5

Implications for the nonagricultural sector

Total agricultural income figures shown in Table 6 include estimates of income from forestry, fruits, vegetables, and livestock. These estimates are largely illustrative at the present time. The estimates of agricultural income from agricultural sources outside the model were not varied between solutions. The estimates are included in Table 6 only to arrive at an estimate of total farm income.

The estimates of impact of alternative agricultural development programs on nonagricultural income and employment are derived by the use of multipliers obtained from a preliminary version of the macroeconometric model developed as part of the sector analysis project. The initial multipliers show that alternative development programs for Thai agriculture would affect nonagricultural employment by as much as 100,000 jobs.[1]

Comparisons of alternative development policy effects between regions

The effects of the respective development programs, given by Solutions A, B2, and F, on income and employment of the average household in each region are summarized in Table 8 and shown in Figure 9 . Additional supplementary results on land and labor use by regions and by zone are contained in Tables A.11, A.13, and A.14.

The results show that increased domestic and foreign demand along with production expansion policies would mean increases in income to the average Thai farm household. The implied average annual growth in crop

[1]The respective multipliers for output, net income, and employment are 0.9, 0.72, and 0.0757.

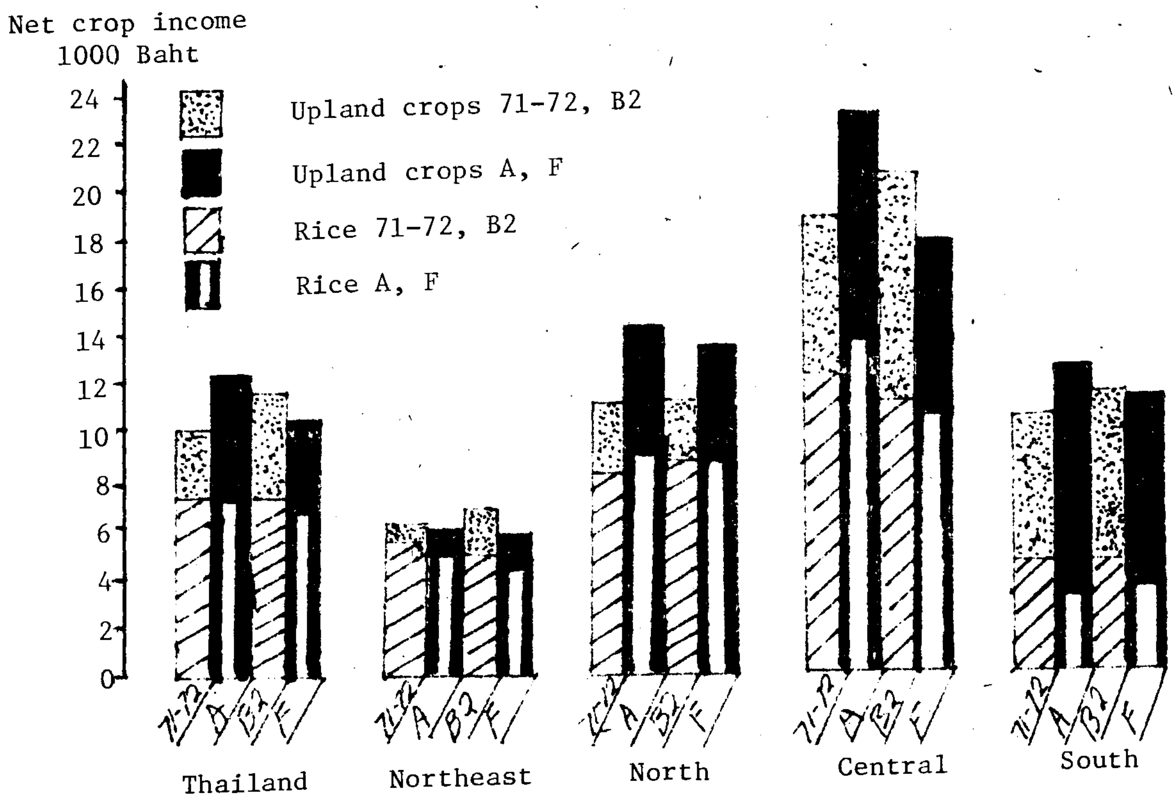

Figure 9. Regional income per household from rice and from upland crop production for Solutions A, B2, and F with calculated income for 1971-72

income per household was 2.5 percent, 1.9 percent, and 6 percent for solutions A, B2, and F, respectively. Examination of changes in total crop income in each of the four major regions of Thailand shows that while the average household in the North, Central, and South regions could expect net gains in income and employment, the corresponding position of the Northeast household could be expected to decline relative to 1971-72 levels. The Northeast is currently the region with the lowest level of income per farm.

The decline in income for Northeast households, as shown in Table 8 in Solutions A and F, relative to current levels would result if production were allocated according to an economic efficiency criterion. The yields per unit of land in the Northeast are lower for both rice and upland crops than in the other regions. Furthermore, a solution A production policy for rice production involving increased irrigation, new varieties, and fertilizer use would be concentrated in the Central Plain and North regions. Similarly, as the increased utilization of forest area already in farms occurs more rapidly in the North and Central Plain regions which have the highest yield potential, the competitive position of the Northeast in upland crop production declines even under a land expansion type policy.

Examination of the effects of the initial development policies on regional incomes resulted in the definition of a further alternative, namely B2. As was stated previously, the major purpose of the income constraints used in this study was to search for a countervailing policy which might be extended to the Northeast to increase income per household by $50 U.S. relative to 1971-72 levels. The resulting effects on the average farm household in each region are shown in Tables 8, 9, and 10. The effects of the income constraints alone are shown in Tables 10 and 11 where reference is made to solution B1 which is identical to solution B2 except for the addition of income constraints.

The objective of B2 was to search for those crops that could most efficiently be grown in the Northeast to increase income. The major production shifts shown were in terms of upland crops that could be grown.

The implications for the income constraints can best be studied in Table 11 where the changes for the Northeast are compared to the corresponding gains or losses from the remaining regions. The increased income for the Northeast comes at the expense of lowered efficiency and lower total farm income for the Kingdom. However, at the Kingdom level, the reductions in income are about $5 U.S. per agricultural household.

The changes in regional income earnings per household implied by increasing income in the Northeast are outlined in Table 10. When the market size is limited as between B2 and B1, the gain in the Northeast income would come largely at the expense of households in the North and Central Plain. With no interregional migration, there would be an estimated 2,026,000 households in the Northeast by 1981 and 1,144,000 and 928,000 in the North and Central Plains, respectively. The total increase in Northeast income between Solutions B1 and B2 is 2,204,000 Baht. Total crop income for Thailand would decline by 815,000,000 Baht. On the average with a mixed market and constant prices, each Baht increase in Northeast income caused a loss of 1.37 Baht net crop income from the North, Central Plain, and Southern regions.

Table 9. Levels of technical inputs for rice and upland crops for each region in solutions A, B, F and estimated for 1971-72

Item	Solution	Unit	Region				
			NE	NO	CP	SO	KG
					Rice production		
Planted Rai	71-72	mr	21.4	9.4	13.3	3.2	47.3
	A	mr	22.6	12.5	16.8	3.7	55.6
	B2	"	23.0	12.2	15.7	3.6	54.5
	F	"	22.3	10.1	13.8	3.0	49.3
Rai Fertilized	71-72	"	6.4	1.1	5.3	1.0	13.8
	A	"	9.1	1.1	6.4	1.3	17.9
	B2	"	8.4	1.2	6.6	1.3	17.5
	F	"	6.7	1.2	5 8	1.0	14.7
RD Rice area	71-72	"	1.0	.3	.7	.0	1.0
	A	"	1.5	.4	3.0	1.5	6.4
	B2	"	1.7	1.8	3.7	1.1	8.3
	F	"	2.2	1.7	5.4	.7	10.2
Yield per rai (allrice)	71-72	Kg	184	331	281	254	245
	A	"	207	356	336	326	288
	B2	"	207	365	348	308	289
	F	"	190	404	387	313	310
Rai Irrigated	71-72	mr	1.2	1.1	6.8	.3	9.3
	A	"	2.8	4.4	13.0	1.8	22.0
	B2	"	1.9	3.0	9.8	1.2	15.9
	F	"	1.2	1.5	8.4	.5	11.7
					Upland crops		
Planted Rai	71-72	"	4.2	5.7	5.6	7.5	23.0
	A	"	4.3	14.7	9.7	10.9	39.6
	B2	"	11.1	7.5	8.2	10.6	37.4
	F	"	5.5	13.6	9.5	10.9	39.6
Inputs[a]	71-72	mb	201	161	924	108	1724
	A	"	205	697	1729	554	3185
	B2	"	949	335	1270	430	2986
	F	"					
Net Revenue/Rai	71-72	"	311	450	704	387	488
	A	"	452	425	911	446	553
	B22	"	364	381	843	490	498
	F	"	447	439	818	447	533

[a]Expense for seed, fertilizer, pesticide, and machine devices.

Abbreviations used: mr = million rai, mb = million Baht, kg = kilogram

Table 10. Comparison of regional income and employment in BE 2524 for Alternatives A, B1, and B2

	Region				
	NE	NO	CP	SO	KG
Total crop income (Baht/year)					
B2	6,551	11,293	20,645	12,306	11,235
B2-B1	1,088	-1,555	-1,463	- 736	- 97
B2-A	1,052	-3,017	-2,677	- 14	- 666
Net upland crop income (Baht/year)					
B2	1,994	2,487	7,446	8,070	4,005
B2-B1	1,096	-1,559	-1,497	- 731	- 101
B2-A	1,028	-2,975	-2,117	- 469	- 629
Total crop labor required (days/year)					
B2	263	205	336	331	272
B2-B1	55	- 33	- 2	- 5	15
B2-A	51	- 57	-31	-17	-
Capital (Baht/year)					
B2	1,437	1,554	3,895	787	1,858
B2-B1	535	-287	- 60	-470	88
B2-A	562	-180	-403	-245	90
Upland Area (rai/year)					
B2	5.5	6.5	8.9	16.5	7.9
B2-B1	3.4	-2.8	-1.2	-.5	.5
B2-A	3.4	-6.3	-1.6	-.5	-.5

The total capital, labor, and upland resources for the Kingdom increased between Solutions B1 and B2. Because the yields per rai are low in the Northeast, producing a given volume of output requires more land and hence more capital and labor resources.

Between Solutions B1 and B2, the net change in farm income was less than 100 Baht per household for the Kingdom. However, the costs of the income transfer were estimated to be nearly 1,500 Baht per household in the North and Central Plain.

In general, with the exception of capital, the resource requirements for B2 were still less than for Alternative A where there were more exports.

Table 11. Comparison of income gains in the Northeast and decreases in income in the other regions of Thailand by crops between Solutions B1 and B2

Changes			Northeast			Rest of Thailand		
			B1	B2	B1-B2	B1	B2	B1-B2
Crop INC		MB	11,058	13,272	-2,214	42,666	36,646	2,503
Labor		MD	421	532	-111	798	759	39
Capital		MB	1,829	2,912	-1,083	6,568	5,900	758
Maize	PA	TR	94	2,632	-3,538	11,632	10,101	1,531
	INC	MB	52	673	- 621	5,597	4,920	677
Cassava	PA	TR	57	1,235	-2,178	2,941	2,159	783
	INC	MB	17	351	-334	828	1,102	274
Kenaf	PA	TR	1,778	2,124	346	235	0	0
	INC	MB	484	517	27	87	0	0
Sugar cane	PA	TR	136	136	0	1,521	1,521	0
	INC	MB	73	73	0	2,358	2,358	0
Cotton	PA	TR	376	375	0	475	476	0
	INC	MB	66	66	0	180	180	0
All bean	PA	TR	1,166	3,687	-2,521	5,023	2,145	2,878
	INC	MB	487	1,086	- 599	1,476	727	749
Soybean	PA	TR	19	122	- 103	394	473	79
	INC	MB	7	115	- 108	255	116	139
Ground nut	PA	TR	382	429	- 47	347	299	48
	INC	MB	333	375	- 42	289	245	44
Mungbean	PA	TR	68	2,167	-2,099	3,945	1,427	2,518
	INC	MB	12	396	- 384	676	179	497
Other	PA	TR	417	978	- 561	2,198	2,168	30
	INC	MB	651	134	- 517	3,891	3,980	89

Abbreviations used: TR = thousand rai; MB = million Baht; INC = Net income, interest charges on borrowed capital are not deducted; PA = planted area; MB = million days

Comparison of the gains and corresponding reductions in income and planted area between the Northeast and the rest of Thailand are summarized along commodity lines in Table 11. For the major crops listed in Table 11, the increase in planted area requirements in the Northeast were greater than the corresponding reduction of planted area for the same crops in the other regions of Thailand. For example, between B1 and B2 the area planted to maize in the Northeast increased by 3.5 million rai while the planted area declined by 1.5 million rai in the other regions. The income from Northeast maize production increased by 621,000,000 Baht while maize income declined by 677,000,000 Baht in the remaining regions.

The crops that showed the greatest change between Alternatives B1 and B2 in response to the imposition of the income constraint were maize, cassava, and mungbeans. The area planted to maize was up to the trend level bounds in all zones of the Northeast. The income target in the Northeast thus required that areas planted to maize and cassava continue to expand at BE 2511-2517 trend-level rates.

Summary and Conclusions

The results of Solutions A, B2, and F can be summarized by reference to Figures 10 and 11. The levels of employment are naturally higher with high export levels in Solution A. Figure 10 does indicate that a high degree of seasonal underemployment and unemployment will continue to be a problem even if market conditions remain favorable for "high" levels of exports. On a regional basis, the problems of finding further employment opportunities are greatest in the Northeast and North.

The graphs in Figure 15 include estimates of farm income from livestock, fruits, and vegetables in addition to the crop income figures examined previously. The results show that the implementation of the programs for irrigation, fertilizer, and rice varieties could be expected to increase income for the average agricultural household. However, if households in all regions are to receive non-negative gains, additional measures must be adopted to increase farm income in the Northeast.

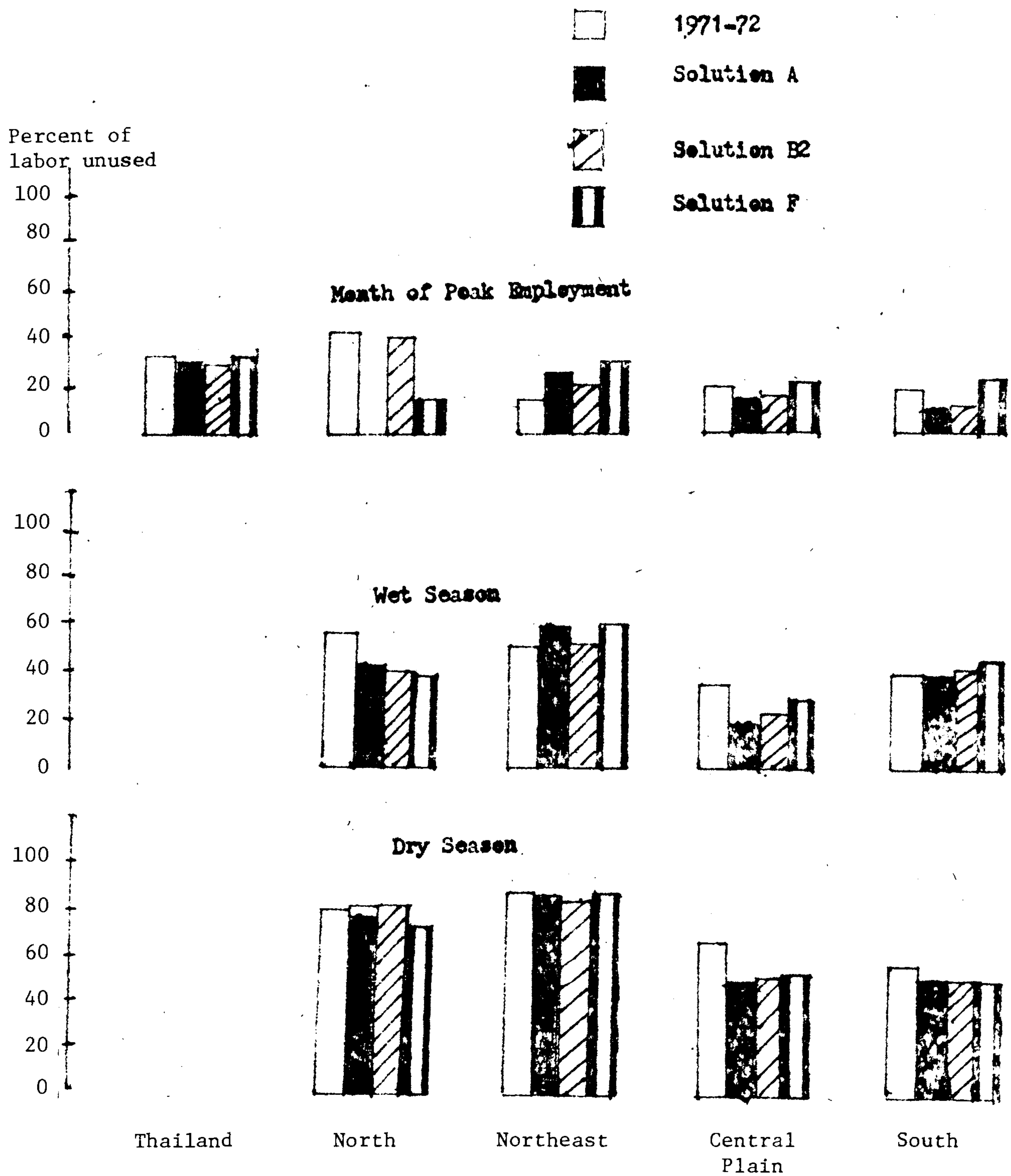

Figure 10. Levels of underemployment[a] in Thailand in Solutions A, B2, and F in 1981 and calculated levels for 1971-72

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[a]Underemployment or unemployment measured here is the percentage of the total days in each period when labor is not required.

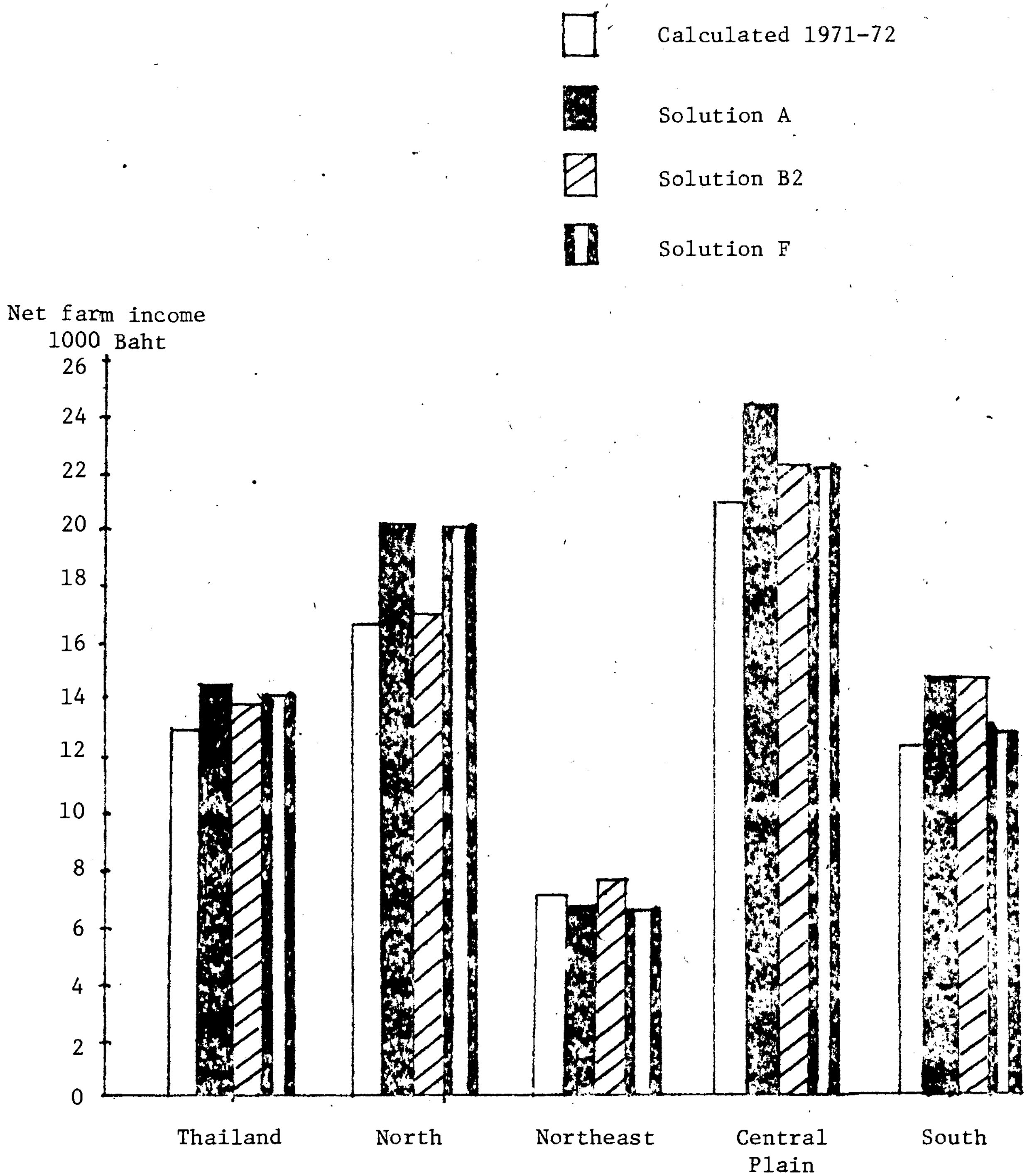

Figure 11. Net farm income in Thailand for Solutions A, B2, and F calculated for 1971-72

The results of the model give only general guidelines as to how the results for Solution B2 can be implemented. The model indicates that the increased income might be generated most readily through increased production of crops such as maize and cassava. The production of these crops must increase at rates at least as great as past trends. Further research in the area of finding varieties and production practices that would lower cost per unit or production in the Northeast is already in process.

Table A.1. Current area planted, trend projections used as upper bounds, and B2 solution levels for maize, kenaf, and cassava in the Northeast

Zone	Maize			Cassava		
	Current BE 2517	Upper bound	Solution level	Current BE 2518	BE 2524 Upper bound	Soulution level
	(thousand rai)					
1	87	120	120 [a]	76	100	0
2	66	110	110 [a]	3	20	0
3	19	20	20 [a]	199	580	196
4	200	410	410 [a]	67	180	0
5	1,184	2,125	2,125 [a]	471	1,040	1,040 [a]
NE	1,556	2,785	2,785	816	1,920	1,236
	Kenaf					
1	400	680	0			
2	220	550	0			
3	880	1,537	559			
4	510	1,060	1,060			
5	680	1,160	464			
NE	2,690	4,987	2,083			

SOURCE: Division Agricultural Economics, Ministry of Agriculture and

[a]B2 Solution level at upper constraint

Table A.2. Current rain-fed paddy area and upland area, estimated average proportion of rain-fed rice area receiving sufficient rainfall for rice production, and projected upland area for BE 2524

Zone	Total rain-fed paddy area	Average proportion planted to rice	Expected area for rice production BE 2524	Upland area in farms BE 2516	Expected upland area in farms BE 2524	2524/2516 percentage
				(Thousand rai)		
Z1	7950	.56	4476	1625.	3036.	187.
Z2	5486	.60	3267	525.	1099.	209.
Z3	8541	.63	5421	2043.	2676.	131.
Z4	7829	.61	4801	1041.	2035.	195.
Z5	4970	.70	3470	2456.	3034.	124.
NE	34776	.62	21435.	7690.	11880	154.
Z6	4653	.52	2420.	3974.	4514.	114.
Z8	3243	.62	2011.	1540.	2260.	147.
Z9	1609	.69	1110.	1374.	1654.	120.
Z10	1845	.92	1698	257.	465	181.
NO	11351	.64	7239.	7145.	8893.	124.
Z7	1376	.58	798	1671.	1821	109.
Z11	1827	1.00	1827	727.	978	135.
Z12	870	.96	836	1252.	2009	160.
Z13	2629	.70	1829	738.	1155	157.
Z14	981	.25	245	117.	244	209.
Z15	497	.72	359	1557.	1789	115.
Z16	310	.68	211	212.	457	216.
CP	8491	.72	6105.	6274.	8453.	135.
Z17	2465	.82	2013	3945	5587	142.
Z18	453	.85	385	1967	2714	138.
Z19	665	.66	437	1748	2547	146
SO			2835	7660	10848	142.
KG.	58202.	.65	37614.	28769.	40074.	139.

Table A.3. BE 2524 land constraints used for Alternatives A, C, and D[1]

Zone	Deep flooding paddy Land 1	Irrigated wet season Land 2W	Paddy dry season Land 2D	Rain-fed paddy Land 3	Upland Land 4
			(Thousand rai)		
Z1		519.	111.	4338.	3035.
Z2		182.	47.	3199.	1100.
Z3		1068.	380.	5049.	2675.
Z4		153.	21.	4721.	2034.
Z5		415.	148.	3413.	3033.
NE		2337.	707.	20720.	11877.
Z6	627.	1100.	97.	2004.	4513.
Z8	1548.	1173.	297.	1459.	2260.
Z9	416.	570.	162.	920.	1654.
Z10		1191.	471.	1040.	464.
NO	2591.	4034.	1027.	5423.	8891.
Z7	16.	677.	39.	629.	1820.
Z11	320.	6859.	2310.	1828.	979.
Z12		1267.	245.	217.	2009.
Z13		1905.	148.	884.	1155.
Z14		799.	170.	88.	243.
Z15		183.	4.	325.	1790.
Z16		37.	3.	199.	458.
CP	336	11,727.	2919.	4170.	8454.
Z17		959.	117.	1558.	5587.
Z18		220.	8.	254.	2713.
Z19		530.	.00	121.	2548.
SC		1700.	125.	1933.	10848.
KG	2927.	19,807.	4778.	32,246.	40,070.

[1]Land type 5 constraint of 104.4 thousand rai not shown.

Table A.4. Land constraints for Alternatives B1 and B2[1]

Zone	Deep flooding paddy Land 1	Irrigated wet season Land 2W	Paddy dry season Land 2D	Rain-fed paddy Land 3	Upland Land 4
			(Thousand rai)		
Z1		359.	53.	4429.	3035.
Z2		125.	20.	3233.	1100.
Z3		737.	173.	5297.	2675.
Z4		105.	10.	4750.	2034.
Z5		287.	78.	3413.	3033.
NE		1613.	334.	21122.	11877.
Z6	627.	759.	47.	2181.	4513.
Z8	1548.	810.	138.	1684.	2260
Z9	416.	393.	113.	1041.	1654.
Z10		821.	318.	1379.	464.
NO	2591	2783.	616.	6285.	8891.
Z7	16.	447.	30.	750.	1820.
Z11	320.	4732.	1763.	2440.	979.
Z12		874.	192.	593.	2009.
Z13		1314.	189.	1298.	1155.
Z14		551.	94.	151.	243.
Z15		127.	4.	365.	1790.
Z16		25.	2.	205.	475.
CP	336	8070.	2274.	5802.	8471.
Z17*		661.	70.	1800	5587.
Z18		151.	3.	321.	2713.
Z19		365.	0.	230.	2548.
SO		1177.	73.	2351.	10848.
KG	2927	13,643.	3297.	35,560.	40,087.

[1]Land type 5 constraint of 104.4 thousand rai not shown.

Table A.5. BE 2524 Land constraints assumed for Alternatives E and F[1]

Zone	Deep flooding paddy Land 1	Irrigated wet season Land 2W	Paddy dry season Land 2D	Rain paddy Land 3	Upland Land 4
Z1		318.	8.	4477.	3035.
Z2		28	.0	3268.	1100.
Z3		472	5.	5421.	2675.
Z4		64.	.0	4801.	2034.
Z5		303.	20.	3470.	3033.
NE		1185	33.	21437.	11877.
Z6	627.	300.	5.	2420.	4513.
Z8	1548.	283.	8.	2010.	2260.
Z9	416.	294.	72.	1110.	1645.
Z10		475.	191.	1699.	464.
NO	2591	1352	276.	7239.	8882.
Z7	16.	383.	23.	799.	1820.
Z11	320	5345.	1317.	1828.	979.
Z12		621.	150.	837.	2009.
Z13		540.	94.	1830.	1155.
Z14		153.	32.	245.	243.
Z15		138.	7.	360.	1790.
Z16		18.	1.	211.	458.
CP	336	7198.	1624.	6105.	8454.
Z17*		393.	31.	2013.	5587.
Z18		65.	.	385.	2713.
Z19		47.	.0	438.	2548.
SO		505.	31.	2836.	10848.
KG	2927	10240.	1963.	37616.	40061.

[1]Land type V constraint of 104.4 thousand rai not shown.

Table A.6. Projected BE 2524 agricultural workers for forestry, fruits and vegetable production annual hourly livestock labor requirements and labor available for crop production

Zone	Agricultural workers age 15-64	Workers for forestry, fishing, fruits, & vegetables	Workers for crop and livestock production	Labor hours required for livestock production	Crop/labor wet season	dry season
	(Thousand workers)			(Million hours)		
1	1723	10.4	1712.6	450	2466	1726
2	790	7.1	782.9	122	1127	789
3	1818	12.2	1805.8	267	2600	1820
4	1390	7.9	1382.1	247	1990	1393
5	1093	6.8	1086.2	159	1564	1095
6	907	23.3	883.7	183	1273	891
7	269	15.8	253.2	18	365	255
8	666	39.2	626.8	155	903	632
9	838	23.9	814.1	230	1172	821
10	721	25.4	695.6	204	1002	701
11	966	63.7	902.3	60	1299	910
12	460	124.1	336.9	30	484	339
13	285	32.5	252.5	29	364	255
14	134	54.9	79.1	10	114	80
15	178	53.6	82.4	15	119	83
16	118	94.5	23.5	4	39	24
17	932	63.0	869.0	200	1244	883
18	327	28.2	298.8	59	428	304
19	439	21.8	417.2	54	597	424
KG	14,052	748.0	13,304.0	2452	19145	13423

Table A.7. Alternative levels of export demand assumed for Thai crops in BE 2524

Commodity	Export level		
	High	Medium	Low
	(thousand tons)		
Rice N.g. paddy equiv[1]	1604	1321	944
Rice glut., paddy equiv[1]	96	79	56
Maize[1]	3000	2500	2000
Rubber	450	400	350
Cassava	6568	5481	4426
Sugar, sugar cane equiv	9999	7333	4667
Kenaf (bailing)	104	78	52
Mungbeans	125	110	85
Soybeans	30	20	10
Ground nuts	10	7	4
Castor beans	40	30	20
Sesame	15	12	8
Sorghum	300	220	160
Jute	4	3	2
Raw cotton	5	4	3
Tobacco	40	30	20
Coconut	300	200	150

[1]Maximum quantity that could be exported at specified wholesale prices of 2,870, 2,770, and 2,470 Baht per ton for non-glutinous paddy, glutinous paddy, and maize, respectively.

Table A.8. Estimated levels of domestic consumption per person in BE 2524

	Kg./person	Population level Low	 Medium	 High
			(Thousand tons)	
Non-glutinous paddy	161.56	7784	7894	8002
Glutinous paddy	117.30	5652	5732	5810
Sugar, kg sugar	130.97	6302	6391	6478
Cassava roots, fresh	11.13	536	543	551
Coconuts	17.35	836	847	859
Mungbean	2.86	138	140	142
Soybean	1.23	59	60	61
Groundnuts	3.45	174	176	179
Sesame	.39	19	19	19
Human maize	.45	22	22	23
Castor bean	.07	3	4	4
Domestic demand projections independent of population levels				
Kenaf	1,000 tons	245	245	245
Rubber	"	17	17	17
Cotton	"	134	134	134
Jute	"	9	9	9
Maize feed	"	789	789	789
Sorghum	"	18	18	18
Tobacco (vir)	"	24	24	24
Tobacco native	"	26	26	26
Raw silk	"	1	1	1

Table A.9. Constraints for maximum rice area which could be planted to RD varieties for each land class by season and maximum rice area which could be fertilized in each region in each solution

Maximum restraint	Solution A	B1	B2	C	D	E	F
	thousand rai						
Northeast							
RD land 2 wet season	533	276	276	533	533	270	135
RD land 3 wet season	4019	3076	3076	4019	4019	4158	2079
RD land 2 dry season	565	269	269	565	565	27	27
Rice area fertilized	9084	8958	8958	9084	9084	8192	6718
North							
RD land 2 wet season	3163	1637	1637	3163	3163	1061	531
RD land 3 wet season	1767	1537	1537	1767	1767	2360	1180
RD land 2 dry season	821	491	491	821	821	221	221
Rice area fertilized	1834	1760	1760	1834	1834	1667	1020
Central Plain							
RD land 2 wet season	8015	4126	4126	8015	8015	4905	2452
RD land 3 wet season	1281	2386	2386	1281	1281	3357	1678
RD land 2 dry season	1335	1764	1764	2335	2335	1298	1298
Rice area fertilized	8120	7100	7100	8120	8120	6802	6126
South							
RD land 2 wet season	710	368	368	710	710	210	105
RD land 3 wet season	726	661	661	726	726	1066	532
RD land 2 dry season	99	58	58	99	99	25	25
Rice area fertilized	1528	1482	1482	1528	1528	1402	1110
Kingdom							
RD land 2 wet season	12421	6407	6407	12421	12421	6446	3223
RD land 3 wet season	7793	7660	7660	7793	7793	10941	5469
RD land 2 dry season	3820	2582	2582	3820	3820	1571	1571
Rice area fertilized	20566	19300	19300	20566	20566	19634	14974

Table A.10. Regional center wholesale prices[a]

Conmodity	unit	Northeast	North	Central	South
Rice, non-glutinous,paddy	kg.	2.76	2.78	2.87	3.04
Rice, glutinous, paddy	"	2.66	2.68	2.77	2.94
Maize, feed use	"	2.00	2.05	2.47	-
Maize, human food	"	.28	.21	.32	.24
Sorghum	"	1.55	2.25	2.25	-
Mungbeans	"	4.20	4.05	5.31	5.33
Soybeans	"	4.25	4.03	5.16	-
Black bean	"	4.79	4.03	5.16	-
Kak beans	"	4.79	4.94	4.94	-
Groundnut	"	3.95	4.11	4.23	4.58
Black Sesame	"	8.48	8.48	8.75	-
White Sesame	"	8.48	8.15	9.01	-
Kenaf	"	2.26	2.34	2.29	-
Jute	"	3.24	3.24	3.27	-
Cotton	"	4.24	5.13	5.30	-
Castor Seed	"	5.86	4.06	6.06	-
Cassava	"	.35	.35	.45	.24
Sugarcane, eating	"	.86	.49	1.45	1.15
Sugar cane, manufacturing	"	.30	.30	.30	-
Tobacco, native	"	8.00	8.00	8.00	8.00
Tobacco, Virginia	"	16.12	20.75	20.75	-
Tobacco, Burley	"	16.12	20.75	20.75	-
Watermelon	"	4.00	4.00	4.00	4.00
Garlic	"	6.0	4.62	4.62	-
Native silk thread	"	100.	-	-	-
Hybrid silk thread	"	150.	-	-	-
Rubber	"	-	-	8.0	8.0
Coconut	fruit	-	-	1.91	1.91

[a] Regional center wholesale prices were used because the farm-to-market costs are included as part of the production costs on each producing activity.

Table A.11. Resource use by Agroeconomic Zone for Solution A.

Zone	Deep flooding paddy	Irrigated paddy Season		Rain-fed paddy	Upland Season		Labor Wet season	
		Wet	Dry		Wet	Dry	Plant	Harv.
	L1	L2W	L2D	L3W	L4W	L4W		
	(Thousand rai)						(Million hours)	
				Northeast				
Z1		519	111	4338	197	134	313	184
Z2		182	0	2329	432	45	211	115
Z3		1068	175	5048	182	161	449	288
Z4		153	22	4721	274	240	432	231
Z5		415	147	3413	3034	2978	524	357
NE		2337	456	19849	4120	3558	1929	1175
				North				
Z6	627	1099	97	2004	4514	4514	507	337
Z8	1548	1174	0	1548	2260	2260	354	306
Z9	416	571	163	920	310	1654	90	119
Z10		1191	471	1039	465	132	158	122
NO	2591	4035	731	5511	7549	8460	1109	884
				Central Plain				
Z7	16	646	39	0	1821	1821	179	83
Z11	320	6859	1190	1827	978	978	425	379
Z12		1267	246	216	2009	1999	137	232
Z13		1824	147	884	485	0	176	172
Z14		615	170	87	244	244	55	30
Z15		184	4	325	1789	1789	54	37
Z16		37	0	198	61	61	15	15
CP	336	11432	1766	3537	7387	6892	1041	948
				South				
Z17		958	91	1557	5393	5587	227	346
Z18		219	8	254	2173	2174	151	164
Z19		529	0	121	2544	2547	129	100
So		1706	99	1932	10650	10848	507	610
				Kingdom				
KG	2927	19510	3052	30829	29706	29758	4586	3617

Table A.12. Estimated production, consumption, and net surplus by region for BE 2524 under Alternative A

Commodity	Type of Statistic	Region				
		NE	North	Central Plain	South	Thailand
				(Thousand tons)		
Rice NG	Prod	1,642	2,271	5,144	1,195	10,252
	Cons	1,361	1,260	3,734	1.428	7,784
	Exports	- 521	1,011	1,410	- 234	2,468
Rice G	Prod	3,056	2,193	522	27	5,799
	Cons	3,577	1,989	59	27	5,652
	Exports	281	2,205[1]	463[1]	0	147
Maize	Prod	39	2,171	1,400	0	3,610
	Cons	39	1,661	405	0	610
	Exports	0	2,004[1]	996[1]	0	3,000
Kenaf & Jute	Prod	280	44	0	0	324
	Cons	278	1	45	0	324
	Exports	1	43	(re-export) - 45	0	100[1]
Cassava	Prod	421	43	4,990	1,656	7,109
	Cons	73	43	6,966	23	7,105
	Exports	347	0	-1,976	1,633	6,596[1]
Sugarcane	Prod	639	598	15,064	0	16,302
	Cons	639	598	15,064	0	16,302
	Exports	0	0	0	0	10,000
Rubber	Prod	0	0	49	416	466
	Cons	0	0	49	416	466
	Exports	0	0	0	0	450[1]

[1] Fixed level.

Table A.13. Resource use by agroeconomic zone for Solution B2

Zone	Deep flood paddy L/W	Irrigated paddy season wet L2W	Irrigated paddy season dry L2D	Rain-fed paddy L3W	Upland season wet L4W	Upland season dry L4D	Labor wet Planting	Labor wet harvest	Capital
1	-	358	12	4428	795	1363	317	310	530.
2	-	125	0	3233	505	120	278	149	108.
3	-	736	173	5296	948	2675	502	540	949.
4	-	105	9	4750	1535	1858	488	335	832
5	-	286	77	3430	3033	3033	553	305	493
NE	-	1612	273	21139	6818	9052	2138	1639	2912
					North				
6	627	758	46	2181	1639	2004	268	326	939
8	1548	809	0	1684	2259	2259	354	337	402
9	416	393	0	1041	216	117	88	78	222
10	-	821	317	1378	140	88	135	120	216
NO	2591	2783	363	6286	4255	4470	844	860	1778
					Central Plain				
7	16	466	30	432	1241	1820	179	92	434
11	320	4732	1475	2440	978	978	356	303	1447
12	-	874	192	592	2008	1730	124	232	715
13	-	1314	0	1297	638	0	176	150	210
14	-	551	94	151	77	77	50	28	352
15	-	126	4	365	1125	1125	53	29	434
16	-	25	0	205	63	63	15	16	23
CP	336	8091	1797	5485	6134	5797	983	859	3615
					South				
17	104	661	54	1800	5391	5586	248	313	369
18		151	3	321	2370	2371	149	161	83
19		365	0	229	2544	2547	105	80	56
SO		1177	58	2351	10306	10505	503	555	507
					Kingdom				
KG.	2927	13665	1548	35363	27515	29825	4467	3912	8812

Table A.14. Resource use by agroeconomic zone for Alternative F

	Land						Labor	
	RL1	RL2W	RL2D	RL3	RL4W	RL4D	RLBP	RLBH
	(Thousand rai)						(Million hours)	
				Northeast				
Z1		317	7	4476	197	134	312	178
Z2		28	0	3267	437	49	267	148
Z3		472	6	5421	182	1210	459	330
Z4		64	0	4801	431	398	444	242
Z5		303	19	3470	3034	2978	508	335
NE		1184	32	21435	4281	4769	1990	1233
				North				
Z6	627	301	5	2420	4514	4514	512	418
Z8	1548	283	6	2011	2260	2260	358	342
Z9	416	294	73	1110	572	1654	90	113
Z10		475	191	1698	83	32	197	174
NO	2591	1353	275	7239	7429	8460	1157	1047
				Central Plain				
Z7	16	383	24	798	1527	1821	179	71
Z11	320	5345	1316	1827	978	978	332	320
Z12		622	0	836	2009	2009	138	173
Z13		540	94	1829	954	0	176	136
Z14		153	0	254	244	244	46	40
Z15		138	6	359	1441	1441	56	54
Z16		17	0	211	65	65	15	16
CP	336	7198	1440	6114	7218	6558	942	810
				South				
Z17	L5 (104)	393	25	2013	5394	5587	235	333
Z18		65	0	385	2713	2714	140	170
Z19		47	0	437	2544	2547	110	82
SO		505	25	2835	10651	10848	485	585
Kg.	2927	10240	1772	37623	29579	30635	4574	3675

IV. THE LIVESTOCK MODEL: CATTLE AND WATER BUFFALO[1]

Chumlong Sukidee and Somnuk Sriplung

Problem Specification

Cattle and water buffalo are the animals that are considered in the model. The two major reasons for considering them are that 1) the total number of animals is declining while the domestic demand for meat and milk consumption is increasing and 2) the increased use of machines in agriculture has affected the labor value of cattle and buffalo. At the same time, the price of fuel (which is imported) has been rising. Consequently, substitution of machines for labor may not be more economic and necessary in the future.

Background of Cattle and Buffalo Production

Cattle raising in Thailand has three purposes: animal power (male cattle), milk production, and meat production. Most cattle are raised for labor purposes. The number of milk cows is relatively low compared to other cattle and buffalo and the number of cattle raised solely for meat production is almost negligible because most of the meat supply is obtained from retired labor animals. Water buffalo are raised mostly for labor and, when retired, are then used for meat purposes.

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[1]Thanks must be given to Chulsiri Suwansiri for collecting basic information for initial model construction. This model was initially constructed by Dr. Somnuk Sriplung and expansion and elaboration of the model was conducted in consultation with Dr. Arthur Stoecker.

Survey information from the Department of Local Administration, Ministry of Interior showed that in April 1975 there were about 4,478,000 head of cattle and 5,157,000 head of water buffalo. The number of cattle and buffalo are shown by sex in each zone in Table 12. The number of female animals both for cattle and water buffalo are greater than the number of males. This is because female animals cannot be exported. In some zones, however, there are more males than females because farmers in these zones buy male animals from other zones. This data lends support to the idea of shipment of animals between zones.

Model Structure

At this stage there are three purposes for the model. The first is to allocate working animals to be raised in each zone in order to meet the demands for labor and meat. The second is to project future production based on observed fertility rates and the existing feed supply. The third is to study the competition for farm resources between livestock and crop production.

The linear programming model is presented in matrix form (Figure 17). The matrix can serve only for the first purpose because it covers only a one-year period. To serve the second and third purposes, the model must be solved in recursive form which should cover at least the duration of maturity ages of the animals (four years).

Coefficient Specification and Estimation

Coefficients in C-row are prices per unit of those activities. In row R4 the coefficient represents a birth rate. Rows R5 and R6 determine

Table 12. Number of cattle and water buffalo by zone

Zone	Cattle			Buffalo		
	Male	Female	Total	Male	Female	Total
1	209,632	252,528	462,160	425,299	562,176	987,475
2	139,920	133,216	273,136	176,827	171,630	348,457
3	225,417	285,869	511,286	331,812	373,773	705,585
4	133,198	154,628	287,826	271,745	325,433	597,178
5	185,167	181,673	366,840	206,418	217,766	424,184
6	108,577	111,321	219,889	133,634	141,469	275,103
7	92,843	105,554	198,397	52,108	62,943	115,051
8	131,125	143,873	274,998	178,874	179,407	358,281
9	130,303	134,514	264,817	135,211	160,299	295,510
10	148,871	152,589	301,460	136,971	158,419	295,390
11	89,022	108,840	197,862	129,439	122,590	252,029
12	199,944	178,031	377,975	27,073	33,790	60,863
13	24,695	18,236	42,931	69,874	55,210	125,084
14	2,778	2,200	4,978	4,222	641	4,863
15	12,145	5,787	17,932	27,174	15,355	42,529
16	1,720	976	2,696	12,059	11,682	23,741
17	187,906	219,996	407,902	44,713	73,977	118,690
18	23,580	40,721	64,301	26,227	43,478	69,705
19	89,556	111,471	201,027	23,798	33,789	57,587
Total	2,136,399	2,342,014	4,478,413	2,413,478	2,743,827	5,157,305

SOURCE: Department of Local Administration, Ministry of Interior.

ROW		SIGN	YMBi	YFBi	MMBi	MFBi	KMMBi	KMFBi	SMBSi	SFBSi	EMDMij	EFBMij	EMBLij	BBi	SDMi	EXMij	EXMji	LBSi	EXLBij	EXLBji	AMUi	FRLi	RLWi	UPCWi	RLDi	UPCDi	UNLWi	UNUPWi	UNUPDi	RSTMi	STWWi	STWDi	GRZWi	GRZDi	GRSWL	HTRCi	YMBEi	YFBEi	MMBEi	MFBEi
	Objective Fn (Max C)		-A	-A	-A	-A									A	A	-A		A	-A																-A	A	A	A	A
R1	Beginning stock of animal	≤	1	1	1	1																																		
R2	Trans. male animal	=			-1		1		1		1		1																											
R3	Trans. female animal	=				-1		1		1		1																												
R4	Reproduction	=						-a						1																										
R5	Produce meat	=							-a	-a					1		-1																							
R6	Produce meat	=									-a	-a				1																								
R7	Produce labor	=					-a	-a										1		-1																				
R8	Produce labor	=											-a						1																					
R9	Animal unit	=	-a	-a			-a	-a						-a						-a	1																			
R10	Human labor supply	≥																					a	a	a	a					a	a	a	a	a					
R11	Forest land	=																				1																		
R12	Lowland in wet season	=																					1				1													
R13	Upland in wet season	=																						1				1												
R14	Lowland in dry season	=																							1					1										
R15	Upland in dry season	=																								1			1											
R16	Straw in wet season	≥																					-a								a									
R17	Straw in dry season	≥																							-a							a								
R18	Grazing area in wet season	≥																				-a						-a					a							
R19	Grazing area in dry season	≥																				-a					-a		-a	-a				a						
R20	Grass supply in wet season	≥																					-a				-a								a					
R21	Feed consumed in wet season	=																			1										-1		-1		-1					
R22	Feed consumed in dry season	=																			1											-1		-1						
R23	Animal labor use	≥																-a					a	a	a	a										-1				
R24	Ending stock of animals	=	-a											-a																							1			
R25	" " " "	=		-a										-a																								1		
R26	" " " "	=	-a				-a																																1	
R27	" " " "	=		-a				-a																																1
B	Bounds		B1	B2	B3	B4				B5					B6								B7	B8	B9	B0														

Figure 17. General zone livestock matrix format

Matrix Identification (Figure 17)

Column names

YMBi = young male bovines (subscript i stands for zone)
YFBi = young female bovines
MMBi = mature male bovines
MFBi = mature female bovines
KMMBi = keep mature male bovines
KMFBi = keep mature female bovines
SMBSi = sell mature male bovine for subsistence demand
SFBSi = sell mature female bovine for subsistence demand
EMBMij = sell mature male bovine as meat from the i^{th} zone to the j^{th} zone
EFBMim = sell mature female bovines as meat from the i^{th} zone to the j^{th} zone
EMBLij = sell mature male bovine as labor from the i^{th} zone to the j^{th} zone
BBi = bovines born during the year
SDMi = subsistence demand for meat
EXMij = export meat from the i^{th} zone to the j^{th} zone
EXMji = import meat from the j^{th} zone to the i^{th} zone
LBSi = animal labor supply
EXLBij = export animal labor from the i^{th} zone to the j^{th} zone
EXLBji = import animal labor from the j^{th} zone to the i^{th} zone
AMUi = animal unit calculated from feed requirement equivalent
FRLi = forest land and other uncultivated land
RLWi = area planted to rice in wet season
UPCWi = area planted to upland crops in wet season
RLDi = area planted to rice in dry season
UPCDi = area planted to upland crops in dry season
UNLWi = unused rice land in wet and dry season
UNUPWi = unused upland in wet season
UNUPDi = unused upland in dry season
RSTMi = rice straw residue in dry season
STWWi = rice straw in wet season
STWDi = rice straw in dry season
GRZWi = grazing area in wet season
GRZDi = grazing area in dry season
GRSWi = grass supply in wet season
HTRCi = hired tractor labor for crop production
YMBEi = young male bovines at the end of the year
YFBEi = young female bovines at the end of the year
MMBEi = mature male bovines at the end of the year
MFBEi = mature female bovines at the end of the year

Row names

R1 = beginning stock of bovines
R2-R9 = transfer rows
R10 = labor supply (human labor)
R11-R15 = supply of land of various types
R16-R23 = transfer rows
R24-R27 = ending stock of bovines

Bounds

B1-B4 = column fixed bounds of beginning animal stock
B5 = column lower bound of female bovines kept for breeding
B6 = column fixed bound of subsistence demand for meat
B7-B0 = column lower bounds of subsistence demands for crops

the carcass weight obtained from mature animals. Row R7 represents draft power equivalent obtained from labor animals.

In row R9 the animals are converted into animal units which is based on animal weight. The weight is estimated by ages and was done by E. Price.[1] Coefficients in row R10 are man labor requirements of crop production and animal raising activities. Both crops and livestock must compete for the same farm labor supply.

In rows R16-R20 we insure that the feed carrying capacity (negative sign) obtained from various types of land is equal to the feed requirement for all animal units (positive sign) in wet and dry seasons. The amount of rice straw consumed for feed must be limited in order to avoid nutrient deficiencies from feeding excess straw to animals. The animal carrying capacity of alternative feed sources has been estimated by regressing animal units on area grazed, grass consumed, and straw consumed by animal units (a similar procedure was used by E. Price).

Data required in estimating these coefficients are now being obtained from surveys and aerial photo maps. The samples are taken by purposive sampling because the survey must be done in the large animal raising area and where aerial maps are available.

The first survey is being taken in agroeconomic zone 7. The size of all areas where animals are being grazed must be measured. The fastest and cheapest way of measuring these areas is by using planimeter measures on the map. The interviewers ask the animal raisers to identify on the maps where their herds graze.

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[1] E. C. Price, Jr. Aggregate Bovine Supply in Northeast Thailand. Unpublished Ph.D. dissertation. University of Kentucky, 1973.

The samples are stratified into three strata based on the proportion of cultivated area that is planted to rice. These strata are: 1) the area composed of less than 40 percent of rice area, 2) the area composed of 40-80 percent of rice area, and 3) the area composed of more than 80 percent rice area. The strata are drawn under the assumption that the number of animals raised varies in proportion to the rice area. Previous survey results indicate the assumption is valid for operational purposes. Therefore, if the feed carrying capacity functions derived from each sample strata are significantly different, the activities and resource supply in each zone will be classified in accordance with these strata.

The data collection procedures are underway, and we expect models for all zones to be operational within six months.

V. TRANSPORTATION, STORAGE AND PROCESSING MODEL FOR RICE[1]

Chumlong Sukdidee and Somnuk Sriplung

Problem Specification

Rice is the staple food for Thailand. Thai farmers have been growing rice for centuries. In the old days, rice production was largely consumed on the farms where it was produced. The expansion of trade and the improvement of communication and transportation have encouraged greater specialization. Rice farmers have easily increased production to meet increased market demands.

For decades, rice has been the largest source of income for Thai farmers and of foreign exchange for the Thai government. The price of rice, as with other agricultural commodities, has monthly and yearly fluctuations caused by interactions of supply and demand both internally and internationally. The price fluctuations are a source of uncertainty to both farmers and merchants.

The purpose of price stabilization is to decrease price uncertainty. Under the existing situation, one seemingly effective procedure in handling price stabilization is supply control by means of seasonal and yearly stock management policies. The main objective in this research is to

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[1]This model was initially constructed by Dr. Somnuk Sriplung and expansion and elaboration of the model was conducted in consultation with Dr. Arthur Stoecker.

Thanks are due to Mr. Chamnong Watana, Mr. Aran Roongsawang, and Miss Amporn Ruayruen for collecting basic information needed for initial model construction.

answer the question about the optimal size and location of processing and storage facilities. The initial step has been to specify a linear programming model of rice transportation, processing, and storage. The first use of the model will be to determine the adequacy of initial storage and processing facilities along with the optimal seasonal storage and transportation pattern which will minimize the total marketing cost. Analysis of discrete specified changes in size and/or location of storage, processing, and transportation facilities will be made.

Rice Production and Marketing

The policy of the government is to encourage production by means other than expansion of the land area in agriculture and to encourage greater efficiency in marketing, transportation, and processing.

From 1970 to the present time, rice production has been rather stable at about 13.5 million metric tons of paddy per annum. Two crops of rice can be grown, i.e., wet season cropping and dry season cropping. Dry season cropping is limited by the area of land irrigated.

The cultivated area in Thailand is delineated into 19 agroeconomic zones. The distribution of paddy production by agroeconomic zones (in 1975) is shown in Table 13. In the same table, demand deficit and supply surplus in each zone are calculated.

The main rice crop (grown in the wet season) is harvested from November to January and largely supplied to markets in January and February. The dry season crop is harvested in July and supplied to markets in those months. Table 14 is an illustration of farmer's selling patterns of paddy.

Table 13. Production and consumption of paddy by zone

Zone	Prod - seed use	Human consumption	Surplus + Deficit -
1	1,175,856.	820,500.386	355,355.614
2	581,199.7	437,015.101	144,184.599
3	986,430.9	1,110,369.701	-23,938.801
4	767,823.7	743,210.688	24,613.012
5	413,728.	613,391.908	-199,663.908
6	990,030.	520,800.013	469,229.987
7	520,354.	222,639.702	297,714.298
8	1,187,772.	515,938.857	671,833.143
9	1,434,987.	979,492.344	455,494.656
10	471,345.	407,503.800	63,841.200
11	3,170,228.	1,670,326.925	1,499,901.075
12	381,296.	342,843.258	38,452.742
13	648,254.	211,665.102	436,588.898
14	124,085.	185,134.633	-61,049.633
15	142,802.	204,138.018	-61,336.018
16	78,142.	82,350.451	-4,208.451
17	666,351.	675,433.438	-9,082.438
18	155,004.6	226,610.235	-71,605.635
19	99,500.	220,378.623	-120,878.623
Total	13,995,188.9	10,089,743.183	3,905,445.717

Table 14. Farmers selling pattern of paddy in 1975

Month	North	Northeast	Central	South	Kingdom
Jan.	17.50	6.74	16.32	33.67	15.57
Feb.	22.80	24.66	38.51	1.76	33.11
Mar.	41.18	32.30	25.06	5.17	26.09
Apr.	5.65	9.23	1.96	5.47	3.78
May	4.20	4.50	0.64	11.05	2.17
June	1.45	2.55	1.47	6.23	1.97
July	0.72	3.53	2.75	7.03	3.06
Aug.	0.45	2.35	4.53	4.56	3.88
Sept.	1.53	3.32	3.20	7.50	3.40
Oct.	0.81	2.55	0.85	4.62	1.40
Nov.	1.91	3.29	1.25	4.38	1.87
Dec.	1.80	4.98	3.46	8.56	3.70
	100.	100.	100.	100.	100.

SOURCE: Marketing Economics Branch, Division of Agricultural Economics, Ministry of Agriculture and Cooperatives. Agricultural Economics Bulletin Series No. 98.

A large portion of marketable paddy from farmers is sold early after harvesting. Many farmers may have to sell their product very soon after harvest even though the price is low because they need money to repay debts and for family living expenses.

The marketing activities from the farm gates to the consumers' hands are undertaken by various middlemen. The middlemen at the village level purchase and collect paddy from farmers for rice mills and for warehouse storage. The paddy stored by merchants is for two purposes, i.e., selling when the price is high and milling for white-rice to sell to consumers. The merchants have been accused of taking advantage of both farmers and consumers. Another objective of research, then, is to examine the performance of the rice transportation, storage, and processing sector.

Data Collection

Most of the data have been obtained by face-to-face interviews with the concerned persons. The sample selection is purposive sampling. The total samples is about 300 and the sample size in each zone varies in proportion to the area planted to rice in the zone. Information sought included:

1) the annual costs of storage for farmers and merchants,
2) the cost of milling and the conversion rate of paddy to white-rice, and
3) the transportation costs of paddy and white-rice.

The received information is tabulated by agroeconomic zones. In addition to the above primary data, some supplementary information is necessary. For example, the production of paddy in each zone, the monthly paddy selling pattern, the per capita consumption of rice, and the demand for export are also necessary.

The Structure of the Model

The model structure is illustrated in the flow chart form and in matrix form in Figures 18 and 19, respectively. The flow chart describes the flow of paddy from farmers through various marketing activities--transportation, storage, processing, consumption, and export.

The marketing activities are divided into three time periods. In each period there are activities for the supply of paddy, the demands for consumption and export, storage of rice, the processing of rice, and alternative transportation modes. The supply of paddy is large at the first period. The cost of storage is proportional to the time span. The availability of transportation modes is dependent in some zones upon the seasons of the year, i.e., wet or dry. The model presented here is simply constructed in line with the existing market pattern.

Calculation of Coefficients and Bounds

The storage cost (A1, A5) is calculated by adding up the per year building cost and repairing cost of the warehouses together then dividing the result by the yearly average quantity of paddy stored then adding the quotient with the yearly variable cost per unit of paddy stored.

The processing cost (of each size of rice-mill) is calculated the same way as storage cost but weighted with the amount of paddy produced in the area where the mills are situated.

The computation of transportation cost is much different from the storage and processing costs. The cost of transportation tabulated from

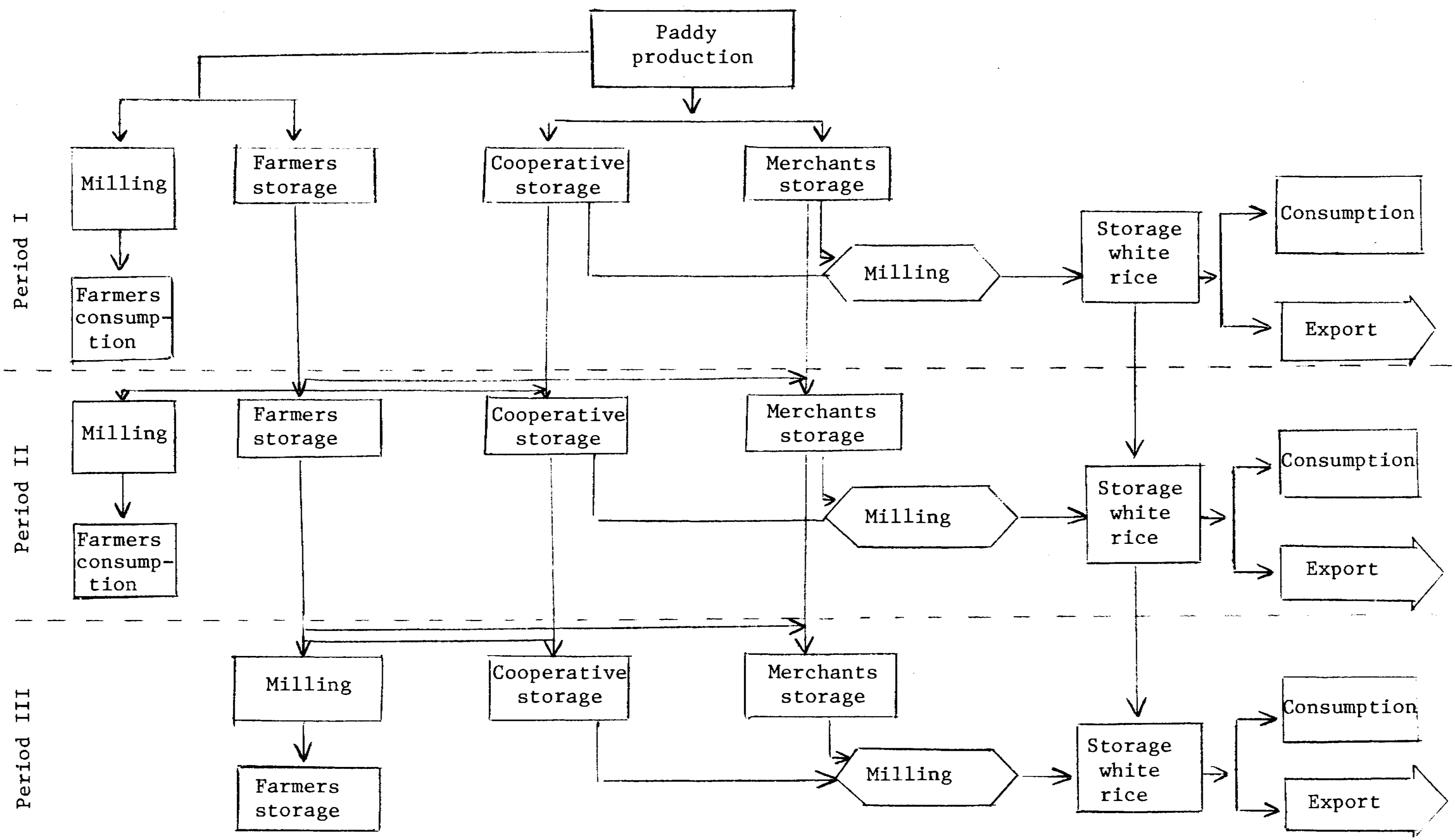

Figure 18. The flow chart of the TSP Model

Matrix Identification (Figure 18)

Column names

FKC1i = farmers keep paddy for family consumption in period 1 in the i^{th} zone
FSPT1i = farmers sell paddy loaded by truck in period 1 of the i^{th} zone
FSPB1i = farmers sell paddy loaded by barge in period 1 of the i^{th} zone
FSTP1i = farmers store paddy in period 1 for sale in later period of the i^{th} zone
STP1i = paddy stored by merchants and cooperatives in period 1 of the i^{th} zone
MILM1i = milling by medium size rice-mill in period 1 of the i^{th} zone
MILL1i = milling by large size rice-mill in period 1 of the i^{th} zone
RNC1i = white rice consumed by nonfarm people in period 1 of the i^{th} zone
FSS2i = farmers sell paddy (second crop) in period 2 of the i^{th} zone
REX1ij = outshipment of white rice from the zone i^{th} (if it is surplus) to the j^{th} deficit zone
REX1ji = inshipment of white rice from the j^{th} surplus zone to the i^{th} zone (if it is deficit)
BKRi = broken rice produced from rice milling in the i^{th} zone
BRNi = rice bran produced from rice milling in the i^{th} zone
DEXP1 = demand for export of white rice in period 1

Row names

R1i = total supply at the beginning of the periods in i^{th} zone
R2i-RAi = transfer rows
bounds = column bounds set in accordance with the constraints of demand, capacity of each transportation mode, capacity of each zize of mills and supply of paddy in each period

Coefficients

A's = costs per unit of transportation, processing and storage
a1's = represent percentage of loss due to storage duration
a2's = represent conversion rate of paddy to white rice
a3's = represent broken rice obtained from milling one unit of paddy
a4's = represent rice bran obtained from milling one unit of paddy

			Transportation, processing, storage activities — Period I								Period II									Period III							Export act.			Import act.			By-product		Export to world mkt.			
		SIGN	FKC1i	FSPT1i	FSPB1i	FSTP1i	STP1i	MILM1i	MILL1i	RNC1i	FSS2i	FKC2i	FSPT2i	FSPB2i	FSTP1i	STP2i	MILM2i	MILL2i	RNC2i	FKC3i	FSPT3i	FSPB3i	STP3i	MILM3i	MILL3i	RNC3i	REX11i	REX21i	REX31i	REX11i	REX21i	REX31i	BKRi	BRNi	DEXP1	DEXP2	DEXP3	PCRVi
	Objective fn. (Min C)	C	A1	A2	A3	A4	A5	A6	A7	A8		A1	A2	A3	A4	A5	A6	A7	A8	A1	A2	A3	A5	A6	A7	A8	A9	A9	A9	A0	A0	A0						
R1	Paddy supply at period I	=	a_1	1	1	1						a_1								a_1																		
R2	Paddy shipment at period I	=		-1	-1		1	1	1																													-1
R3	Milling in period I	=						$-a_2$	$-a_2$	1																	1			-1					1			
R4	Farmers sell in period II	=				$-a_1$					-1		1	1	1																							
R5	Paddy shipment in period II	=					$-a_1$						-1	-1		1	1	1																				
R6	Milling in period II	=															$-a_2$	$-a_2$	1									1			-1					1		
R7	Farmers sell in period II	=													$-a_1$						1	1																
R8	Paddy shipment in period III	=														$-a_1$					-1	-1	1	1	1													
R9	Milling in period III	=																						$-a_2$	$-a_2$	1			1			-1					1	
R0	Broken rice	=	$-a_3$					$-a_3$	$-a_3$			$-a_3$					$-a_3$	$-a_3$		$-a_3$				$-a_3$	$-a_3$								1					
RA	Rice bran	=	$-a_4$					$-a_4$	$-a_4$			$-a_4$					$-a_4$	$-a_4$		$-a_4$				$-a_4$	$-a_4$									1				
	Bounds	=	B_1		B	B_3				B_2	Q_{i2}	B_1		B_3	B				B_2	B_1		B_3				B_2									B	B	B	B

Figure 19. The matrix of the model

the interview results are regressed (cost on distance). Once the function has been estimated, the distance to be substituted in the function must be determined. The estimation of the distance for the cost of transportation is rather difficult. Some important routes of transportation are not shown on the state highway maps. These routes are mostly used for hauling paddy from farmers to the merchants' warehouses or to the rice mill. However, as mentioned before, the area planted to rice is distributed throughout each district. Therefore, the simple assumption is made that the shipment of rice from the farm to the merchant occurs within the area of each district and that the paddy marketed in that area is shipped to the center point of the district. The production area in each district is converted into a circle. The distance of handling paddy is assumed to be equal to half of the length of the radius calculated. The distance estimated is weighted with the quantity of paddy traded in each district then averaged for each zone. Finally, the transportation cost is calculated by substituting the estimated distance into the function.

The transportation cost for white-rice is calculated the same way, but the distance of shipment is estimated on the basis of the routes shown on the road map of the state highway department.

Setting the value of some bounds is very difficult, particularly the amount of paddy the farmers release to the market in each period because the supply is related to some degree to the market selling price. At the present time, the flow supply of paddy from farmers in each period can be estimated only on the basis of the farmers' selling pattern (shown in Table 14) obtained from a survey in a particular year.

Demands for rice can be separated into two parts--demand for domestic consumption and demand for export. Demand for domestic consumption can be forecast. This demand is expected to be fairly inelastic with respect to price change. It stands to reason that the supply to meet the domestic demand would be fully absorbed by the rice miller if the price of white-rice is set at the level covering the added costs of transportation, storage, processing, and paddy prices. However, this would hold only if the excessive supply (when the export price is lower than the domestic price) is eliminated from the domestic consumer market. And if the program of price stabilization is to be effective, the government must be ready to purchase the excess amount of paddy. To reduce the costs in carrying out the program, the government should know where to buy and how much and the commodity should be assembled from and to the points which have the least costs.

At the present time, the computation of the model for all 19 agro-economic zones is being completed. We expect the first computer run by December 1975. The initial results will be compared to existing information on storage, transportation patterns, and quantities milled in each zone. After the checks of the model have been completed, the first use of the model will be to study effects of alternative warehouses in specified locations on total storage, processing, and transportation costs.

VI. APPLICATIONS OF THE REGIONAL CROP MODEL OF THAILAND[1]

Prapai Vongmonta and Herbert H. Fullerton

Introduction

Focus and region delineation for this study

The Sector Analysis Project of the Division of Agricultural Economics (DAE), Office of the Under-Secretary of State for Agriculture, Ministry of Agriculture and Cooperatives in Thailand has been characterized as the linear programming approach to planning. Although the national, inter-regional linear programming model of agricultural production and transportation is a core part of the agricultural sector analysis project in the DAE, other models are being constructed and supporting research conducted simultaneously. Specifically, these include demand analysis, marketing research, macroeconomic modeling of intersector linkages, and regional development. However, the initial focus was constructing a national linear programming model and regional linear programming model of agricultural crop production and transportation as the first step toward building research capability in analysis and development of agricultural objectives and policies. When conducting modeling type analysis at the national

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[1]The applications presented here could not have been completed without the benefit of earlier studies by members of the DAE/ISU Team. These include: "Crop Model for Thailand's Fourth Five-Year Plan" by Arthur L. Stoecker, et al.; "End of Tour Report," Thailand Agricultural Sector Analysis by Keith D. Rogers; and "Thailand Fourth Five-Year Agricultural Development Plan, BE 2524-Guidelines" by Charles F. Framingham, et al.

level, it is often desirable to conduct further analysis at the regional level, at the agroeconomic zone level, in specialized models (such as those for transportation and marketing) or for representative types of farms.

The national model of crop production was made to approach the problem on a region-by-region basis. In other words, a series of regional models was developed with internal consistency so they could be linked together in a national model. Therefore, the work with the zone model, or a series of zone models, was initially developed with internal consistency so they could be linked together in a regional model. For the planning purposes of the national and regional crop models, the 71 Changwads have been grouped into 19 agroeconomic zones. In the current model 4 of the 19 agroeconomic zones as utilized in the national model have been identified as consuming regions for the purpose of measuring supply and demand relationship for each agricultural commodity.

Economic conditions of the North and Northeast Regions

Planning for agricultural development in Thailand should be proceeded from and based on current conditions. Therefore, the planners for agricultural development should know the details of the present and a description of these conditions: for example, the number of people both in nonfarm population and farm population; the land resources available for use in development; the capital stock or infrastructure available in the form of livestock, machinery, and equipment; the current productivity of agricultural production; export-import situation; and the current income and employment in agriculture.

The total population of Thailand in BE 2513 (the year of the most recent census) was 34.4 million people. Total land area is 312 million rai. The Northeast Region has the biggest number of both nonfarm and farm population and also the smallest average farm income. The farm population of the North Region is 5,599,613 people and the average farm family income from farm and nonfarm sources is only 3,789 Baht per year (Table 15). This compares with average family income of 10,746 Baht for the Kingdom.

Employed farm population and the amount of land in farms is shown in Table 16. The North Region has economically active farm population, employed farm population, and land in farm of 23.18 percent, 23.01 percent, and 21.97 percent while the Northeast Region also has 35.88 percent, 37.58 percent, and 43.69 percent of the total kingdom respectively. A problem of greater concern for policy is the fact that fewer than 60 percent of the economically active farm population is employed in this sector.

The agricultural land area of Thailand consists of four types of land. Land type I is that land which is continuously flooded and hence suited only for production of floating rice. Land type II is that land area where controlled irrigation practices can be employed. Land type III is that land area which permits only rainfed paddy production. Land type IV is that land area in Thailand which can produce only upland crops. Both the North and Northeast Regions have these four types of land, but some zones do not have all four types of land. For example, zone 10 of the North Region has only land types II, III, and IV.

Table 15. Characteristic features of Thailand's population, gross regional products, and average farm family income in 1970

Region	Total population		Farm population(1)		Gross regional product(2)		Average farm family income(3)			
							Farm source		Nonfarm source	
	Person	%	Person	%	Million baht	%	baht	%	baht	%
North[a]	7,813,000	22.71	5,599,613	25.77	20,508	15.07	2,187	46.51	1,602	26.51
Northeast[b]	11,700,000	34.01	9,407,088	43.29	21,413	15.74	952	20.24	1,064	17.61
Rest of Kingdom	14,884,000	43.28	6,722,595	30.94	94,121	69.19	1,563.5	33.25	3,377.5	55.88
Total Kingdom	34,397,000	100.00	21,729,296	100.00	136,042	100.00	4,702.5	100.00	6,043.5	100.00

SOURCE: (1) Population and Housing Census National Statistical Office, Office of the Prime Ministry, 1973. Table 1, area 2. (2) National Account Division, Office of the National Economic and Social Development Board. Gross Regional Product at Current and market prices 1970-1973. (3) Division of Agricultural Economics, Ministry of Agriculture and Cooperatives, Royal Thai Government Farm Income and Expenditures in Thailand BE 2513 Bangkok, Thailand.

[a]North--includes changwat Loei.

[b]Northeast--excludes changwat Loei.

Table 16. Economically active farm population, employed farm population, and farm holdings

Region	Economically active farm population (15-64 yrs.)		Employed farm population(2)		Farm holdings(3)	
	Persons(1)	Percentage	Persons	Percentage	Rai	Percentage
North[a]	3,402,233	23.18	1,925,664	23.01	24,035,568	21.97
North-east[b]	5,268,192	35.88	3,145,111	37.58	47,802,248	43.69
Rest of Kingdom	6,010,375	40.94	3,297,345	39.41	37,568,590	34.34
Total Kingdom	14,680,800	100	8,368,120	100	109,406,406	100

SOURCE: (1) Population and Housing Census, National Statistical Office, Office of the Prime Minister, Royal Thai Government, 1973, Bangkok, Thailand, Table 19. (2) Estimated by using proportion from 1973 General Survey, Division of Agricultural Economics, Ministry of Agriculture and Cooperatives. (3) The Center for Agricultural Statistics, Division of Agricultural Economics; Ministry of Agriculture and Cooperatives, Royal Thai Government.

[a]North--includes changwat Loei.

[b]Northeast--excludes changwat Loei.

Structure of the Regional Linear Programming Models

Description of the LP Model

Four major regions were delineated for the first regional modeling effort, as mentioned earlier. The Northern Region model (NOREGON), which is a linear programming, inter-zone competition model with four consuming and producing regions, is a typical example of these regional models. Other regional models are the Northeastern Regional Model, Central Regional Model, and Southern Regional Model.

The Regional crop model of the North is composed of four consuming and producing regions, agroeconomic zones 6, 8, 9, and 10. The model contains 502 activities and 442 rows of equations. A schematic model of the North Region is shown in Figure 20 . The activities in the model include one or more production processes in each zone for each commodity on each type of land during each season where production has been observed historically. Separate activities have been defined for the same commodities whenever a distinct production process could be identified that would affect the resource requirements, costs, and (or) yields. Although this does not provide for unlimited resource substitution, it does provide for some basic substitution. As new activities are defined and the model expanded, further resource substitution will be possible.

In addition to the production activities, the model contains separate supporting activities for each zone. These include: subsistence demand (on farm consumption) for selected commodities; marketing activities for each commodity; transportation activities among zones and regions; buying of fertilizers (nitrogen and phosphorous) activities; capital borrowing by month from institutions, relatives, and merchants; and capital transfer activities.

The North model has separate bound sets for each zone which include land by type and month, labor by month, capital by month, and capital borrowing by source. In addition to the bound sets for each zone, point demand estimates which were taken from the national model have been added in the form of regional marketing bounds for each commodity. These point demand estimates serve as upper limits for on-farm consumption and off-farm marketing at the prices specified in the model. These restraints

Resource supplies	Type of constraint	Crop activities				Subsistence demand and marketing activities								Transportation activities: Export to Bangkok				Export to center to reg				Import from center to reg				Buying fertilizer activities: Nitrogen				Phosphorus				Borrowing activity from institution	Transfer capital activities
		PZ06	PZ08	PZ09	PZ10	SDZ06	MKZ06	SDZ08	MKZ08	SDZ09	MKZ09	SDZ10	MKZ10	Z06	Z08	Z09	Z10	Z06	Z08	Z09	Z10	Z06	Z08	Z09	Z10	Z06	Z08	Z09	Z10	Z06	Z08	Z09	Z10	Mar to Feb	Mar to Feb
C_j		$-C_1$	$-C_2$	$-C_3$	$-C_4$	$-C_5$	$-C_6$	$-C_7$	$-C_8$	$-C_9$	$-C_{10}$	$-C_{11}$	$-C_{12}$	$-C_{13}$	$-C_{14}$	$-C_{15}$	$-C_{16}$	$-C_{17}$	$-C_{18}$	$-C_{19}$	$-C_{20}$	$-C_{21}$	$-C_{22}$	$-C_{23}$	$-C_{24}$	$-C_{25}$	$-C_{26}$	$-C_{27}$	$-C_{28}$	$-C_{29}$	$-C_{30}$	$-C_{31}$	$-C_{32}$	-0.12____-0.01	0_____0
Land I Mar-Feb	≥	{1}	{1}	{1}																															
Land II Mar-Feb	≥	{1}	{1}	{1}	{1}																														
Land III Mar-Feb	≥	{1}	{1}	{1}	{1}																														
Land IV Mar-Feb	≥	{1}	{1}	{1}	{1}																														
Labor Mar-Feb	≥	{a}	{a}	{a}	{a}																														
Capital Mar-Feb	≥	{1}	{1}	{1}	{1}																													{-1- - - - - - -1}	{-1- - - - - - -1}
Transfer yield Z06	≥	-y				1	1							1				1				-1													
Transfer yield Z08	≥		-y					1	1						1				1				-1												
Transfer yield Z09	≥			-y						1	1					1				1				-1											
Transfer yield Z10	≥				-y							1	1				1				1				-1										
Rows of Subsistence demand Z06	≤	-y				1																													
Rows of Subsistence demand Z08	≤		-y					1																											
Rows of Subsistence demand Z09	≤			-y						1																									
Rows of Subsistence demand Z10	≤				-y							1																							
Rows of fer, n for rice Z06	=	n																								-1									
Rows of fer, n for rice Z08	=		n																								-1								
Rows of fer, n for rice Z09	=			n																								-1							
Rows of fer, n for rice Z10	=				n																								-1						
Rows of fer, p for rice Z06	=	p																												-1					
Rows of fer, p for rice Z08	=		p																												-1				
Rows of fer, p for rice Z09	=			p																												-1			
Rows of fer, p for rice Z10	=				p																												-1		
R.Center of reg.	≥																	-1	-1	-1	-1	1	1	1	1										
R.Exp. to Bangkok	≤													1	1	1	1																		
RD Var Land II wet season	≥	1	1	1	1																														
RD Var Land III wet season	≥	1	1	1	1																														
RD Var Dry season	≥	1	1	1	1																														

Figure 20. Crop model in northern Thailand

force the four zones to compete against one another for a limited region market.

Model constraints

The constraints included in programming of the Regional Crop Model for the North Region are outlined in Table 17. The land constraints are defined for four major types of land by month as mentioned earlier.

Table 17. Resource constraints used in the regional crop production model for the North Region

Type of resource	Type of constraint
Crop land in each agroeconomic zone	
Land I (deep flooding paddy)	Monthly constraint
Land II (paddy in irrigation area	"
Land III (ordinary paddy rice)	"
Land IV (upland)	"
Other constraints	
Farm labor	"
Farm capital	"
Borrowed capital	Institutional loan constraint. Merchant loan constraint. Friends and relatives loan constraint.
Subsistence demand	Lower bounds on all production activities except rice which requires that subsistence needs are met. Row constraints that insure mat production is greater than or equal to subsistence needed in each zone.
Constraints on areas planted to RD rice	1. Wet-season Land 2 2. Wet-season Land 3
Constraints on fertilizer use on native varieties	Constrained to trend level projection
Fertilizer application per rai fertilized	Additional production activities are defined using specific levels of fertilizer

Procedures for modifying the zone models

In the original zone models, production activities were defined as a combination of producing and marketing activities so that the coefficient in the objective function represented the minimized cost for the activity. In order to guarantee sufficient production to satisfy subsistence demand, production activities were fed into a subsistence demand row for that commodity. The subsistence demand row was bounded by a lower bound which required at least some predetermined level of production. No explicit marketing was included. Although this formulation is sufficient for minimization subject to specific constraints, it does not allow for direct accounting of marketing in excess of subsistence demand or differentiated pricing of on-farm consumption and off-farm sales. With separate marketing activities, it is also easier to check or adjust cost and price coefficients.

The modified structure for each zone model includes separate marketing activities for each commodity and separate subsistence demand activities for selected commodities, which were identified from the farm survey as having been produced within the zone. To complete the linkage between production and marketing or consumption, a new transfer row was defined for each commodity in each zone and bounded (upper bound) at zero. This structural formulation requires new coefficients as follows: variable cost coefficients (objective function) and yield coefficient (transfer row) for each producing activity; a use coefficient (transfer row) for each marketing and subsistence demand activity; and column bound (equality for each subsistence demand activity).

Solution Results for North Region

Adoptation of zone models for this application and assumptions for alternative solutions

There are some factors that can affect the achievement of agricultural development planning objectives. They might be classified into two groups: namely, those affecting the demand for agricultural products and those affecting the supply of agricultural products. Those factors affecting the product demand side are population, income, exports, and commodity prices. The factors affecting the product supply side are agricultural land area and use, irrigation, technology adoption, commodity prices input costs, and climatic conditions. Therefore, to achieve the agricultural development planning objective of the government, plan formulation of agricultural development should require consideration of alternative ways to pursue the identified policy objectives. It also requires specific decisions concerning issues not a part of agricultural policy affecting those objectives. Each specification is one "Plan Alternative." Seven plan alternatives were identified and evaluated for the Fourth Five-Year Development Plan (2520 - 2524) for agriculture of Thailand. Those seven plan alternatives are plan alternatives A, B_1, B_2, C, D, E and F. Alternative F represents a "do nothing" future or the absence of any plan in agriculture. Plan alternative B_2 is the principal plan alternative considered as most probable, and the other five plan alternatives (A, B, C, D and E) were illustrative of alternative combinations. The assumptions among plan alternatives are different, but only those of plan alternatives B_2 and F, as shown in Table18, will be discussed and evaluated in this chapter.

Table 18. Plan alternatives analyzed

Planning factors	Plan alternatives	
	Plan B_2	Plan F
Demand factors		
1) Population:		
Growth rate (percent)	2.5	2.1
2) Income		
Growth rate (percent)[a]	Minimum[b]	2.2
3) Exports	Medium	High
4) Commodity price	BE 2516 - BE 2518 Average level or government specified	
Supply factor maximum use levels		
1) Land available: (1,000 rai)		
Total	111,547	111,547
Type I	2,927	2,927
Type II	13,649	10,241
Type III[c]	54,794	58,202
Type IV	40,073	40,073
Type V	104	104
2) Irrigated land: (1,000 rai)		
Total	16,992	12,205
Wet season	13,665	10,241
Dry season	3,228	1,964
3) Technology adoption: (percent or 1,000 rai)		
RD variety use:		
Percent of land Type II in wet season	49.9	31.5
Total land type II	6,407	3,223
Percent of land Type III area bound	21.5	14.3
Total land type III	7,659	5,470
4) Fertilizer use: (kgs. per rai)		
On native varieties	25	trend
On RD varieties	80	levels
Area fertilized (1,000 rai)	19,300	14,974

[a]This growth rate is based on past trends and assumes their continuation.

[b]16,662 Baht per farm family.

[c]Cropable area under plan alternatives B_2 and F for Type III land were 35,544 and 38,242 respectively.

Under alternative F, demand factors were assumed to reflect "low" population growth and "high" levels of export. These compare with medium rates of population and medium levels of export under alternative B_2. Thus, alternative B_2 could be expected to show either greater or lesser total demand for agricultural commodities than under alternative F depending on whether the larger increase in population under B_2 is large enough to offset the reduction in demand resulting from lower exports. Alternative F describes a "do nothing" future in the sense that all technology options available to agriculture are assumed to follow trend levels and no new type II land is added.

An additional assumption of the alternative B_2 is that it specifies an income policy objective. The solution to alternative B_2 indicates the distribution of crop production by region and land type required to meet specific minimum region income levels per farm. The specified minimum levels were at least BE 2516 income levels. In alternative B_2, the policy objective of increasing farm income is explicitly identified and analyzed along with the objective of insuring agricultural production to achieve self-sufficiency in food production for Thailand. These are possibly the two most important policy objectives in agricultural development in Thailand and its regions. Alternative F provides a base line solution against which the impact of changes in agricultural sector policy can be measured. It is important to realize that B_2 represents only one of several possible alternatives to alternative F which could be evaluated for possible introduction into Thailand's national agricultural sector plan.

Solution results for Alternative F in BE 2524

The estimated levels of production, farmer's consumption, and net surplus for major crops by each zone of the North Region are shown in Table 19. The results indicate that all major crops should be produced in each zone except that soybeans should not be produced in zones 6 and 8 and cotton should not be produced in zone 8. It is also noticed that the products of each major crop (after the farmers have consumed) are in surplus in all zones in the North Region. Maize (feed) of zone 6 is the biggest surplus of 1,294,458.6 tons and soybeans of zone 10 are the smallest surplus of 6,318.8 tons among all major crops.

The estimates of net income, employment, and resource use are shown in Table 20. Annual net crop income estimates range from a low of 9,567 Baht per household in zone 9 to a high of 17,785 Baht in zone 6. These income estimates are dependent on support prices of 2,500 Baht and 2,400 Baht per ton of non-glutinous rice paddy and glutinous rice paddy respectively. The rest of all other net revenue calculations is based on the average prices of crops in BE 2516, 2517, and 2518. If the current prices of BE 2518 are used, the estimates of net farm income from crop production vary between 2,245 and 5,717 million Baht and 7,551 and 17,085 Baht per household. The low per-household earnings from crop production in zone 9 result from small quantities of land use of land type I, II, and IV.

Summaries of monthly land use for zones 6, 8, 9, and 10 are shown in Figures 21, 22, 23, and 24, respectively. Land types I, II, III and IV are limiting in 8, 11, 7, and 2 months respectively in zone 6 as shown in Figure 21. All available paddy land is used. Land types I, II, III, and IV

Table 19. Production, farmers' consumption, and net surplus by major crop (zones) by commodity in BE 2524 with Alternative F

Commodity	Zone 06	08	09	10
Rice ng prod.	801,427.0	888,153.8	77,304.1	199,149.1
farmers' cons.	283,402.7	327,481.5	63,294.7	36,524.2
surplus	518,024.3	560,672.3	14,009.4	162,624.9
Rice gt prod.	296,642.6	144,517.8	703,483.8	844,017.2
farmers' cons.	184,534.7	38,696.3	501,304.0	813,824.1
surplus	112,107.9	105,821.5	202,179.8	30,193.1
Maize (feed) prod.	1,294,511.2	722,623.5	51,478.1	76,460.0
farmers' cons.	52.6	19.1	14.4	4.4
surplus	1,294,458.6	722,504.4	51,463.7	76,455.6
Mungbean prod.	62,590.2	151,935.9	2,463.9	8,192.6
farmers' cons.	14.7	143.7	20.8	160.8
surplus	62,575.5	151,792.2	2,443.1	8,031.8
Soybean prod.	-	-	246,765.5	6,375.7
farmers' cons.	-	-	5.0	56.9
surplus	-	-	246,760.5	6,318.8
Cotton prod.	17,857.3	-	20,992.5	24,514.8
farmers' cons.	260.8	-	253.9	5.3
surplus	17,596.5	-	20,738.6	24,509.5

Table 20. Zone income and employment from crop production and resource use in BE 2524 under Alternative F

Item	Zone 06	08	09	10
Net crop income (million Baht)	5,951	3,750	2,956	2,798
Net crop income (Baht/hsld.)	17,785	15,272	9,567	10,528
Labor, wet season (days per hsld.)	234	247	106	136
Labor, dry season (days per hsld.)	62	105	69	13
Peak month (days per hsld.)	63	54	36	49
Net crop income Land 1 (Baht/hsld.)	1,072	2,978	999	-
Net crop income Land 2 (Baht/hsld.)	1,133	862	980	3,072
Net crop income Land 3 (Bhat/hsld.)	4,810	5,764	3,482	6,543
Net crop income Land 4 (Bhat/hsld.)	10,770	5,668	4,106	913
Net income evaluated at current price (million Baht)	5,717	3,198	2,333	2,245
Net income evaluated at current price (Baht/hsld.)	17,085	13,023	7,551	8,447

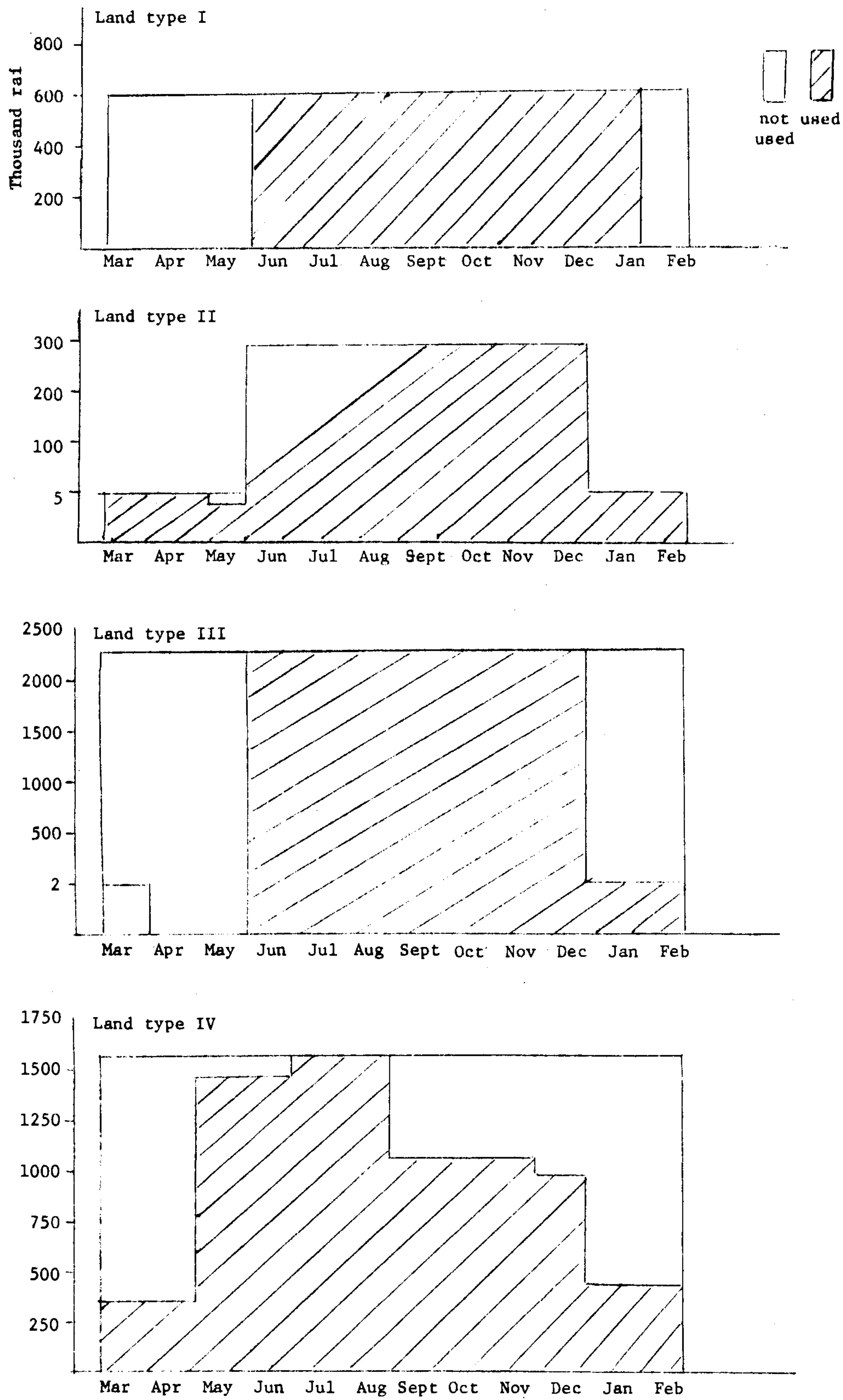

Figure 21. Monthly land use by type of land for the North Region in Zone 6 in BE 2524 for Alternative F

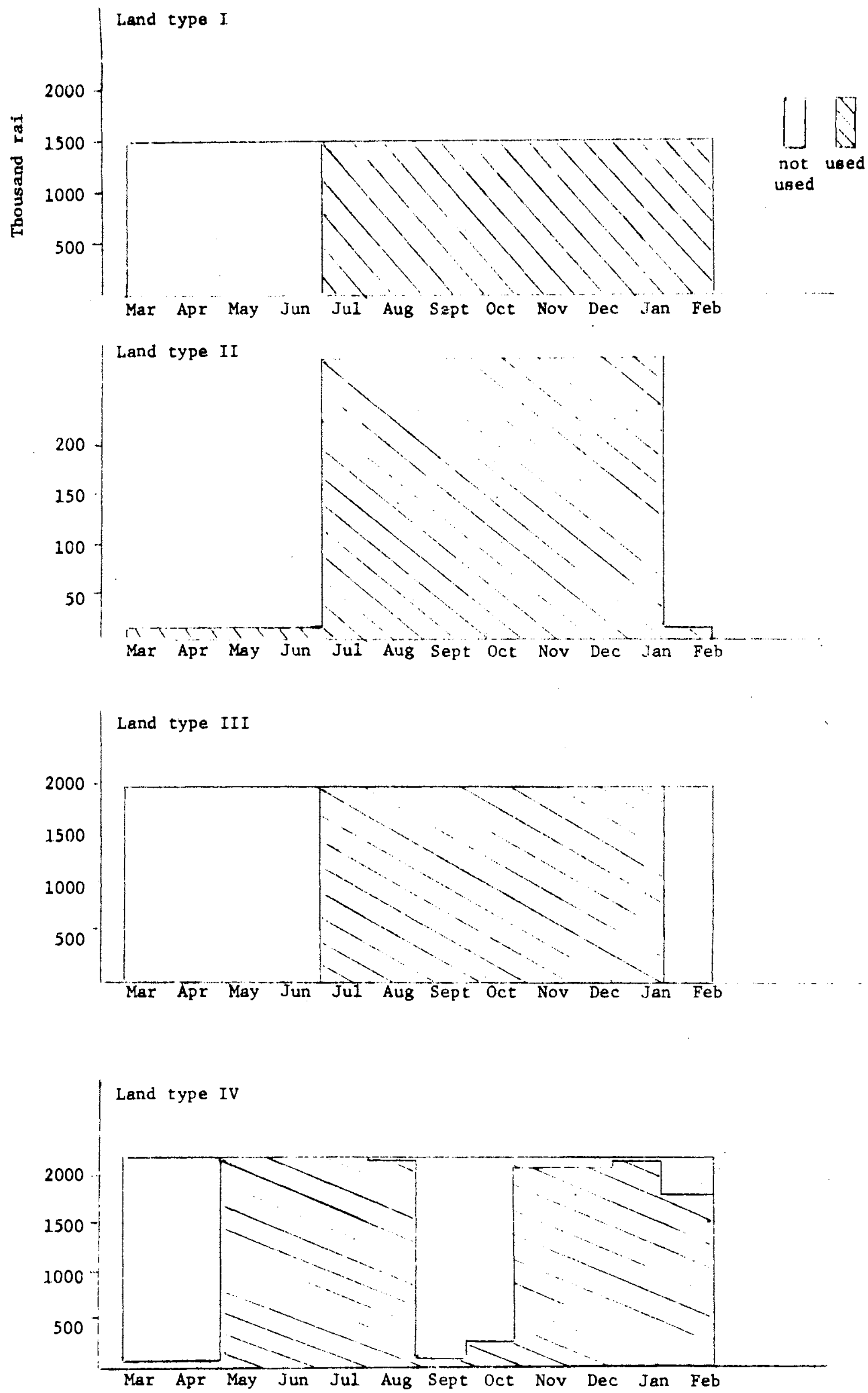

Figure 22. Monthly land use by type of land for the North Region in Zone 8 in BE 2524 for Alternative F

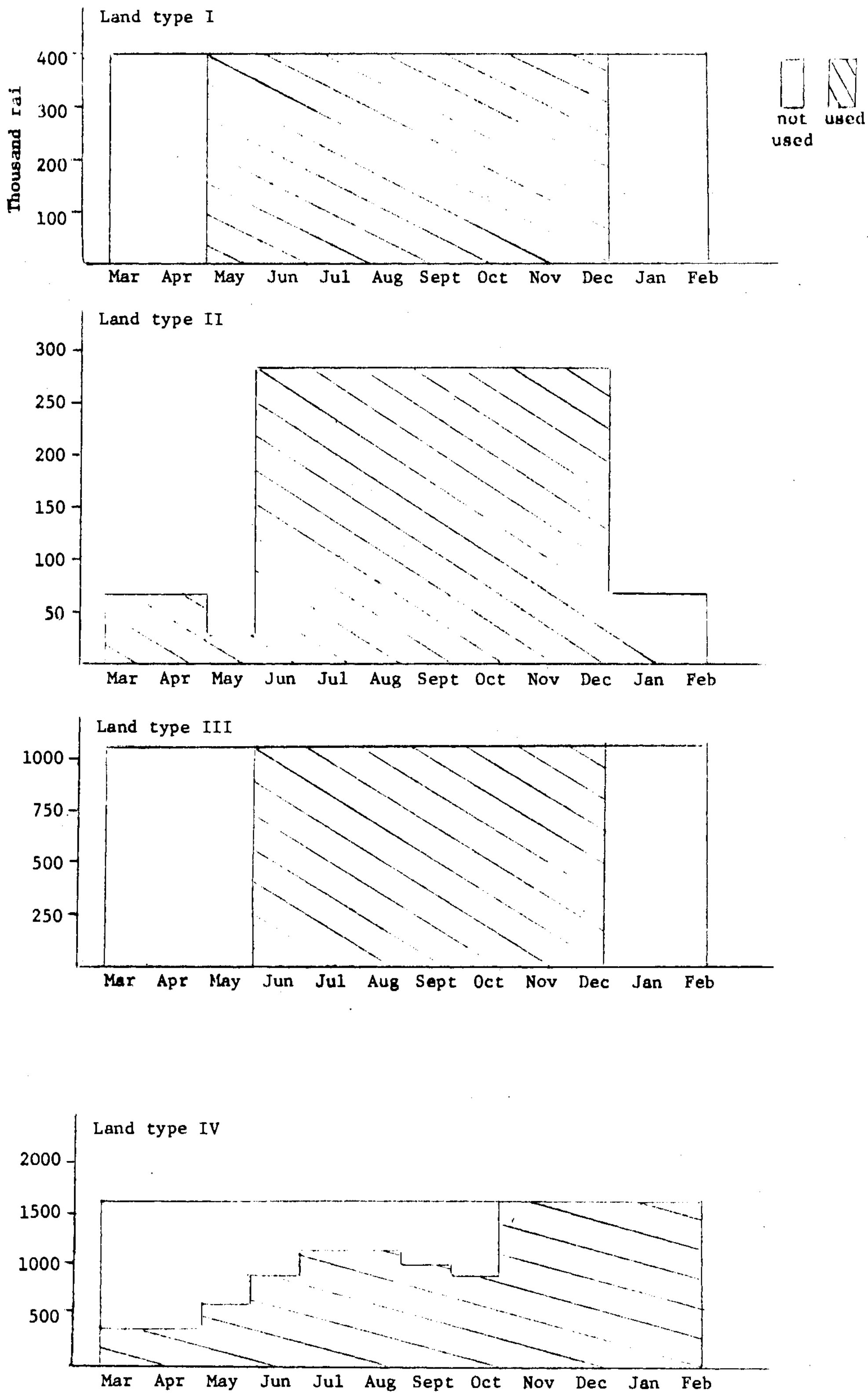

Figure 23. Monthly land use by type of land for the North Region in Zone 9 in BE 2524 for Alternative F

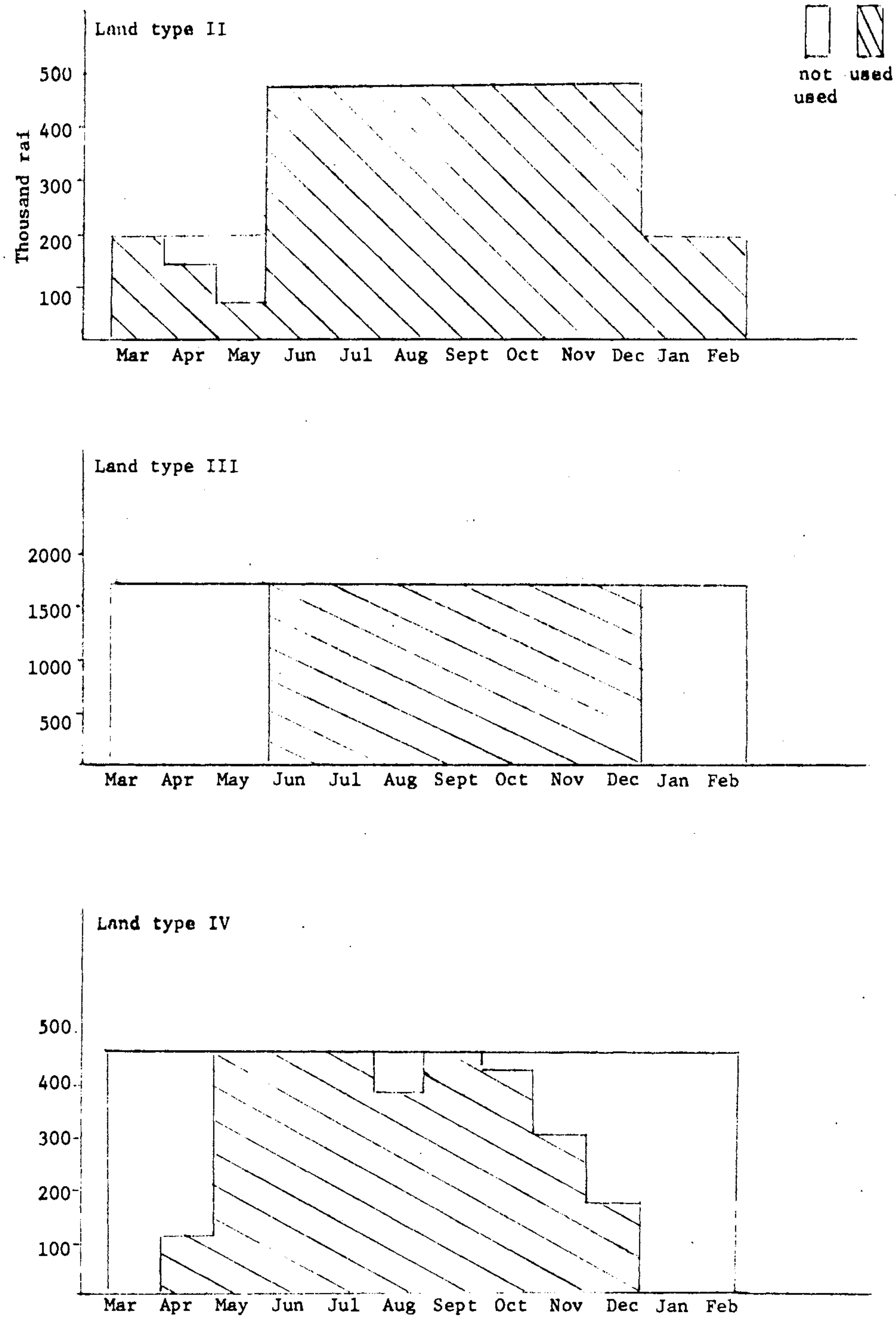

Figure 24. Monthly land use by type of land for the North Region in Zone 10 in BE 2524 for Alternative F

are limiting in 8, 12, 7, and 3 months respectively in zone 8 as shown in Figure 22. A very similar pattern of land utilization is observed in zones 9 and 10 as shown in Figures 23 and 24, respectively.

The monthly labor use by each zone of the North Region is presented in Figure 25. Crop labor supplies of all four zones are in excess of requirements in all monthly periods.

Solution results for Alternative B_2 in BE 2524

The estimated levels of production, farmers' consumption, and net surplus for major crops by each zone of the North Region under Alternative B_2 are shown in Table 21. The results indicate that the production of all major crops that are produced in each zone exceed farm subsistence consumption and some surplus is available to sell to the consumers of the nonagricultural sector. Maize (feed) of zone 8 is the biggest surplus of 709,285.61 tons while mungbean is the smallest surplus of 1,619.79 tons among all major crops. The estimates of net income, employment, and resource use are shown in Table 22. Annual net crop income estimates range from a low of 9,285 Baht per household in zone 9 to a high of 18,285 Baht in zone 8. These income estimates are dependent on support prices of 2,500 Baht and 2,400 Baht per ton of non-glutinous rice paddy and glutinous rice paddy, respectively. Other net revenue calculations are based on the average prices of crops in BE 2516, 2517, and 2518. If the current prices of BE 2518 are used, the estimates of net farm income from crop production vary between 2,227 and 4,351 million Baht and 7,028 and 16,542 Baht per household.

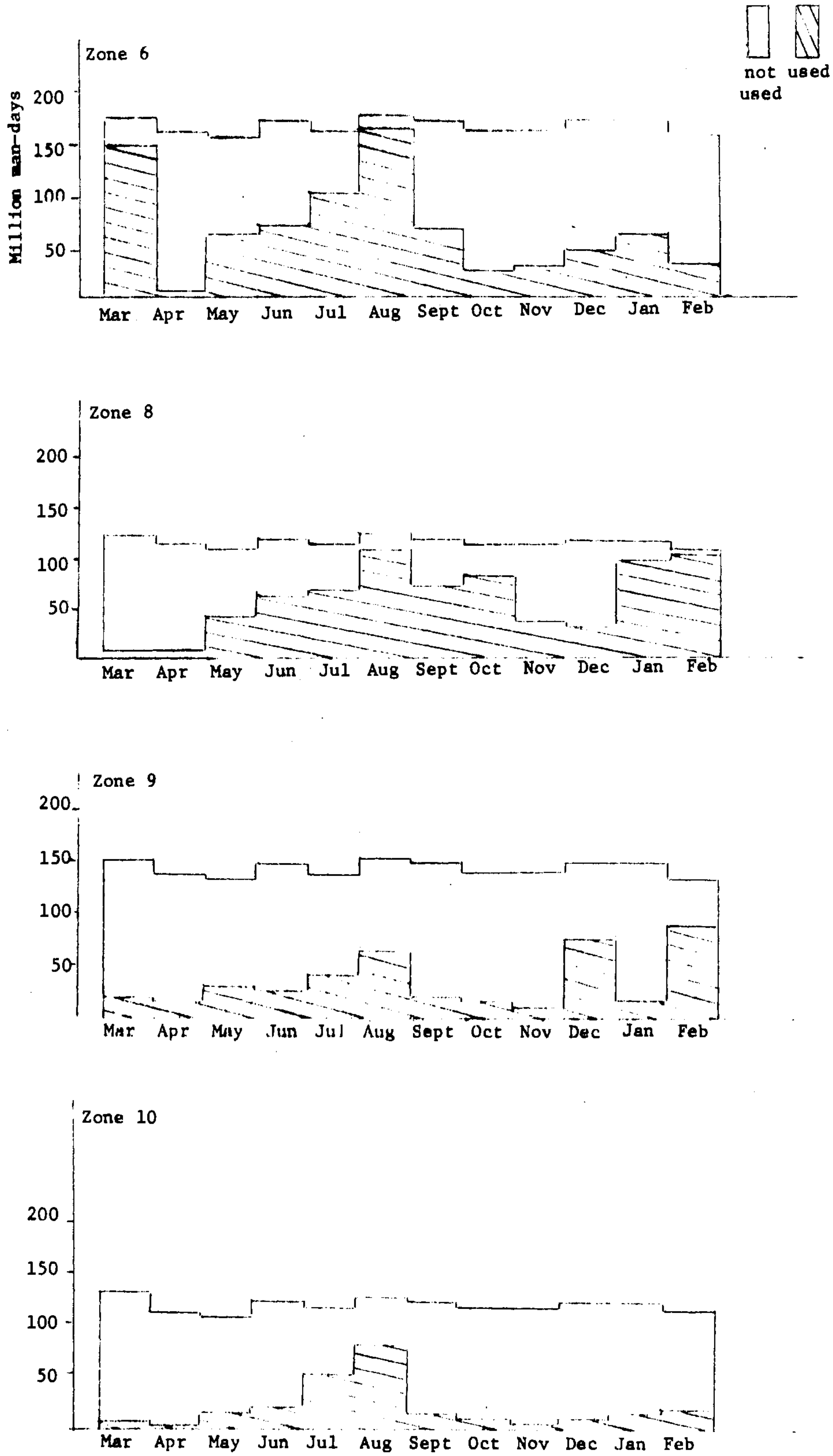

Figure 25. Monthly labor use by zone for the North Region in BE 2524 for Alternative F

Table 21. Production, farmers' consumption, and net surplus by major crop (Zone 8) by commodity in BE 2524 with Alternative B_2

Commodity	Zone 06	Zone 08	Zone 09	Zone 10
	Tons			
Rice ng prod.	741,369.9	874,722.0	179,161.5	203,786.9
farmers' cons.	288,095.0	332,903.0	64,342.6	37,128.8
surplus	453,274.90	541,819.0	114,818.90	166,658.1
Rice g prod.	316,966.8	148,229.4	622,932.7	928,769.1
farmers' cons.	187,590.0	39,336.9	509,604.0	826,749.3
surplus	129,376.8	108,892.50	113,328.60	102,019.8
Maize (feed) prod.	441,876.6	709,305.3	41,811.3	121,024.8
farmers' cons.	53.53	19.69	14.59	4.47
surplus	441,823.07	709,285.61	41,796.71	121,020.33
Mungbean prod.	47,764.0	167,747.1	1,640.9	8,421.6
farmers' cons.	14.96	146.08	21.11	163.51
surplus	47,749,04	167,601.02	1,619.79	8,258.09
Soybean prod.	-	-	293,295.0	3,634.5
farmers' cons.	-	-	5.076	60.39
surplus	-	-	293,289.92	3,574.11
Cotton prod.	13,490.7	-	16,003.03	18,899.2
farmers' cons.	265.11	-	258.19	5.38
surplus	13,225.59	-	15,744.84	18,893.82

Table 22. Zone income and employment from crop production and resource use in BE 2524 under alternative B_2

Item	Zone 06	08	09	10
Net crop income (million Baht)	4,830	4,490	2,869	3,031
Net crop income (Baht/hsld.)	14,435	18,285	9,285	11,405
Labor wet season (days per hsld.)	203	252	101	146
Labor dry season (days per hsld.)	46	79	34	20
Peak month (days per hsld.)	63	58	32	51
Net crop income Land 1 (Baht/hsld.)	-	2,998	999	-
Net crop income Land 2 (Baht/hsld.)	2,794	2,673	1,315	5,120
Net crop income Land 3 (Baht/hsld.)	4,337	7,028	3,281	5,261
Net crop income Land 4 (Baht/hsld.)	7,304	5,586	3,690	1,024
Net income evaluated at current price (million Baht)	4,351	4,062	2,227	2,429
Net income evaluated at current price (Baht/hsld.)	13,003	16,542	7,208	9,139

Summaries of monthly land use by zones 6, 8, 9 and 10 are shown in Figures 26, 27, 28, and 29, respectively. Land type II is limiting in 11 months in zone 6 as shown in Figure 26. Land supplies of land type II, III, and IV are in excess and only land type IV is used in all monthly periods. Land types I, II, III, and IV are limiting in 7, 7, 4, and 3 months respectively in zone 8 as shown in Figure 27. Land supplies of all four types of land in zone 8 are in excess but no land type is used in all monthly periods. Figure 28 indicates that land types I, II, III, and IV are limiting in 8, 11, 7, and 2 months respectively in zone 9. Land types II, III, and IV are limiting in 9, 6, and 5 months respectively in zone 10 as shown in Figure 29.

The monthly labor use by each zone of the North Region is shown in Figure 30. It is shown that crop labor supplies of all four zones are as in excess as under alternative F. Only the labor supplies of zone 6 and zone 8 in December and February are all used.

Alternatives F and B_2 compared

Alternative B_2 represents moderate success in achievement of planned changes relative to alternative F with respect to completion of irrigation projects, rate of fertilizer adoption, increases of crop activities, and also increases in the rate of fertilizer per rai of paddy land. Alternative B_2 shows a higher population growth rate and lower export demand than does alternative F. Population is assumed to grow at the rate of 2.1 percent and 2.5 percent under alternatives F and B_2, respectively. Imports are assumed to be at "high" levels under F and "medium" levels for alternative B_2. Relative to alternative F, expansion of export levels is "less"

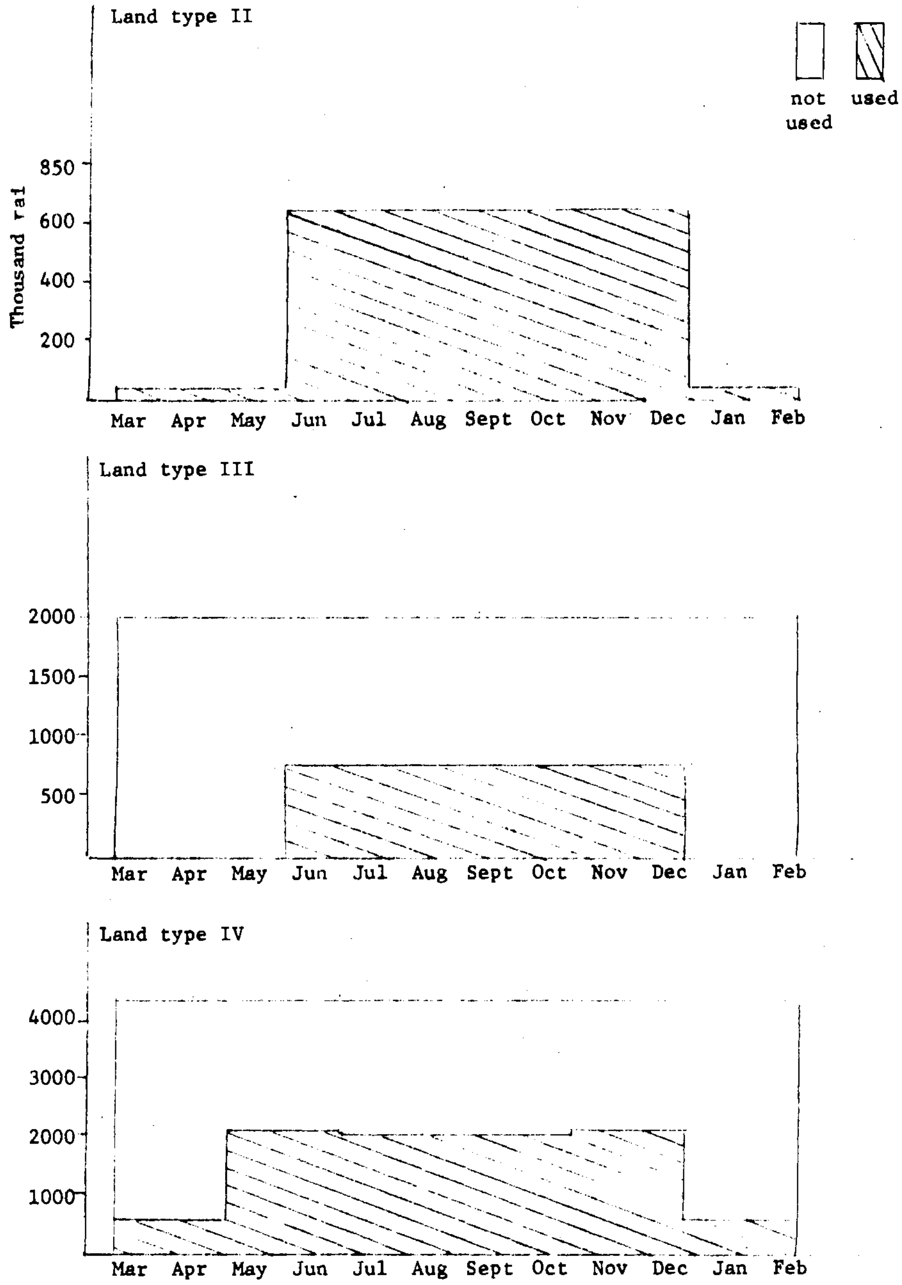

Figure 26. Monthly land use by type of land for the North Region in Zone 6 in BE 2524 for Alternative B_2

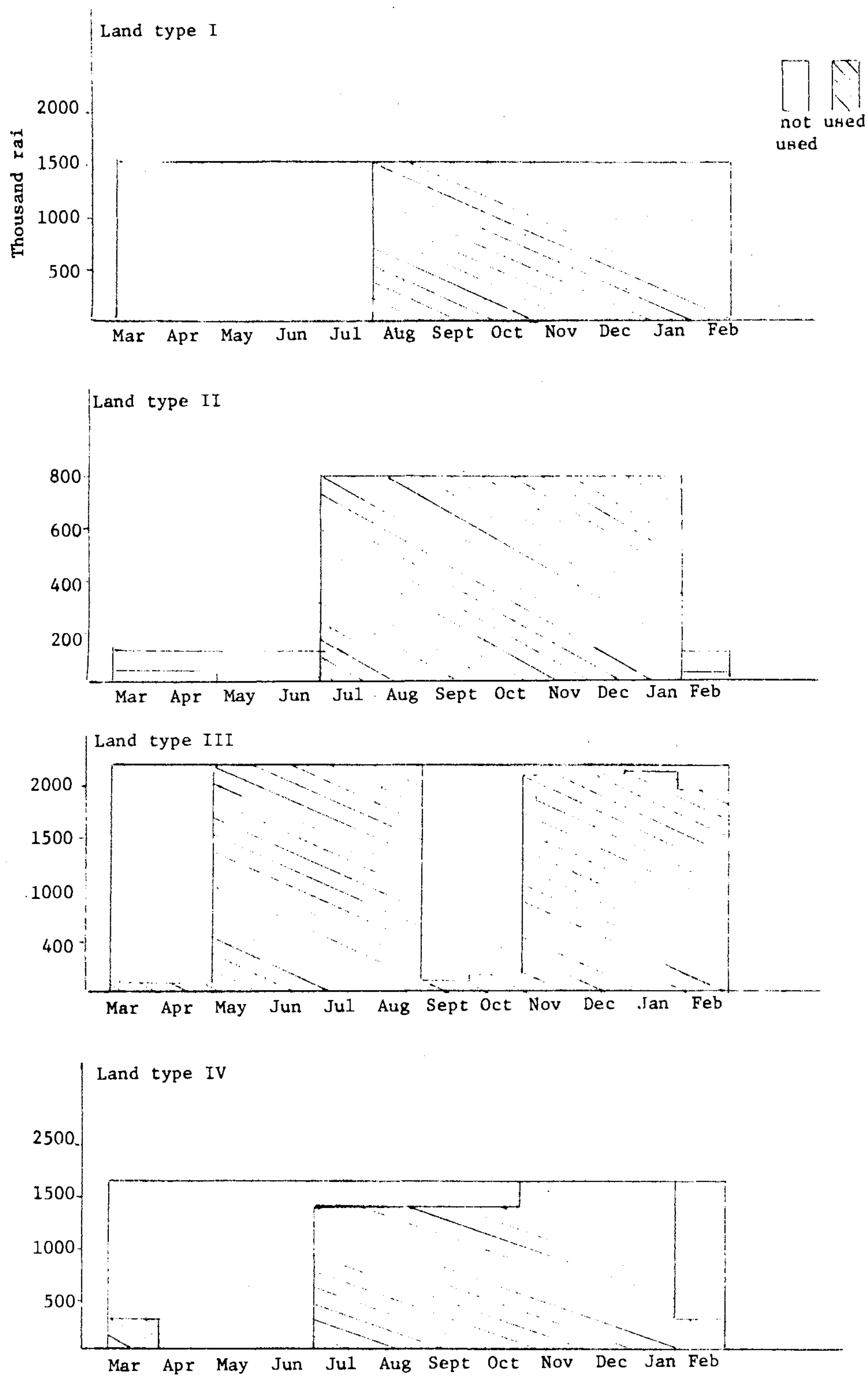

Figure 27. Monthly land use by type of land for the North Region in Zone 8 in BE 2524 for Alternative B_2

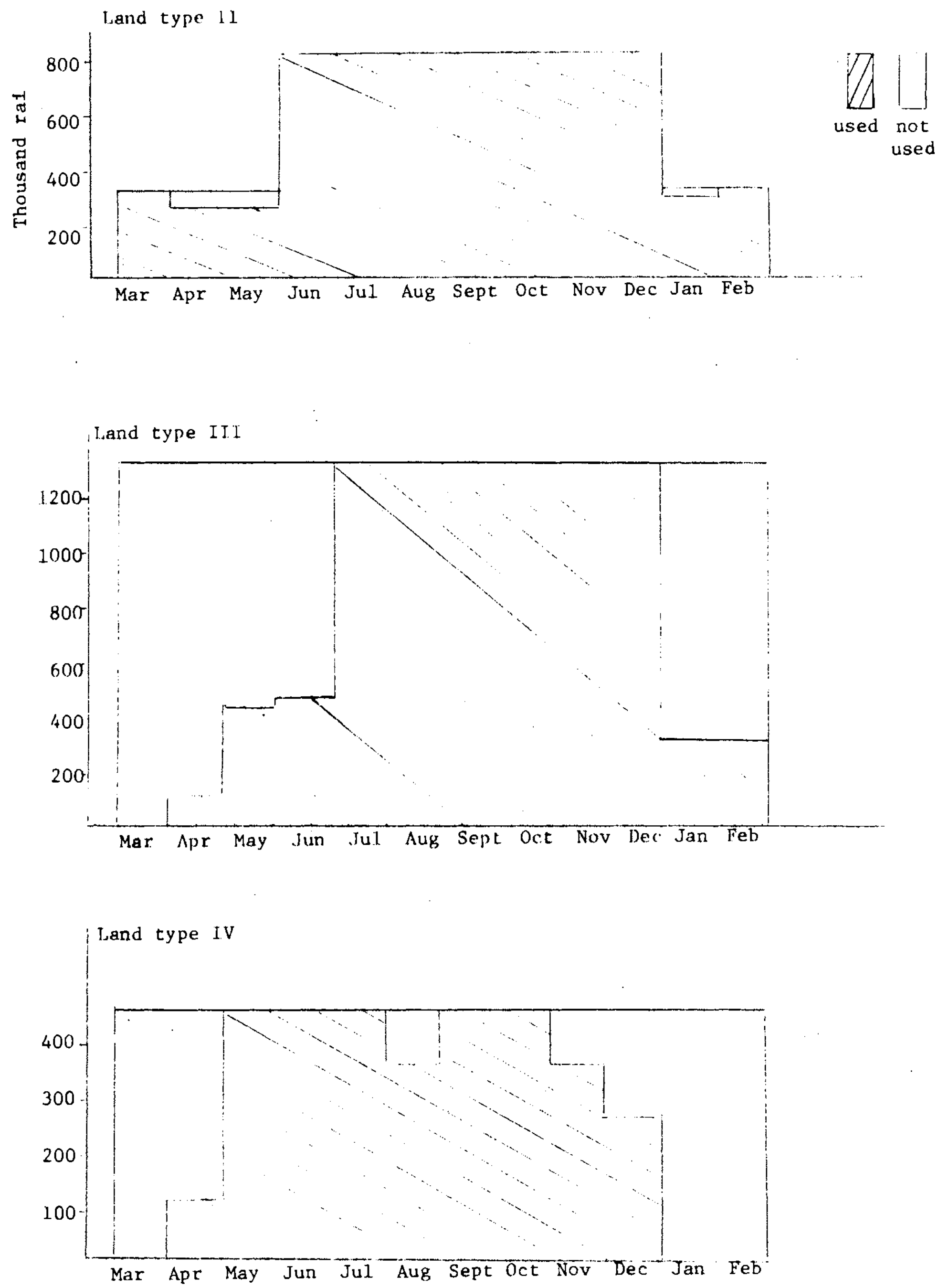

Figure 29. Monthly land use by type of land for the North Region in Zone 10 in BE 2524 for Alternative B_2

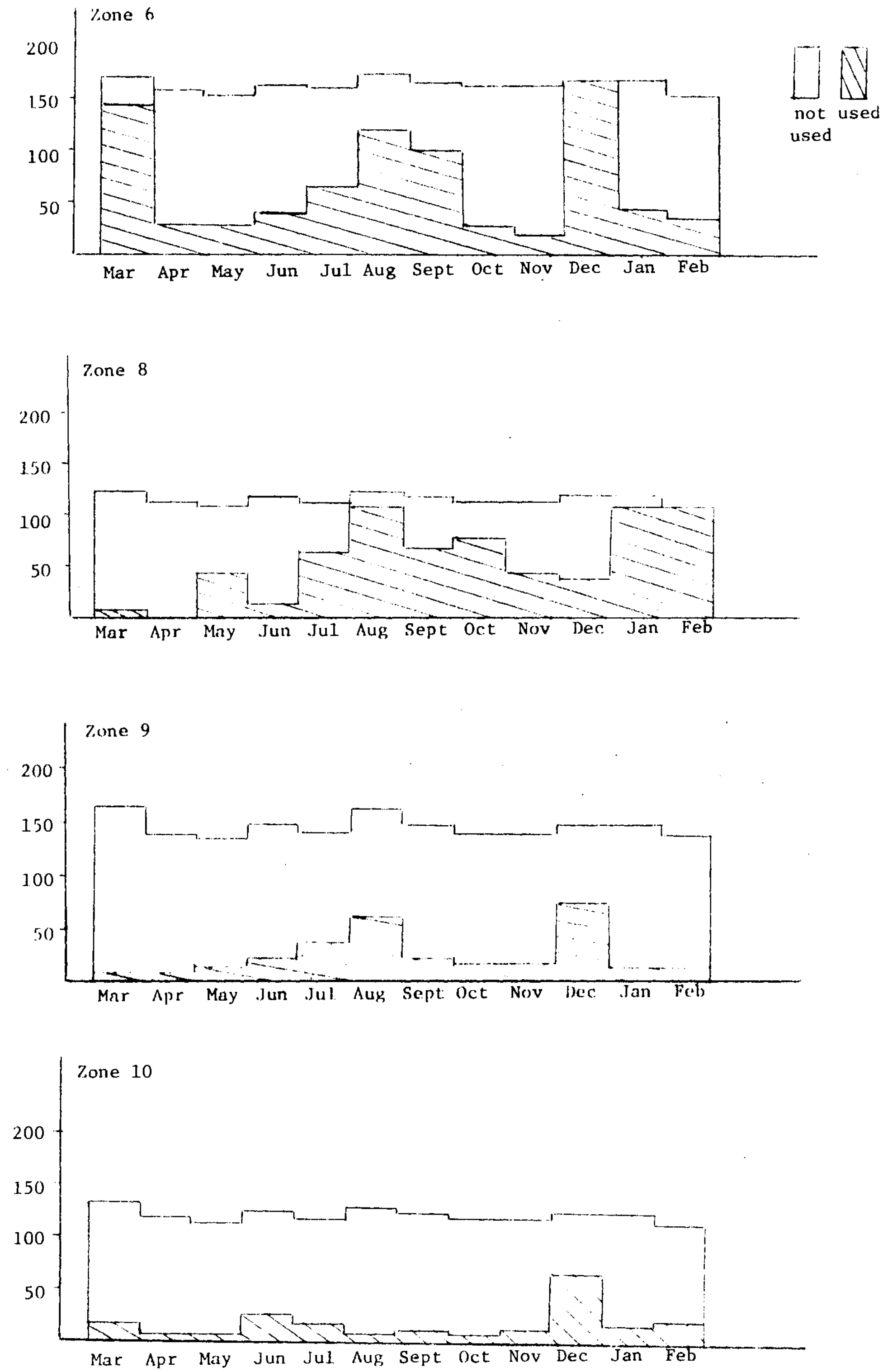

Figure 30. Monthly labor use by zone for the North Region in BE 2524 for Alternative B_2

in B_2, which means that foreign demand for Thai crop products is less under alternative B_2 than alternative F. The higher population growth rate in B_2 means a higher level of consumer demand under that alternative which should partially offset the influence of lower exports. The increases in irrigated area, RD adoption rates, and fertilizer levels of alternative B_2 over F means a larger productive capacity for crops relative to alternative F.

The changes in the major parameters are summarized in Table 23. The net effect is that alternative F contains some 810.1 thousand rais of total useable paddy fewer rai than does alternative B_2. The potential capacity under alternative B_2 is further enhanced because of assumed higher adoption rates for fertilizer and RD varieties. The value of domestic demand is 138.1 million Baht more with alternative F than with B_2 because the high demand for exports in alternative F more than offsets the lower population growth rate (reduced domestic demand) in F. The farm sale value of exports to Bangkok under alternative B_2 is 405.9 million Baht less than for alternative F because of the lesser exports to foreign countries.

Net farm income is estimated to be 235 million Baht higher under alternative F than under B_2, as shown in Table 24. This results primarily because of the reduction of net revenue of maize (feed) in alternative B_2. Table 24 also indicates that the total unused paddy land under alternative B_2 is 1,049.9 thousand rai higher than under alternative F. The fertilized rais of rice planting for alternative B_2 is 750.0 thousand rai larger than under alternative F. But the area of planting RD varieties of alternative B_2 is 165.2 thousand rai higher. The average yield per rai of

Table 23. Resource supplies and demand levels assumed in Alternatives F and B_2

Item	Alternative F	Alternative B_2	Alternative B_2 - F
Domestic demand (mil. Baht)	8,669.4	8,531.3	- 138.1
Exports[a] (mil. Baht)	8,837.2	8,431.3	- 405.9
Irrig. paddy, wet season (thous. rai)	1,353.5	2,781	1,427.5
Irrig. paddy, dry season (thous. rai)	275.9	613	337.1
Rainfed paddy, wet season (thous. rai)	7,238.5	6,284	- 954.5
Max. area fertilized SW (thous. rai)	1,010	1,760	750
Max. area, RD varieties			
wet season	1,710.5	3,174.0	1,463.5
dry season	220.7	491.1	270.4
Total useable paddy rai/year (thous. rai)	11,458.9	12,269	810.1

[a]Exports include the exporting of crop commodities to the rest of the Kingdom and to the world markets.

rice planting with alternative F is 335.8 kilograms and would have to be 354 kilograms with alternative B_2 because of higher fertilizer use and higher use of RD varieties.

The net effects of alternatives F and B_2 on planted area, yield, labor use, and net income by major commodity group are summarized in Table 25. The area planted to rice (both glutinous and non-glutinous), maize (feed),

Table 24. Resource use for plan Alternatives F and B_2 at the North Region level

Item	Alternative		
	F	B_2	B_2 - F
Net farm income (mil. Baht)	15,455	15,220	- 235
Cost (mil. Baht)	2,050.8	1,741.8	- 309.0
Deep flooding paddy (thous. rai)	2,590.9	1,964.0	- 626.9
Irrigated paddy WS (thous. rai)	1,353.4	2,781.0	1,427.6
Irrigated paddy DS " "	185.1	344.5	159.4
Rainfed paddy WS (thous. rai)	7,236.1	6,036.2	-1,199.9
Upland area year " "	8,891.9	7,210.2	-1,681.7
Total unused paddy (thous. rai)	93.4	1,143.3	1,049.9
Labor wet season (mil. hours)	1,600.0	1,663.5	- 63.5
Labor dry season (mil. hours)	404.9	571.9	167.0
Peak month crop labor (mil. workers)	2.2	1.8	- 0.4
Rai fertilized (thous. rai)	1,010.0	1,760.0	- 750.0
RD varieties (thous. rai)	195.7	360.9	165.2
Fert (16-20 equi.- tons)	444.4	1,179.2	734.8
Kg. fert. per rai fert.	0.44	0.67	0.23
Rice yield Kg. per rai	335.8	354.0	18.2

and the total labor use of those commodities are shown to decline under alternative B_2 because these commodities depend on export markets. But the yield per rai and net revenue of those commodities are increased except in the case of maize (feed) which is decreased. The other commodities including mungbeans, cotton, groundnuts, and tobacco show a reduction in

Table 25. Comparison of effects of alternatives F and B_2 on planted area, yield, labor use, and net income by major commodity group

	Area planted			Yield/rai		Labor use			Net revenue			
	F	B_2	B_2-F	F	B_2	F	B_2	B_2-F	F	B_2	B_2-F	B_2 percentage of F
	Thousand rai			Kg./rai		Million hrs.			Million Baht			
Rice ng	6,835.2	6,591.3	- 243.90	287.6	303.2	546	522	- 24	4,501	4,599	98	102.18
Rice gt	4,941.8	4,752.3	- 819.50	402.4	424.4	488	499*	11	4,479	4,555	76	101.70
09 Maize (feed)	6,642.6	4,319.3	-2,323.3	322.2	304.2	527	394	-133	3,096	1,935	-1,161	62.50
12 Mungbeans	2,721.3	2,674.4	- 46.9	82.7	84.3	145	144	- 1	383	387	4	101.04
13 Soybeans	1,722.2	2,031.3	309.1	146.9	146.1	57	73	16	758	876	118	115.57
23 Cotton	380.5	291.2	- 89.3	111.3	111.2	52	39	- 13	217	165	- 52	76.04
18 Groundnuts	119.5	103.4	- 16.10	289.9	339.8	28	16	- 12	98	98	-	100.0
29 Tobacco (Vir.)	335.5	335.5	0	185.25	185.25	105	105	-	1,315	1,315	-	100.0

planted area and labor use, with the exception of soybeans in which resource use is increased slightly. Under alternative B_2, yields per rai increased for mungbeans and groundnuts but soybean and cotton declined while tobacco was unchanged. Net revenue was increased under alternative B_2 for mungbeans and soybeans, was decreased for cotton, and groundnuts and tobacco remained unchanged.

Examples of Other Regional Applications of the Crop Models

Examples of two other applications of regional linear programming models are presented in this section. These are farm-level supply response and labor resource utilization. These studies were recently conducted by members of the Northeast Region group[1] using an earlier version of the model presented in this paper. It is anticipated that similar studies will be conducted in all planning regions in the next few months, using current models. The study of supply response is of special concern for policy analysis because of the interest in introducing minimum price policies for some of the upland crops as well as for rice. Similarly, the resource utilization studies of labor are critical in evaluating the potential labor supply available for use in expanded agricultural processing and nonfarm industries which have been suggested as possible areas of policy concern. Alternatively, one can estimate the impact on agricultural output and agricultural income with successful introduction of nonagricultural employment opportunities which compete for farm based labor.

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[1]Working paper is on responsiveness of maize production to price changes, written by Dr. Keith D. Rogers and Mr. Prasit Itharattana.

Supply response for maize

The supply response study reported here is for maize. The study was designed to examine the primary impact of maize prices on production and income patterns for the Northeast. Labor supply was projected at a 3 percent growth rate from the 1970 population census. Upper bounds on off-farm employment were retained at maximum levels implied in the census. Bounds on regional marketing activities for maize were removed, and parametric pricing used to solve the system at various price levels. The model was solved seven times at 250 Baht increments from 500 Baht per ton to 2,000 Baht per ton wholesale maize price.

The result and implication of the study of maize supply response in Northeast Thailand is shown in Figure 31. Although results are only tentative at this point, the supply response breaks into three distinct segments. The response from 500 to 1,000 Baht and 1,500 to 2,000 Baht is relatively small, while significant response is experienced from 1,000 to 1,500 Baht. This suggests that policies designed to manipulate price below 1,000 Baht or above 1,500 per ton would have much less impact on supply than in the range from 1,000 to 1,500 Baht. Therefore, the additional supply of the maize from 1,000 to 1,500 Baht should be utilized by domestic consumption and exporting. Consequently, a program to raise the maize price by 250 or 500 Baht per ton appears to have real potential for expanding maize production in Northeast Thailand and supply available for export. However, the expanded production will have an impact on production of other crops, and the higher prices may affect consumer welfare and livestock production.

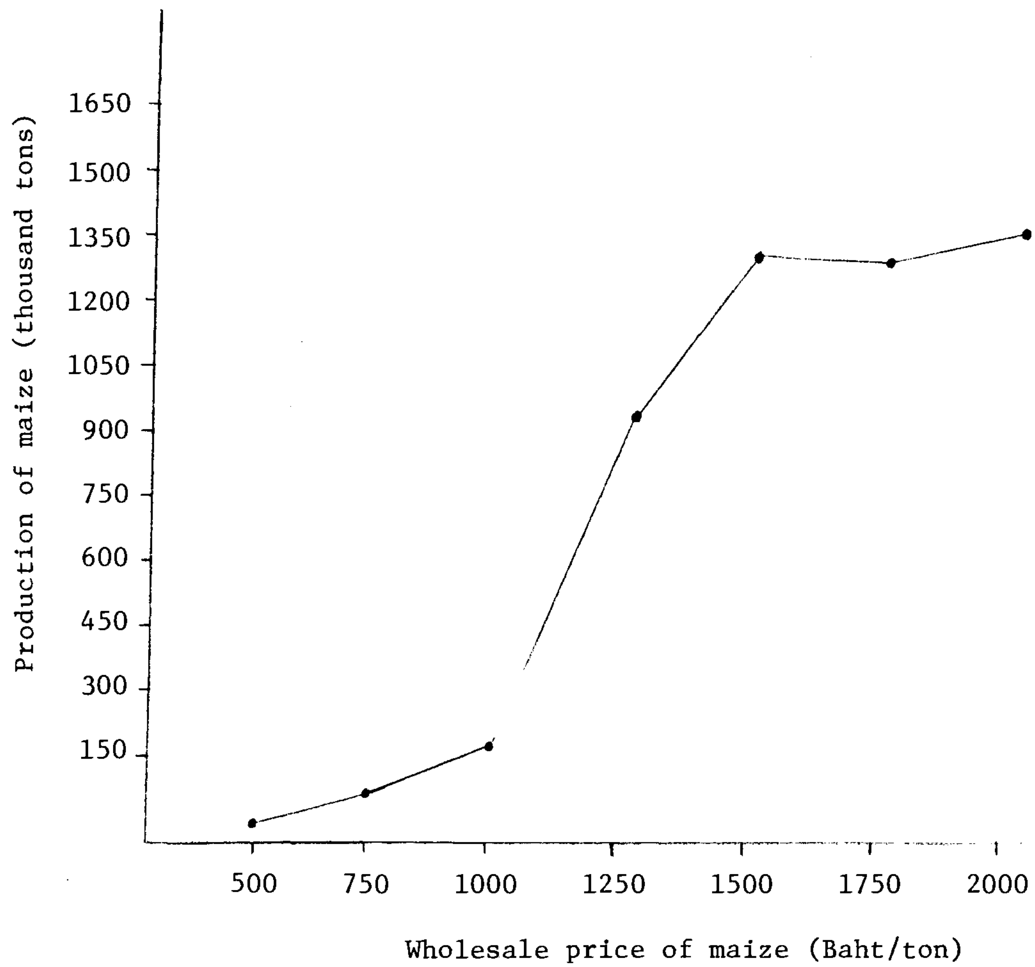

Figure 31. Normative maize supply response to varied maize prices in Northeast Thailand--base year 1971-72.[a]

[a]Source: NEREGON - Solution 19.

Labor utilization

The resource utilization is the second example which is expected to be applied in the North and Northeast regions using current models in the next few months. In this application, resource utilization focused on agricultural employment and potential migration which could be generated in the Northeast Region on Thailand.[1] The demand for agricultural labor was modeled by creating an artificial labor hiring activity. Inclusion of such an activity permits the LP model to determine whether the productivity of labor is greater in agriculture than the price or wage used in the artificial hiring activity. If not, the optimization procedure requires that the labor be "drawn off" in the labor hiring activity. Labor will only be used in agricultural production when the marginal productivity in agriculture is greater than the artificial wage or price on the hiring activity. It should be made clear that the artificial hiring activity provides no information about how many people can actually find work outside of agriculture. The significant measure is the number of people employed in agriculture, given a specified artificial wage or price on the hiring activity. In other words, those left in agriculture are known to have marginal productivity at least as great as the artificial wage. Combining these characteristics with the parametric procedure and a series of artificial wage rates, a normative demand for agricultural labor can be derived.

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[1]Working paper written primarily for the DAE Regional Planning group for the understanding and use in developing and applying large LP models to regional policy questions. The focus of this paper is on labor productivity in agriculture, employment, migration, and income.

The labor analysis was conducted in parametric run. The artificial wage started at 4.0 Baht per day and was incremented at 4.0 Baht per day up to 24 Baht per day. During the wet season, all labor was employed in agriculture when the artificial off-farm wage rate was one and two Baht per day. However, when the wage was raised to 2.5 Baht per day, some of the labor began to be taken out of agriculture, as shown in Figure 32. The graph indicates that with the given resources, technology, and agricultural production practices defined in the model, a little over 200,000 people have a productivity of less than 2.5 Baht per day in agricultural production. As the artificial daily wage increases from 2.5 to 4.0 Baht per day, the number of workers employed in agriculture drops from about 5.0 million to 4.85 million.

As the daily wage increases from 4.0 Baht to 8.0 Baht per day, there is a major drop from over 4.85 million employed in agriculture to just under 3.6 million. This says that there are approximately 1.25 million agricultural workers in the Northeast whose productivity in agriculture exceeds 4.00 Baht per day but is less than 8.0 Baht per day. From 8.0 Baht on up to 24.0 Baht, the number of people employed in agriculture gradually decreases by another 200,000. Approximately two-thirds of the total agricultural labor force has a marginal productivity in agriculture of 8.0 Baht per day or more during the wet season in Northeast Thailand.

In sharp contrast, at a competitive wage rate of 1.0 Baht per day during the dry season, only 820,000 of the 5.2 million people in the agricultural labor force were employed in agriculture, as shown in Figure 33. Thus only 15.7 percent of the labor force had a marginal productivity in agriculture of at least 1.0 Baht per day. This amounts to a total labor

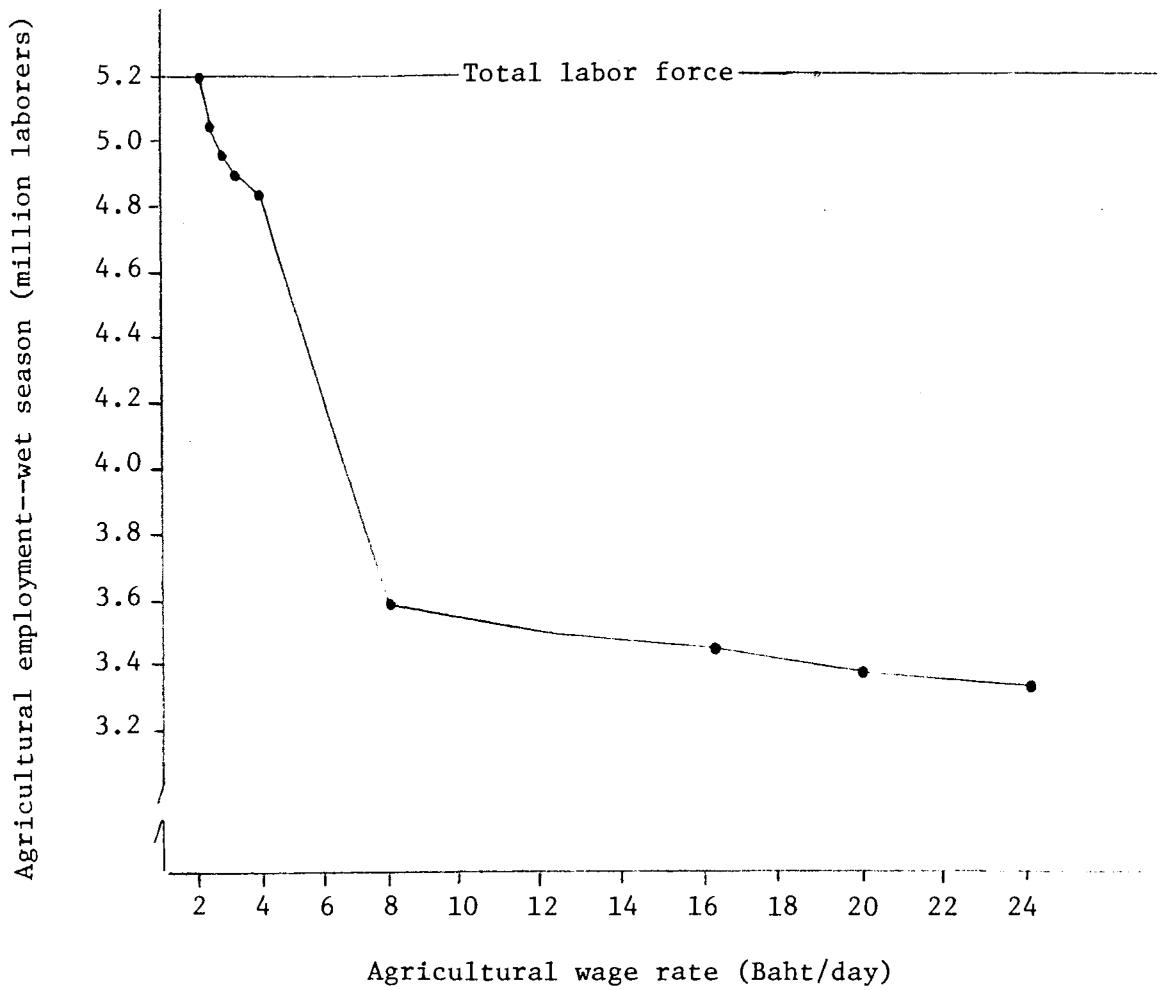

Figure 32. Normative demand for agricultural labor during wet season in Northeast Thailand--base year 1971-72.[a]

[a]Source: NEREGON - Solution 13 and 14.

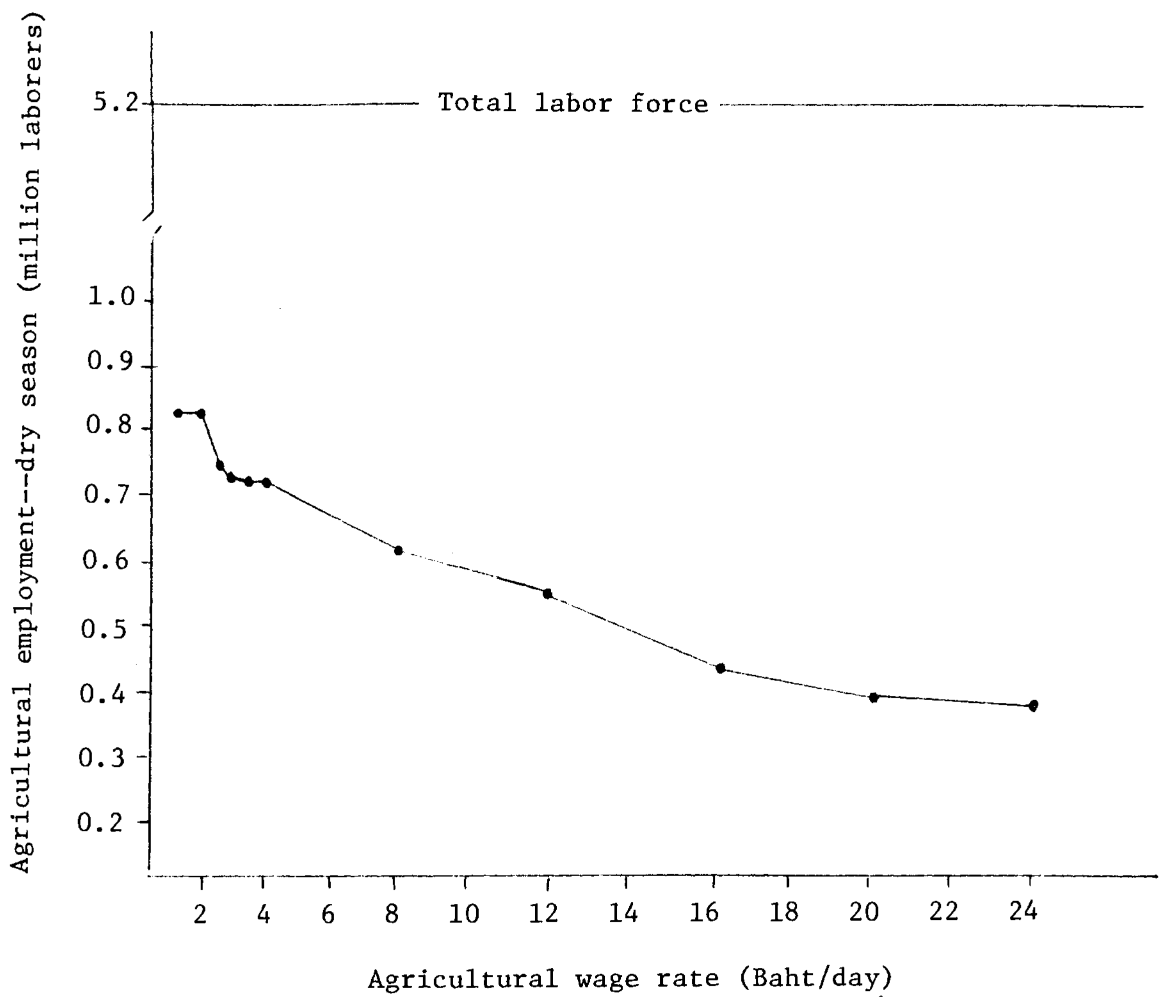

Figure 33. Normative demand for agricultural labor during dry season in Northeast Thailand--base year 1971-72.[a]

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[a]Source: NEREGON - Solutions 13 and 14.

return of only about 125 Baht for the whole dry season or 25 Baht per month. Unlike the wet season, the decline in employment in agriculture is relatively steady and gradual over nearly all of the range from 1.0 to 24.0 Baht per day. As a comparison, while 68.7 percent of the agricultural labor force has a productivity of 8.0 Baht per day in the wet season in Northeast Thailand, only 12.1 percent has a productivity of 8.0 Baht during the dry season. Alternatively, there are nearly 4.9 million people whose productivity is less than 4.0 Baht per day for the entire year.

Conclusion and Prospective of Future Applications

The purpose of this paper was to demonstrate some of the existing and potential applications of regional linear program models in Thailand. We have briefly examined only two possibilities which included 1) assessment of a national planning alternative against a base-line future for the North Region of Thailand and 2) parametric analysis of price changes to analyze potential changes in commodity supply and resource use in the Northeast Region of Thailand. These experiments were conducted during the past 12-18 months. Similar applications could be completed with existing models in a matter of days, but more than three years effort has been invested in the development of the data base and initial zone models (coefficients, resource supply data, and testing), which could be duplicated in another setting only with similar investment of time and effort.

The research possibilities opened for investigation with models of the sort presented here are virtually without limitations. Also, because model development costs are high relative to some other research alternatives and marginal cost per application is small (a few hours of computer time), one is encouraged to make maximum use of a model once it has been developed and tested. In the present situation in Thailand, it would be desirable to examine numerous other alternatives in addition to F and B_2 which were presented here. The obvious alternatives are those also examined in the National Model as a part of the background research for the National Agricultural Sector Plan. Also, it would be useful to take a look at changes in resource avaibability consistent with possible shifts in land and irrigation policy, which would result in changing not only absolute levels of availabilitiy, but also the timing and regional distribution of new resource supplies. The very substantial amount of under-utilized labor in the rural regions of Thailand also prompts us to look further at labor use and at capital for labor substitution alternatives under alternative technologies (new activities) which are currently being encouraged.

Supply response studies, similar to the maize experiment reported here, are scheduled for several upland crops in the next few months in all regions. The primary constraint we anticipate encountering is one of time and the necessity of committing a substantial effort in updating current models to include additional activities which could not be estimated or were not identified in earlier versions of the models. For example, current models are basically field crop models. Specialty crops and livestock are treated as constants in terms of their demands on resources and contribution to income. Also, multiple cropping (more than one crop per year) and poly period (more than one year life) production activities have need of being incorporated. Some effort also is currently being made to develop and incorporate activities representing agricultural processing in order to assess regional effects on the agricultural sector of programs aimed at decentralizing processing capacity.

VII. FUTURE PLANS FOR AGRICULTURAL SECTOR ANALYSIS IN THAILAND[1]

Herbert H. Fullerton

Introduction

Discussion in this chapter focuses on agricultural sector analysis (ASA) and future plans for activities of this sort in Thailand. The temporal vantage point for this discussion is approximately three years and three months after formal initiation of the Thailand Agricultural Sector Analysis Project, and more than five years since efforts to conceptualize and design such a project were begun. The project was conceived and developed as a cooperative program involving the Ministry of Agriculture and Cooperatives, Division of Agricultural Economics (DAE) and Iowa State University (ISU). Financial responsibility, to this point, has been shared by the United States Operations Mission to Thailand and the Royal Thai Government.

The primary objective of this study effort was, and continues to be, the development of analytic capability and information which are used to understand and facilitate the development of Thailand's agricultural sector. Ultimately this effort is designed to evolve into an integrated

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[1]This manuscript was prepared on behalf of the team by Herbert H. Fullerton. Arthur L. Stoecker, Chief of Party; Charles F. Framingham, Policy Analyst; and Somnuk Sriplung, Director of the Division of Agricultural Economics were instrumental in sketching the outline for this manuscript and played substantial roles in defining and developing the ideas and research plans reported.

research unit. It was anticipated that this research and planning unit would place strong emphasis on a broad scope of concerns including 1) participation in problem identification, 2) maintenance and assembly of data and models, 3) conduct of research and analysis, 4) dissemination of research results to decision makers and 5) participation in the expansion of research capability.

It was anticipated that a second reading of the title of this paper should provoke caution concerning the interpretation and potential applicability of DAE/ISU experience for use in another setting. Complete and accurate specification of analysis required by a particular nation or region in advance of the actual evolution of issues, problems, and research capacity is subject to omission and error. Even under conditions of perfect specification and analysis for Thailand, it would be essential to exercise caution in making extrapolations to another country or region in which conditions, aspirations, and commitments are different from those found in Thailand. What we offer is our current judgement of future research which appears useful and is also expected to be feasible in the sense that it can be conducted within the limits of our current and projected research capability.

The discussion which follows is divided into two major sections. The first addresses what appears to be different approaches to ASA and concludes by identifying the motivation or determinants that influence the feasibility of ASA and shape its focus overtime. The second major section identifies current and future areas of analysis and supporting activity in Thailand and summarizes the anticipated research outputs.

Determining Future Directions for Agricultural Sector Analysis

Agricultural sector analyses have been around for a long time. Current examples can be found in a variety of forms, stages, and conditions in countries throughout the world. Given a sufficient number of data points of this sort, it should be possible to estimate an empirical basis which could be used to predict the "future" of a given ASA. Typically we would expect the future of ASA in a particular country to evolve in very much the same pattern as contemporary examples which have been around for a longer period of time. But can we or should we rely on such a model? The existence of a relatively large number of contemporary studies could be explained as the obvious emulation of a few early successes. There is a chance, at least, that initial success in ASA is being emulated in a cross sectional sense, country by country. The only requisite to successful ASA is the passage of time. Soon those of us who currently work on ASA will be looking for new challenges. A less flattering, but more realistic interpretation of persistent and numerous ASA (old and new) is that our efforts have been only partially successful or possibly not successful at all. We may have given rigorous solutions to one problem or a set of problems in a country only to find that a new set has evolved which extends beyond the contract period. Or worse, we have polished our tools and impressed our colleagues by addressing problems that have only marginal significance to the host country and problems and a demand for some type of analysis continue.

A third interpretation of the persistence and variety we find in ASA is that ASA may be subject to scale economics and also exhibit stages, critical mass or threshold tendencies which are not automatically transcended. If the latter situation holds, neither persistence at the same scale nor more appropriate selection of problems and tools will be sufficient to move ASA capability beyond its current status. In the section which follows, three reasonably distinct stages (approaches) found in ASA are identified and explored in terms of how they may represent what we observe as differences in approach among ASA and also as a basis to speculate reasonably about the desirability of changing stages (approaches) if we are not content with our current stage (approach).

Stages in Agricultural Sector Analysis

In this chapter an hypothesis is posited that much of what we observe to be differences in ASA can be explained on the basis of scale economies in the provision of indigenously produced ASA and a tendency toward threshholds or stages (critical mass). The extent to which distinct stages exist is a subject for empirical investigation, but it does appear that differences in approach which we observe may be perfectly rational adjustments.

A cursory examination of ASA efforts leads me to suggest that they fall into three categories or stages.[1] The first stage is characterized as the "report or batch" approach, the second as the "project counterpart" approach and the third as the "process" approach.

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[1]I hesitate to use the word "stages" because of the implication of preference ordering between stages and the related implication that all stages are attainable. It is possible that neither assumption is warranted in some countries.

Stage One--Report or Batch Approach

The first stage, "reporter batch," is characterized by approaches to ASA which focus rather compulsively on a prespecified question or batch of questions. The answers to these questions (reports) are then orchestrated into some equivalent of ASA. The processes of problem specification and research other than the orchestration, assembly of data, and clerical duties are assigned to a specialist, typically a foreign technician or a consulting group. The objectives of analysis do not extend beyond the derivation and explanation of the technical solutions. The development of a residual research capability is merely inadvertent if it does occur at all.

Motivations and justification for this type of approach are several. The most plausible are that information needs are critical, indigenous research capability is either nonexistent or fragmented to such an extent that it is not accessible, the analyses are specific in nature and have little chance of being repeated, and for the foreseeable term, the cost is probably considerably less than an indigenous effort. In short, for reasons of cost the host country is content with a "report" or series of reports because nothing of greater consequence can be produced at lower cost under prevailing conditions within a timeframe which doesn't also preclude benefits or introduce higher cost. Some of the extremes in quality of research product are generated by this mode, but the basic issues are cost and timeliness.

Stage Two--Project Counterpart Approach

The second stage is characterized as the "project counterpart" approach to ASA. It differs from the report or batch approach in that it typically is justified not only on the basis of problems it is to address in ASA, but also in terms of training counterpart scientists. The life span of the "project counterpart" is crucial to its success in at least two ways. First, any training of scientists which also includes even minimal on-the-job training must necessarily have three to four years for the initial trainees to mature. Six to seven years is more reasonable, and I am aware of some which were considered "immature" as they entered their tenth year. Second, the time advantage of having a narrowly specified question or group of questions is typically foregone in favor of an "umbrella" which permits some degree of latitude to the project staff in articulating the objectives in terms of the issues which are salable and likely to be completed in the time-frame of the project. The shorter the time-frame the smaller is the opportunity to address real issues and to involve counterpart scientists in the process of problem identification and on the job exposure to research.

Probably a large majority of the formally identified ASA falls into this middle stage. Obviously the approach offers the distinct possibility of developing indigenous ASA capability and also of focusing on a few relative issues. The degree of success or failure could be expected to be highly correlated with the patience of their sponsors and ingenuity on the part of technical personnel in identifying issues which are both salient and researchable within a relatively short time-frame. Also there must be a genuine desire to incorporate the counterpart scientist into a real research situation. In many respects the second stage can be viewed as a disequilibrium position where there is a strong tendency to revert into a sequence of "reports and batches" not unlike an extended stage one approach, although we will maintain the facade and costs of indigenizing research capacity so long as the contract is funded. The difficulty encountered in indigenizing research capacity is further complicated by the tendency of young scientists trained in the developed countries to drift into the international field or to be lost in administrative positions where their high marginal value is essentially untapped. Professional rewards in the developed countries often prompt the initiation of studies which go beyond the needs and research capacity of the host country.

Stage Three--Process Approach

Now, what can be said about a stage three approach? A stage three approach is characterized by those few stage-two projects where all of the "ifs" encountered can be resolved and the scope of analysis and time horizon can be extended to permit integration of the "process" of research to the extent that the focal research unit can become self-sustaining, i.e., the responsibility and capacity to identify researchable issues and to conduct research are contained in a unit which gains political and professional legitimacy.

At the present time, few stage three examples exist outside the developed countries. In many respects this may reflect rational response to the high costs associated with small-scale research operations, or of pushing the scale of activity beyond some minimum critical level where it can be self-sustaining and vital to the decision making process. One could ask whether or not there is reasonable justification to push for self-sufficiency in research capability (ASA) if the activity is subject to scale economies which cannot be captured by the demand for ASA of a particular country or region? What conditions within a country or region of the world provide sufficient reason to develop ASA only by selective use of a stage-one approach? Alternatively, what conditions of size, desire for independence, security etc., are sufficient to justify the commitment of finds and patience which appear to be required to push a "project" into a self-sustaining "process"? The critical area where most of our bets are placed seems to be on stage-two approaches. The empirical questions concerned with measuring the conditions which are critical for success in moving into a stage-three position deserve full attention. The section which follows focuses on the determinants or factors that have important influence on the future of "project" approaches whose objective is to attain "process" capability.

Determinants of the Future of Agricultural Sector Analysis

Three factors or general categories have been identified as being critical to the feasibility and future direction for ASA. The first of these factors is issues or problems. The future of any stage or form depends heavily on the emergence and recognition of researchable issues and problems. The primary qualification or constraint on the selection among issues is based on their researchability which is largely determined by the second determinant, that is, research capability. Research capability is defined to include human capacity in terms of numbers, training, experience, competency, interest, and access to qualified consultants; facilities including space, equipment, computer, library, data base; and funding from both internal and external sources.

The third determinant or category is called "situation." "Situation" describes the social-political-economic environment in which interesting issues and capability are united and flourish or wither. In a sense, "situation" can serve as the medium to support ASA or as the catalyst which ignites it.

Selected Agricultural Sector Issues in Thailand

The Thailand Agricultural Sector Analysis Project faces many issues which are similar to those faced in other developing countries. Thailand is concerned about income disparity between rural and urban people, among regions, and between the agricultural sector and the rest of the economy. Thailand is also concerned with the potential for expanding production to insure adequate food supplies and to earn foreign exchange. Export expansion and import substitution are recurring topics. Thailand has an unusually large agricultural sector both in terms of production and population. Thailand has continued to be a major rice exporter while still meeting the food demand of a fast growing population. This has been accomplished primarily by land-extensive methods which cannot be relied upon to meet future needs.

Thailand faces unique political and economic challenges in several rural areas where poverty and insurgency walk together. There is motivation to explore the potential of expanding irrigation and to push for higher participation in multiple cropping. Under-employment is a serious problem for agricultural laborers. A high rate of migration from the low income rural areas of the Northeast contribute to the problems of congestion and unemployment in Bangkok.

Research topics which can be distilled from these conditions include the following:

1) Price and income situation for major agricultural commodities including demand analysis and commodity supply response
2) Land and irrigation expansion potential and alternative intensive methods which expand productivity (new varieties, fertilizer)
3) Analysis of alternative varieties and fertilizer use for upland crop production
4) Resource utilization and capital for labor substitution (labor, capital, machines)
5) Agricultural marketing and transportation
6) Distributional impacts of national programs on agriculture and of agriculture on the national economy
7) The relationship between the retail price of selected food, foreign exchange earnings, and farm income

Research Capability in DAE

Earlier it was suggested that capability to conduct ASA consisted of the following:

1) Human capacity in terms of numbers, training, experience, competency, interest, and access to qualified consultants
2) Facilities including space, equipment, computer, library, and data bank
3) Funding adequacy from both internal and external sources

Human capacity in the DAE currently includes approximately 800 persons. Included in this number are 293 people with professional degrees comprised of 4 Ph.D., 69 M.S., and 220 B.S. degrees. Since 1973, the number of total persons with professional degrees has increased by only 26, but Ph.D. and M.S. degrees were increased by 40. When people currently enrolled in graduate programs are finished, the number of post graduate degrees will increase by another 35 persons including 11 Ph.D.'s. Interest in research is strong and job commitment is unusually high. It is not unusual to find several of the research officers delivering a considerable amount of uncompensated, extra time work. Access to outside consultants is adequate and improves as new Ph.D.'s return from abroad and larger numbers of foreign advisers gain long-term experience with the project.

Faciltities are adequate and equivalent to the average in Thai bureaucracy. More important than floor space is proximity to decision making and the center of government. Present facilities have the benefit of good proximity to the ministry and to national government. Computer access has been very good on an IBM 1130, but current work loads are queing even with 24-hour operation. Larger capacity must be secured in the near future. Library facility includes virtually all published statistical information and selected journals in technical areas of agricultural economics and statistics. The computer-based data bank of agricultural data is maintained by the DAE. It contains an extensive general farm survey (annual). Numerous other special surveys have been conducted including farm records (monthly), agricultural processing, and rice transport, marketing and processing.

Funding is obtained from sources both inside and outside Thailand. However, more than half of a budget ranging between 27 and 45 million Baht (1,350,000 $U.S. to 2,250,000 $U.S) in the past five years has come as a line item from The Royal Thai Government. This high percentage provides evidence of strong governmental commitment to the DAE. Since 1973, funds and staff have been augmented by US/AID to cover five Ph.D. level positions for foreign scientists. This outside support accounted for only 23 percent of the total budget in 1976, and the balance of about 20 percent was derived from other assistance programs and international agencies.

The Situation in Thailand

Several rather unique features have been combined to enhance the potential of conducting extensive ASA in a relatively short period of time. First, an essentially complete cross-sectional data base was already in place before the project (DAE/ISU) was formally initiated. Second, the Project Director, Chief of Party and the Director of the DAE as well as several of the other scientists were known to each other and had worked under a similar system in the United States. Third, the DAE and its director have had a unique consultative role in high levels of public decision-making for several years. Hence, confidence and communication with research clientele were already in place at the time of project initiation. Fourth, in the first three years of the project, a liberal quantity of scholarship aid was made available sufficient to accomodate 68 persons. Forty of these have already completed their degrees and have re-entered employment with the DAE. Fifth, the first 18 months of the project, the team was able to deliver useful research material on a variety of issues ranging from rice buffer stocks to fish marketing and still were able to make satisfactory progress on project objectives. This enhanced credibility and confidence with clientele and among fellow researchers in the DAE.

Future Directions for ASA

The process for identifying, defining, and re-evaluating research topics has not been formalized at the DAE. However, as a matter of principle ideas are circulated and reviewed by a substantial group of people. The ideas and scheduled research activities presented in this chapter represent the particular thinking of no one person but are an edited amalgam from several sources. The three determinants discussed above were fully operative in this selection process. There was a certain "inertia" based on past experience, tested models, and further applications which can be made easily with only very small additional cost. There was a pull to new issues which have emerged in recent months--not all of which can be treated within the limits of our capability or what we expect it to be within the next 12 to 24 months. Finally, we anticipate encountering an element of "situation" based on the necessity of making some trade of time and more compulsive focus on academically interesting objectives to gain credibility and support from potential users of the research project.

Areas of Analysis and Research Support Activity

Five major areas of activity have been identified in our current program of on-going and future ASA. These activity areas include:

1) National and regional agricultural models and related analyses
2) Macroeconometric and impact models for national and regional analyses

3) Special studies

4) Data bank maintenance and general survey and statistical support activities

5) Staff development

Table 26 describes the three levels of linear programming analysis which are a part of ASA at the DAE. These include a national agricultural model, 4 regional agricultural crop models, 19 zone models, and a potential of more than 100 zone/farm level models. As indicated in earlier presentations, these models may vary substantially in size depending on the amount of detail required. However, typical national and regional models contain more than 400 real activities, and zone models approximately 100. Zone/farm level model work is only getting underway, but it is anticipated that these models will contain a somewhat smaller number of elements than the zone models. Expected applications and anticipated outputs for these models are discussed in the next section.

The second area shows (Table 27) macroeconomic and regional models and analysis, contains the national macroeconometric model and regional multiplier and interindustry models. Initial estimates of two versions of the macro model have recently been completed. These models contain 45 and 55 equations in their present form. However, it is anticipated that the amount of disaggregation will be increased as much as possible in subsequent versions to facilitate linkage with other models. Regional multipliers and interindustry models are new areas. Area multipliers are being estimated for each of the four planning regions and the 19 agroeconomic zones. The interindustry analysis is also new. It is anticipated that a national table and four regional tables will be

Table 26. National and regional agricultural models and related analysis

Model, activities and anticipated change in capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
<u>National Agricultural Model (NAM)</u>			
A. Modifications and input for model improvement			
1. Revise input cost data	X		
2. Develop demand projection program	X		
3. Complete check on Type IV Land resource	X		
4. Complete check (re-estimation) of labor and capital resources		X	
5. Add livestock activities		X	
6. Add agricultural processing activities		X	
7. Add new technology activities		X	
B. Capability and expected focus of research application			
1. Examination of alternative rice price policies and supply response	X		
2. Evaluation of long term potential food demand (capacity)		X	
3. Examination of the relationship between rice price policy, farm income and international balance of payment		X	
4. Update on national agricultural sector plan alternatives			X
<u>Regional Agricultural Model(s) (RAM)</u>			
A. Modifications and input for model improvement			
1. Update consistant with current version on NAM	X		
2. Add new technology activities		X	
3. Add new livestock activities		X	
4. Add agricultural processing		X	
5. Add multiple crop and poly-period crop activities		X	

Table 26. continued

Model, activities and anticipated change in capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
B. Capability and expected focus of research application			
1. Evaluation of agricultural sector plan alternatives at region and zone level	X		
2. Farm level supply response for upland crops (price policy)	X		
3. Evaluation of potential shifts in irrigation/land policy among regions		X	
4. Update on national agricultural sector plan alternatives at region and zone level			X
Zone/Farm Models[a]			
A. Input for model construction			
1. Select zone for pilot study	X		
2. Identify activities to be included from farm records and from general farm survey	X		
3. Select typical or representative farm types		X	
4. Assemble coefficient and resource data		X	
5. Obtain initial solutions for testing and evaluation against known conditions and revise		X	
6. Extend to other zones and to fuller representation of farm types			X
B. Capability and expected research application			
1. Evaluation of resource utilization and the efficiency of resource allocation; Pilot area		X	

Table 26. continued

Model, activities and anticipated change in capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
2. Evaluate potentially important new activities suggested by studies		X	
3. Simulated management response to changes in input and output prices		X	
4. Initial solutions from other zones			X

[a]It is assumed that only activities A-6 and B-4 will extend beyond the pilot study

Table 27. Macroeconometric and impact models for national and regional analysis

Models, activities and anticipated change capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
National Macro Econometric Model MEM)			
A. Modification and inputs			
1. Further disaggregation to facilitate linkage	X		
2. Re-estimation with new data		X	
B. Capability and expected research application[a]			
1. Annual projection of Thailand national economy	X		
2. Projection of Thailand national economy with input from NAM		X	
3. Projection of Thailand's national economy with re-estimated models		X	
4. Full linkage with NAM			X
Interindustry Models (I/O)			
A. Inputs			
1. Assemble data for agricultural sector and selected agricultural processing and input industries	X		
2. Assemble current national and regional I/O coefficient	X		
3. Test and develop capability to manipulate existing I/O models	X		
4. Assemble coefficients for combined agricultural-non-agricultural sector, final demands primary inputs and intermediate industries for regions and the nation		X	
5. Test the national model		X	
6. Estimate I/O multipliers at national level		X	
7. Test first regional models		X	

Table 27. continued

Models, activities and anticipated change capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
B. Capability and expected research application			
1. Use coefficients to facilitate linkage of NAM and MEM		X	
2. Evaluate for consistency the implied changes in demand on other industries indicated in solutions of MEM and NAM models which are consistent with policy alternatives of the national plan			X
3. Evaluate for consistency the regional impact changes in demand implied with national plan alternatives in one region			X
<u>Multiplier Analysis</u>			
A. Inputs			
1. Assemble industry specific data on employment and product for regions, zones, changwats	X		
2. Impact multipliers based on minimum requirements and average requirement	X		
B. Capability and expected research application			
1. Provide cross sectional estimate of potential impact associated with change in regional exports	X	X	
2. Provide estimates of regional level impact of national agricultural sector plan alternatives	X		
3. Provide estimates of zone level impact of national agricultural sector plan alternatives		X	

[a]Research applications are contingent upon close cooperation and success of joint data assembly efforts by DAE and the National Economic and Social Development Board. It is anticipated that substantial amounts of data on I/O coefficients will be available before model construction is completed.

developed from a primary data base. Maximum industry detail is approximately 180 plus primary input and final demand vectors. Two-region formulations if developed without aggregation would require a matrix of about 400 rows and columns.

Special studies comprise the third area of ASA activity. These are shown in Table 28. This area contains a variety of ad hoc work plus the development and testing grounds for the bulk of anticipated extensions of the linear programming models. Activities included in this area are the linkage of the national crop model with the macroeonometric and interindustry models; marketing; transportation and demand analyses; agricultural processing studies; and linear programming application to livestock, multiple crops, and poly-period crop; and various statistical analyses.

Table 29 depicts data bank maintenance, general survey, and statistical support. This area provides and maintains the data base essential for virtually all other activity. The fifth area, shown in Table 30, is staff development. It is comprised of three types of activity. These include formal M.S. and Ph.D. -level training, inservice training in the DAE, and experience on the job.

Expected Research Capability and Phasing of Activity

Expected research capability and phasing of major research activities are also shown in Tables 26-30. Some effort was made to classify modifications and/or inputs required in the various areas under the headings "A" and research outputs and/or changes in research capability under the headings "B". Exceptions will be noted in Tables 29 and 30

Table 28. Special studies and analysis

Models, activities and anticipated change capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
<u>MEM and NAM Linkage</u>			
A. Inputs			
1. Further disaggregation of MEM	X		
2. Possible respecification of MEM	X		
3. Re-estimation of MEM for linkage with current data		X	
B. Capability and expected research application			
1. Estimation of macro nonfarm economy impact on agriculture	X		
2. Estimation of agricultural policy impacts on the nonfarm economy	X		
3. Fully linked MEM, NAM, I/O models			X
<u>Marketing, Transportation and Demand Analysis</u>			
A. Inputs			
1. Further development and extension of existing studies on rice to other major commodities	X	X	X
B. Capability and expected research application			
1. Estimates of transport and assembly cost on major commodities at village, changwat, zone, regional and national assembly points	X	X	X
2. Estimates of rural and urban demand for major commodities under alternate price and income conditions	X	X	X
3. Market information on commodity supplies and price	X	X	X

Table 28. continued

Models, activities and anticipated change capability (product)	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
<u>Agricultural Processing, Livestock, Multiperiod and Poly-Period Crop Models</u>			
A. Inputs			
1. Develop estimates of input-output coefficients and resource supplies from industry survey and general agricultural survey	X	X	
B. Capability and expected research application			
1. Description of existing capacities, output and resource utilization in these areas	X	X	
2. Input-output coefficients suitable for use in zone/farm, RAM and NAM		X	
<u>Statistical Analysis</u>			
A. Inputs			
1. Experimental results from the agronomic research of the ministry, universities and international agencies	X	X	
B. Capability and expected research application			
1. Coefficients for models at all levels suitable for defining new activities	X	X	X
2. Description of results to be expected with a variety of changes in the input-output relationship from survey and experimental sources	X	X	

Table 29. Data maintenance and statistical support

Activity and expected capability	Near term 3-6 months	Intermediate term 6-12 months	Next generation 12-24 months
Data Bank Maintenance			
1. Documentation of data sets from General Farm Survey	X	X	
2. Complete general retrieval program with user control options		X	
3. Complete specialized price data retrieval capacity		X	
General Survey			
1. Computerized sample allocation program		X	
2. Statistical check on data reliability using previous year data		X	
Farm Records			
1. Computerized data storage and retrieval capacity		X	X
Statistical Support			
1. Maintain programs for OLS and TSLS, regression, RFORM, GAUSS-Seidel, Moving Average	X	X	X
2. Extend and maintain input-output and simulation programs			
3. Adapt and develop new software as required by research activity	X	X	X

Table 30. Staff development

Activity	Remarks
Inservice Training (classes)	
Economic theory Econometrics Linear Programming Computer Programming Policy Analysis Regional Economics	Theory and general tools classes are taught at regular intervals --specialized tool classes such as linear programming and Fortran are taught to coincide with introduction of new people to research tasks.
Expected annual participation (100)	
Inservice Training (job assignment)	
General participation in research process, number participating (95)	Assignment of personnel is made by work area. There is no designation of counterparts. Organization has been modified to fit research and planning objectives.
Formal Advanced Degree Programs	
Thailand Number participating (14)	Several M.S. programs have been completed in which DAE research assignments provided the thesis material
Abroad Number participating (25)	Effort has been exercised to enter people into programs where former advisors are working or policy research tradition exists

where only expected capabilities are identified in discussing the data maintenance and statistical support. Table 30 identifies the inputs to staff development.

The outputs or changes in capability anticipated for the several areas should approximate the list of issues and problems which have been identified as requiring research.

National and Regional Agricultural Models

National and regional agricultural models are expected to provide information on national commodity price policy, supply response, long-term sector capacity under alternative technology assumptions, price/income/balance-of-payments relationships, land and water development and also something of the distributional consequences at the regional and zone levels. All of these outputs are scheduled for completion within the next 12 months. The updated versions of the NAM and RAM will be used to re-evaluate agricultural sector plan alternatives within the next 24 months.

Several issues listed 1-7 in Figure 34 can be treated in this research area. These include price, income and supply response; new technologies for upland crops; resource expansion and utilization; and distributional impacts within the agricultural sector. A summary array of issues identified by information source are also shown in Figure 31

Macroeconometric and Impact Models

Macroeconometric and impact models are used primarily to provide information about inter-relationships between the agricultural and nonfarm

Research Areas

I. National and Regional Agricultural Models

- A. NAM (1,3,4)
- B. RAM (1,2,3,4,6)
- C. Zone/Farm (2,3,4,6)

II. Macroeconometric and Impact Models

- A. MEM (6,7)
- B. I/O (5,6,7)
- C. Multiplier Analysis (6)

III. Special Studies

- A. MEM and NAM Linkage (6,7)
- B. Marketing, Transport and Demand (1,5,7)
- C. Processing, Livestock, Multicrop and Policy-Period (1,4,5,6)

1. Price, Income and Supply Response
2. Land, Irrigation and New Technology Development
3. New Technologies for Upland Crops
4. Resource Utilization C/L Substitution
5. Marketing and Transportation
6. Distributional Impacts
7. Price, Income and Foreign Exchange

Figure 34. Policy issues identified by potential information sources

sectors at national, regional and zone levels. This is reflected in the anticipated outputs in terms of distributional impacts and of the interrelationship between commodity prices, income and balance of payments noted in Table 27 and Figure 34.

Special Studies and Supporting Aanlyses

Special studies are directed to several areas. Some are important in their own right and others as means for improving models already in use in other areas.

The linkage between national agricultural and macroeconometric models reflects integration of two "stand alone" efforts, one directed at analysis in the agricultural sector and the other the total economy. The linkage is designed to permit two directional assessment of impacts. That is, changes in the agricultural sector can be traced to the total economy and vice versa in a recursive sequence. Issues which can be examined with this hybrid-type model are concerned with impacts, such as items 6,7 in the issues list of Figure 34.

Other Support Activities

Special studies have been identified as contributing to the improvement of other areas. Other activities even more critical to the improvement and general capacity to conduct research are based on data maintenance and staff development. These are critical to the maintenance and exapansion of capability in all aspects of research and contain the means for making adjustment in the focus and role of the research unit. Change in human capacity to do research is limited by the learning rate of old staff and success in hiring or training new staff in desired skill areas.

At the same time, the effectiveness of a staff with adequate training is considerably enhanced by a computer based data maintenance, retrieval, and statistical support facility. Items which are being developed at the DAE in the next 24 months are identified in Table 29. These include documentation of survey data, retrieval programs, computerized sample allocation programs, and maintenance and expansion of the program library in response to research needs.

The primary concern in this area is to provide a source of complete and current information which is accessible to the research staff. Additionally, emphasis is being placed on building up the library of software packages to cover the full scope of research work.

In-service training is essential to staff development and is accomplished at the DAE by using a formal classroom approach in combination with on-the-job training. Some effort has been made to phase classes with anticipated manpower needs in research, particularly in the areas of linear programming, computer programming, and regional economics. Based on past enrollments, more than 300 quarter hours will be used in a 12-month period. Although counter parts are not formally identified, contact between project personnel and permanent research staff is maximized by joint and group approaches to problem definition and conduct of research. Some internal reorganization has been required to facilitate communication and to make the organization fit research objectives.

Formal training outside the DAE is expected to be a scarce item in the next two years. No new starts are anticipated except under support from scholarship or private funds. However, approximately 40 people will be engaged in advanced degree programs.

In all of this it must be kept in mind that we are reporting anticipated applications and related studies and what is expected to be drawn from them. Typically, more is obtained in some areas than others. The situation may change. Previous experience suggests that numerous demands can emerge which can effectuate changes in emphasis and can delay some activities in favor of others.

Summary and Prospectus

The future of agricultural sector analysis (ASA) is not easily predicted. In this chapter effort was made to provide some basis for classifying existing ASA into reasonably distinct stages or approaches. The hypothesis was posited that differences in approach may reflect admustment to scale economics or threshold type phenomena in the provision of ASA type research capability. These three stages were identified as the 1) report or patch stage, 2) the project counterpart stage, and 3) the process stage. Stages one and three appear to be a tenable position but stage two begs the empirical question of whether it could or should be boosted to stage three or revert to stage one, where costs are less.

Three major categories of factors were identified which tend to shape ASA. These included 1) policy issues and problems, 2) existing research capability, and 3) situation or local policy environment. In the absence of real policy issues, ASA efforts are futile exercises. Research capability and human capacity, in particular, place bounds on the issues and problems which can be researched. Finally, it was suggested that the catalyst of situation may and possibly should compete successfully for ASA time and budget because it gives sense of vitality and is a good means of establishing credibility with potential users of research output.

ASA activities in several countries in the developing world were judged to be anticipating or already participating in a stage two approach. Certainly the ASA project in Thailand is a stage two approach designed to develop into stage three. A decision to move to stage one or three from a stage two, or even to initiate a stage two would be considerably improved if the empirical question of scale economies in the provision of research capability were addressed. If scale economies exist, there is an obvious justification for focusing attention on two additional questions. First, what conditions are sufficient to justify a push for stage three and second, how can more of ASA type information be assembled and utilized from adhoc studies in stages one and two?

The future of ASA in Thailand is traced over the next 24 months through five major research and supporting activity areas. These areas were identified as 1) National and Regional Agricultural Models and Related Analyses, 2) Macro Econometric and Impact Models for National and Regional Analyses, 3) Special Studies and Analyses and 4) Staff Development. Each of these areas was further identified in terms of 15 activities (tools) and changes in capability and research output anticipated over the next 24 months.

The general pattern is one of balancing effort and resources among new issues, developed capability and changes in the near term policy environment.