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BANGLADESH AGRICULTURAL RESEARCH PROJECT PHASE-II

A Suggested Approach to Model Use and Development at the Bangladesh Agricultural Research Council

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BANGLADESH AGRICULTURAL RESEARCH COUNCIL
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A SUGGESTED APPROACH
TO MODEL USE AND DEVELOPMENT
AT BANGLADESH AGRICULTURAL RESEARCH COUNCIL

Consultancy Report

To

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By

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TABLE OF CONTENTS

A SUGGESTED APPROACH TO MODEL USE AND DEVELOPMENT AT BANGLADESH AGRICULTURAL RESEARCH COUNCIL

		Page No.
I.	INTRODUCTION	1
II.	A BRIEF DESCRIPTION OF THE MPO MODEL	2
III.	PROPOSED MODELS FOR USE AT BARC	7
	Relationship of the MPO Model to Model Development at BARC.	7
	Suggested Models for use at BARC.	8
IV.	THE NEED FOR A MODELING CAPABILITY AT BARC	11
	A plan to have MPO model understood and utilized by professionals in irrigation and water management.	11
	Use of other models at BARC	19
V.	CONCLUSION	19

I. INTRODUCTION:

The purpose of this report is to discuss modeling efforts currently going on in Bangladesh, to indicate additional model development that could beneficially be carried out at BARC, and to consider the need for a modeling capability at BARC.

There are two significant modeling efforts that are underway in Bangladesh to assist in the development of the Third Five Year Plan. One of these models is the Investment Analysis Model of the Master Plan Organization (MPO), which is providing a substantial new resource for agricultural economic analysis. This report focuses primarily on the MPO model because that model provides a significant contribution to agricultural analysis. Additionally, this model could have a great impact on the way that economic analysis related to water resource development is conducted. Also the model could have a great impact upon how agricultural economic analysis is conducted in Bangladesh, generally.

Another model is being constructed at the Planning Commission, and in the Netherlands, but is at a stage where there is not a current write-up available. The model, however, does give special emphasis to agriculture. The model has 18 sectors that represent crop production, livestock production, and forestry, out of a total of 42 sectors in the model, which does provide considerable emphasis on agriculture. At a later time this model could be an important resource for agricultural economic analysis. However, it is not now an operational model that is available to BARC and, therefore, it will not be analyzed in this report.

Chapter II contains a description of the MPO model. Chapter III proposes several models for use at BARC in the near future and discusses the relationship of these models to the MPO model. Models are suggested

for the determination of the impact of irrigation on foreign exchange requirements, on labor use, and on regional development. Also Chapter III considers a model for evaluating agricultural development alternatives other than those addressed by MPO. Chapter IV addresses the need at BARC for the capability to use available models and to use models for agricultural research. A plan is developed for an initial capability at BARC where participants would understand and use the MPO model and be in a position to do further model development. The Conclusion suggests that BARC establish a capability for model use and development and that its first project should be to understand and use the MPO model in addressing agricultural research problems.

II. BRIEF DESCRIPTION OF THE MPO MODEL:

This is a description of the Investment Analysis Model that has been developed by MPO. This description is to provide BARC personnel with an understanding of what the model does and how the model does it.

This description of the model provides background information that is relevant to the consideration of establishing a modeling capability at BARC. The description of the model will enable BARC personnel to be able to (1) consider how the model could be employed in addressing agricultural research questions and (2) consider, in a general way, the framework that the model provides for future agricultural research.

Overview

The Investment Analysis Model is a computer programming system. The computer program enables the systematic evaluation of a large number of investment alternatives. The alternatives are evaluated one by one, starting with the investment alternative that has the highest benefit-cost ratio.

The computer program keeps track of the budgetary resources required for this alternative and subtracts them out of the total. What remains after this subtraction will be the amount available when the next investment alternative is introduced. The computer program also keeps track of the amount of land required for this alternative (still the one with the highest benefit-cost ratio) and subtracts this total from the total amount of land; once the amount of land required for this alternative is subtracted, the remaining land will be available for the next highest alternative investment (concerning the land discussed above, the model considers land of a particular soil type, under particular flood conditions).

The computer program considers water resources in the following way. For the investment alternative with the highest benefit-cost ratio, that we are still considering, the quantity of water required per hectare is a known quantity (separate requirements will exist for surface and ground water).

The program will determine the total requirements of ground and surface water used by this investment alternative and subtract it from the total amount that is available. The remaining quantity of water will be available when the investment alternative with the next highest benefit-cost ratio is considered by the computer program. Actually, the water constraint is converted to a land constraint by the program, but its effect is as described above.

The computer program then goes on to consider the investment alternative with the next-highest benefit-cost ratio and will go through the same process all over again. The computer program will determine the financial resources that are available and test to see that they are

sufficient to fund this alternative. The program will then compute the remaining financial resources that will be available when the investment alternative with the next highest benefit-cost ratio is considered. The land requirement of this investment alternative and the water requirement of this alternative are handled in a way that is generally similar to the way that financial resources are treated. Once this investment alternative is considered the program begins considering the investment alternative with the next highest benefit-cost ratio. In this way the computer program evaluates a set of investment alternatives, arrayed according to their benefit-cost ratios.

The investment alternatives that are considered by the model are only in the agricultural sector. Fisheries, inland waterway transportation, and industrial use, however, do have an impact on how much water will be available for agriculture.

Alternatives

As indicated above, the model concerns itself with the evaluation of investment alternatives that relate to the agricultural sector. The model considers the following investment alternatives: LLP, STW, and DTW irrigation, a number of major irrigation projects, and a number of major flood control and drainage projects. These types of investments were considered for land having (a) five different flooding conditions (b) two different crop production technology levels (c) five irrigation categories and (d) 60 different regions (Third Interim Report, Vol. VIII, Appendix C).

For example, a particular investment alternative would be providing LLP irrigation (I_1) for non-flood land (F_0) in a location where high

technology in crop production is assumed (T_1) in planning area 25. Another investment alternative would be providing STW irrigation (I_2) to this same land (F_0) with the same technology pattern (T_1) in planning area 25. For each of these investment alternatives, as well as all other alternatives, estimates must be made of the following in order for it to be properly evaluated by the model:

1) estimated benefits
2) estimated costs
3) land required
4) ground water requirements
5) surface water requirements.

Investment alternatives were prepared for various proposed projects. It should be noted that throughout the report investment alternatives are referred to as "modes of development" and "transitions." Each transition or mode of development is the equivalent of a movement of a particular area of land out of one hydrological-crop mix-technology combination into a more productive one (Second Interim Report, Chapter 3, page 1).

Benefit-cost ratios

Four benefit-cost ratios are calculated for each alternative, each to reflect a different level of government subsidy. The model can be operated when all the investment alternatives considered are computed using the same definition for the benefit-cost ratio. Annex A of The Third Interim Report, page 16, provides the various definitions of these benefit-cost ratios.

Benefits

The procedure for estimating for each investment alternative or mode

of development is given in the Annex of the Third Interim Report, page 8. Because the model focuses only upon crop production in agriculture, the gross benefits figure for each investment alternative results from increased net farm income in crop production. Each investment alternative has an associated benefit stream that indicates the benefits related to a project in various years after start of construction (Annex, Third Interim Report, page 60). There is also a cost stream associated with each investment alternative, which is discussed below. Getting back to the benefits side, the value of benefits at market prices are recomputed using shadow prices. These shadow prices are designed to estimate the true economic value of goods and services. (Annex, Third Interim Report, page 22).

Costs

For each alternative investment that is going to be considered by the model, it is necessary to develop estimates of costs. The various elements that were considered in the estimation of costs are provided in section 3.1.2 of the Second Interim Report, specifically items: (c), (d), (e), (h), (i), (j) and (k). The procedure employed is similar to those typically used in economic feasibility studies. There are, however, several procedures that should be noted specifically.

LLP, STW, and DTW irrigation were considered after the procedures that are shown in Section 3.1.2. were developed. With respect to these types of irrigation, costs are developed in the usual way, except that they are phased, as are all costs for alternative investments. Both capital costs and operation and maintenance costs are phased; for example phasing for capital costs for major flood control, drainage and irrigation

projects (FCDI) and flood control and drainage projects (FCD) are shown in the Second Interim Report, Vol. VIII, page 45. One final point is that estimated financial costs are adjusted to reflect the economic values using shadow prices (Annex, Third Interim Report, page 23).

Review of MPO Model

In review, MPO has a model for evaluating alternative investments. They have evaluated a large number of alternative investments prior to completing the Third Interim Report. The model has been used to address specific "modes of development" for particular soil types, under particular flood conditions, in particular planning areas. MPO has obtained detailed soil information and has the potential to know the amounts of land of each soil type in each of 60 planning areas. Furthermore, MPO appears to be working with cropping patterns for a particular soil type in a particular region. Therefore, this is a powerful system for analyzing various investment strategies. The system can consider non-irrigated investment alternatives as well as those involving supplemental irrigation. It has the potential to be a very useful analytical technique in many areas of agricultural research.

III. PROPOSED MODELS FOR USE AT BARC:

Relationship of the MPO Model to Model Development at BARC

The MPO model, also known as the Investment Analysis Model (IAM), is the centerpiece of model development that is here being proposed for BARC. The models that are suggested for development at BARC require that the full Investment Analysis Model be operated, with all its constraints, whenever analysis is undertaken. By doing this type of

analysis, with the full MPO model, an efficient agriculture can be identified. Although MPO does not claim that their model optimizes, the components selected should be looked upon as the most efficient set of those considered. If a better method is developed it can be used, but until this better method can actually be employed, the MPO model provides the best avenue to quality economic analysis of the water sector at BARC.

Suggested Models for use at BARC

There are several areas where the MPO model contributes to further model development. The first two models that will be discussed involve the impacts of irrigation modes of development on (1) foreign exchange and (2) agricultural labor. Both of these formulations begin by using the MPO model to identify an efficient agricultural pattern and then go on to analyze the impacts that would result. The next model that was developed utilizes the end-product of agricultural labor model and then goes on to consider questions of regional income change and nutrition, through the use of economic base models, models of town and city growth, or input-output models. Finally, a model is discussed that can be used to examine the impacts of various agricultural investment alternatives, not necessarily related to water resources develorment.

Foreign Exchange

Figure 1 presents a flow chart of the MPO Model. It is presented here in order to emphasize the strong relationship between this model and the models that were developed. Also, the inclusion of this flow chart will enable the comparison of boxes in the various models with those in the MPO model, which is referred to in the flow charts as IAM.

Figure 2 describes the model designed to trace the impact of various development scenarios on the balance of payments. It should be noted that the three top boxes all come from the IAM: two from the top line and the one at the bottom line.

The model utilizes a solution of the IAM as its starting point. The model then goes on to trace the consequences of activities and investments specified by IAM on foreign exchange requirements. The quantities of various imported inputs would be computed using the data already contained in the IAM. The foreign exchange requirements of these purchases would be estimated, using appropriate prices and transportation costs.

On the far right of the flow chart, a sequence is shown for the computation of foreign exchange earnings of the agricultural activities selected by the IAM. Estimates would be made of the quantities of each commodity that is sold in foreign trade. Prices and transportation costs would then be used to estimate the foreign exchange earnings.

In the middle of the flow chart, the process is shown for estimating the reduction of foreign exchange required to import food grains. It would be necessary to estimate the reduction of the quantity of grain imports that would be consistent with a particular scenario. Then, prices and transport costs would be considered, and savings in foreign exchange would be estimated. Finally, the three elements are brought together to estimate the impact of the scenario on the balance of payments of Bangladesh.

Labor Use and Income

This model (shown in Figure 3) examines consequences of a particular scenario of activities and investments selected by IAM. It should be observed that the top two boxes are taken from the IAM. The labor use

pattern of a particular scenario will yield a requirement for labor in each region (second box down from the top on the right). This labor requirement will in turn generate a labor demand in that region, which will interact with the supply of labor in that region to generate a wage rate. The existing wage rate, called "old wage rate" in the flow chart, may also have some impact on the wage rate for the region. The amount of hired labor and the wage rate combine to yield the direct income of agricultural workers. Direct income of agricultural workers is a key variable for estimating food consumption and nutrition, shown at the bottom right of the flow chart.

Regional Development

A model to estimate the direct and indirect effect of an IAM scenario on regional income is outlined in Figure 4. This flow chart starts with the change in family income (direct), one of the intermediate boxes shown in Figure 3, and the change in farm income. In order to estimate the indirect effect of incomes earned in agriculture on a region's economy, it would be necessary to employ one of the models listed in the second box from the top. These models will yield the multipliers by which farm income plus farm labor income would be multiplied in estimating total regional income. Total regional income would then be used along with the marginal propensity to consume food to estimate changes in food consumption and changes in nutrition. Also, regional income is an important index for estimating other welfare parameters.

Alternative Agricultural Development

The flow chart provided in Figure 5 concerns the utilization of the IAM to examine alternative agricultural development possibilities other than those addressed by MPO. This flow chart starts with three boxes, which

are similar to three boxes that IAM starts with (Figure 1) and which contain the data describing the additional agricultural development project. For this model, the additional agricultural development projects would be synthesized and their benefit-cost ratio and other requirements estimated. The IAM would then be operated with the inclusion of these new development projects and a new development scenario would emerge. A comparison could then be made between this and other scenarios, which would yield the impacts shown in the bottom box.

IV. THE NEED FOR A MODELING CAPABILITY AT BARC:

There is a general need within the agricultural research community world-wide to do better professional work. Appropriate computer-based models are helpful in doing better professional work, and so models should be understood and utilized. There are recent developments in computer-based models in Bangladesh. There is a need to understand these models, not only at BARC but throughout the agricultural research community.

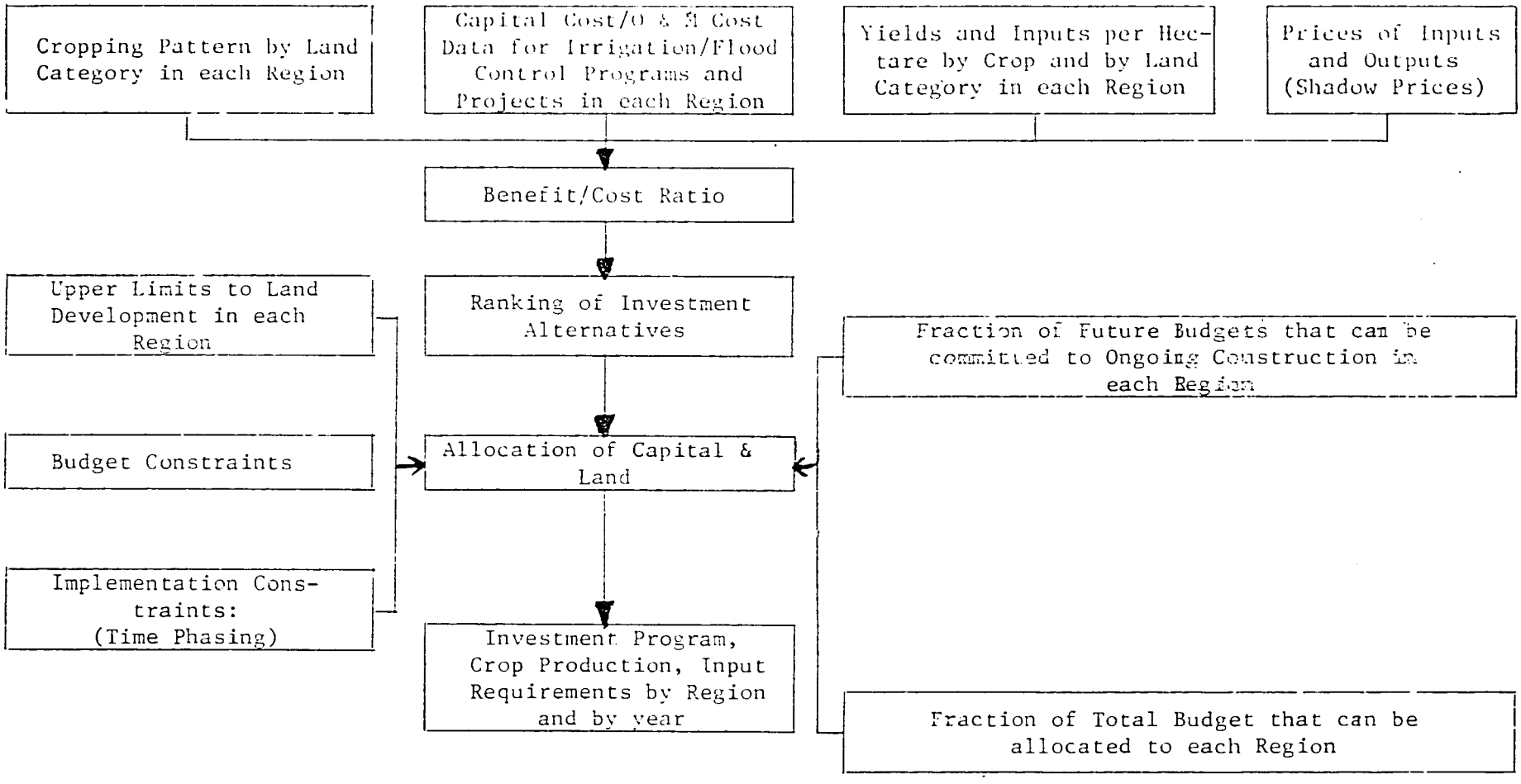
This chapter considers the need for a modeling capability at BARC and presents a plan for BARC to make a first step toward establishing a capability to undertake modeling activities. This first step is to gain an understanding of the MPO model and how to use it. The next step would be for BARC to use the MPO model and some of the models that were developed in Chapter III.

A. A Plan to have the MPO Model Understood and Utilized by Professionals in Bangladesh.

Proposal: A Team Approach at BARC

A team of researchers and analysts can be formed to undertake and carry out this project. The plan is that the team will work together at BARC for

Figure 1. Schematic Diagram of Investment Analysis Model (IAM)



Source: Second Interim Report of MPO, Vol. VIII, Appendix E.

Figure 2. Flow chart of model to examine impact of irrigation on foreign exchange requirements

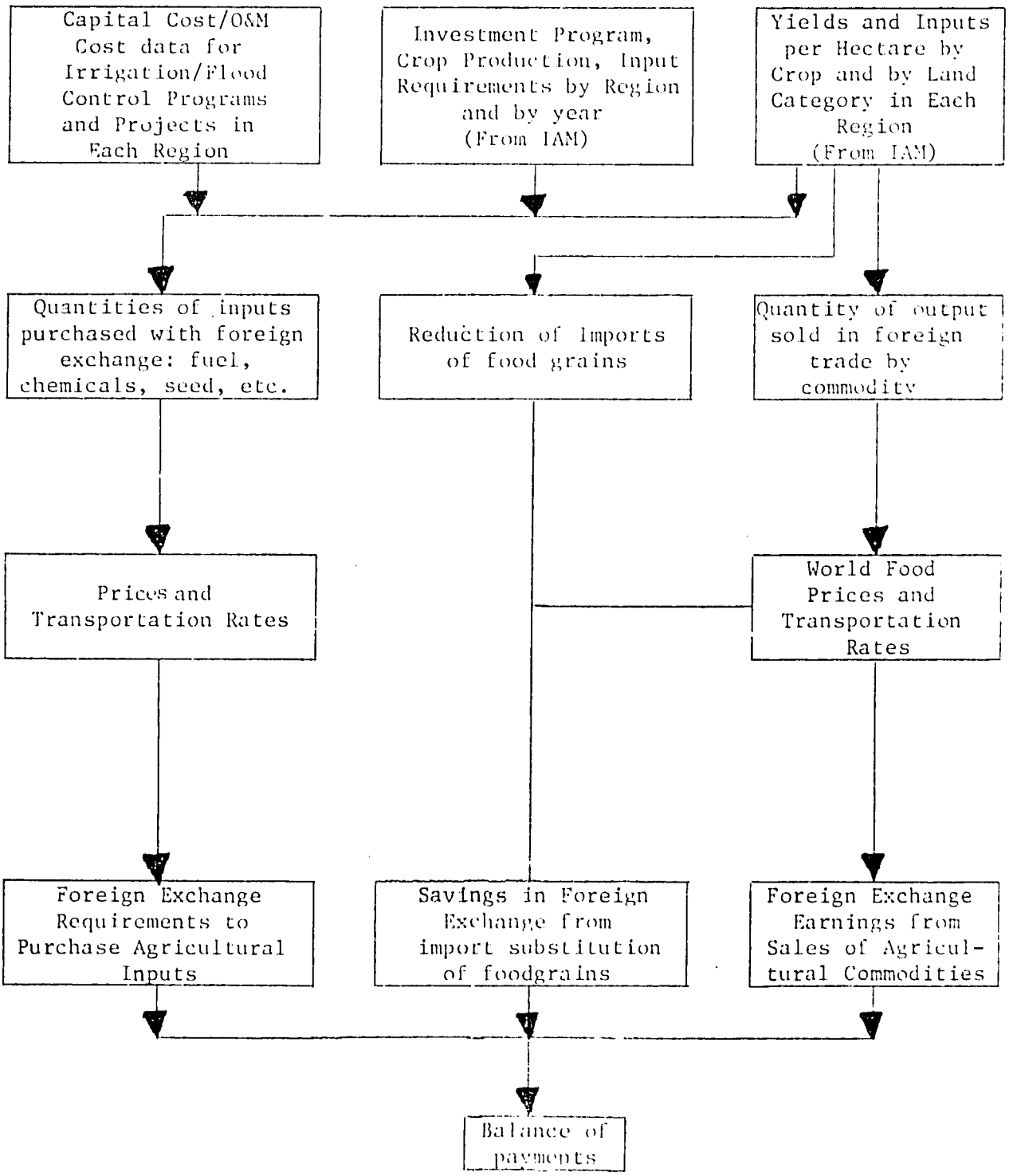


Figure 3. Flow chart of model to examine impact of irrigation development on labor use and on income of agricultural workers

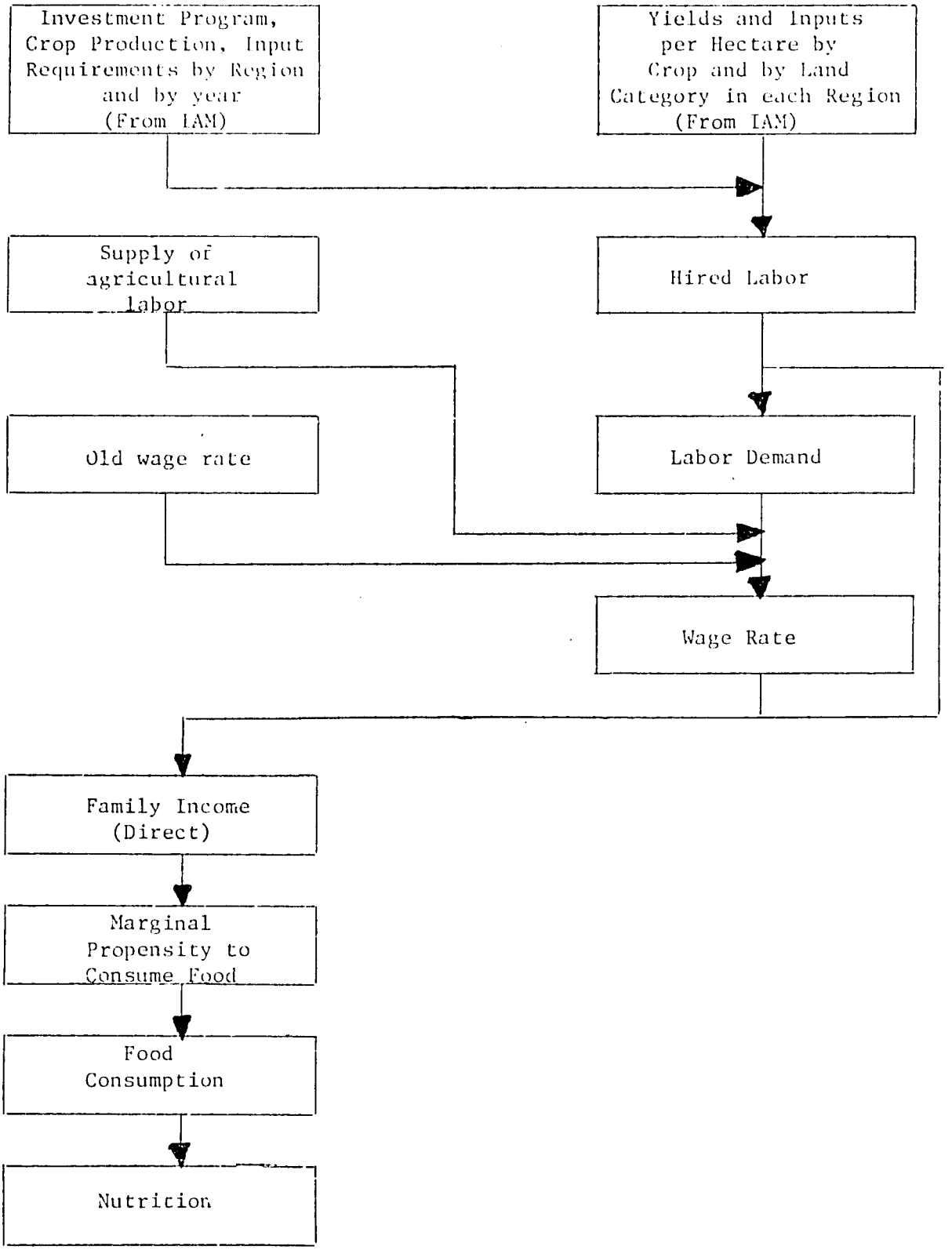


Figure 4. Flow chart of model to examine direct plus indirect impact of alternative irrigation development on regional development

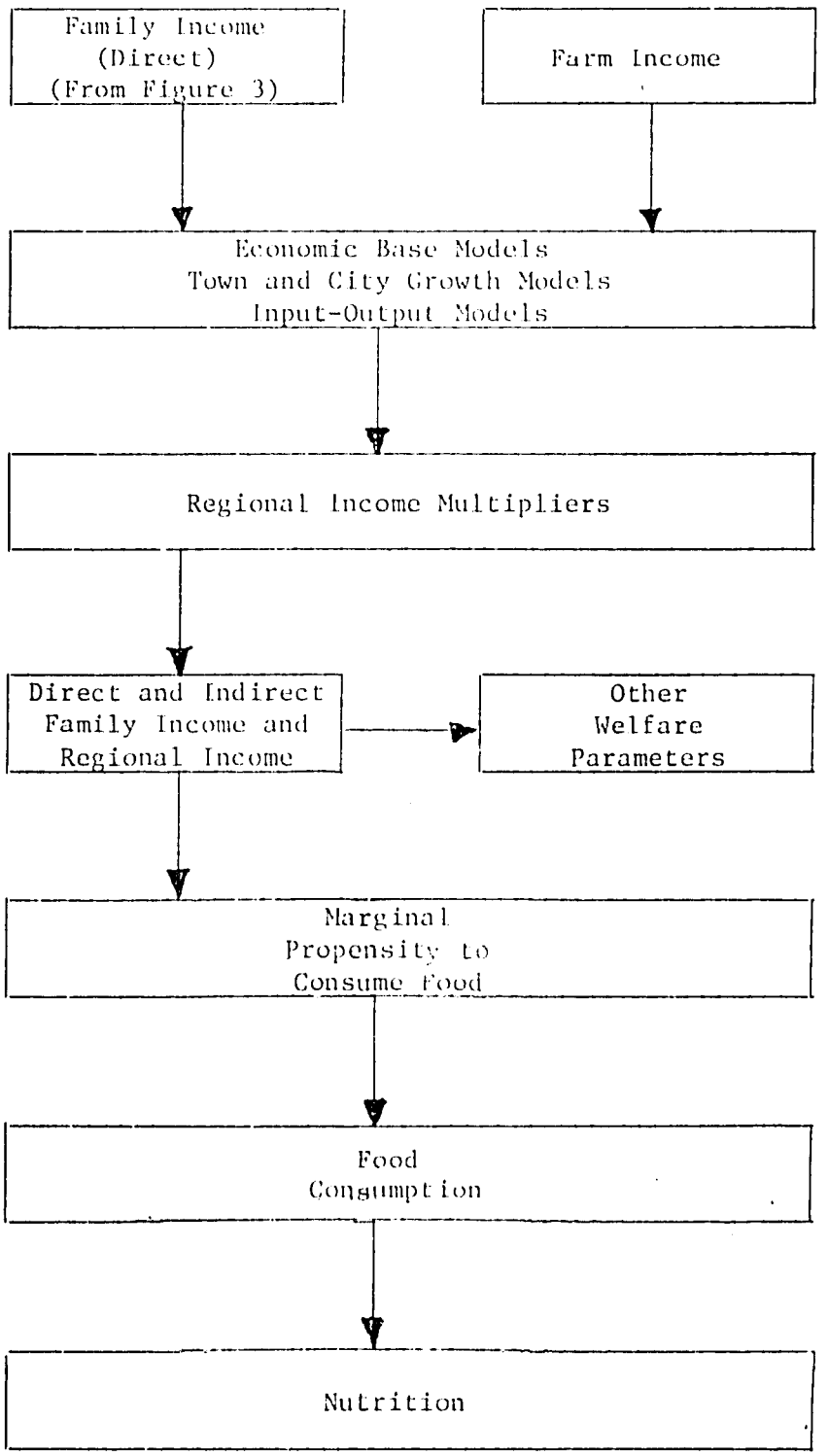
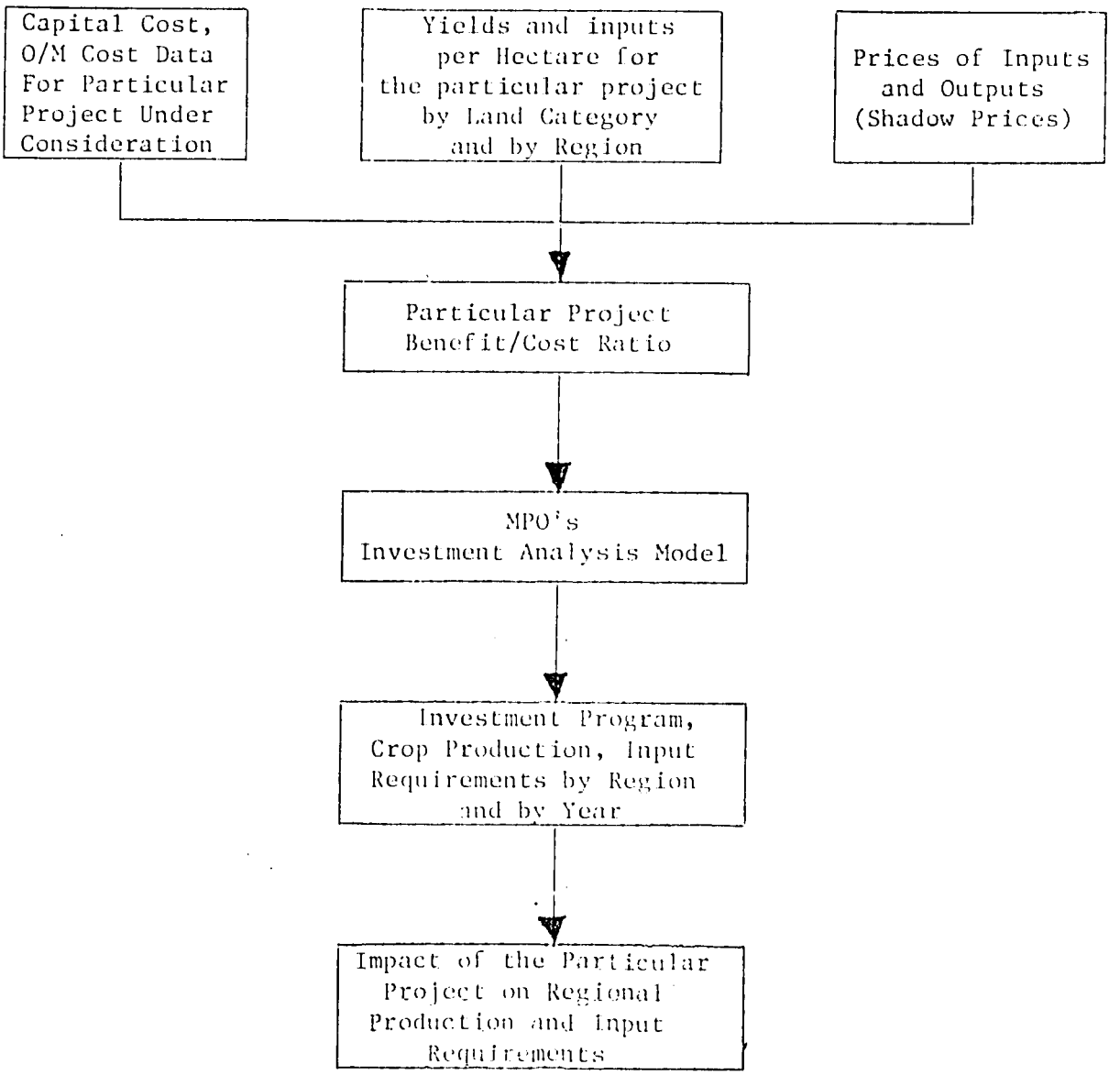


Figure 5. Flow chart of model to examine impacts of investment alternatives not considered, as yet, by MPO



a period of time and learn to utilize the model. After completing this phase, team members would continue to be a source of information and knowledge when they return to their institutions. Team members should have the necessary background to actually utilize the model in problem-solving. The team members should plan to return to their institutions and continue to work in the area of analysis and research, utilizing the IAM and other models. Team members will have a reasonably long-term relationship with the modeling efforts at BARC and will be considered when working groups and committees are formed in the area of water policy analysis, modeling, and research.

Work required: General

The Team would establish at BARC the capability to run the IAM. The Team would work closely with the MPO personnel so as to obtain up-to-date versions of the model as they become available. A close relationship with MPO personnel will be necessary as BARC scientists develop their understanding of the model. (BARC will internally consider the best means for transmitting information and expertise from the MPO staff to those at BARC. Also, BARC will consider what types of time commitments might be required of MPO personnel in order to efficiently educate the BARC team.)

The BARC Team would establish the capability to analyze the research-related components of the IAM at the computer center at BARC. The Team will make various computer runs in order to get hands-on experience in (1) introducing inputs into the model and (2) in interpreting the model's output. In brief, the team will become intimately familiar with the model. Once the team has developed a detailed understanding of the model, it will analyze the model's sensitivity to various parameters. The Team will, further, explore the impacts of various alternative hypothetical policies.

The team would also analyze the implications that the model has for agricultural research. The IAM divides Bangladesh into 60 catchment areas and there are some parameters that are used by the model that relate to each of these areas. This breakdown into these 60 areas has significance for agricultural research in Bangladesh if the results of the research are going to be used to improve the IAM. There will be many similar implications of the model upon agricultural research that the team would consider.

Report

The team would produce a report that will be directed towards agricultural researchers in irrigation and water management. The report would describe the model and how it can be utilized. The report would indicate the types of questions that can be addressed by the model. The report would contain examples of how the model was used in the analysis of specific studies. The report would provide a description of the parameters contained within the model and describe the data that have been used in estimating those parameters.

The report would also focus on how the researcher can use the model. The input requirements of the model will be specifically addressed. The report would also discuss the model's output. The report would discuss the format of the model's output and the interpretation that should be given to the various outputs.

Course

The team would present a course directed toward agricultural researchers that will extend the knowledge that they have developed. The idea of the course would be to provide key personnel from around Bangladesh with intensive, hand-on experience with the model. Those who complete the course

would be in a position to make immediate use of the capability housed in the computer center at BARC.

B. Use of Other Models at BARC

In Chapter III models were presented that extended the MPO model. Once the capability has been established at BARC to utilize the MPO model, these models should be employed to examine the various impacts of alternative scenarios of water resource development. Agricultural development options not considered by MPO should be analyzed using the model. These could include such wide ranging alternatives as supplementary irrigation programs, speciality crop development, up-graded agricultural extension services, etc.

It is suggested that, at the earliest possible time, birth rates and other appropriate population-growth parameters be considered by BARC scientists in models of food self-sufficiency. It will be beneficial to government policy generally if an appreciation can be developed for the enormous negative impact of small changes in population growth parameters on food self-sufficiency. The MPO model was used to estimate the extent to which, under certain assumptions, agricultural and related resources were sufficient to produce the food needed by a growing population. It is suggested that a similar formulation be used by BARC on the production side (the MPO model) while disaggregated parameters are used on the population side. Sensitivity analysis could then be carried out to determine what the impact would be of changes in birth rates and other population growth parameters.

V. CONCLUSION:

This paper has briefly described the MPO's Investment Analysis Model. Models were developed to analyze labor use, foreign exchange requirements,

and regional development aspects of various development scenarios. The models required that the MPO model be run and that a constrained optimum set of projects be identified. Then, the labor use consistent with that particular solution can be estimated, through the models described. In a similar way, the foreign exchange impact of a scenario would be examined.

The analysis of regional development impacts of a particular scenario are estimated in a similar way. The MPO model would be run, and the constrained optimum set of agricultural activities or projects would be identified, and the direct income effects identified. Then, through the use of various regional multipliers, estimates could be made of direct and indirect regional economic effects of the scenario.

These types of impacts could be examined for various scenarios and compared. For example, a scenario that emphasized deep tubewells might be compared with a scenario where shallow tubewells were the principal irrigation method employed. A scenario that emphasized irrigation could be compared with one where low-water-using crops were investigated. A scenario that emphasized manually operated pumps could be compared with one where manual pumps were not considered. A scenario that examined the impact of supplementary irrigation could be run. A wide range of scenarios could be evaluated, but each scenario first has to be developed through the use of the full MPO model. When the result is available through the model, various aspects of the scenario can be evaluated further. Therefore, the models that were developed in Chapter III cannot be operated separately from the MPO model.

Chapter IV examined the requirement at BARC for a capability to use existing models and to develop additional models that will benefit agricultural research. A team approach is suggested, with the team learning how

the MPO model operates and analyzing the agricultural research-related components of the model.

The author has concluded that BARC would benefit from an enhanced capability to address modeling issues. BARC could establish contact and support among analysts that are interested in various phases of model building for economic and other social science analysis. Computer systems analysts, computer programmers, mathematicians, statistical analysts, econometricians, economists, demographers, and sociologists all will be needed to develop a multi-dimensional understanding of the impacts of government, donor, and industrial policy.

BARC has received several proposals from individuals who are interested in modeling. There are at BARC people who have training in one of the above areas who would like to participate in modeling work. BARC now has the computer facilities to begin the modeling efforts suggested.

This paper suggests that BARC begin the process of model use and development by understanding and using the MPO model. It is further suggested that BARC then goes on to use several models that were developed during this consultancy, within the framework of the MPO model. Finally, it is suggested that BARC move promptly to build this capability, especially at this time when the MPO model is just starting to reach its potential.

ADDITIONAL BARC PUBLICATIONS

ON

IRRIGATION WATER MANAGEMENT

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