WATER RESOURCES

IN

EGYPT'S FUTURE

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MANAGEMENT SUMMARY

An intensive study of Egypt has been undertaken over the past nine months to determine the role of water resources in that country's development, and to further test the application of the system dynamics methodology to the sponsor's analysis responsibilities. This report summarizes the study's achievement of both objectives; a technical appendix provides details on the research done for the study and the analytic tools produced for continuing use.

The potential exists that Egypt will be unable to satisfy the future water requirements of the country's agricultural sector. Various development programs to address this problem are identified in the report, including the potential gains from internally and externally financed investment. A carefully planned program of investment in water control facilities may be necessary to avert a serious erosion of the population's nutrition early in the next century.

The study also identified a number of agricultural or demographic developments that might significantly affect the requirements for water. Increased mechanization of agriculture, for example, would boost the requirements for water far above what could be provided with current management practices, making new water development programs even more imperative. A reduction in the urban population's preference for water-intensive fruits, vegetables, and rice, on the other hand, would ease the requirements for water and allow the country to achieve a stable level of nutrition with existing water management and agricultural practices. Reductions in Egypt's net birth rate of the magnitude now being discussed by the government would also allow the country to maintain adequate nutrition with existing practices.

From a methodological viewpoint, the study has demonstrated the ability of systems dynamics to meet a number of the sponsor's analytic requirements. The methodology encourages an inter-disciplinary approach that can integrate the results of hydrologic, agricultural, demographic, and economic research. A wide range of different assumptions about physical and social processes, or government policies, can be easily investigated. The process of simulation model development focuses attention on the most important subjects for further research. Moreover, the computer model from this study will remain available for continuing review of developments in Egypt.

I. INTRODUCTION

For all of recorded history Egyptian development has been intimately linked with the Nile River.[1] Until the construction of dams and other water-control facilities, the annual flooding of the Nile in August and September was the mainstay of Egypt's agricultural production. The easy transportation offered by the Nile River allowed a succession of rulers to tie Egypt into a single, well-unified country, at a time when many other parts of the world were split into tiny political fragments. The Nile River and its control have dominated the economic development of Egypt:

> Egypt was and is a desert traversed by a river, and by and large the inhabitants were and are locked in place ..From the earliest of times the government of Egypt has been organized around a single venture -- the regulation of the Nile's waters in an attempt to decrease their damage and to realize their full potential for good...The country depends on irrigation to support and expand its principal sector, agriculture.[2]

Furthermore, the Nile environment has sustained the unique social and cultural tradition of Egypt's agricultural peasantry, the Fellahin:

> Of all persistent factors (in Egypt), none is more historically distinctive than the ethnic and cultural homogeneity of the Fallahin. The combination of unceasing work, an agricultural economy determined by the Nile, rural poverty, widespread disease (often carried by the Nile), and separation from political power maintained a high degree of consistency in their outlook and customs...The fellah was not led to expect more from life than had traditionally been his lot.[3]

Although completion of the Aswan High Dam has allowed more effective use of the Nile water, Egyptian agriculture may no longer have the capacity to keep pace with population growth. Egypt's population has been growing steadily at a rate of 2 to 2 1/2 percent a year, and now numbers some 38 million. Nearly all of Egypt's people are concentrated in the narrow agricultural valley along the Nile, making it one of the most densely populated regions in the world. For example, the ratio of population to arable land in Egypt, 6 1/2 people per acre, is almost double the 3 1/2 people per acre in the People's Republic of China. Although Egypt's agricultural production has kept pace with its population growth over the last two decades, the maintenance of present per-capita food standards is in doubt:

> Egyptian agriculture is in crisis. Yields of all major crops have stagnated since the middle 60's as have available per-capita resources in food grains. With the population growing inexorably by a million or more each year and with good land going out of production, it is impossible to avoid the judgement that all these ratios will get worse before they get better, if they ever do.[4]

The potential agriculture-population imbalance is aggravated by Egypt's limited raw material and industrial base. Aside from the Nile waters and deposits of oil and natural gas, Egypt is virtually bereft of natural resources.[5] Agricultural exports, chiefly cotton, provide the large amount of foreign currency necessary to pay for Egypt's imported food. The government has not yet been able to follow the lead of other resource-poor nations (e.g., South Korea or Taiwan) by industrializing to enter the world market for manufactured goods. Hence, Egypt's future and its population's well-being are highly dependent on the performance of agriculture.

In view of Egypt's limited industrial base and precarious population-food balance, orderly economic and social development in the coming decades will be difficult. The Nile will be a key determinant of success, since the river's water could potentially support a dramatic increase in food and/or cash crop production. The Nile might also provide an enormous amount of hydro-electric power to fuel industrialization, but the use of the river for power to some degree precludes its use for irrigation. Finally, Egypt's economic and social development will itself determine the importance of the Nile water in the country's growth -- determine, indeed, whether the availability of water becomes a limitation on the prospects for growth. It is important, therefore, to assess the potential impacts of water resources on Egypt's future.

This brief description of the inter-relationships between water resources and economic and social development only hints at the complexity surrounding the subject. A host of industrial, agricultural, demographic, and political pressures all combine to shape the course of Egypt's development. Furthermore, these pressures will interact with each other over time in a way that further complicates any analysis. For example, industrial trends involving income and consumption have a major influence on population growth. Resulting food requirements determine how much of the country's agricultural capacity is available to grow non-food crops for internal use as raw materials or export to earn foreign currencies. The availability of raw materials and foreign currencies may, in turn, influence industrial activity. The inter-relationships from this example could be extended to encompass literally thousands of factors.

Another important complication arises from the nature of the data and information available. Although the Egyptian government has engaged in an extensive process of data collection stretching back over many years, the reliability of many of the statistics is open to doubt.[6] Furthermore, much of the important information is descriptive and qualitative, rather than quantitative. It is contained in reports on Egypt's economy and population filed by various internal and external observers, and in the minds of experts on Egypt who are available to answer specific questions. The doubt and uncertainty surrounding numerical data and the subjectiveness of verbal information impose additional requirements on any attempt to assess the role of water resources in Egypt.

This report describes the results of an extensive study of the questions surrounding water resouce management in Egypt. The purpose of the study was to investigate and assess various options available for affecting Egypt's economic and social development. Because many of the consequences of water management decisions would only be visible over a longer time frame, a time horizon of 20-30 years was specified for the study.

Fortunately, analytic methods are available to reduce the complexity of a study such as this one to tractable proportions. Quite specifically, the mathematical modeling, computer simulation, and analysis techniques of System Dynamics provide a means for integrating the diverse economic, demographic, environmental, technological, and hydrological factors which must be considered.[7] The System Dynamics method can draw upon case studies, statistical analyses, and other related efforts. Time-series and cross-sectional data can be combined with more qualitative, subjective information, such as the opinions and theories of knowledgeable people. This allows for the fullest use of everything that is known about the problem.

Furthermore, the approach provides a powerful, but inexpensive, means for answering "what if?" questions. Simulation experiments can test the consequences of hypothetical changes in government policies, varied estimates for important pieces of data, or alternative assumptions about the "system" itself. Sensitivity analyses can be performed to pin-point the most critical assumptions and data needs. After such tests, data collection and analysis activities can be focussed with efficiency on the areas of greatest impact.

Chapter II of this report describes the conduct of the study -- the reference material assembled, and the development of a computer simulation model. Chapter III describes the "base simulation" of the Egypt model that illustrates the function and workings of a simulation model and serves as a benchmark for policy analysis. Chapter IV describes the results of a dozen simulation experiments with the model to address the study's analysis goals. Chapter V describes the conclusions to be drawn from the work. Appendices to the report provide a detailed description of the simulation model used for the study and analysis of 20 more simulation experiments with the model.

Besides the lessons to be drawn about water resources in Egypt, a further goal of the study was to improve the client personnel's facility with the System Dynamics methodology. Throughout the study, both client and consultant personnel divided the research and model development effort. Each phase of the work was thoroughly reviewed with the sponsor before proceeding to the next to maximize the sponsor input to, and understanding of, the project.

II. METHOD OF STUDY

The Introduction of this report outlined some of the methodological challenges confronting an analysis of the role of water resources in Egypt. The complex inter-relationships between water resources and the balance of the economy, the many economic and demographic pressures on Egyptian resources, the quality and quantity of information availlable -- all combine to tax the limits of any study.

This Chapter describes the approach used to overcome the various methodological hurdles. The first Section reviews the research conducted at the beginning of the study to illustrate the types of information collected. The second Section describes the simulation model that was created to assemble all of the research information in an accessible form. The final Section describes the assessment of the model to determine the accuracy of its portrayal of the Egyptian hydrologic, economic, and social systems, and its resulting utility for policy analysis.

Research -- The study team for the Egypt water resources project analyzed a wide range of material in the course of developing the computer simulation model. The sources consulted included written studies of Egyptian economic and social matters, an extensive review of literature on the hydrology of Egypt in particular, and hydrologic processes in general, and discussions with government experts on Egyptian affairs.

The literature on Egyptian matters includes materials published both in Egypt and the United States. The Egyptian government has conducted several economic and agricultural studies, and the results of this work are available in translation. In addition, international development agencies have conducted their own studies, and published findings on alternatives for economic and agricultural development. Finally, various American academic and government teams have conducted their own in-country research.

The bibliography in Appendix A lists the dozens of written materials reviewed during the study, but two of the sources cited in the bibliography are worthy of attention here. First, a combined team of U.S. Department of Agriculture experts and Egyptian personnel conducted an intensive study of alternative development programs for Egyptian agriculture, and published Egypt: Major Constraints to Increasing Agricultural Production to present their findings. The book is a valuable source of information on the effect of water and other production inputs on Egyptian agriculture. Second, John Waterbury is stationed in Egypt with the American Universities Field Staff, and has published a number of reports on Egyptian agricultural and demographic matters. Waterbury enjoys the advantages of extended residence in Egypt, and the resulting access to informed Egyptian observers. His material includes a wealth of descriptive insight.

Another important resource was an extensive body of literature specifically addressing hydrologic topics. Some of this literature is oriented to water processes in Egypt, with particular attention to the changes wrought by the erection of the Aswan Dam. Other works address hydrologic processes in more general terms, without regard to geographic area. A final element of the literature is a limited collection of material on other attempts to create simulation models of hydrologic systems.

The written material on Egypt was supplemented during the study by interviews with various government experts on Egyptian matters. Meetings were held with members of the U.S. Department of State, Agency for International Development, Department of Defense, Bureau of the Census, Department of Agriculture, and Hydrologic Service, to name just a few. The interviews provided an important opportunity to ask questions and solicit further information on matters insufficiently covered in writing.

Although the material gathered on Egypt is extensive, there were several important gaps. Some of the missing information was identified in the process of developing the simulation model, when the data gathered during the project research phase was assembled in a single logical framework. Other information gaps were identified during the course of experiments with the model. An attempt will be made to fill some of these gaps through direct contact in Egypt with experts on hydrologic and agricultural affairs.

Creation of the Model -- A sizeable collection of descriptive and quantiative information can only be the beginning of an analysis of Egyptian water resources. The information must be assembled in a form that permits an analysis of all its implications. Such a form should also provide the means for testing the consequences of different assumptions, of conflicting pieces of information, or of hypotheses substituted for information that is unavailable.

A computer simulation model provides an ideal form for assembling information to meet the requirements outlined above. As described in the Introduction, System Dynamics models are capable of accepting both descriptive and quantitative information, or informed hunches when reliable information is not available. The consequences of alternative assumptions about information or future policies can be readily determined (as is demonstrated in Chapter IV). A simulation model produces an unambiguous statement of the implications of any body of information or assumptions.

Any simulation model must have a problem focus to limit its contents to the information that truly matters, and to avoid inefficient attempts to cover all possible ground. The focus of the computer simulation model described in this Section matches the focus of the study itself -- an analysis of the role of water resources in Egypt's future. The key structural elements of the simulation model are diagrammed in Figure 1.

The focus of the model is a description of hydrologic processes in Egypt. These include the collection of water behind the Aswan Dam, seepage and evaporation from Lake Nasser, and release of water from Lake Nasser to satisfy agricultural and hydroelectric requirements. Downstream from the dam the water is diverted from the Nile into an extensive irrigation system, where some of it is again lost to evaporation and seepage and the remainder is applied to the soil. Most of the water applied to the soil is removed for use by plants or evaporates away, but a significant portion will percolate through the soil into underground bodies of water. Phreatic considerations include the extent of drainage facilities and the height of the water table as determined by the balance of flows into and out of the phreatic area. Finally, the mechanics of salinity are closely connected to phreatic

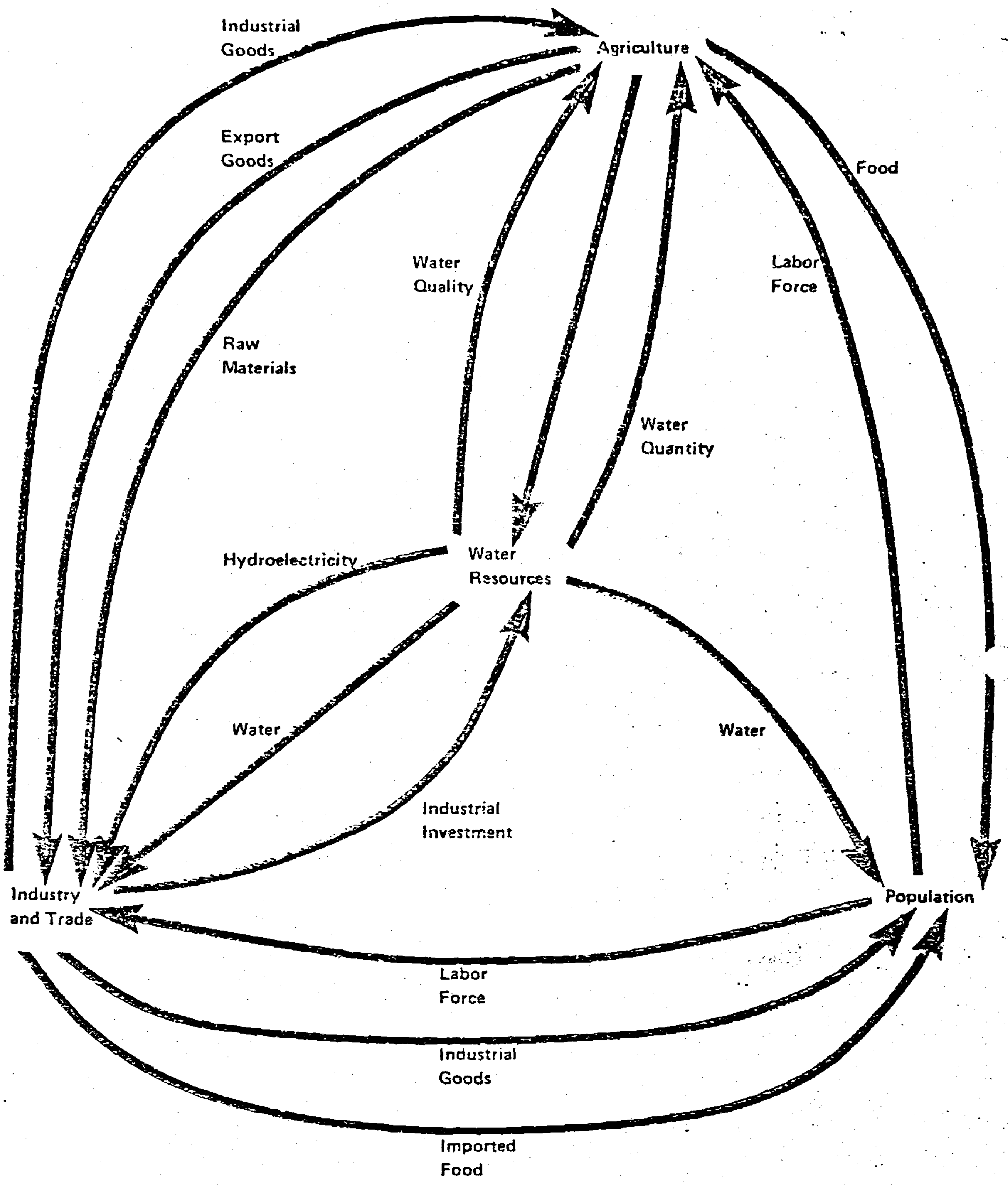


FIGURE 1: Structure of Egypt Model

processes, and have considerable impact on the cultivation of agricultural crops. All of these hydrologic matters are discussed in Chapter III of Appendix A.

The structure described above would, by itself, be enough to constitute a sizeable simulation model. However, a model limited to hydrologic processes would not be capable of serving the purposes of our study. Developments in the water sector will be importantly dictated by the resources and requirements determined by other sectors of the Egyptian economic and social system. Furthermore, the consequences of water resource management cannot be assessed without considering the varied impacts the water sector has on those other economic and social sectors. Therefore, the modeling effort proceeded from hydrologic matters to the three other major areas diagrammed in Figure 1.

After the water sector, the second most detailed portion of the model is the agricultural sector. The detail is necessary to properly determine both the future water requirements of Egyptian agriculture and the impact on agriculture of deviations from desired water quantity and quality. The model distinguishes among five different categories of agricultural production, and assesses the impact of twelve different influences on the production of each crop category. Included among these influences are: the amount of water, water table height, and salinity (determined by the water sector of the model); labor force availablity; and the machinery and fertilizer provided by domestic industry and foreign trade. In turn, agriculture supplies food to the population and raw materials and export goods for industry and trade. Chapter V of Appendix A describes in detail the model's treatment of agriculture.

The most important consequences of water resource and agricultural management are ultimately visited upon Egypt's population. The model represents in some detail the determinants of fertility and mortality in Egypt to provide projections of Egypt's future population in a wide range of scenarios. The size of the population determines the requirements for food (including imports), water, and certain categories of industrial goods. In turn, the population supplies a labor force for use in agricultural and industry (and the population sector itself, for service employment). Chapter IV of Appendix A describes the model's treatment of demographic matters.

The final model sector diagrammed in Figure 1 is industry and trade. The treatment of industry and trade in the Egypt model is more rudimentary than the treatment of either agriculture or population: the direct impacts of the water sector on industrial development are are less important than the impacts of other factors, and the reverse impacts of industrial activity on the water sector are also less significant. The industrial sector requires water and hydroelectricity from the water sector, labor from the population, and raw materials and export goods from agriculture. It provides capital investment to all of the other sectors, industrial goods (e.g., consumer durables) and imported food to the population, and fertilizer to agriculture. The model's treatment of industry and trade is described in Chapter VI of Appendix A.

The complete simulation model, comprising the four sectors identified in Figure 1, numbers more than 1500 variables. The descriptions of relationships and flows contained in this Section have been translated into mathematical equations that specify the dependence of the variables upon each other. The model's equations have been copied onto the sponsor's computer system, where the model is available for the type of policy analysis described in succeeding Chapters of this report.

Assesing Model Validity -- Before a simulation model can be used with any real confidence, however, some assessment must be made of the accuracy of its representation of real world inter-relationships. The various checks of model validity might be divided into three categories -- review of model contents, comparison of simulated output with actual data, and statistical tests. The remainder of this Chapter describes the application of these concepts to the Egypt simulation model.

The most comprehensive validity test of a simulation model is an intensive review of the information it contains. Such a review would identify contradictory information, questionable assumptions, missing data, or outright errors. For the Egypt study, this review was accomplished by documenting the various stages of the project work in reports that were studied by client personnel and various experts on Egyptian matters. Their reactions to the reports were incorporated in changes, where necessary, to the model equations.

The second validity test is a comparison of simulated with actual behavior. The Egypt model is programmed to begin all simulations with conditions as they existed in 1960. Internal model relationships then determine model behavior for succeeding years, as the model reproduces the real world processes of population growth, capital formation, hydrologic flows, and agriculture. Because the simulations begin almost 20 years in the past, the simulation projections for model variables over the 1960-1975 period can be compared with the actual performance of Egyptian variables over the same period. If the simulated variables duplicate the performance of the real world variables, for the correct reasons, then the model has passed an important validity test.

Figure 2 plots the simulated values for four key variables from the model's water sector, along with available historical data for two of the variables.[8] The amount of water in Lake Nasser begins to rise with the completion of the Aswan Dam in the mid-1960's. The model uses historical data to specify the flow of water from the Sudan into the Lake, but the flow of water out of the dam (also plotted in Figure 2), as well as the water loss from seepage and evaporation, are all calculated internally. Therefore, the close correspondence between simulated and actual data for both the water in Lake Nasser and the release from the Dam is evidence that the model is properly balancing the flows of water into and out of the Lake, and is correctly estimating the downstream requirements for water.

Historical data does not exist for the other two variables in Figure 2 -- soil salinity and water table height. Both curves do correspond to descriptions of the timing and magnitude of agricultural problems,[9] the best information currently available. Attempts are planned to fill this information gap through the direct contact with Egyptian authorities described earlier in this Chapter.

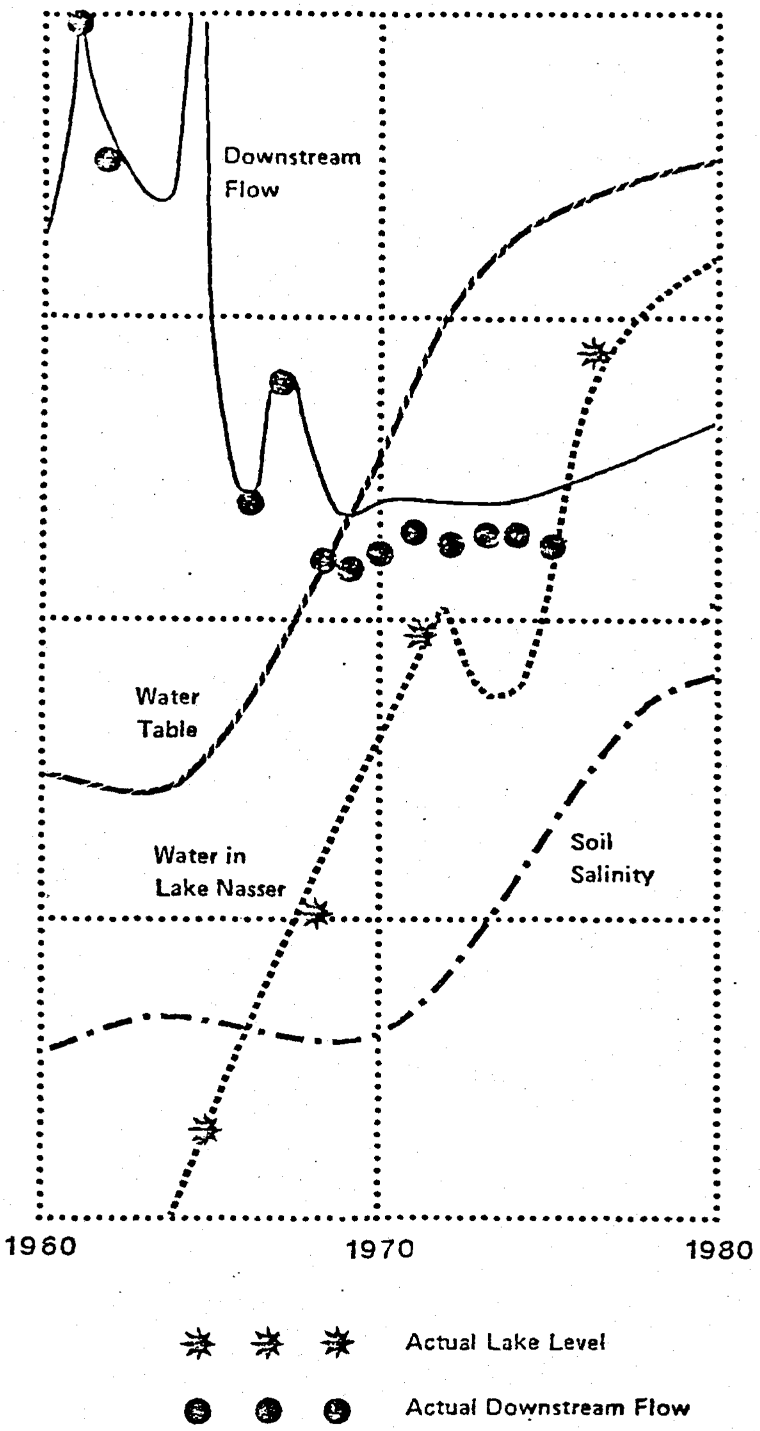


FIGURE 2: Key Hydrologic Variables

Figure 3 traces simulated and actual data for acreage and yield information on the five major crop categories.[10] The exception is fodder, for which no reliable year-by-year yield information is available. All five crops match the historical data well, and for reasons that correspond to the forces at work in Egypt during the last 20 years. Acreage for fruits, vegetables, and rice increases in response to the growing urbanization of Egypt's population and the resulting shift in overall dietary preferences. In addition, rice cultivation is expanded as the control of the water supply with the Aswan Dam increases the effective amount of water available for agriculture. Yields of cotton and non-rice grains respond to the increasing application of water and chemical fertilizers. In addition, yields of wheat and other grains in the 1970-1975 period benefit from an assumed switch to higher yielding seeds and improved cultivation techniques.[11] Yields of all crops begin to suffer from the late 1960's onward, first from the impact of rising water tables, and later from increasing salinity.

The final simulated/actual data comparison (Figure 4) tracks demographic information. Total simulated population growth over the 15 year historical period matches the actual data well,[12] confirming the model's treatment of fertility and mortality influences. The model also manages to duplicate the limited historical data on the division of the population between urban and rural areas. The division is determined by any differences in birth rates between rural and urban regions, and the migration between the two.

The third validity test is statistical measures of the "closeness of fit" of model behavior to historical data, with closeness of fit

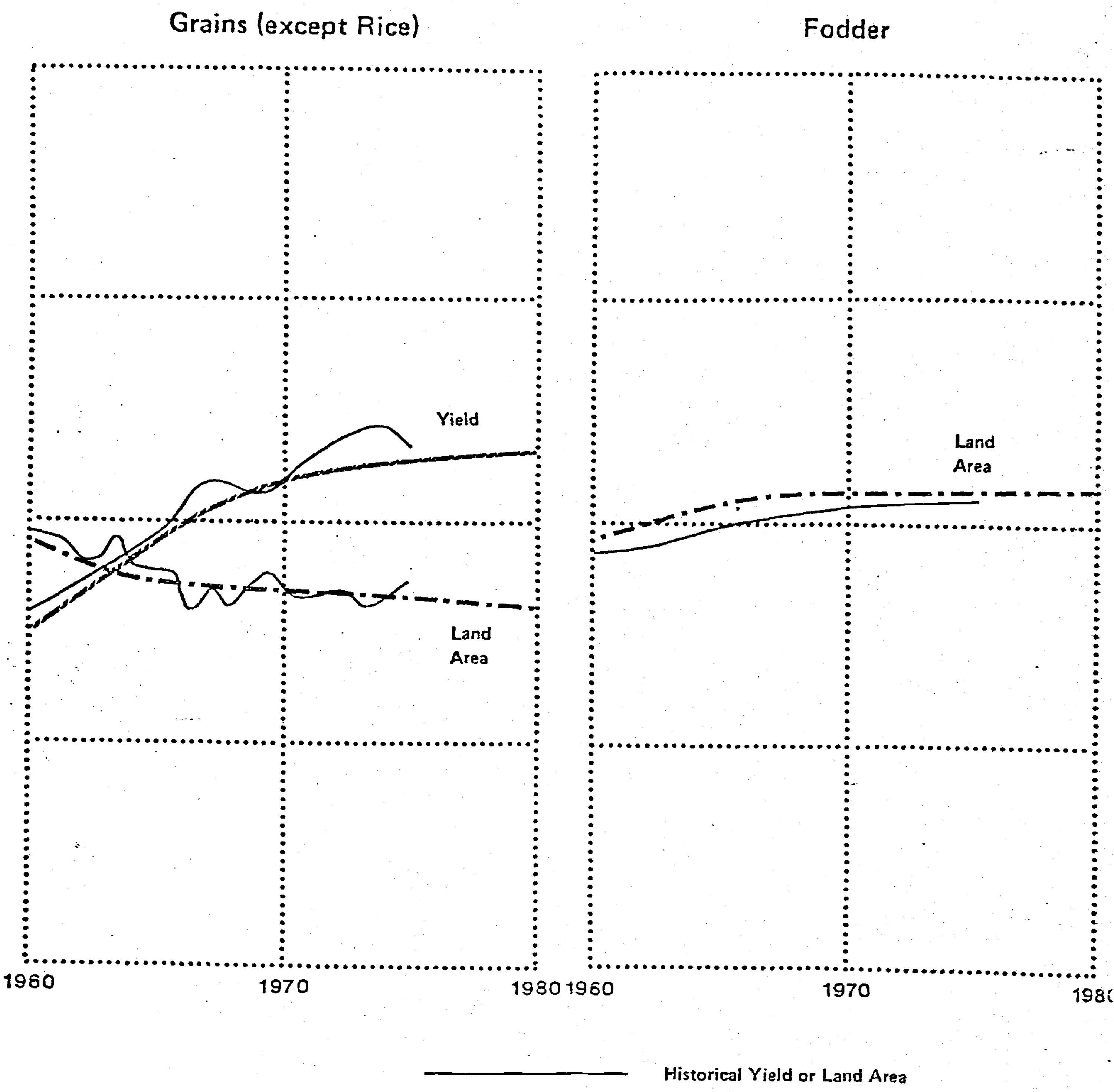
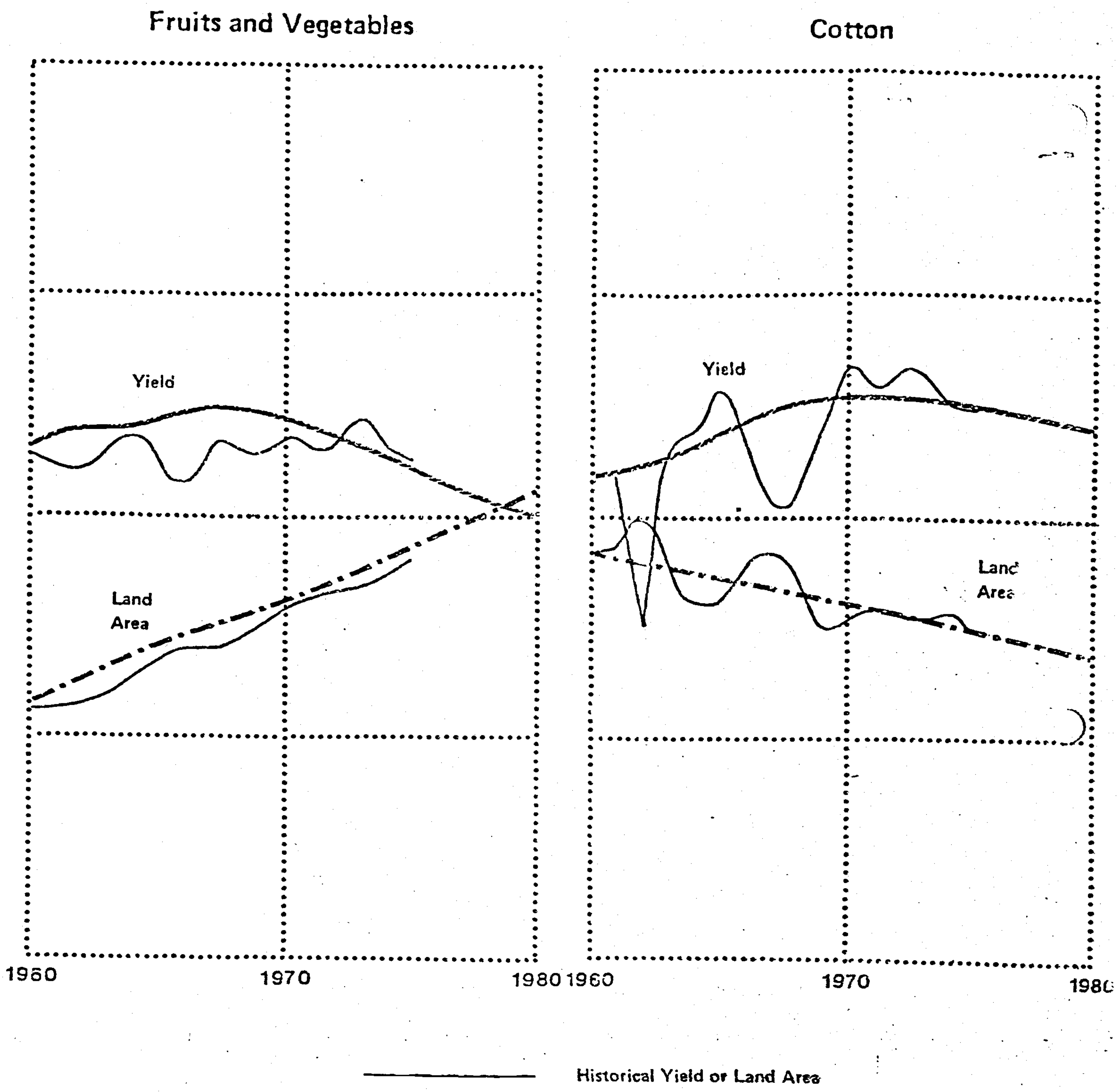


FIGURE 3: Yield and Land Area Comparison



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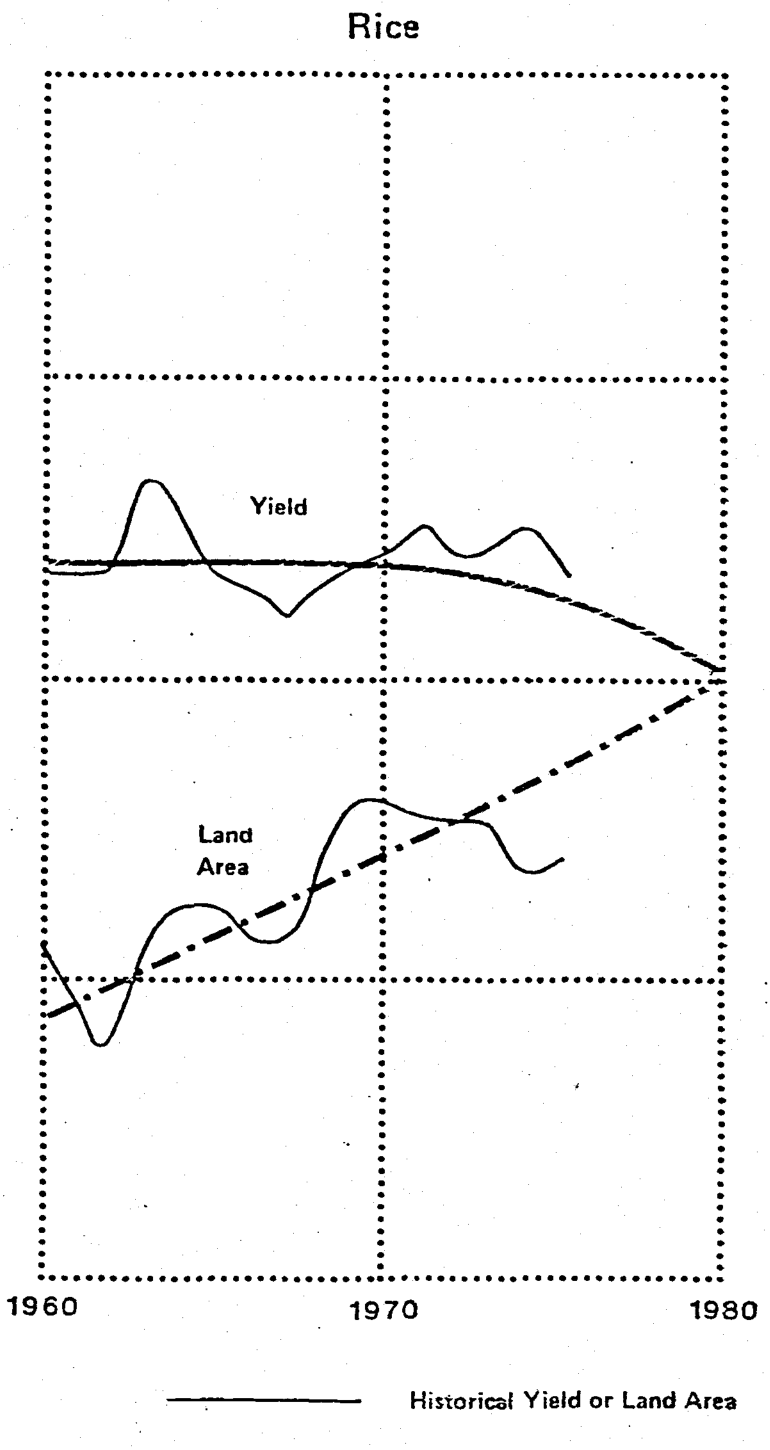


FIGURE 3: Yield and Land Area

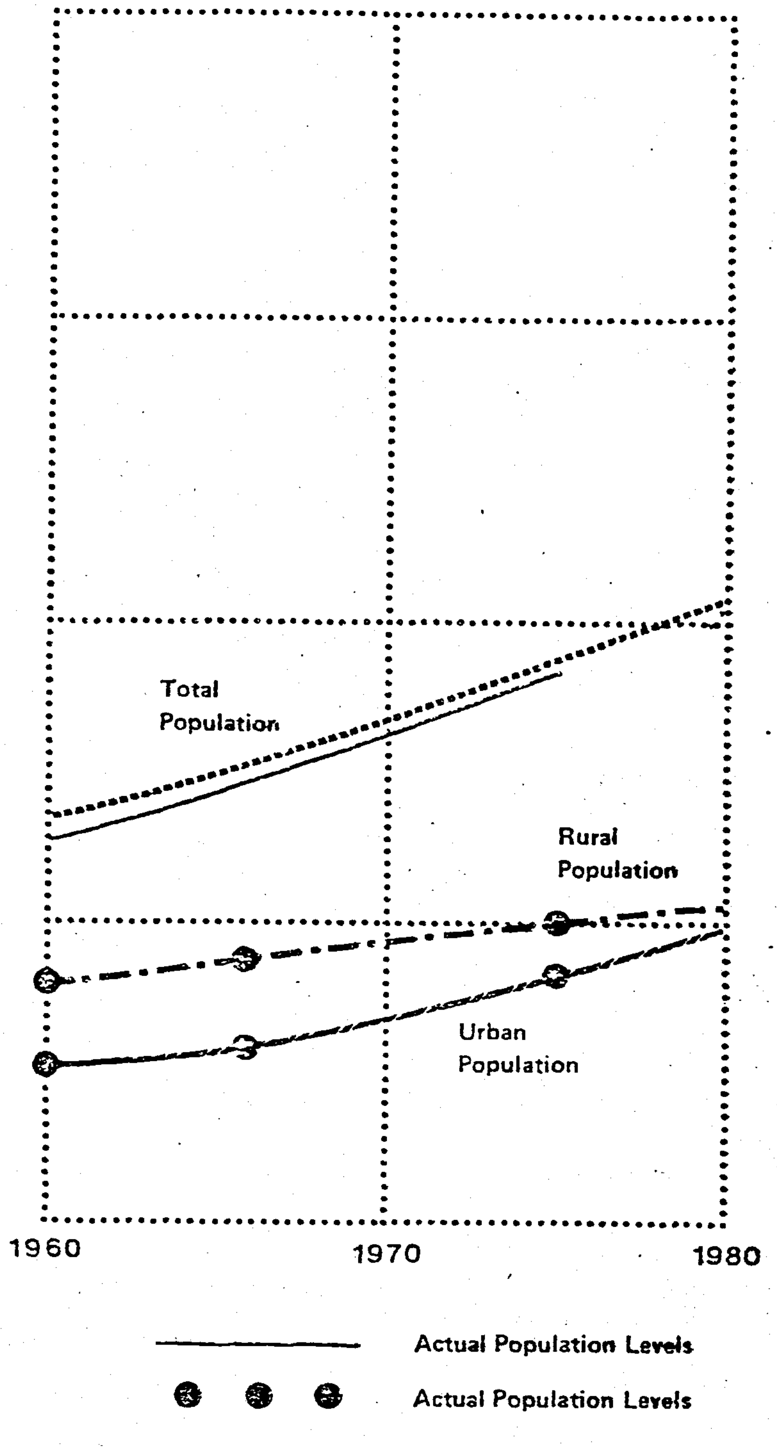


FIGURE 4: Key Demographic Variables

defined in a number of different ways. Powerful statistical tests for dynamic models have been developed.[13]

Two considerations prevented application of the third validity test to the Egypt project. First, the necessary numerical data on a wide range of Egyptian economic, demographic, hydrologic, and agricultural variables was not readily available, and could not be assembled in the time frame of the project. Second, the project resources (both manpower and money) necessary for sophisticated statistical validity testing were not budgeted at the beginning of the project. Statistical approaches exist for the type of economic modeling undertaken by the sponsor, however, and may be tested in a later project.

This Chapter has described the research, model creation, and model validation executed for our study of water resources in Egypt. The work described here produced a simulation model that passes the two important validity tests applied to it. The next Chapter illustrates the workings of the simulation model by reviewing in detail a single simulation.

III. BASE SIMULATION

This chapter demonstrates the use of the Egypt simulation model to project future trends for hydrologic, argicultural, demographic, and economic variables. Besides providing a description of Egypt's likely future, given certain important assumptions, the demonstration provides further insight into the assumptions and data incorporated in the model.

The focus of the chapter is a single simulation with the Egypt model -- identified as the "base simulation". As mentioned in the previous chapter, the model contains several important assumptions about future government policies and various physical, economic, and demographic processes. Any of the model's specific assumptions regarding these policies and processes are open to debate, since different observers of developments in Egypt may well reach different conclusions about important future trends. Therefore, each assumption can only be offered as a probable, rather than certain prospect, and any simulation based on such a collection of probable prospects is itself only one among many possible future outcomes.

For the above reasons, it is important not to treat the base simulation as a forecast for Egypt's future. Instead, it is used in this report to ilustrate the workings of the Egypt model and serve as a bench-mark for policy analysis. By varying individual assumptions, or collections of assumptions, from their base simulation conditions and comparing the resulting simulations, it is possible to determine which assumptions are most important to Egypt's future. If reasonable variations in assumptions for certain policies and processes yield little significant change in simulation projections, one is led to conclude that those policies and processes are not high priority candidates for further investigation. If, on the other hand, reasonable variations in other asumptions do yield important simulation differences, one should conclude that a careful review of the policies and processes concerned is necessary.

The extensive collection of information and observation that forms the framework for the Egypt model is described in detail in Appendix A to this report. Of the asumptions about policies and processes discussed there, many are based upon extensive research into written material on Egypt or conversations with experienced observers of that country. These assumptions are cosidered to be reasonably accurate. Other assumptions are based upon well understood biologic, hydrologic, or demographic processes.

The remaining assumptions are those that are: 1) sufficiently related to water management issues that they have a noticeable impact on this study's area of concern, and 2) based on informed judgments about future trends. We do not attempt to argue that each of these assumptions is somehow the most likely description of Egypt's future (if such a probability could even be measured). It is only necessary that the assumptions be reasonable options for Egypt's future. Indeed, the next chapter explores the simulation results of variations in certain of these assumptions, to determine the implications of alternative judgements.

The key assumptions underlying the base simulation are listed below:

1) Egypt will attempt to install tile drainage systems on an average of 250,000 feddans per year. (Whether or not the target is met will depend, in the model, on the ability of the economy to generate the necessary resources.)

2) Present irrigation efficiencies, as measured by the fraction of water removed from the river that actually contributes to plant growth, will be maintained.

3) The average annual flow of 84 billion cubic meters into Lake Nasser will continue in the future, with no major increases from water development projects or decreases to meet Sudanese needs.

4) There will be no major improvements in Egyptian crop yields from new cultivation techniques or new seed strains. Future production totals will be determined by the same technological factors that affect production now.

5) The amount of land devoted to agriculture will remain roughly constant. That is, increases from land development projects will be off set by decreases from conversion of agricultural land to industrial or urban use.

6) There will be no major changes in sociological or governmental influences on Egypt's birth rate (or death rate). That is, any future changes in the birth rate will be determined by internal model conditions (standard of living and perceived child mortality), rather than external factors (changes in religious values or government policy).

7) There will be no major changes in the primary determinants of rural-urban migration.

8) International markets for agricultural products will operate without major disruption, so that Egypt can continue to buy and sell at the current relative prices. The only constraint on imports will be Egypt's foreign currency supplies; the only constraint on exports will be the availability of domestic production.

9) There will be no major change in Egypt's pattern of foreign exchange earnings. That is, there will not be large-scale oil exports, which relieve foreign exchange constraints and allow very substantial growth in imports, nor will there be a large-scale increase in foreign investment in Egypt.

These central assumptions, together with all of the other assumptions described in Appendix A, have been expressed in mathematical equations and combined into a computer simulation model of Egypt's water resources, agricultural production, population, and economic processes. The computer simulation model demonstrates unequivocably the implications and consequences of the entire collection of assumptions. The following review of base simulation results treats important water management issues first, then agricultural, demographic, and economic matters.

Water Management Issues

Because the Egypt model was tailored to the study's focus on water management issues, the simulation results provides considerable detail on important hydrologic variables. This review of water management issues treats water availability, ground water and the water table, salinity, and drainage.

Perhaps the most important water management issue is the simple availability of water for agriculture -- will Egypt be able to deliver sufficient amounts of water to its farmlands to meet the possible requirements for agricultural production? Figure 1 highlights projections for the hydrologic variables associated with the question of availability.

The simulation starts in 1960, that is -- before the Aswan Dam is finished. Thus, the model "recreates" eighteen years of past history. The collection of water in Lake Nasser begins as the Aswan Dam nears completion during the mid-1960's. By the early 1980's the Lake achieves its target capacity of approximately 130 billion cubic

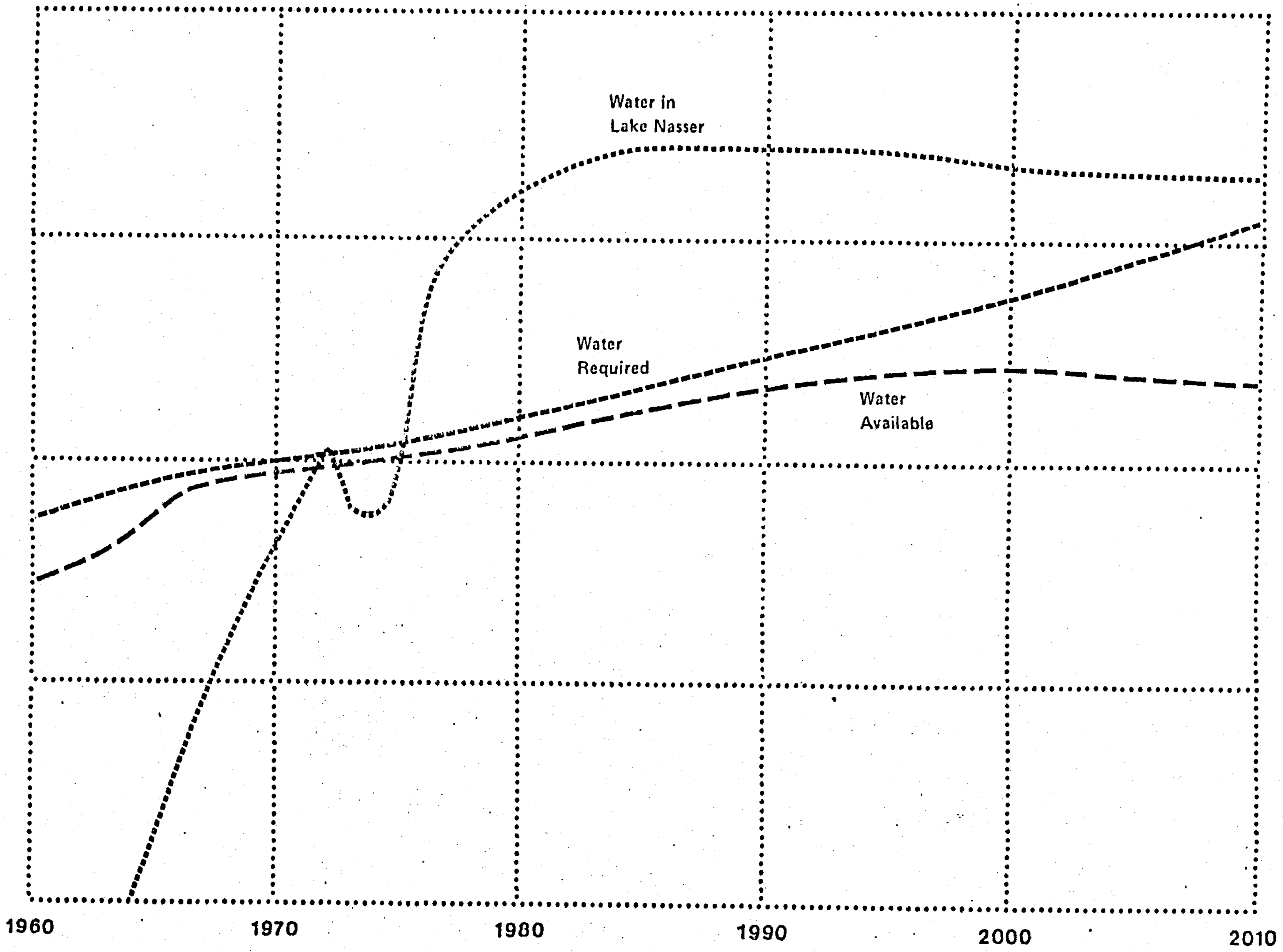


FIGURE 1: Availability of Water

meters, providing both a reserve against low flood years and extra capacity for high flood years. The accumulation of water behind the dam does not detract from the water available for agricultural purposes while the dam is filling. The water captured behind the dam is largely water that would otherwise escape out to sea during the dry season portions of the cultivation cycle. In fact, erection of the dam provides a net increase in water available for agriculture (compare the simulation results for the early and late 1960's) by increasing the country's ability to retain water from the summer flood months for use during the balance of the year.

The base simulation projects a steady climb in water requirements throughout the next several decades. The 23% increase in water requirements between 1980 and 2000 is attributable to two specific factors. Half of the increase results from more intensive use of farmland with increased mechanization: the resulting gains in the number of crops planted per year raise agricultural water requirements. The other half of the increase is attributable to a continuing shift to high water requirement crops -- rice, fruits, and vegetables -- from low water requirement crops -- other grains, cotton, and fodder. Not shown are increasing population and industrial requirements that also compete for for the water resources available.

After the important gains in water availability following erection of the Aswan Dam, water availability increases only slowly during the remainder of the decade. The base simulation provides only two sources of additional water -- reuse of drainage water pumped from farmland, and an assumed gradual reduction in seepage from Lake Nasser as sedimentation blocks pores in the lake bed. The water available from

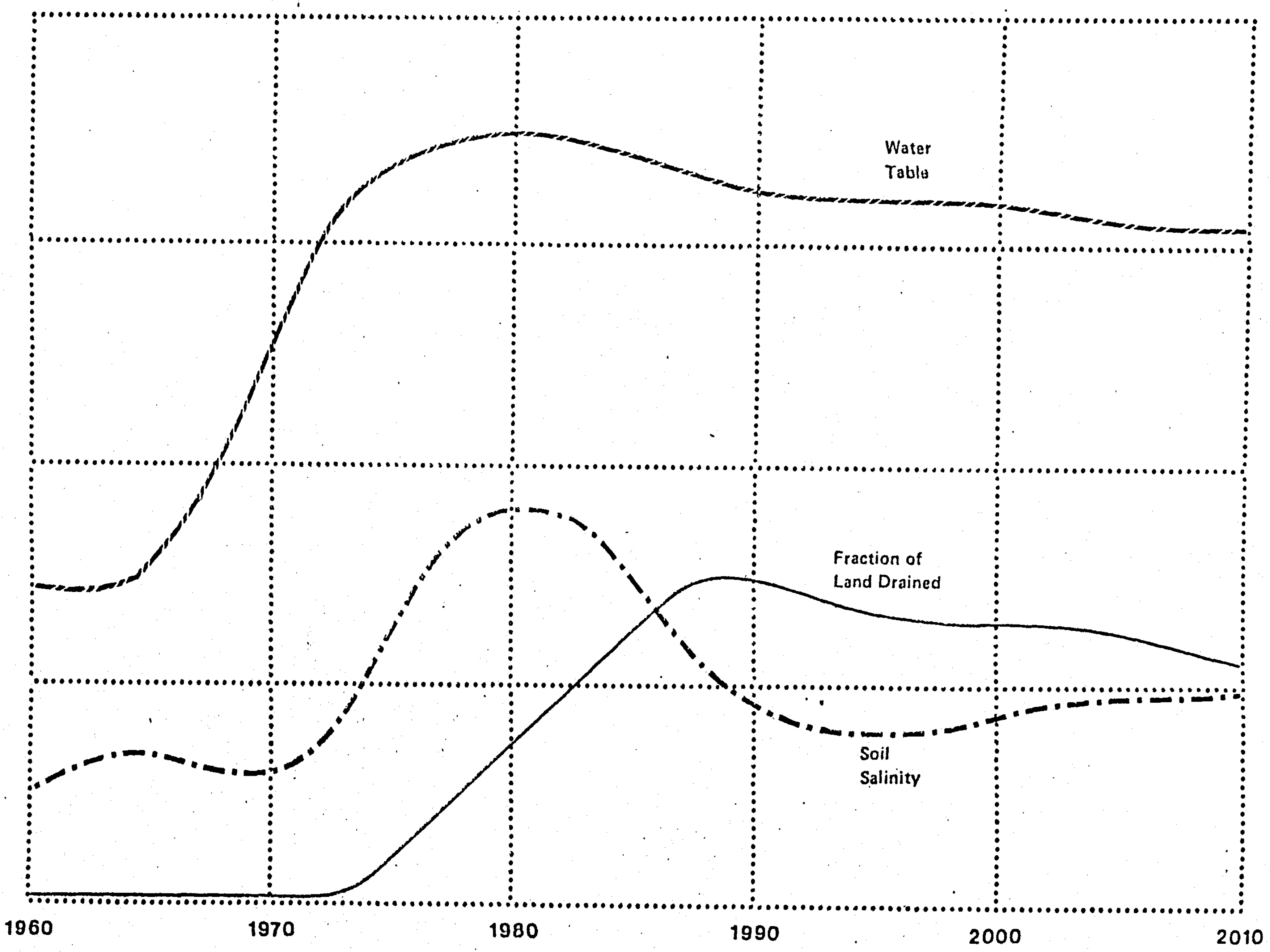


FIGURE 2: Phreatic Conditions

the phreatic system. The water table falls steadily, although slowly, during the 1980's and 1990's. By 2000 more than one-third of the land affected in 1980 has been dried out.

The presence of salt either deposited in the root zone or dissolved in water is another aspect of phreatic water conditions. In the Egypt model the salinity of water is an important quality issue that can impact on agriculture as much as the quantity issues described earlier.

As shown in Figure 2, the salt concentration in the root zone is stable in the early 1960's. Flows of salt into the root zone (carried by irrigation water) are offset by flows out of the root zone (through percolation). The salt concentration in the root zone under such conditions would be cosiderably higher than the salt concentration in the irrigation water applied to the soil, since the evaporation or transpiration of much of the irrigation water concentrates the salt which is left behind. The salt concentration in the root zone remains stable as long as the water table lies below the root zone, allowing percolation to prevent accumulation.

In the simulation, the rising water table begins to pierce the root zone in 1970, reducing the percolation of irrigation water. As discussed earlier, water now leaves the root zone by evaporation alone, so the salt is not carried out. The salt accumulates steadily in the root zone through the 1970's, until the drainage program begins to offer an alternative flow for the salt. Drainage can provide a rapid solution to the salt problem because it is assumed in the model that it will be located where the need is greatest. By 1990 sufficient drainage is in place to service all of the land where the water table has entered the root zone, and the drainage flow stabilizes the salt concentration at tolerable levels just as the percolation flow had 25 years earlier. In addition, the reduction in the water table achieved by drainage restores some of the hydrologic system's natural percolation.

The final key water management issue is drainage. Its role in both ground water and salt concentration matters has already been described, and the remaining important subject is the factors surrounding its installation. The earlier review of base simulation assumptions specified a target for new drainage construction of 250,000 feddans per year. In the base simulation the drainage construction concludes in 1990 with 2,800,000 feddans covered, an average of 160,000 feddans completed per year during the 18 year program. The falling water table after 1990 reduces the total drainage requirement, eliminating any need for new construction.

Agricultural Production

Agricultural performance in the Egypt model's base simulation is dominated by two important considerations. The first is the competition among the various crop categories for agricultural resources, and the consequences of a trend to one crop or another. The second is the interplay among the different factors determining agricultural production, and the way the relative importance of these factors can change over time. Both of these overall considerations are important as Egypt's growing population continues to strain the limits of the country's agricultural capacity.

Figure 3 illustrates the competition among the different crop categories for the most fundamental agricultural resource -- land. The most striking feature is the steady growth in the land cultivated with rice, and fruits and vegetables: the land for each of these two crop categories approximately triples from the beginning to the end of the simulation. The increased cultivation of these crops is forced by the growing urbanization of Egypt's population, since the city-dwellers prefer rice to other grain crops, and can afford to purchase fruits and vegetables. The increased cultivation of these two foodstuffs creates a decline in land cultivated for wheat and other grains.

The allocation of other agricultural resources among the various crop categories is assumed to respond to the same policies and decision processes as the allocation of land. Therefore, shortages of water and fertilizer during various phases of the simulation have the greatest effect on wheat and other grains, and cotton, with available resources being concentrated on rice, and fruits and vegetables.

The impact of the various agricultural resources on production varies significantly over the course of the base simulation. Before the completion of the Aswan Dam, water and fertilizers are the major constraints on agricultural production. With the completion of the Dam fertilization becomes the major limitation, and yields tend to rise as fertilizer use intensifies. In the 1970's however, two depressants on production emerge. First, the rising water table under Egyptian farmlands begins to reduce yields, with an approximately 10% reduction by 1975 that persists through much of the rest of the simulation. Soon after the water table effect is felt, increasing salt

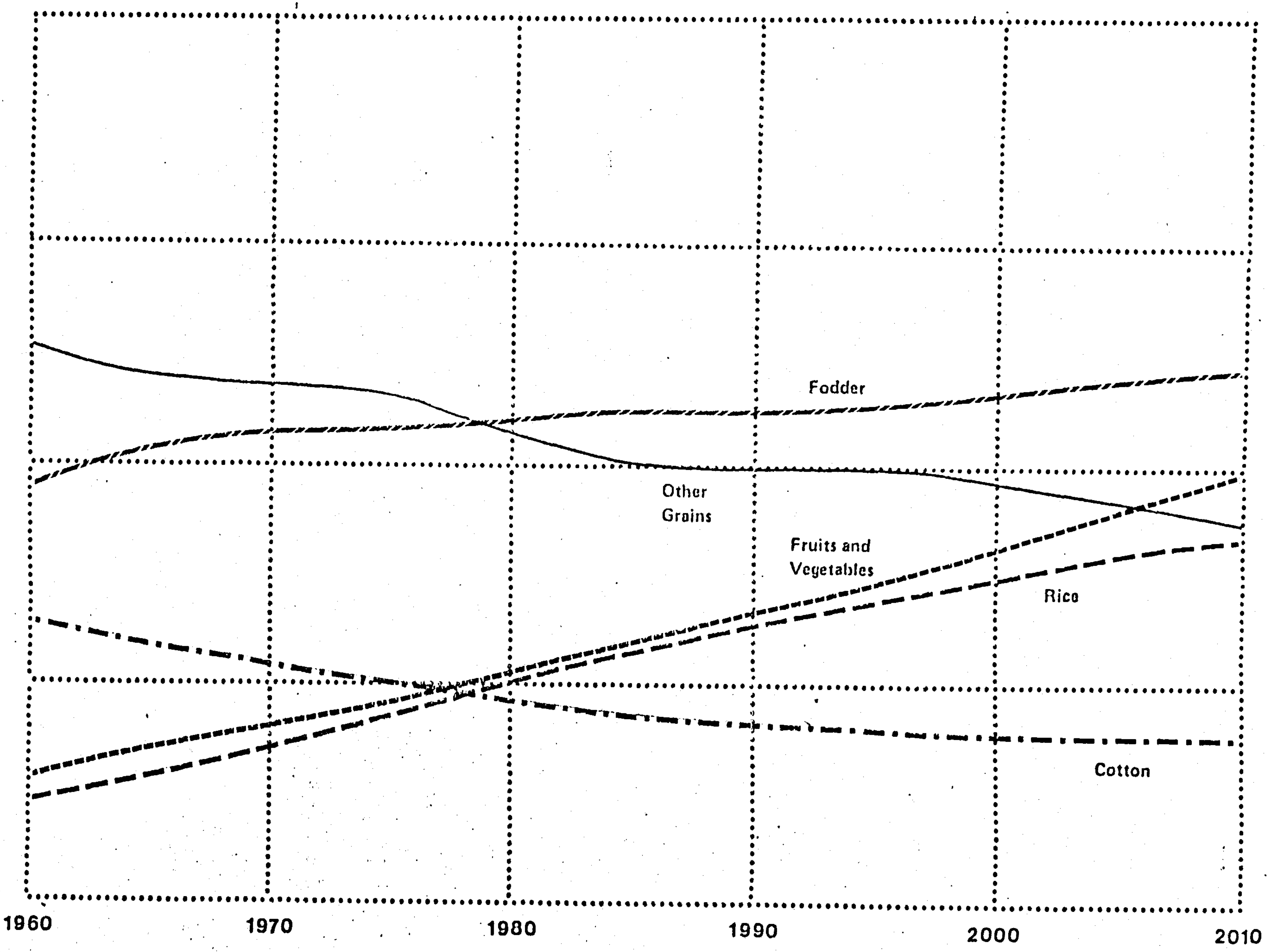


FIGURE 3: Land Alloc ion among Crop Categories

concentrations also began to impact agricultural production. By the mid-1970's yields are reduced an additional 10% from this effect, and a maximum yield reduction of 20% occurs by 1980. Yields recover throughout the 1980's as Egypt's drainage program resolves the salt problem.

Fertilizer re-emerges as the main constraint on production during the latter 1980's, a limitation that is gradually removed through the remainder of the simulation with the help of increased fertilizer production. At the same time, however, water requirements are beginning to outstrip water availability, and in the simulation's final decade water supplies become the only constraint on production.

Because the resource needs of fruit and vegetables, and rice, are satisfied at the expense of wheat and other grains, production of these latter foods is unable to keep pace with growing requirements from Egypt's ever-expanding population. Wheat imports, as shown in Figure 4, supply a larger and larger fraction of total grain consumption. By the end of the base simulation, wheat imports equal Egypt's internal production of wheat and other grains (except rice). The increased domestic requirements for other agricultural goods limits their availability for export. Fruit and vegetable exports, for example, fall from 11% of total production in 1980 to 8% in 2000; cotton exports fall from 55% to 40%. Only rice exports among agricultural goods increases its share of production, from 16% to 19%.

Population

The size and geographic distribution of Egypt's population determines the magnitude of pressures for agricultural production and food

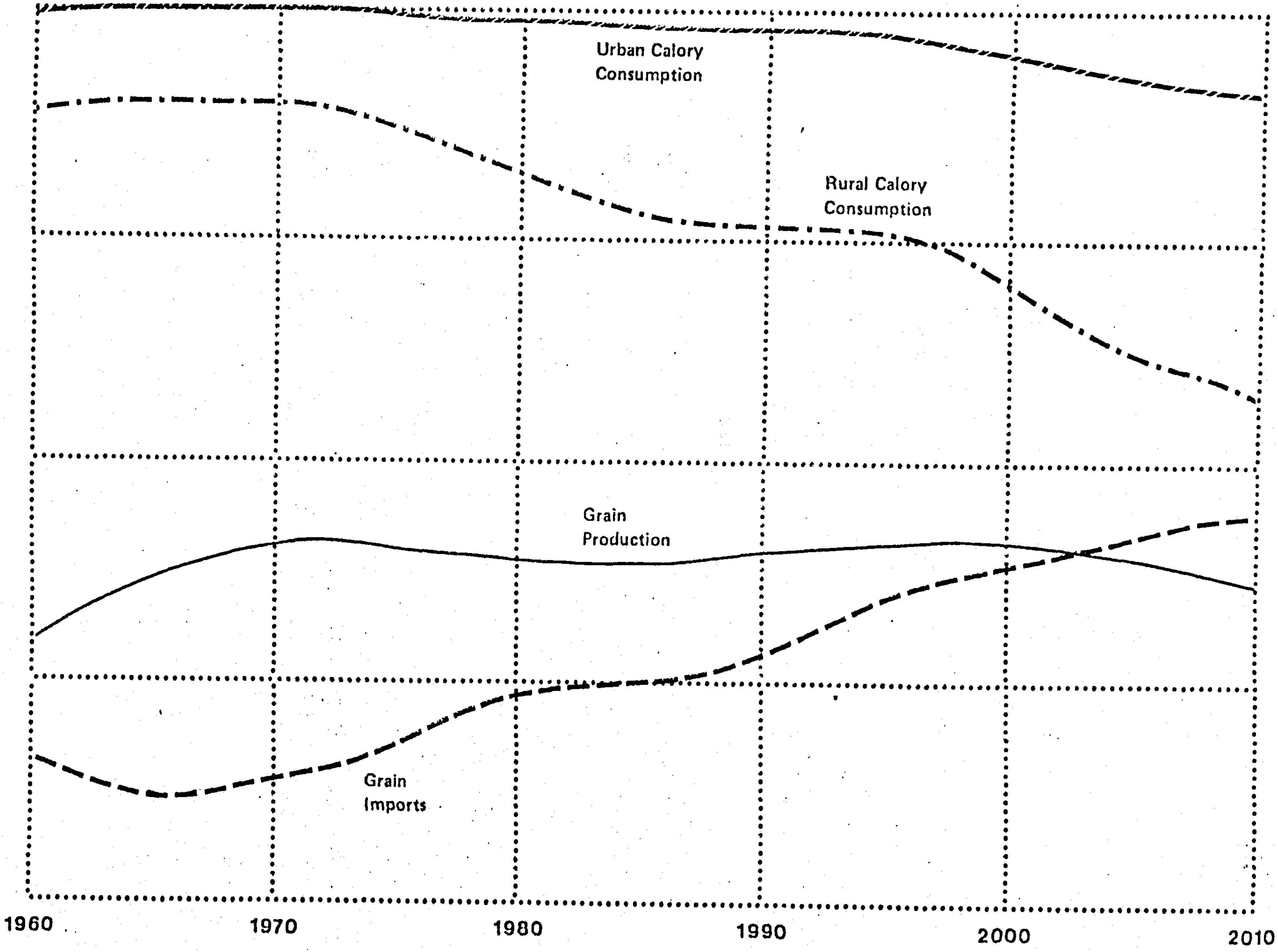


FIGURE 4: Food Production and Nutrition

imports. The agricultural and economic systems' ability to meet these food requirements will determine the overall nutrition of the population, with important implications for mortality and productivity.

Figure 5 traces the base simulation projection for three important demographic variables. Egypt's total population rises from 36 million people in the mid-1970's to 62 million at the end of the century. This 2% average annual growth is comparable to the net growth rate observed during the early 1970's, since the base simulation includes the assumption that no major changes in the social or governmental influences on birth and death rates will occur. Therefore, the death rate holds steady at 1.3% to 1.4% until early in the next century, when deteriorating nutrition begins to increase mortality. The birth rate declines gradually from 3.7% in the mid-1970's 3.3% at the end of the simulation, as declining rural incomes reduce the incentives to have children.

Also shown in Figure 5 are projections for Egypt's urban and rural populations. The urban population shows the faster growth, from 16 million in 1975 to 47 million in 2010. In contrast, the rural population increases in the same period from 20 million to 28 million. Since both areas have similar birth and death rates, the differing total growth rates are attributable to the migration flow from rural to urban areas. The shift in Egypt's population from largely rural in 1960 to largely urban in 2000 has important implications for agricultural production, since the urban population has larger per capita demands for rice, and fruits and vegetables. In addition, the urban population has a higher per capita income expectation to be satisfied by the country's economy.

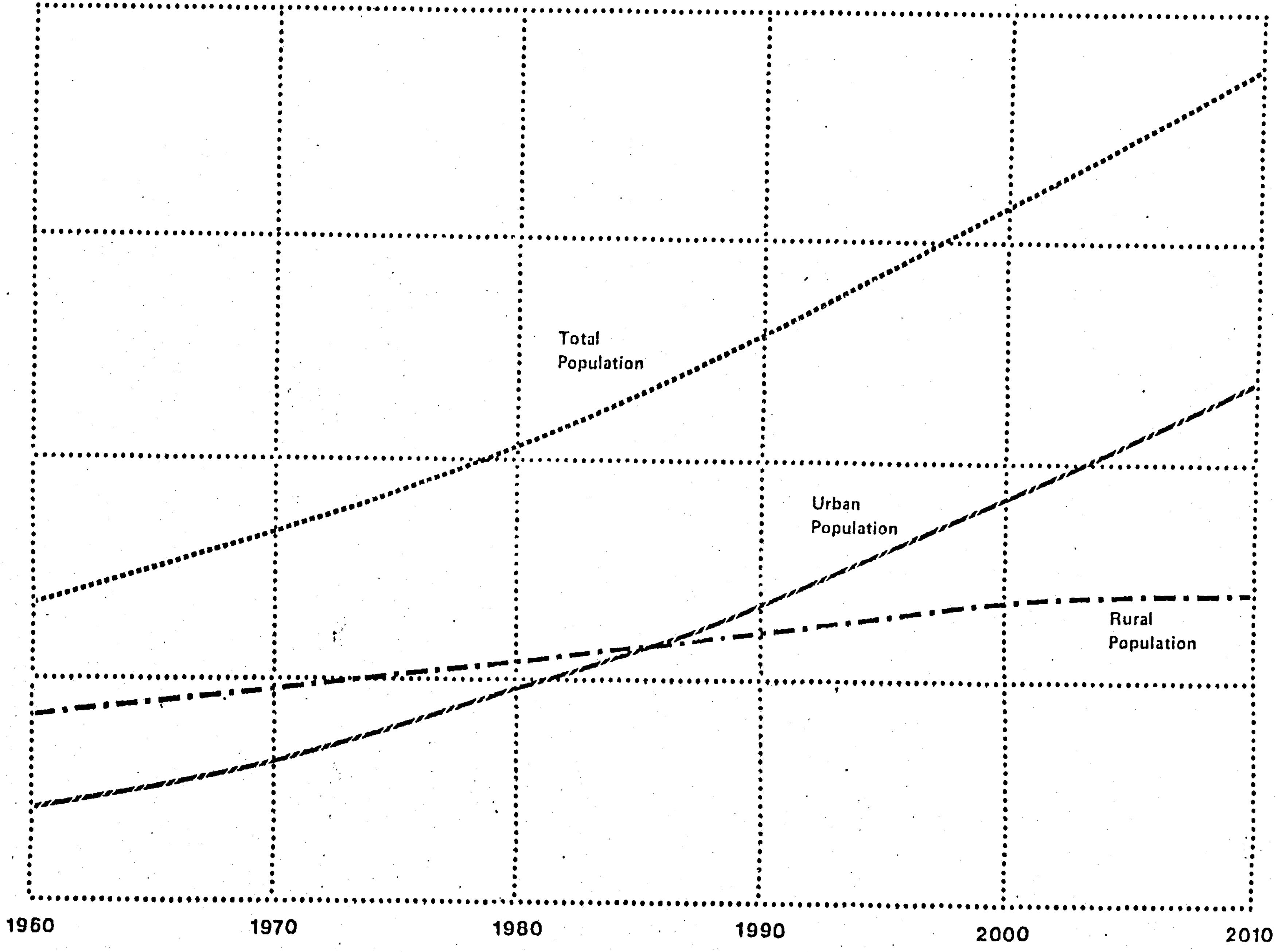


FIGURE 5: Population Growth

The balance between food availability and population requirements is expressed in the Egypt model by the population's daily calorie consumption. This provides an overall measure of the quantity of food available to the population, a fundamental determinant of nutritional adequacy. Figure 4 tracks daily calorie consumption for both the rural and urban populations. The most important development is the gradual erosion of rural consumption from the mid-1970's to the mid-1980's, from 2600 calories per day down to 2250 (the FAO recommendation for developing countries) in the mid-1980's. This is the time frame when the build up of salt in the root zone under Egyptian farmland impacts agricultural production. Nutrition remains stable at these levels until the turn of the century, when the declines in agricultural production created by water shortages force further losses. For the rural population, the decline forces the population below accepted nutritional levels, and the death rate rises as a result.

Economic Issues

Major economic issues are represented in the Egypt model to supply the context necessary for an exploration of water management isues. For example, the ability of the country to undertake drainage programs or mechanize agriculture, both of which directly influence water issues, wil be determined in large measure by the overall vitality of Egypt's economy. And the economic vitality will in turn be determined by the country's agricultural performance, which itself is a product of water management.

The most important economic result from the base simulation is the projection of an increasing reliance on imports of various sorts, particularly food for the urban population and raw materials for industry. The primary export base -- agricultural and consumer goods products -- is unable to grow fast enough to meet the import requirements, with direct consequences for economic vitality and nutrition. The limitation on raw materials imports for manufactured goods reduces the material standard of living of the rural population, while the inability to pay for large amounts of fertilizers prolongs the recovery of agricultural production in the 1980's and 1990's. The limitation on food imports, combined with the rapid population growth, is resposible for the nutrition declines pointed out earlier.

The limited economic growth in the base simulation has an indirect, but important, implication for water management. Investment in agricultural machinery increases the total agricultural capital stock an average of 3% per year for the remainder of the century. This investment rate is insufficient to support extensive increases in multiple-cropping, so overall water requirements are held down.

The review of economic matters concludes this study of the Egypt model base simulation. In the next chapter we investigate the consequences of variations in some of the key assumptions that produce the base simulation.

IV. SIMULATION EXPERIMENTS

The preceding Chapter described a base slimulation of the Egypt model that serves as a benchmark for analysis of water management problems. This chapter focuses on a number of alternative simulations to illustrate the use of models for research purposes, and to identify some of the key determinants of the role of water resources in Egypt's development through the remainder of the century.

The issues involved in water resource management can be divided into two general categories. First, it would be important to understand how different policies for water resource management would affect the remainder of the country. That is, it would be important to determine what alternative courses of action for water management, or what changes in hydrologic or physical processes, would affect Egypt's ability to feed its population and sustain steady economic growth. Second it would be useful to anticipate how changes in Egypt's social and economic development would impact on water management issues, either by changing the requirements for water supply or altering the resources available for water-related projects.

With the Egypt simulation model, both sets of issues can be addressed. The procedure is to translate the alternative water management policies, or social and economic development assumptions, into changes in specific parameters of the computer model. When a new simulation is performed with the parameter adjustment or adjustments, the model's output provides an unambiguous assessment of the consequences of the alternative policy or development assumptions. Combinations of parameter changes can also be used to investigate combinations of policy alternatives or different development assumptions. A comparison of these alternative simulations with the base simulation will measure the impact of the parameter changes on any of the model's hydrologic, social or economic variables.

From the dozens of alternative computer simulations performed during the course of this research, we have selected twelve for detailed review in this Chapter. The specific simulations presented here were chosen to illustrate some of the project's important lessons about Egyptian water management. Included in Appendix B is a description of additional simulation runs to illustrate the workings of the computer model. Also included in Appendix A is a list of the several dozen parameters that incorporate key assumptions about hydrologic, demographic, agricultural, or economic development. This list serves as a guide to the use of the Egypt simulation model for further analysis of water management and related issues.

The organization of computer simulation results in this chapter matches the categorization of water management issues described earlier. The first section treats the impact of water management policies on water availability and on the balance of the country by analyzing seven simulations:

1) A nine billion cubic meter increase in the annual flow of water to Lake Nasser created by a bypass canal in Sudan.

2) More efficient use of irrigation water by eliminating major evaporation losses from irrigation canals.

3) More efficient use of irrigation water by eliminating major seepage losses from irrigation canals.

4) A gradual draining of Lake Nasser later in this century to make more water available for irrigation.

5) An increase in drainage cost as the program now just beginning on Egyptian farmland must be expanded to encompass more and more the country's land area.

6) An acceleration of the planned drainage program with foreign assistance.

7) A combination of simulations 3) and 6) to determine the potential gains from water management programs.

The second section of the chapter treats the impact of social or economic changes on the role of water management by analyzing an additional five simulations:

8) An acceleration of the mechanization of Egyptian agriculture.

9) An increase in the foreign exchange earnings available from oil and other non-agricultural sources.

10) A gradual change in Egyptian dietary preferences away from water-intensive crops.

11) A gradual reduction of Egypt's net birth rate.

12) A combination of simulations 7) and 8) to determine the potential for a co-ordinated program of agriculture and water management programs.

Water Management Issues

Increased Flow to Lake Nasser -- One of the important findings from the base simulation was the indication of a steadily rising gap between water required to support more intensive farming and water available from the limited flow to Lake Nasser and from a re-use of drainage. An approach to this problem being considered by the Egyptians is the construction of a bypass canal for the Nile through or around massive tracts of Sudanese swampland. Much water from the headwaters of the Nile is lost in this swampland as the river slows down and opens up enormous amounts of surface area to evaporation. If a canal could be built to channel the Nile through a narrow area, the savings gained from reduced evaporation could total 18 billion cubic meters of water annually, to be divided evenly between Egypt and Sudan. The simulation assumes that the project is accomplished at no cost to Egypt.

The consequences of the canal project for water availability are diagrammed in Figure 1. In contrast with the base simulaion, where the gap between water requirements and supply begins to open up in 1990 (see page 26), the canal project satisfies Egypt's water requirements through the remainder of the century. The canal project is not a permanent solution, however, since Egypt's water requirements are rising inexorably under the pressure of increased mechanization and a continued trend to water-intensive crops.

In the phreatic zone, the addition of extra water affects the balance of flows that determines the height of the water table. A larger fraction of Egypt's root zone is penetrated by the underground water, increasing the requirements for installation of drainage facilities. For the base simulation, further construction of drainage facilities is unnecessary after 1990, and drainage requirements fall to less than one-third of the total land area by 2010. In this first experiment however, almost half the land area requires drainage by the turn of the century, requiring continued investment in upkeep of drainage facilities.

The impact of the canal project on food production and nutrition is evident, although not extensive. Grain production early in the next century is about 10% higher than the base simulation; further-

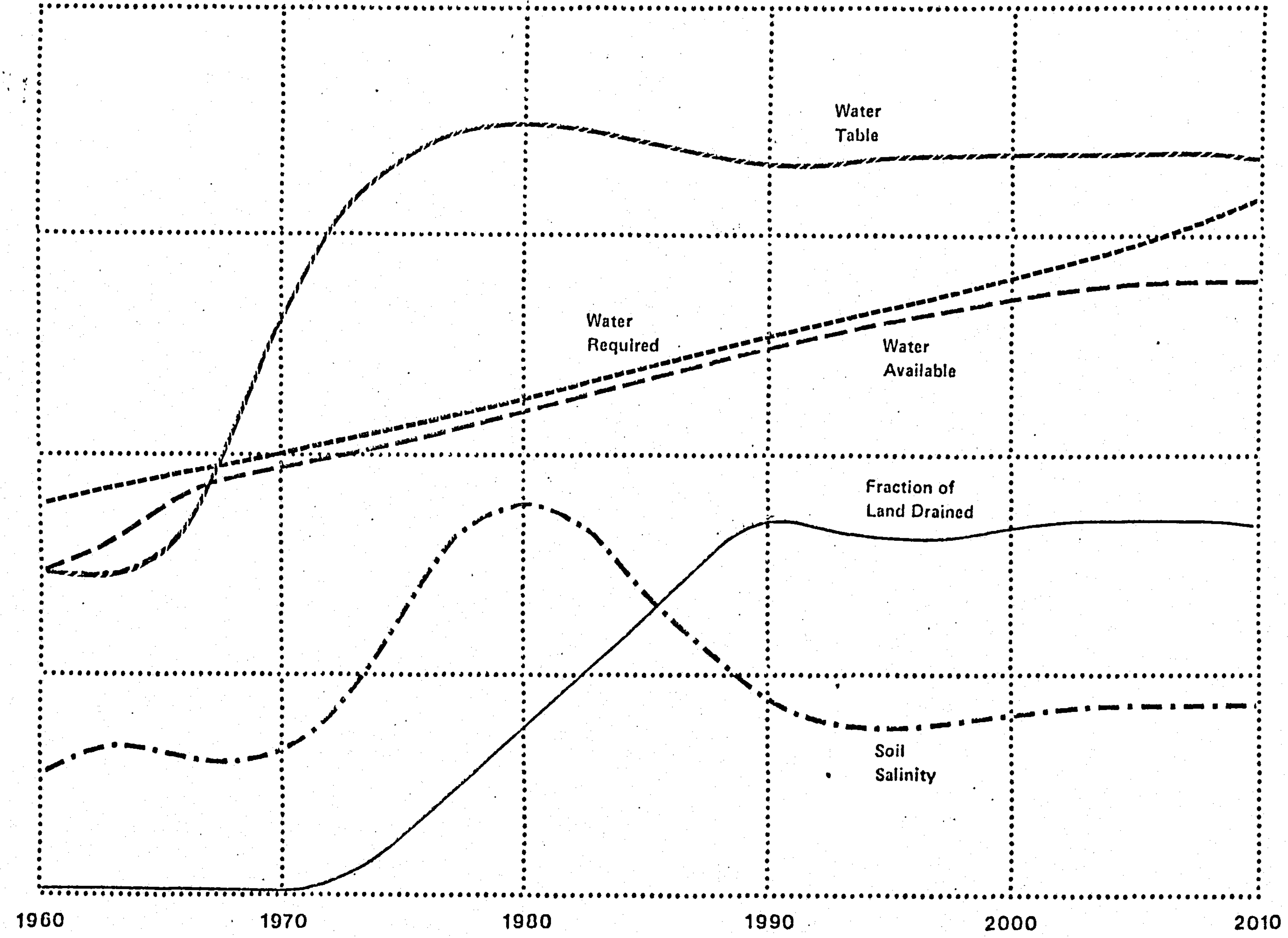


FIGURE 1: Increased Flow to Lake Nasser

more, the increased production of other agricultural crops for export allows grain imports to rise about 5%. The gradual erosion of nutrition observed late in this century in the base run persists in the alternative simulation, however, with perhaps a three or four year lag. Overall economic health shows a similar modest improvement, since the increased agricultural exports sustain the industrial imports that feed Egypt's growth.

More Efficient Use of Irrigation Water -- A large portion of the 84 billion cubic meters of Nile water flowing into Egypt is lost before it can ever reach the country's farmland. These losses from seepage and evaporation both above and below the Aswan Dam are detailed in Chapter III of Appendix A. The next two simulation experiments focus on the water losses during conveyance through Egypt's network of irrigation canals -- a loss estimated at 20%, or 10 billion cubic meters, of the water actually removed from the Nile. The model assumes that this loss is divided evenly between evaporation up out of the irrigation system and seepage down from the irrigation system. Evaporation might be reduced by covering or reshaping the irrigation ditches; seepage would be reduced by lining the ditches with plastic or concrete. Both simulations assume that the necessary improvements to the irrigation system are accomplished at no cost to the Egyptian economy (as would be true, for example, if the projects were funded with foreign assistance).

As shown in Figures 2 and 3, either irrigation improvement program succeeds in delaying any water supply problems until the next century. In this respect, both programs resemble the first simulation alternative -- assumed extra water from the Sudan swamp bypass. The dif-

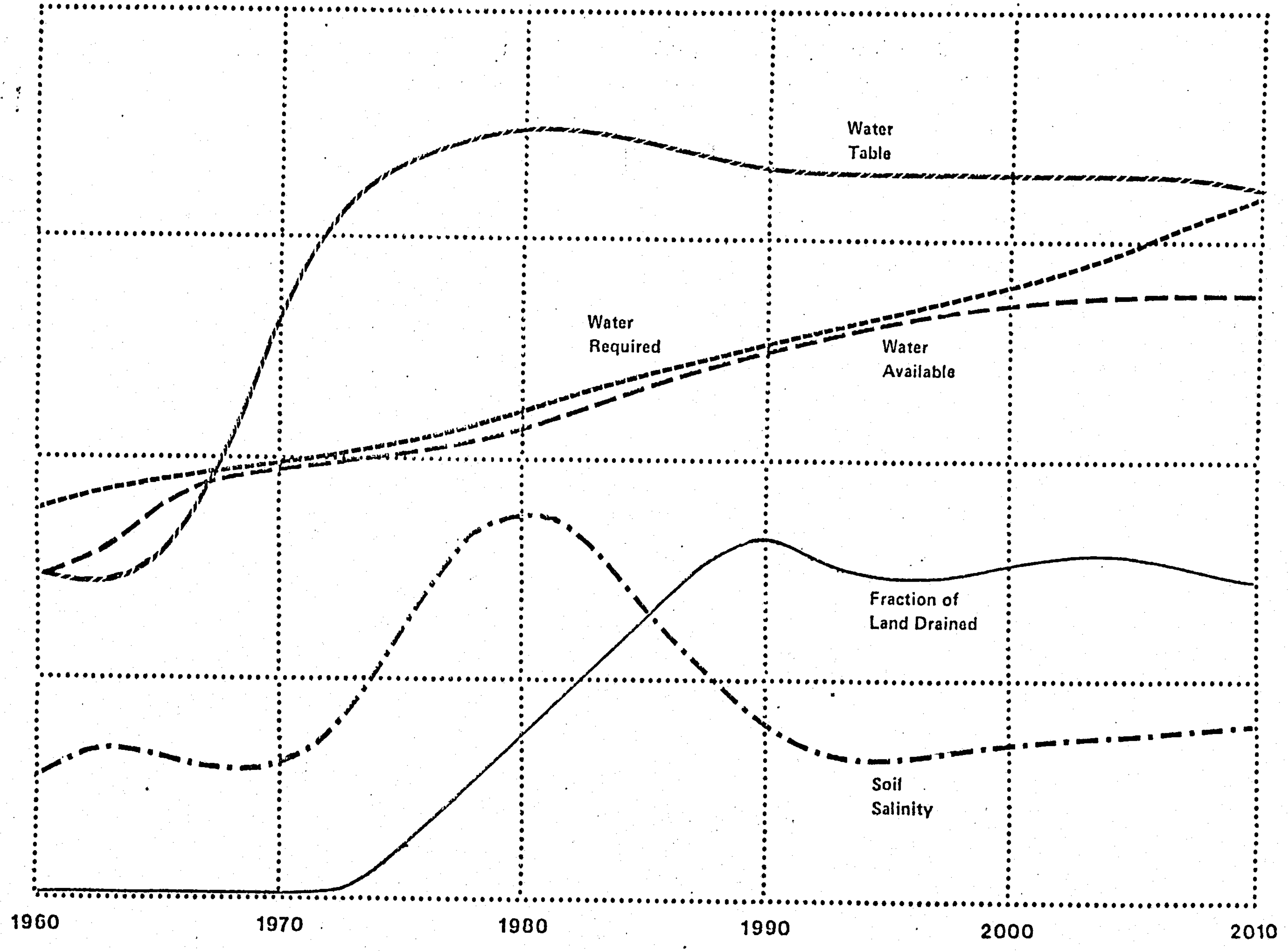


FIGURE 2: Reduced Evaporation Losses from Irrigation

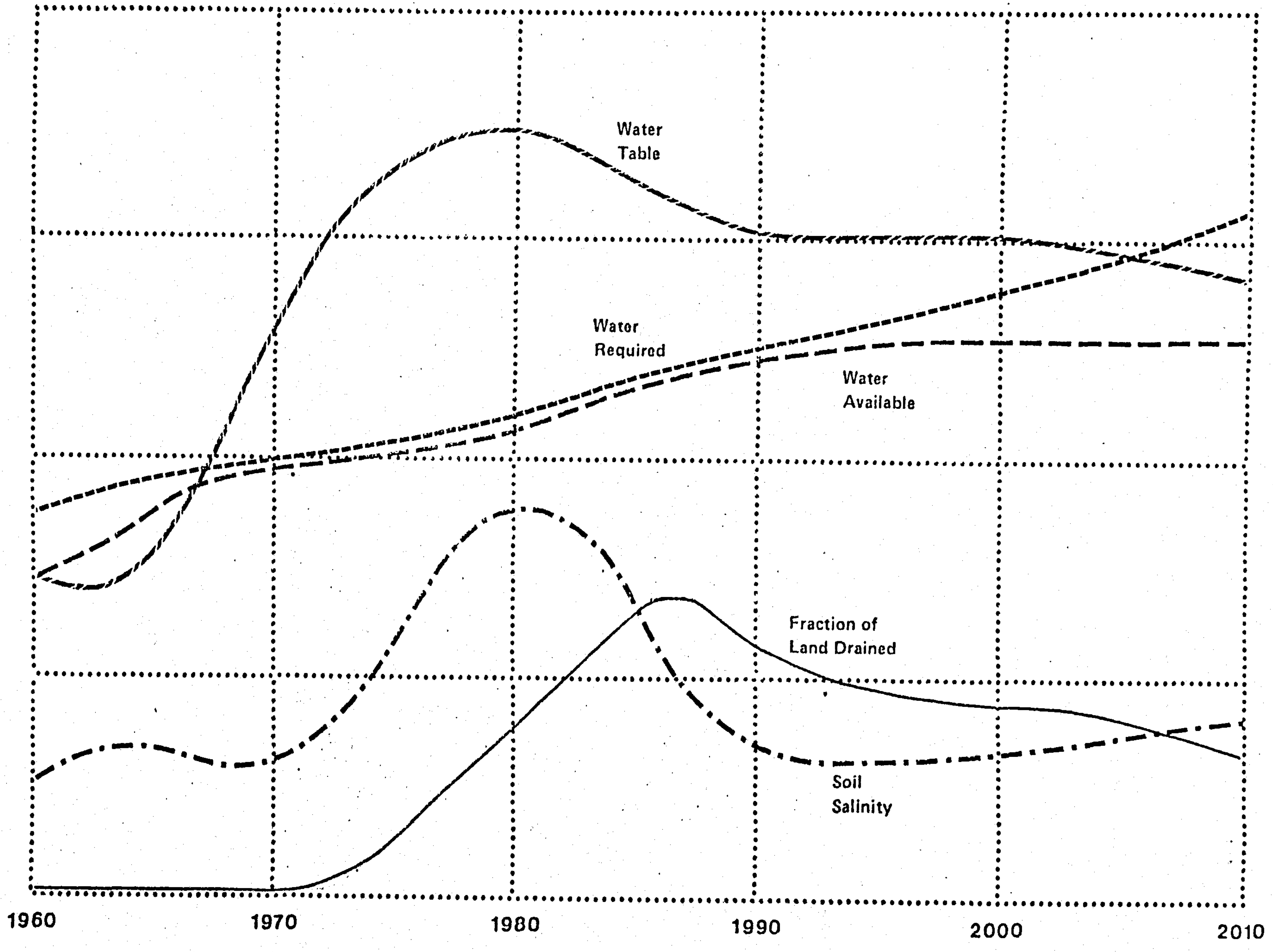


FIGURE 3: Reduced Seepage Losses from Irrigation

ference between the seepage control program and the other two alternatives, however, is visible in the phreatic zone. Elimination of seepage from the irrigation canals removes an important flow of water to the underground aquifer. As a result, flooding of the root zone under agricultural land is much less of a problem than for the other two increased-water experiments simulation (Figure 4). With less of the root zone flooded, there is a smaller requirement for installation of drainage facilities.

Both irrigation efficiency programs are able to sustain a higher level of nutrition for the population through the remainder of the century. As was true in the first alternative simulation, however, the improvement versus the base simulation is only a temporary delay of the nutrition erosion indicated for the turn of the century. The additional water is insufficient to sustain acceptable nutrition through 2010. Finally, the extra water from irrigation improvements makes the same modest contribution to economic development that was visible in the swamp bypass experiment.

<u>Draining Lake Nasser</u> -- Another source of water is available to the Egyptians during the remainder of this century at no short-term cost whatsoever. We refer to the 130 billion cubic meters of water stored in Lake Nasser by the early 1980's. This amount of water is intended to serve as a buffer against the possibility of low summer floods from the Nile River, so it is unlikely that the Egyptians would sacrifice the long term benefits of a stable water supply for the short term gains available from drawing down the lake. Nevertheless, the simulation model does provide a ready means to assess the potential gains from such a strategy.

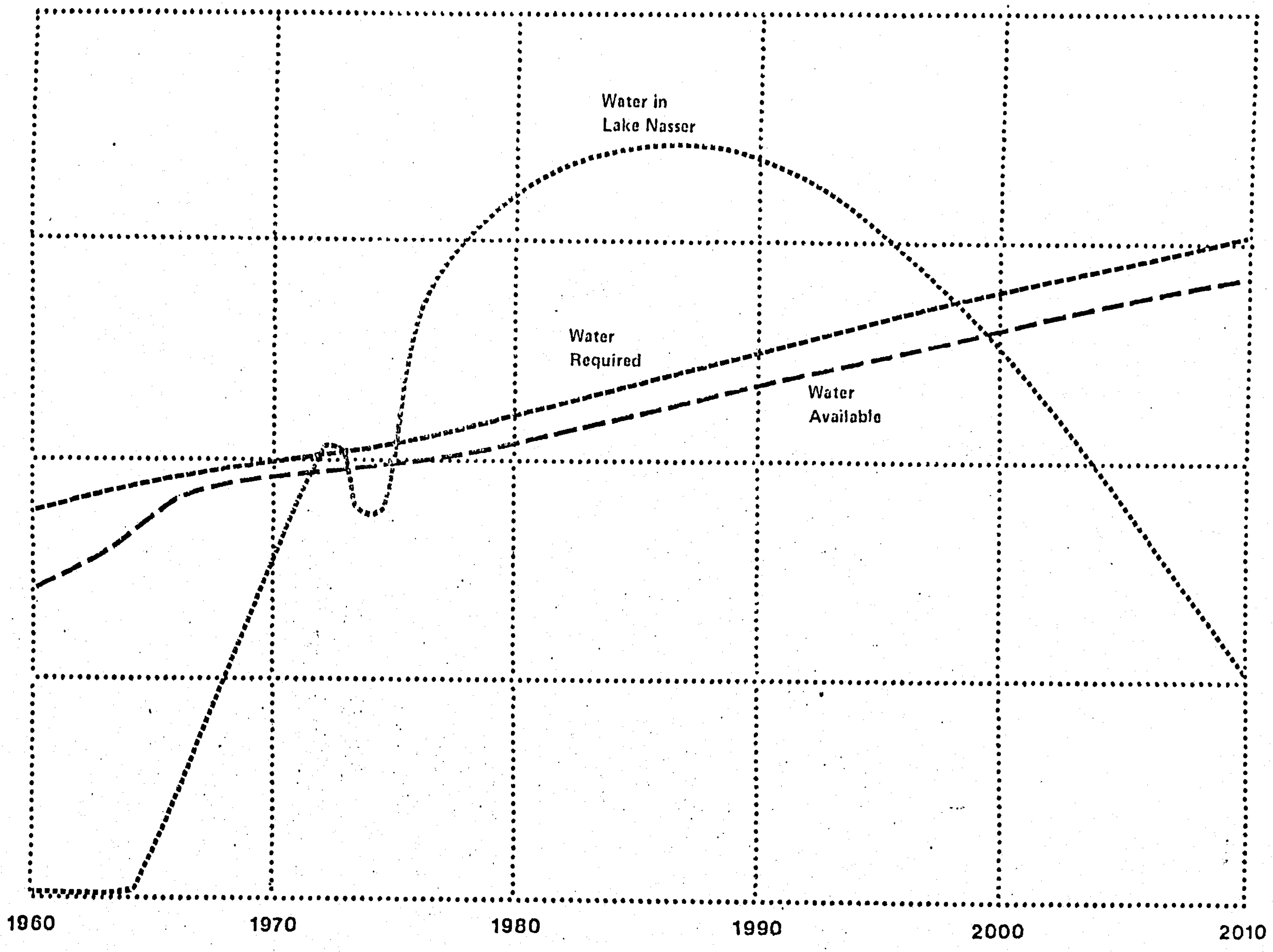


FIGURE 4: Drain Lake Nasser

As shown in Figure 4, draining Lake Nasser provides a means to meet almost all of Egypt's water requirements well into the next century. The water in Lake Nasser falls from 130 billion cubic meters in 1990 to 40 billion in 2010, providing an extra 4 1/2 billion cubic meters of irrigation water per year. In addition, the lower lake level reduces evaporation and seepage losses, adding an additional increment of water. At the sharply reduced volume, Lake Nasser provides no significant reserve against low Nile floods, although the Aswan Dam still serves the important purpose of metering the summer flood out evenly over the 12 month cultivation period.

The agricultural and industrial gains from draining the lake are smaller than for the other simulation alternatives examined, since the amount of water made available is smaller. Therefore, the nutritional pattern for this simulation is quite similar to the base simulation throughout the remainder of the century, with improvements only visible in the period 2000-2010.

Drainage More Expensive -- The base simulation assumed a continuing drainage program for Egyptian farmland at a fixed cost per feddan. The cost figure used for the base simulation was estimated from the projected expenses for major drainage programs now underway. It is quite possible, however, that costs may rise later in the program as drainage facilities are directed at land that is increasingly difficult to treat. For the fifth simulation alternative, we assume that the costs per feddan drained will rise by a factor of four as the drainage program is extended from 20% to 30% of Egyptian farmland.

The major effect of the assumed cost increase is to delay completion of the drainage program. Resources for drainage in the simu-

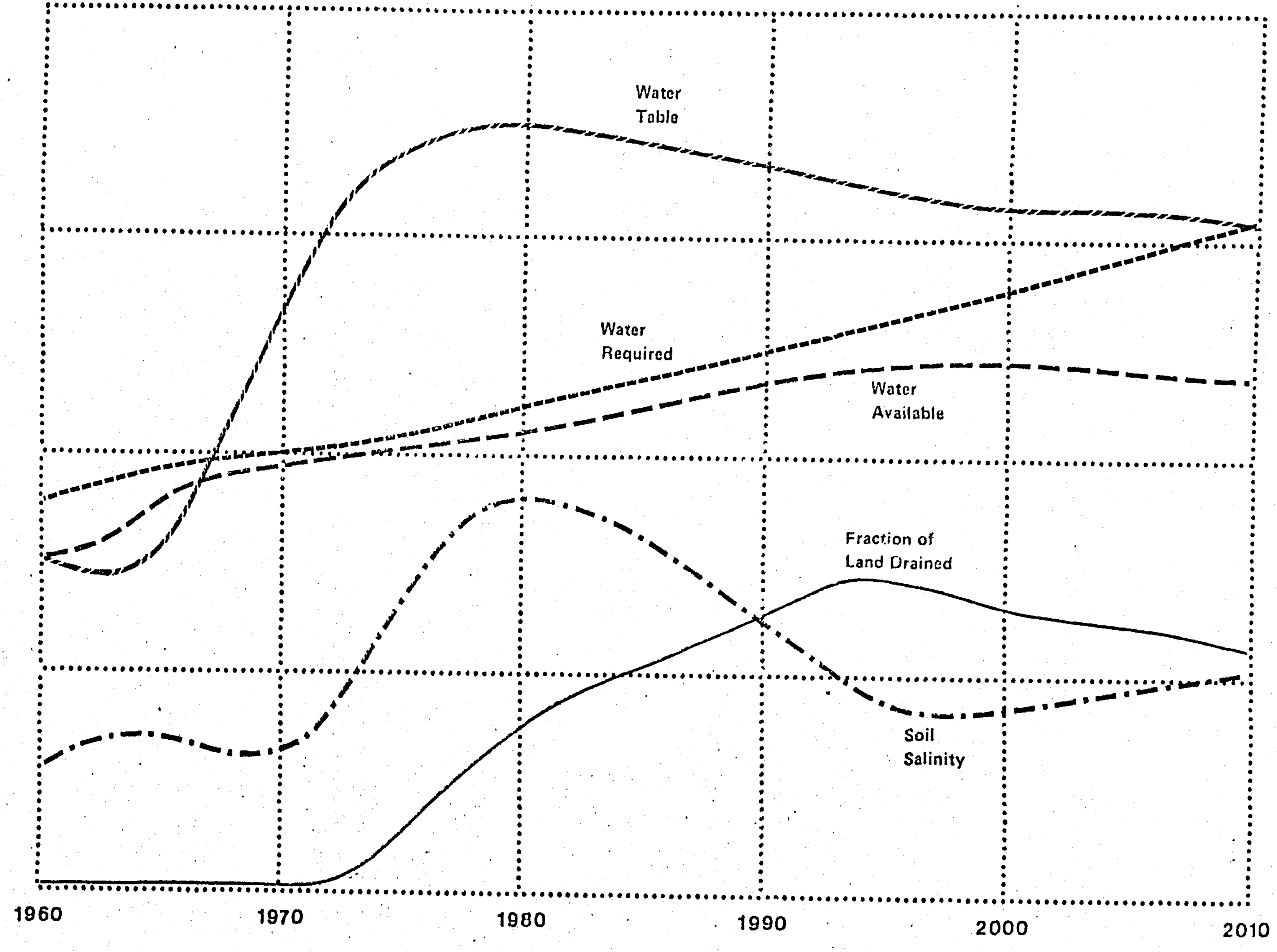


FIGURE 5: More Expensive Drainage

lation model are made available from the country's capital goods sector, which rations out physical investment capability among the competing needs of the entire economy. The increased cost of drainage increases the burdens on the capital goods sector and reduces the productivity (in terms of feddans drained) of the resources allocated to water projects. As a result, the drainage program is not completed until 1994, compared with a 1988 completion in the base simulation.

The delayed completion of the drainage program has direct consequences for phreatic conditions, and indirect, but quite important, consequences for agriculture. In the phreatic zone, restoration of salinity to 1960's levels is delayed until the mid-1990's, compared with the late 1980's in the base simulation (Figure 5). As a result, 1990 agricultural production is reduced 5% to 10% for all crops; grain imports are also reduced because exports of agriculture goods which generate the foreign exchange to finance imports, must be cut back. Nutrition slips badly throughout the 1980's (Figure 6), recovering only in the early 1900's when grain imports increase. By the late 1990's nutrition is restored to base simulation levels, and falls off early in the next century much as in the base simulation. Although the impact on agricultural production from the costlier drainage program is temporary, the effect on industrial development is more long-lasting. Resources for water control and drainage must be diverted from other sectors of the economy, disrupting the process of capital information. Consumer goods production in this alternative scenario is 15%-20% below base simulation levels in the 2000-2010 period.

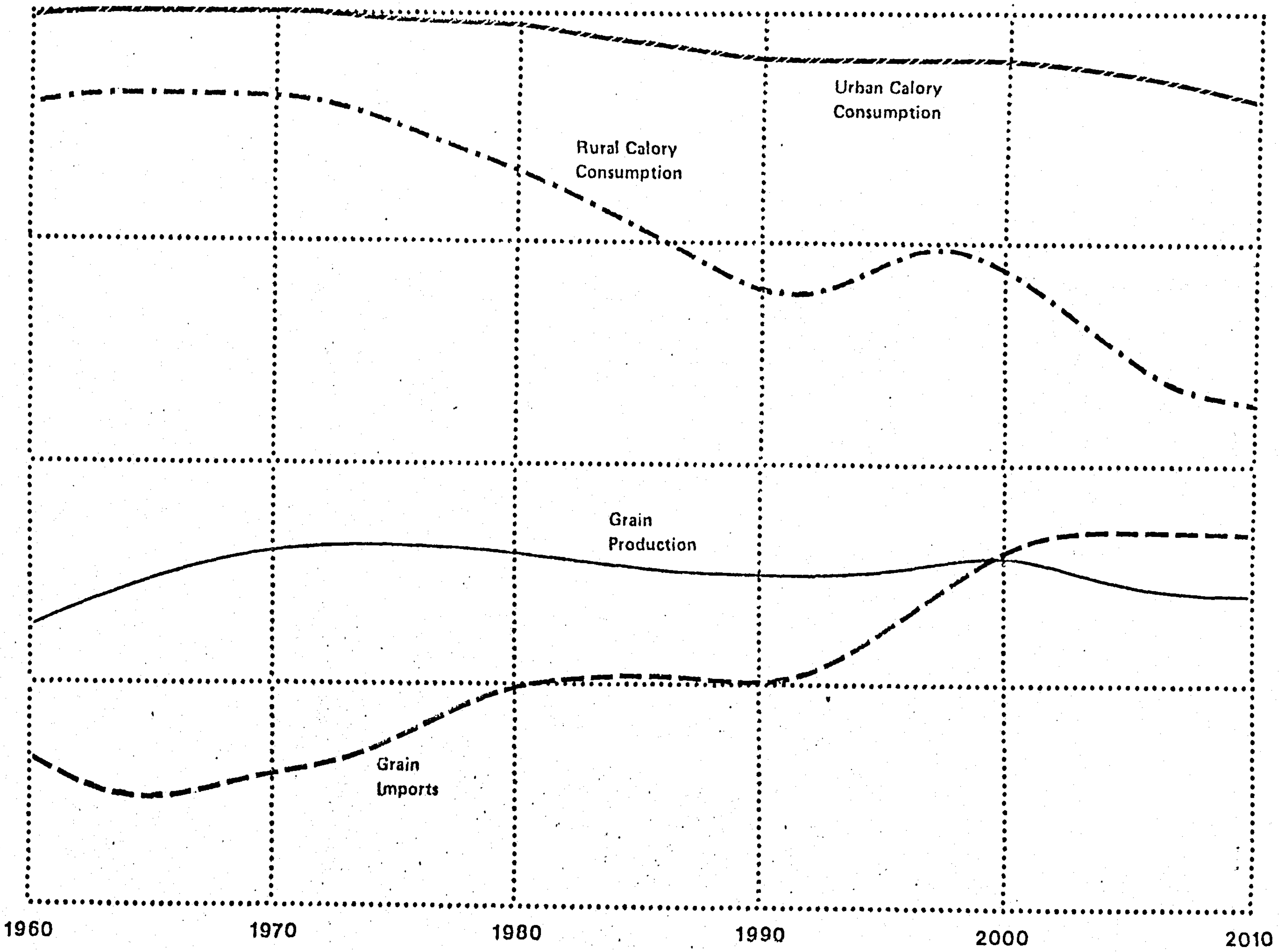


FIGURE 6: More Expensive Drainage

Accelerated Drainage Program -- A recurring problem in all of the simulations examined so far has been a rapid increase in soil salinity beginning in the early 1970's. The salinity is not removed until the completion of a drainage program on affected lands during the latter 1980's. In the next simulation, we assume that the salinity problem is tackled much more forcefully with a drainage program that treats 500,000 feddans of land per year (compared with the base simulation rate of 160,000) beginning in 1980. Because the Egyptian economy would probably be incapable of such an investment itself, we assume that the irrigation program is achieved at no cost, as if funded with foreign assistance.

An accelerated drainage program provides an immediate solution to many of the problems identified in the base simulation during the 1980's. The accelerated program extends drainage facilities to all necessary land by 1983, five years faster than in the base simulation (Figure 7). Salinity is removed as a major constraint to agricultural production by 1985, also five years faster than in the base simulation. Food production is boosted sufficiently to sustain 1980 nutrition levels into the early 1990's (Figure 8). Egyptian industry absorbing the resources that would be otherwise are committed to drainage facilities, also shows some incremental improvement.

The gains from the accelerated drainage program are only temporary, however. The root cause of the base simulation year 2000 nutrition crisis is the inability of agricultural production inputs to grow as rapidly as Egyptian food requirements. The accelerated drainage program removes a constraint on production during the 1980's, but supplies no important additional production inputs during the

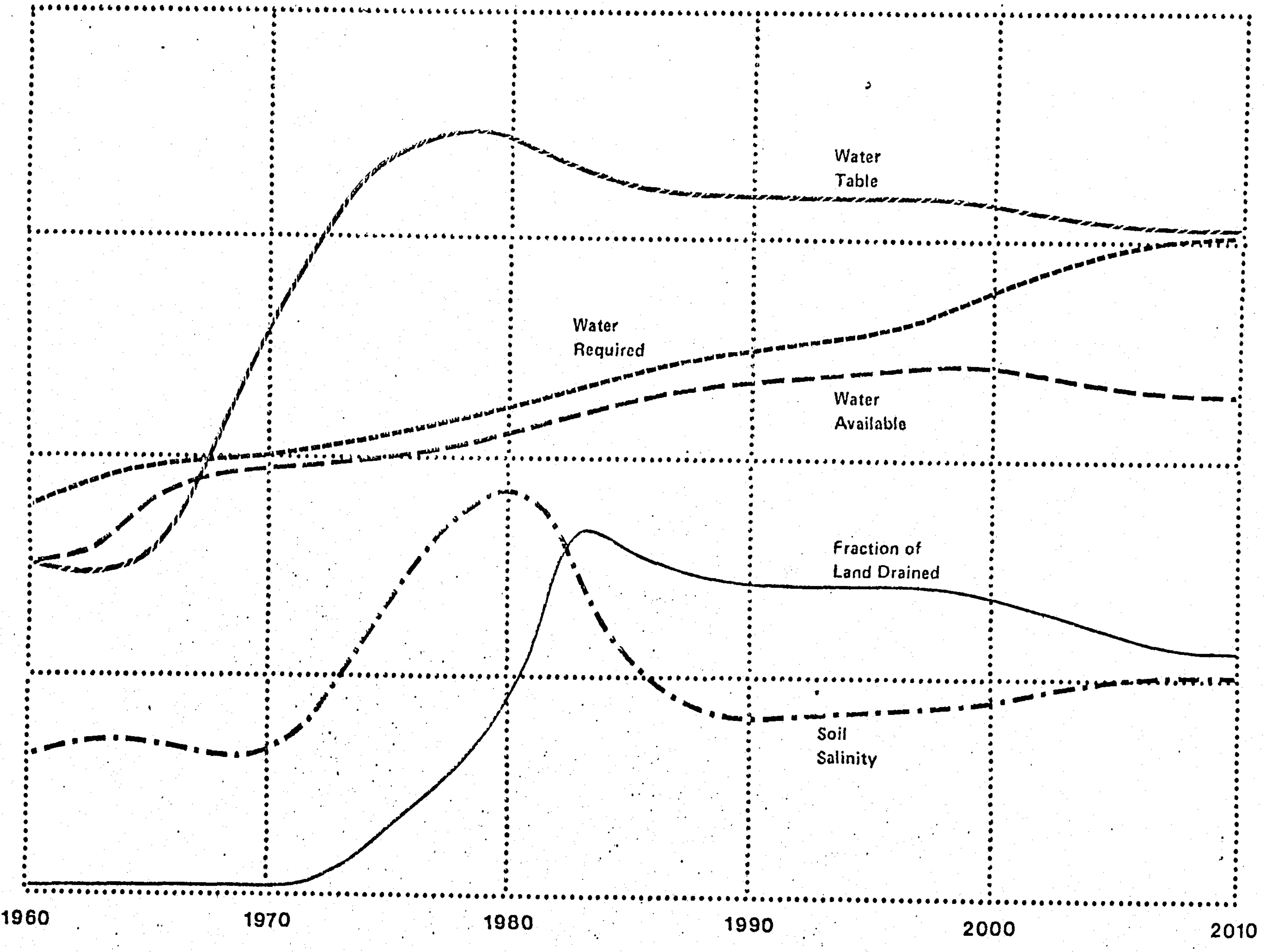


FIGURE 7: Accelerated Drainage Program

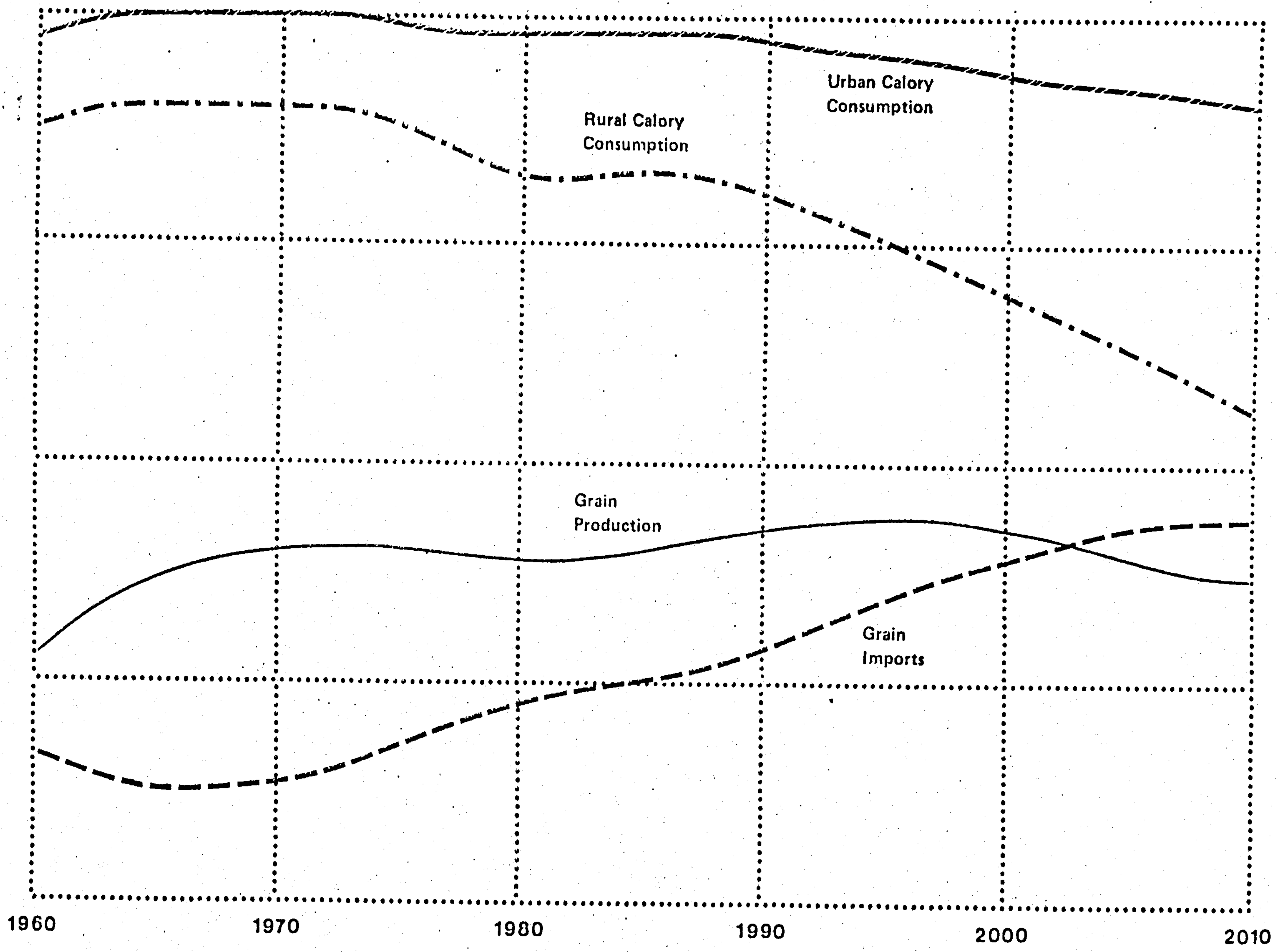


FIGURE 8: Accelerated Drainage Program

1990's or early in the next century. As a result, the final 20 years of the accelerated drainage simulation closely resembles the final 20 years of the base simulation, with the same erosion of nutrition early in the next century.

Combination of Water Management Programs -- The final water management simulation experiment combines two of the programs from earlier simulation experiments to assess the gains available to Egypt from water management programs alone. The simulation combines more efficient irrigation from reduced seepage with the rapid drainage program hypothesized above. As noted in the individual descriptions of the two simulations, the accelerated drainage program provides a short-term solution to salinity problems, while the irrigation efficiency program provides a longer term supply of extra water.

Figure 9 illustrates that the proposed combination of water management programs provides significant improvement versus the base simulation over the course of the model's 30 year time frame. Water requirements for agriculture are satisfied well into the next century, enabling 15% to 20% increases in grain production during the 1990-2010 period. Production and export of other agricultural crops is also increased, providing the foreign exchange to purchase increased grain imports. As a result, nutrition is substantially improved versus the base simulation (Figure 10). A further benefit of the combined water management programs is stable and extended industrial growth. Consumer goods production for this experiment is increased 30% above base simulation levels at the end of the simulation in 2010.

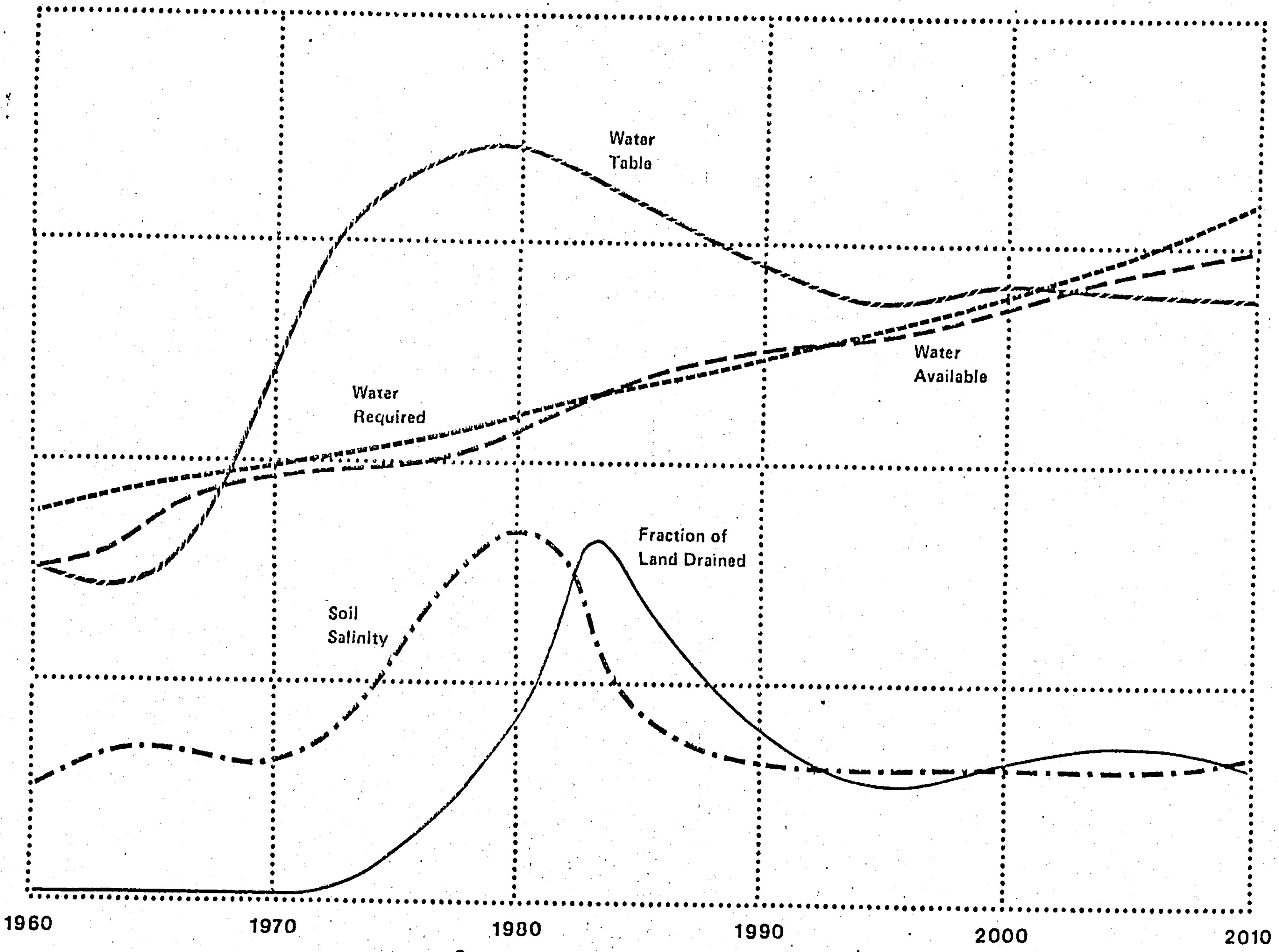


FIGURE 9: Combination of Water Management Programs

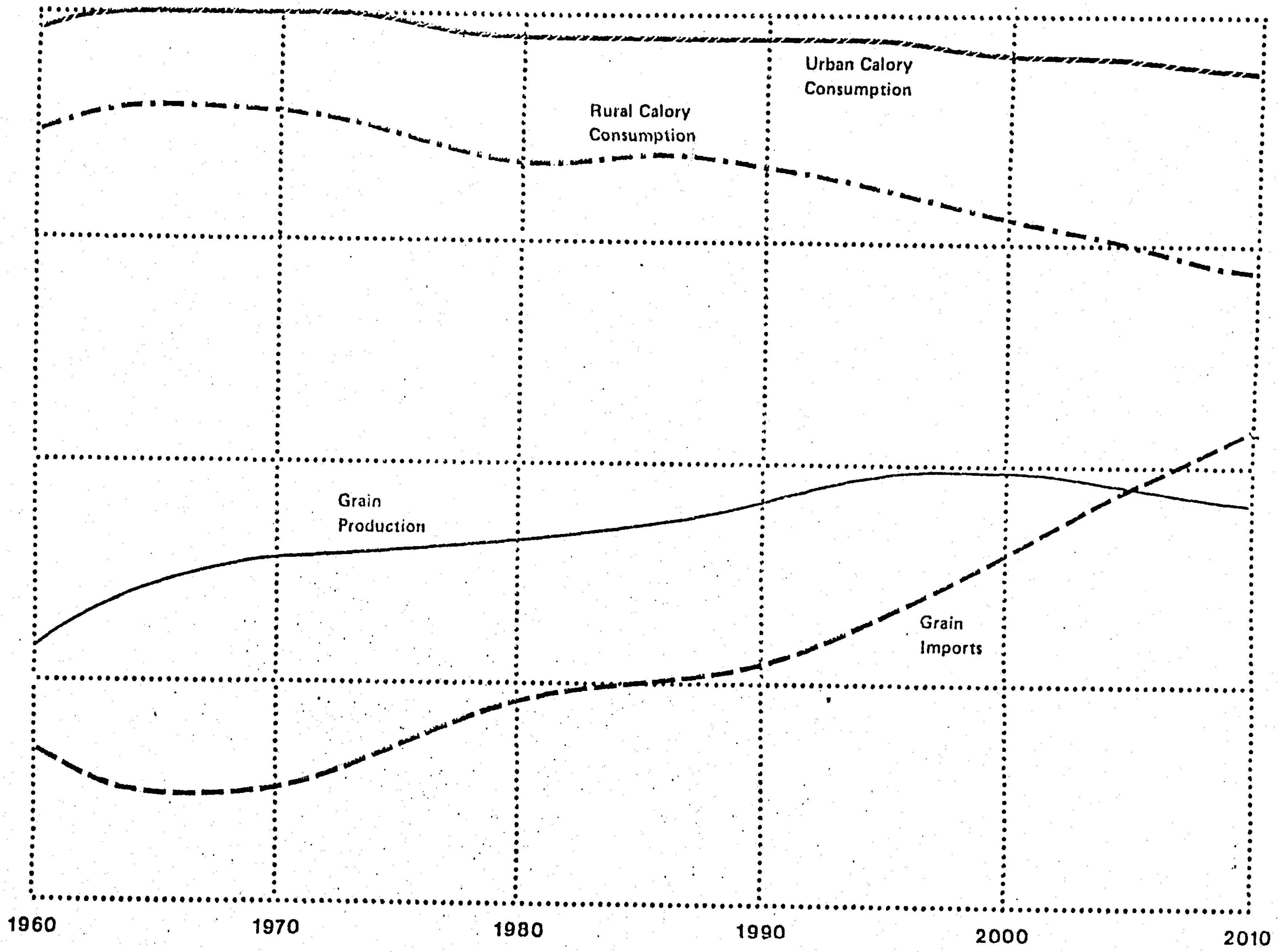


FIGURE 10: Combination of Water Management Programs

Social or Economic Issues

The preceding Section of this Chapter dealt exclusively with alternatives to the base simulation assumptions about water management in Egypt. This second Section addresses a different set of issues, to determine how social and economic change in Egypt outside of the water sector might impact on water management issues. The focus of the section is alternatives that might improve Egypt's ability to adequately nourish its population.

Accelerated Mechanization of Agriculture -- As noted earlier, the root cause of the base simulation nutrition erosion is the inability of agricultural inputs to keep up with population growth. This section's first alternative simulation investigates the desirability of rapid mechanization of agriculture as a means of boosting production. Although mechanization of agriculture does not provide an inherent yield advantage versus the use of draft animals, it does creates the possibility of more extensive multiple-cropping in combination with improved farming practices and careful selection of seed strains.

The results of this simulation experiment illustrate the importance of a balanced adjustment to agricultural inputs. The model indeed shows an increase in cultivable land area from the more aggressive mechanization -- during the 2000-2010 period, cultivated land area is up +20% in the alternative simulation versus the base simulation. Production, however, is almost unchanged, because the more intensive land use increases the gap between water requirements and the relatively fixed amount of water available. Whereas the 70 bil-

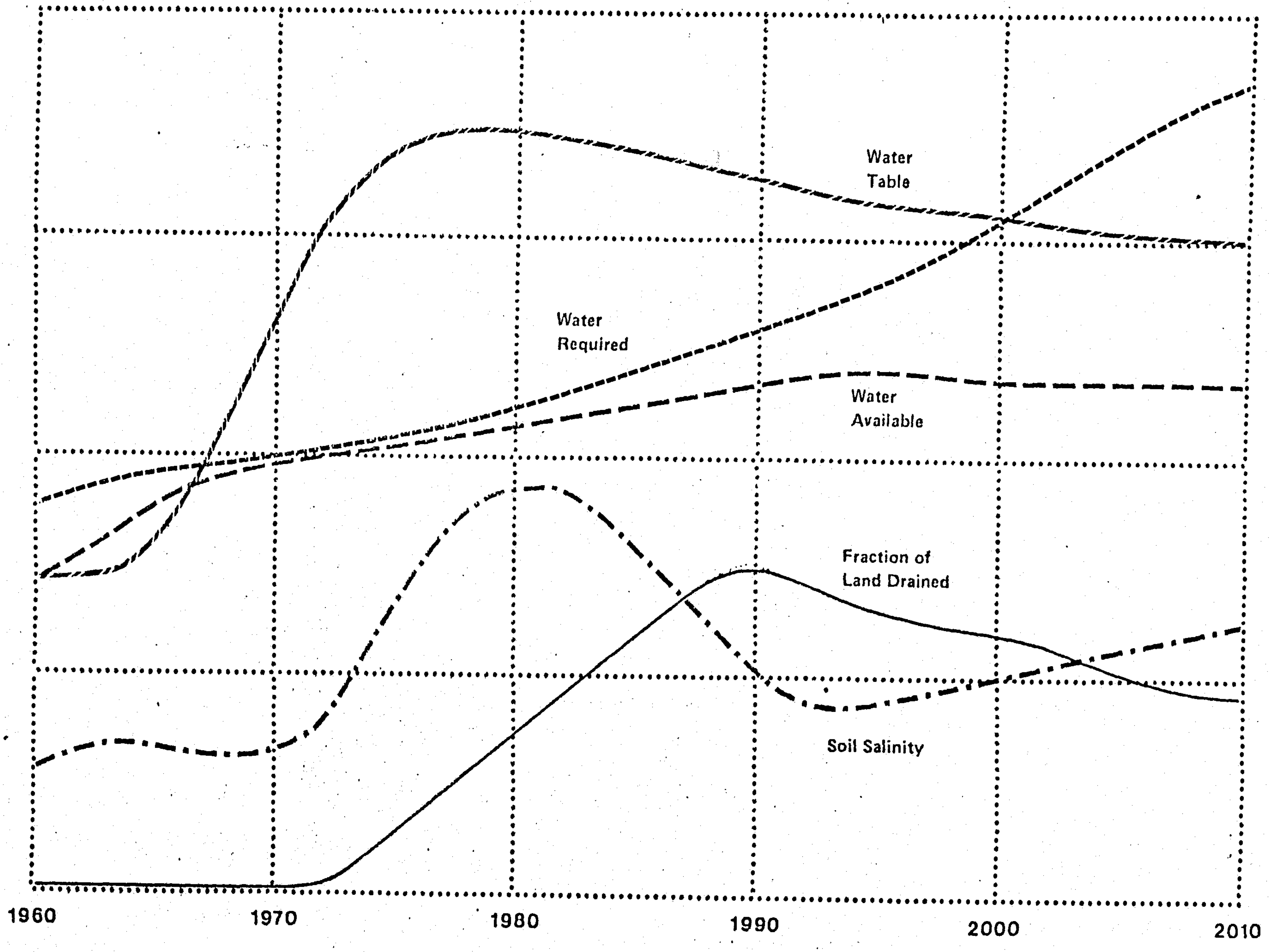


FIGURE 11: Accelerated Mechanization of Agriculture

lion cubic meters released annually from Lake Nasser can satisfy 75% of the base simulation water requirements in the 2010, the same 70 billion cubic meters only meets 50% of the agricultural water requirements in the alternative simulation (Figure 11). As a result, yields in the alternative simulation are falling as fast as cultivated land area is rising.

Nutrition for the alternative simulation resembles the pattern from the base simulation. In fact, nutrition in the alternative simulation erodes somewhat more rapidly, since grain imports are reduced 10% in the accelerated agricultural mechanization experiment. The diversion of resources from industry to agricultural necessary to accomplish the mechanization has weakened Egypt's non-agricultural export base. The final simulation experiment in this Chapter investigates the gains available from a balanced increase in water and other agricultural inputs.

Increased Foreign Exchange -- The next simulation investigates whether Egypt can sidestep water management and agricultural issues altogether by boosting the foreign exchange earnings from non-agricultural sources. (Contributors of additional hard currency might be increased tourism or crude oil exports.) For the alternative simulation, the net export earnings provided by miscellaneous sources is assumed to grow at 7% annually during the 1980's, compared with 3 1/2% annual growth in the base simulation. After 1990, annual growth returns to 3 1/2%. This has the effect of raising the miscellaneous share of total 1990 exports from 35% in the base simulation to 55% i n the alternative simulation.

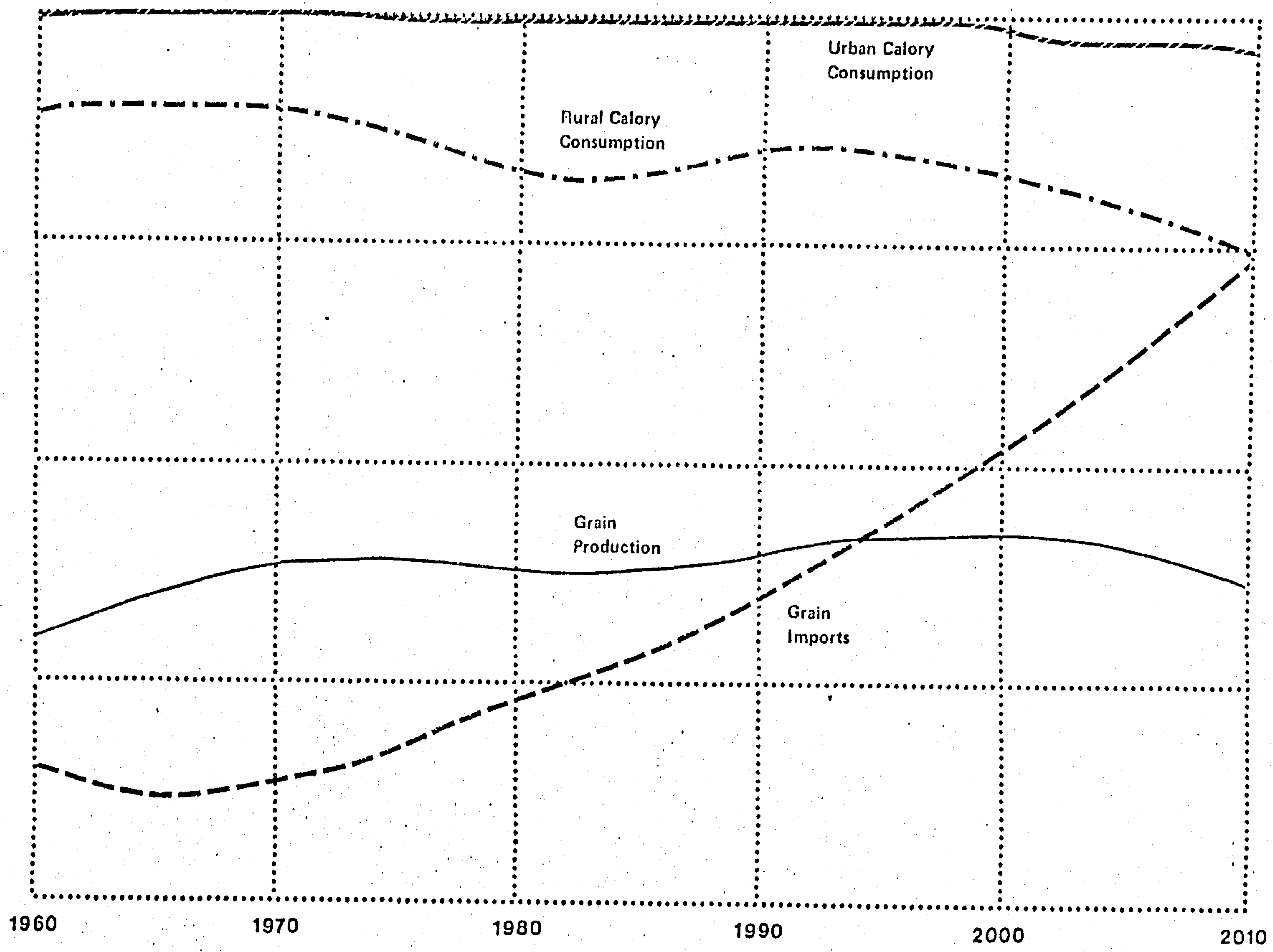


FIGURE 12: Increased Foreign Exchange

The increased export earnings have no visible direct impact on water management or agricultural matters, other than to slightly increase the investment resources available for both areas as the industrial economy is strengthened. The increased foreign exchange does succeed in stabilizing nutrition at 1980's levels for 20 years (Figure 12), before the continually growing population manages to overtake food supplies. Year 2010 grain imports in the alternative simulation are up 55% versus the base simulation. As was seen in other simulations where foreign exchange was increased (by exports of agricultural crops), the higher miscellaneous exports help sustain a steady growth of Egypt's industrial economy. Consumer goods production at the end of the alternative simulation is increased 40% versus the base simulation.

<u>Changes in Dietary Preferences</u> -- The base simulation identified the ever-increasing cultivation of water-intensive crops -- rice, fruits, and vegetables -- as a major contributor to the growing gap between water requirements and water available. The next simulation explores the importance of this trend by postulating a gradual change in dietary preferences. Desired per-capita consumption of rice, fruits, and vegetables is assumed to decrease steadily from 1980 onwards until all have been reduced by 70% at the year 2000. Other grains are assumed to be consumed as substitutes to replace the calories formerly supplied by these foodstuffs. Such a change in dietary preferences would be difficult to achieve, of course, but a proper combination of government incentives and education might succeed in effecting the hypothesized shift over the 20 year time span.

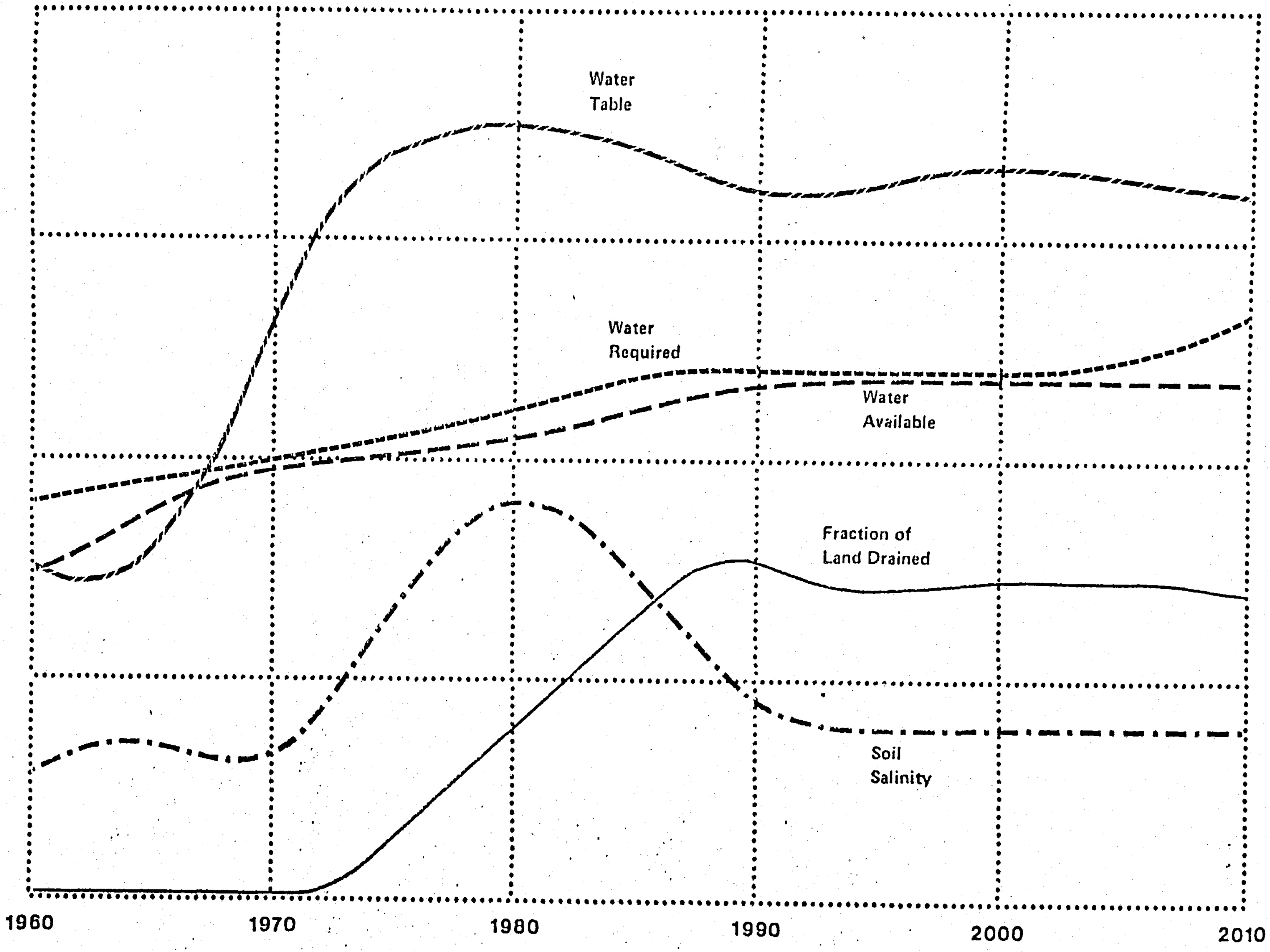


FIGURE 13: Change in Dietary Preferences

The direct result of the shift in dietary preferances is sizeable adjustments to the land use pattern for Egyptian agriculture. In the alternative simulation rice, fruits, and vegetables combine to fill 25% of the cultivated land area in 2000, down from almost 40% in the base simulation. This reduced cultivation of water-intensive crops levels off water requirements for agriculture until early in the next century, allowing the limited water supply to meet all of the demand (Figure 13).

The shift in dietary preferances has significant consequences for overall nutrition and economic growth. The switch to grains succeeds in stabilizing the population's nutrition in the late 1980's (Figure 14), avoiding the serious erosion observed after the turn of the century in the base simulation. The better nutrition is achieved with an exceptional growth in grain production (up 40% versus the base simulation in 2010) and grain imports (up 50%). The increased grain imports are funded by 200% and 100% increases in fruits and vegetables exports, and rice exports, respectively. In addition, the foreign exchange earnings from exporting agricultural produce that would otherwise be consumed domestically are sufficient to fuel industrial growth. By the year 2010, consumer goods production in the alternative simulation is 40% higher than in the base simulation, and growing steadily.

Reduced Population Growth -- The other simulation experiments in this Section attempt to improve Egyptian nutrition by boosting the amount or mix of food available. The next simulation experiment addresses the nutrition problem by attacking the demand side of the food/population balance. Within the past year various elements of the

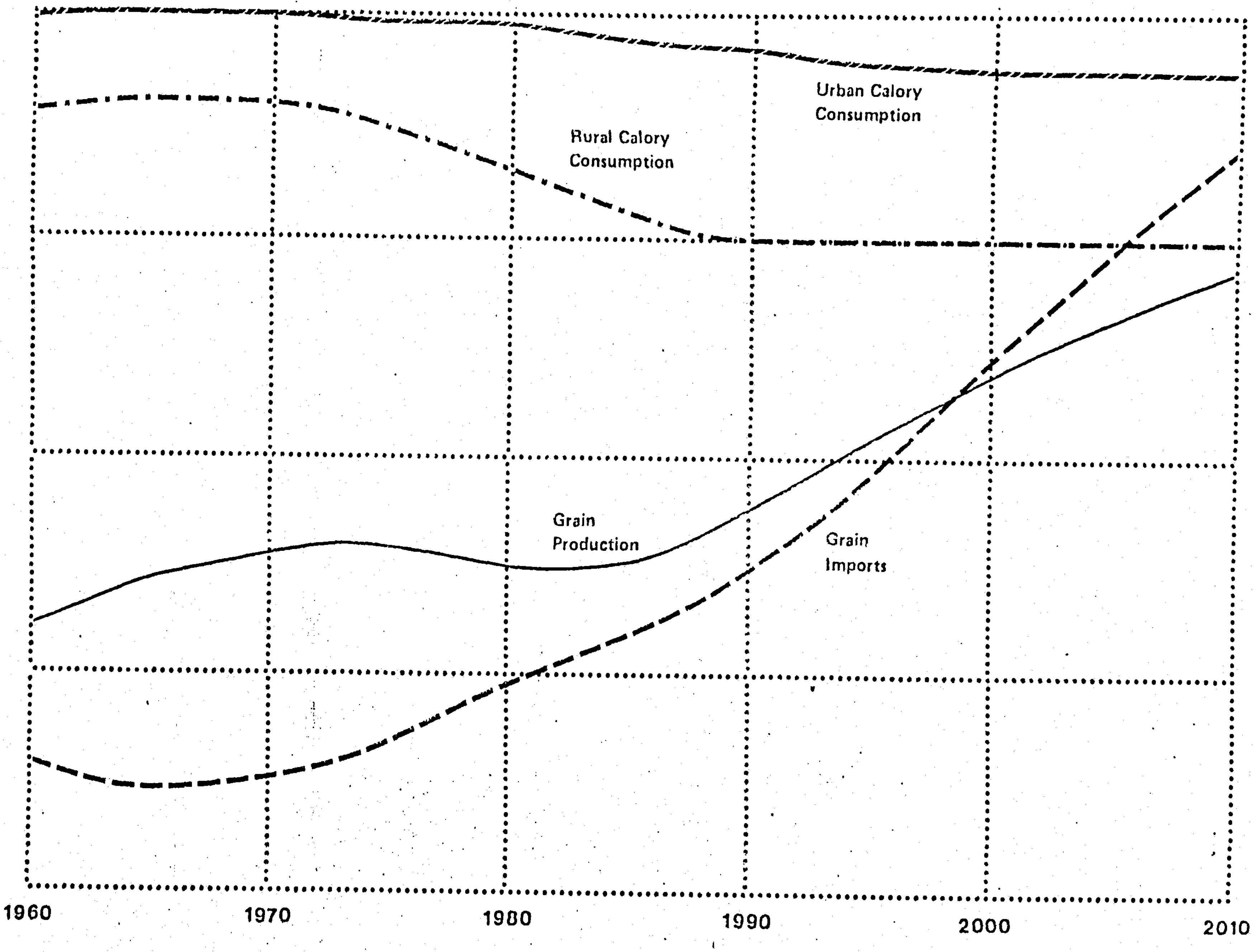


FIGURE 14: Chang◡ in Dietary Preferences

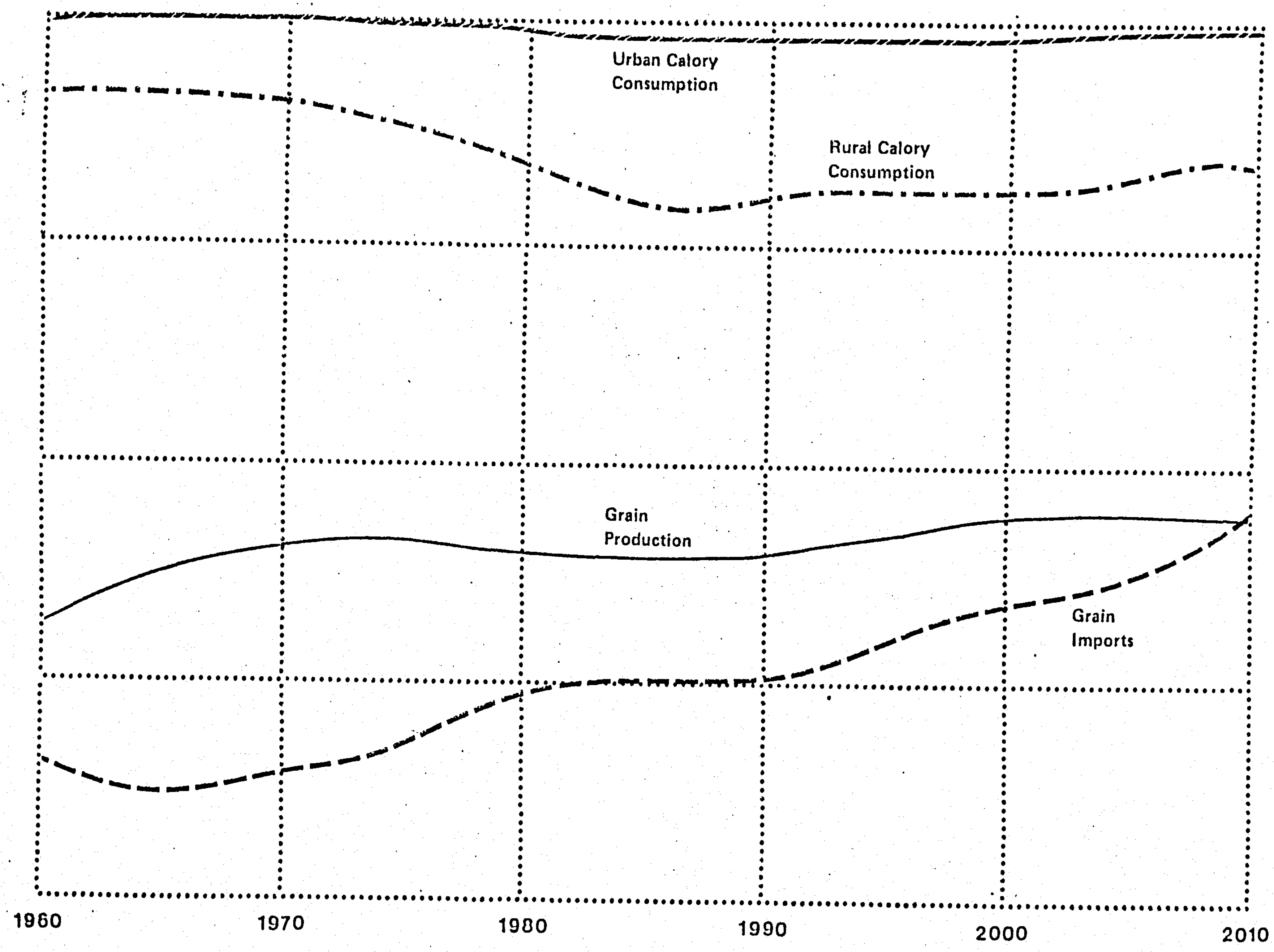


FIGURE 15: Reduced Population Growth

Egyptian government have discussed the need for broadscale birth control programs. Plans are apparently being considered to reduce the country's birth rate to replacement levels by the year 2000. We have used the Egypt model to assess the consequences of such a population control program for nutrition and economic development. To achieve a near-replacement level birth rate in the model, it was necessary to assume a 50% decrease in the average desired family size between 1980 and 2000, and a government attempt over the same time period to extend birth control usage to all of the fertile adult population.

The assumed population control programs succeed in achieving an 8% reduction in the year 2000 population (from 63 million in the base simulation to 58 million in the alternative simulation) and a 20% reduction in the year 2010 population. Water management and agricultural production remain much the same, with a growing gap between water available and water requirements. With the reduced population, however, the agricultural production is quite adequate to meet requirements. Nutrition stabilizes in the mid-1980's (Figure 15), and shows signs of increasing early in the next century. A further benefit of the reduced population growth is improved industrial development, since more of the country's agricultural production is available for export.

Accelerated Mechanization, Combined Water Management -- The final simulation experiment explores the potential for combining mechanization (see pp. 60 to 62) and water management (see pp. 57 to 59), each of which were tested separately, into a single agricultural development strategy. The goal is to determine whether well-conceived water management projects can be meshed with agricultural programs to produce stable or increased nutrition.

Figure 16 shows how the mechanization and water management programs complement each other. Mechanization has increased water requirements sharply versus the base simulation, but the increased irrigation efficiency from the control of seepage meets all water requirements until the turn of the century. Substantial gains in agricultural production versus the base simulation result, reducing grain import requirements until well into the next century.

Year 2000 Agricultural Production Comparisons (Million Tonnes)

	Cotton	Fodder	Fruits & Vegetables	Rice	Other Grains	Grain Imports
Base Simulation	.38	45.8	27.3	4.6	4.9	4.7
Alternative	.46	51.0	29.9	5.3	6.6	4.0
% Increase	+21%	+11%	+10%	+15%	+35%	-15%

The sustained increases in agricultural production match Egypt's population growth, allowing a stable level of nutrition well into the next century. Industrial growth is also strengthened, as in other simulations from this Chapter where increased agricultural production provides the exports needed for more foreign exchange earnings.

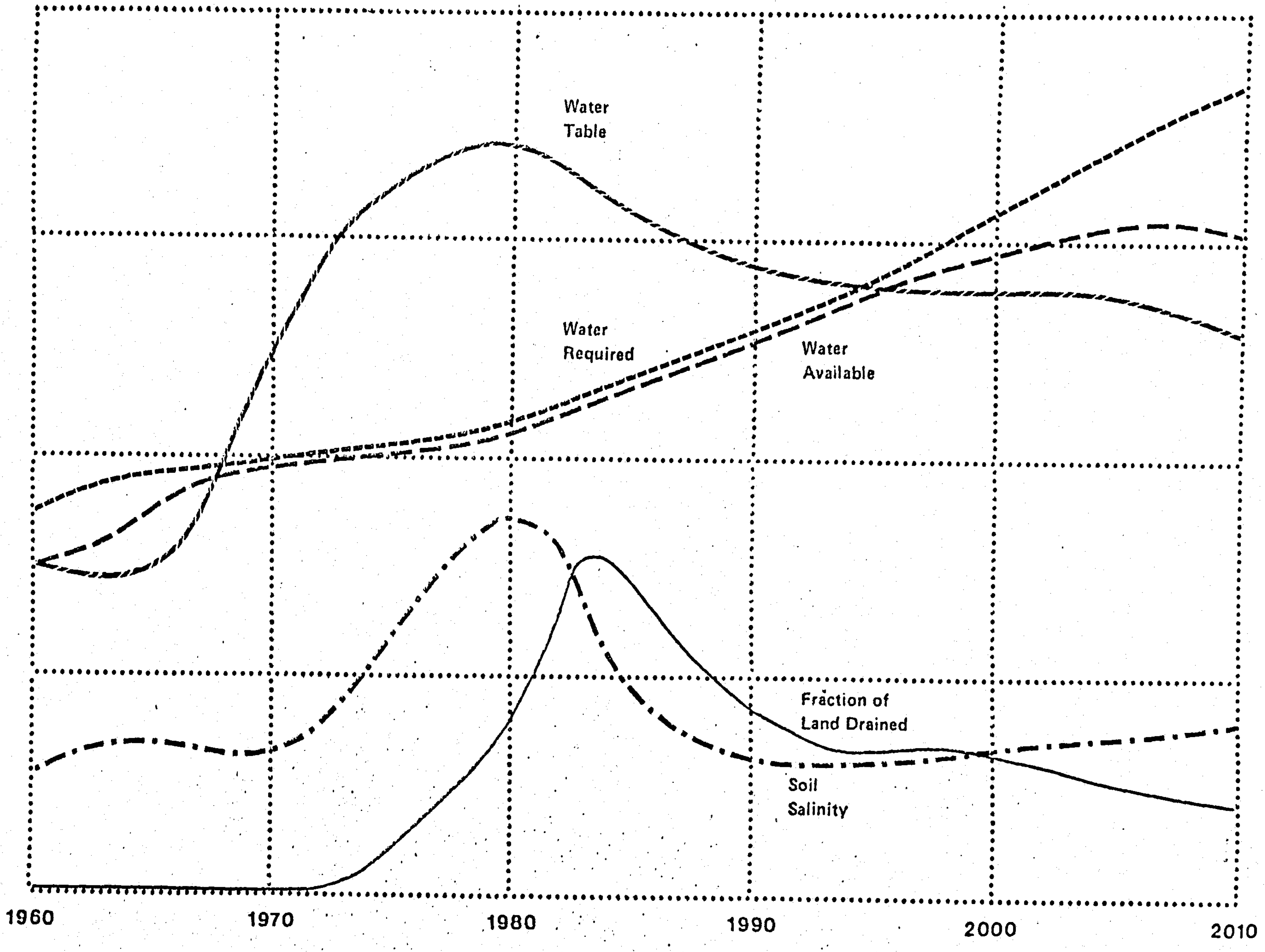


FIGURE 16: Accelerated Mechanization, Combined Water Management

CONCLUSIONS

Preceding Chapters of this report have described the development process for the Egypt computer model, the base simulation of that model, and the exploration of alternative scenarios for Egypt's future. In this final Chapter we summarize the results of the project to draw the important conclusions about the role of water resouces in Egypt and the suitability of the computer simulation approach to the sponsor's research needs.

Simulation analysis with the Egypt model provides a number of important insights into the role water resources will play in Egypt's future. Foremost among these is the inevitability of a growing gap between water requirements and water availability if present use patterns persist. The increasing water requirements result from both agricultural and demographic factors: more intensive land use increases the water required per feddan of farmland, and the steady urbanization of Egypt's population raises the incentives for growing water-intensive fruits, vegetables, and rice. At present, the only additional source of water identifiable for the near future is re-use of the drainage water expected from Egypt's planned drainage program.

Much of the Nile water available for agriculture is lost before it ever reaches Egyptian farmland, either through evaporation and seepage in Sudan, Lake Nasser, and the country's irrigation system, or through mismanagement in application. A number of options for increased water availability are explored in this report, including a bypass canal through the Sudanese swamps and reduced seepage or evaporation loss in the Egyptian irrigation network. Any of the three measures by itself appears to be sufficient to fill most of the gap between water requirements and water supply observed in the base simulation, and achieve improvements in agricultural production. However, the production gains from the three alternative programs are unable to do more than delay the pending food supply problem for more a few years. Increased water supplies by themselves are not the solution to Egypt's long-term food and population problems.

Besides water quantity issues, water quality has been an important aspect of this study. The simulation model focuses on soil salinity as the most important water quality issue likely to arise in Egypt during the project's 20-30 year time frame. A build-up of salt in the root zone underlying Egypt's farmland is expected, the near-term consequence of the rising water table triggered by increased irrigation waters made available by completion of the Aswan Dam. Without reducing water application rates, the only solution to the salinity problem is the installation of drainage facilities to withdraw the salt water from the soil. The simulation model projects that the likely rate of drainage installation would bring the salinity problem under control during the 1980's.

Two alternative possibilities for the drainage program were reported in the previous Chapter. The first scenario postulated that the per-feddan cost of installing drainage facilities might increase as drainage is extended to a larger and larger fraction of Egyptian farmland. The resulting delay in completing the drainage program may create a mild food crisis during the 1980's before salinity is finally brought under control early in the 1990's. Longer-term economic problems should result, however, from the disruption in industrial capital formation caused by the diversion of investment resources to drainage. The second scenario imagined a rapid completion of the drainage program during the 1980's with funding from an external source. The resulting early solution to the salinity problem provides a temporary boost to agriculture and nutrition during the 1980's, but little long-term improvement.

Water management programs alone are capable of meeting the basic nutritional requirements of Egypt's population if combined in a careful manner. A simulation experiment combining rapid drainage installation, for short-term nutrition gains, with increased water in the longer-term from improvements to the irrigation system shows the potential for sustaining nutrition into the next century. Since both water management programs are assumed to occur without cost to the Egyptian economy, however, outside assistance (or much increased export earnings from sources like expanded crude oil production) would be necessary to realize this scenario.

The ability of Egypt's water resources to satisfy internal requirements will be importantly influenced by agricultural, demographic, or economic developments. For example, attempts to increase agricultural production by mechanization could be defeated by the inability of the water sector to meet the increased water requirements with current management practices. Alternatively, the water supply problems projected for the 1990's may be eliminated if the population's consumption of water-intensive crops could be reduced.

The final simulation experiment presented in the report emphasizes the potential gains from complementary water management and agricultural development programs. If externally funded drainage and irrigation programs are timed to coincide with an internally funded mechanization of agriculture, considerable gains in both food production and nutrition can be achieved. This scenario is yet another demonstration of the inter-relationships that exist between water resource and economic development issues.

Besides the improvement of the sponsor's understanding of the role of water resources in Egypt, this project has had the additional objective of testing the utility of the System Dynamics methodology. A number of important conclusions about the methodology will be summarized here to conclude this report.

The study demonstrated the ability of a System Dynamics project to integrate the information provided by a number of different disciplines. Chapter II of this report outlines, and Appendix A details, hydrologic, demographic, agricultural, and economic information has been assembled in a single package -- the simulation model. The combination of varied types of data was instrumental in producing many of the key conclusions form this study: for example, the pending gap between water supplies and water requirements caused by agricultural and demographic trends. Indeed, the System Dynamics methodology all but forces an inter-disciplinary approach, since the process of model construction focuses attention on the inter-relationships among different elements of a real world system without regard for professional disciplinary boundaries that may exist.

A second conclusion about the methodology is the ease with which the simulation process allows investigation of varied assumptions for the relationships or policies incorporated in the model. The dozen simulation experiments described in this report represent only a sample of the simulations that were performed, or could be performed. The ability to execute such a wide range of experiments greatly expands the possibilities for analysis, since the research can explore numerous possible scenarios for a country's future development.

A third important benefit of the System Dynamics methodology is the ability to identify areas where further research is required. To cite a few examples from this report, the simulation experiments demonstrated the importance of the extent and timing of past water table and salinity problems as a way to better understand the nature of effects on agricultural production to be expected during the next ten years. The expected costs of drainage programs for all of the land likely to be drained will have an important effect on both agriculture and industry, and warrant further study. Since Egypt's total population growth will have an important effect on the attainable level of nutrition, research into the government's intentions and capabilities for bith control and family planning would help determine how much of a future increase in agricultural production is necessary. By isolating such instances of a high payoff from further research, a System Dynamics study contributes to the most efficient use of analysis resources.

Finally, the System Dynamics methodology allows for an easy updating of study results as new information becomes available. The sponsor is planning further research into Egypt water resource issues that should improve the model's treatment of hydrologic processes. Any new information can be readily added to the simulation model. The experiments presented earlier in this report could be redone, and new experiments suggested by the additional research could be added. All of this could be assomplished at a fraction of the effort required for the original study, since the simulation process can quickly redo all the calculations necessary to derive projections from the new information. A small investment in a continuing review of developments in Egypt would be sufficient to keep the simulation model up-to-date for continuing use.

FOOTNOTES

[1] Area Handbook for Egypt, (hereafter referred to as AHE), page 66.

[2] AHE, page 1, 66, 13.

[3] AHE, page 13.

[4] John Waterbury, "Aish: Egypt's Growing Food Crisis", page 6.

[5] AHE, pages 65, 295, Waterbury, "The Opening, Part II," pages 10, 11.

[6] For an example of the inconsistencies in official data, see John Waterbury, "Aish", page 3.

[7] The basic references for System Dynamics are Jay W. Forrester's Industrial Dynamics and Alexander L. Pugh's DYNAMO User's Manual.

[8] Waterbury, "The Nile Stops at Aswan", page 6.

[9] Major Constraints, page 10.

[10] World Bank, "Egyptian Agriculture...", Tables 5 and 6.

[11] Waterbury discusses, without quantifying, "Innovations in the use of improved seeds, particularly in wheat, corn, and cottons." Aish, page 4.

[12] U.S. Census data.

[13] Peterson, D. W. Hypothesis, Estimation, and Validation of Dynamic Social Models (Ph.D. thesis, Department of Electrical Engineering, M.I.T. Cambridge, Mass.) June, 1975.

I. INTRODUCTION

This appendix describes a computer simulation model for the study of Egypt's economy and population described in "Water Resources in Egypt's Future." The model focuses on major water management issues, and their impact on Egypt's economy and population. It incorporates a wide body of descriptive and numerical data.

A computer simulation model is a collection of explicit assumptions regarding the determinants of a system's behavior. In this case, the "system" is the combination of economic and social forces which shape Egypt's development. For explanatory purposes, these assumptions can be divided into two categories.

The first category might be labeled the "what affects what", or structural, assumptions. This category contains the largely descriptive, qualitative set of explanations about which important forces interact directly to determine the course of a particular variable within the system. For example, we assume, for purposes of our study, that changes in Egypt's total population (a system variable) will be determined exclusively by internal birth and death rates. Migration in either direction across Egypt's national frontiers is assumed to have so negligible an influence on total population that it may be disregarded for our purposes.[1] Internal birth rates, in turn, are assumed to depend largely on income and consumption patterns, and on the extent of urbanization. These factors have an important influence on desired family sizes. And desired family sizes, together with the population's birth control practices, determine birth rates. The first of these causal factors are, themselves, system variables that will be determined by other forces within the computer model. The last, birth control practices, is used as input to the model that can be varied to reflect different assumptions about the population's adoption of modern methods.

Such structural assumptions define the causal framework of the computer simulation model. The descriptive and qualitative statements can be translated into mathematical equations that specify the relationships assumed. The process of specifying this first class of assumptions focusses the study on the most important forces determining Egypt's future development, thereby avoiding a dissipation of effort among countless possible areas for investigation.

The second category might be labeled the "how much is the effect", or parametric, assumptions. This category includes a large mass of numerical information that specifies the amount of effect one variable has on another. Turning to the earlier example of determinants of Egypt's birth rate, a parametric assumption for the effect of income on family size might be expressed in tabular or graphical form, as shown below. The numerical information can be incorporated in the simulation model to express the response of desired family size to a wide range of possible income levels.

Hypothetical Relationship Between Income and Desired Family Size

Annual Income (LE)	0	50	100	150	200	250	300
Desired No. of Children	4	4½	5	4½	3½	2½	2

The remainder of this report presents our preliminary structural and parametric assumptions concerning Egypt's future development. The assumptions are presented in two forms. The key assumptions are described first verbally, and then mathematically. The mathematical description is comprised of the equations of a computer simulation model. As already noted, the focus of the study — and, hence, the focus of this initial phase of work — concerns the role of water resources in Egypt. This focus has guided the research undertaken to identify important assumptions, and has shaped the network of interrelationships described in detail in succeeding chapters of this report.

Chapter II provides an overview of the interactions among Egypt's water resources, economy, and population, and describes the most important factors influencing the country's development. Chapter III describes the water sector of the Egyptian economy, Chapter IV describes the population sector, Chapter V discusses assumptions concerning agriculture, and Chapter VI describes industrial activity and foreign trade. Chapter VII reviews the model's resource allocation logic.

The Egypt simulation model is written in DYNAMO, a computer language and software package developed specifically for the simulation analysis used in this study. The basic references for DYNAMO are <u>The DYNAMO User's Manual</u>,[2] which describes the language and its conventions, and <u>Industrial Dynamics</u>,[3] which describes the fundamentals of system dynamics. A glossary is included in this appendix to explain the equation format and descriptive material used in this report. The glossary also lists several dozen model parameters that could be used to test different development strategies, and programs, or different assumptoins about the magnitudes of various parametric assumptions.

II. OVERVIEW OF SOCIAL AND ECONOMIC DEVELOPMENT

The role of water resources in Egypt's future can only be examined in the context of Egypt's overall social and economic development. The water sector's largest direct impact is on Egypt's agriculture, since the use of the Nile allows year-round cropping of land that would otherwise be barren. In addition, there are direct effects on the population (through the spread of disease and removal of human wastes) and on industry (through the supply of hydro-electric power and removal of industrial wastes).

Indirect impacts extend to the entire country. Export capability, for instance, will depend to some extent upon Egypt's agricultural production capacity, which, in turn, is directly influenced by water resources. Demographic trends, especially in the rural areas, will depend upon food production, which again is influenced by water resources. Even military strength is linked to water management, since the hard currency usually necessary to import military hardware requires a strong export base (with a link to the water sector that was just described).

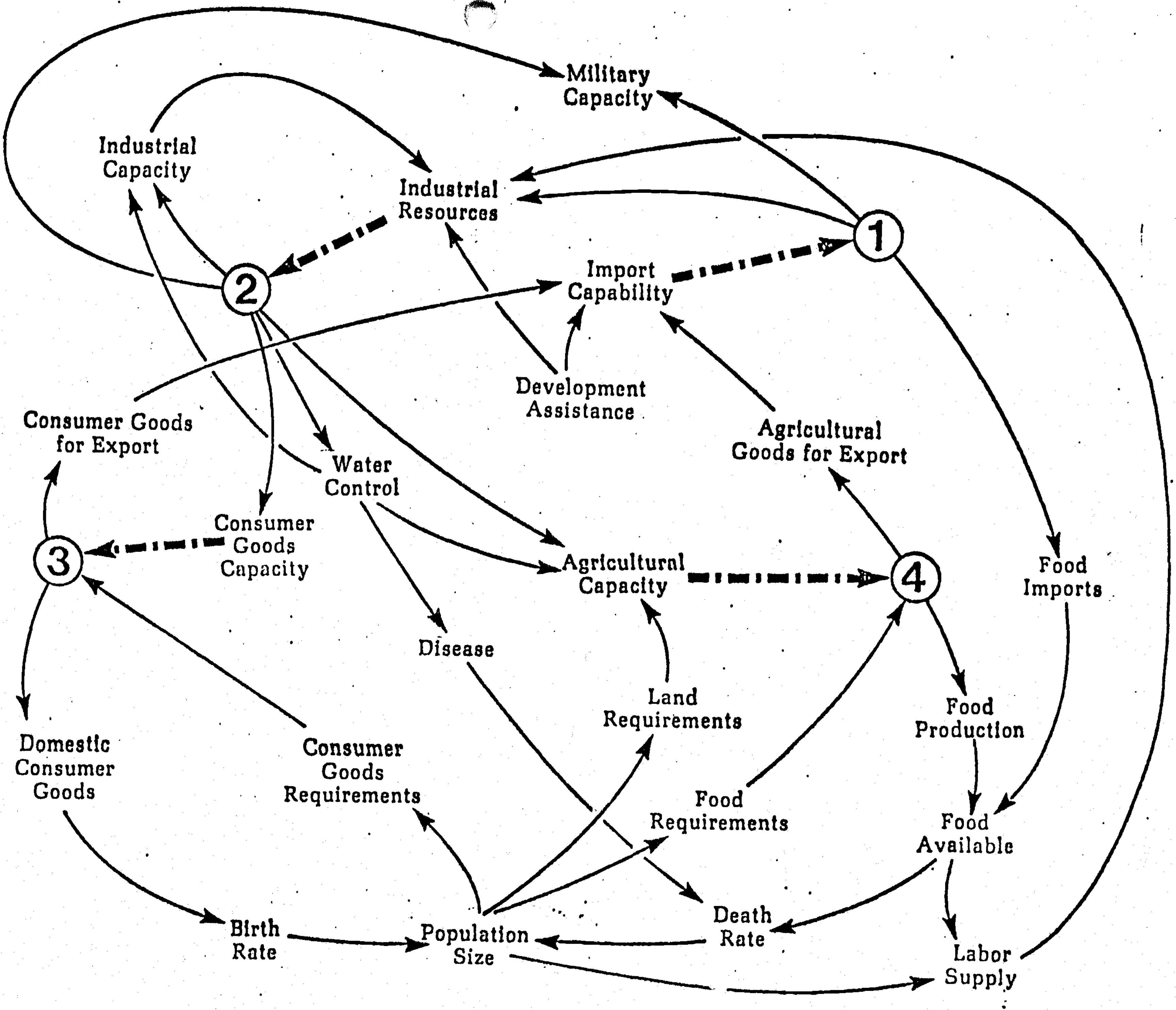
Any attempt to list every determinant of Egypt's social and economic development, and incorporate each of those determinants in a computer simulation model, would be an unmanageable task. The process of trimming down the enormous list of potential influences, while preserving the required accuracy and precision, is a major part of this study. The first step in that process is to define a conceptual "boundary" that encloses the most important of the determinants of Egypt's social and economic development. This involves the consideration and assessment of many factors, to discriminate between those which are essential to the issues being studied and those which are not. Variables "within the boundary", by definition, are explained causally inside the model. That is, the model represents such variables not as external inputs, but as explicit functions of other model variables. Items "outside the boundary" are represented as external inputs (unaffected by the behavior of the model), or are omitted altogether.

A few examples may clarify the logic of selecting the model's boundary. Many factors, such as the world price and supply of wheat, will have an impact on Egypt. But these impacts can be adequately represented as external inputs to the model, as they do not strongly depend on other model variables. For example, while the price and availability of wheat for import may have a tremendous impact on Egypt, developments in Egypt are unlikely to significantly affect the world price and availability of wheat.

Similarly, the commitment of the agricultural peasants (Fellahin) to their Islamic faith is undoubtedly a key determinant of birth rate trends. However, their religious commitment will probably not be affected in any major way by the economic variables represented in the model, at least over the 25-35 year time span of interest. Therefore, religious commitment will be incorporated implicitly into other assumptions about influences on the birth rate, with no explicit treatment in the model.

Our decisions about model boundary and important variables are diagrammed in Figure II-1. The relationships among water control (in the center of the diagram), agriculture, industry, and Egypt's population are all illustrated. The remainder of this section is devoted to a discussion of that network of relationships, and the way those relationships interact to determine Egypt's future.

A recurring feature of the Egyptian economic and social system is the importance of resource allocation decisions. Differing policies for resource allocation can create a wide range of scenarios for Egypt. Some of these



The Role of Resource Allocation in Egypt's Economic Development resource allocation decisions will be dictated by immediate needs, such as food production to meet consumption requirements or the possible production of manufactured goods for export to meet import needs. Others of the resource allocation decisions represent more of a choice among options for the shape of Egypt's development. In this category would be included the division of industrial resources among the economic sectors competing for capital investment.

Figure II-1 uses numbered circles to identify the four most important resource allocation decisions within Egypt. The resources to be allocated are 1) import capability, 2) industrial resources, 3) consumer goods capacity, and 4) agricultural capacity. Each of these are discussed in turn below.

In our treatment of the Egyptian economic and social system, the country's import capability depends on the availability of foreign exchange to finance purchases from abroad. Egypt acquires foreign exchange in part by exporting agricultural goods (cotton, fruits, and vegetables) and manufactured consumer goods.[1] In addition, Egypt's import capability derives from development assistance and other financing tendered by Western countries, by the Soviet Union, and by Arab countries. Further sources of revenue include tourism, the Suez Canal, remittances from workers abroad, and oil.[2]

Figure II-1 distinguishes five major uses for the import capability generated by exports, transfers, and development assistance—industrial resources (machinery, farm equipment, materials, etc.), consumer goods, food, military equipment, and debt service. The different uses have different implications for Egypt's economic and social development. The allocation of import capability to industrial resources represents a long-term investment in Egypt's future growth, potentially raising the production of a number of sectors of the economy. Food imports, in contrast, address a perceived short-term need to raise the food consumption of the country's urban population.[3] The contribution of food imports to economic development is less direct than the contribution of industrial resources, and derives largely from: 1) their effect on the productivity of the labor force; and 2) their role in avoiding desparate, highly inefficient attempts to boost short-term agricultural output. Imports of military goods make no direct contribution to the country's industrial development, and represent a drain on foreign exchange resources.

Allocation decisions for import capability, then, have a direct impact on Egypt's economic development. If the government is able or willing to devote foreign exchange to industrial resources, then imports become a direct source of industrial growth. If Egypt's foreign exchange reserves are instead used to import food, consumer goods, or weapons, then industrial growth must come from some other quarter.

Industrial resources are, like imports, a potential source of growth, depending upon their allocation among the competing needs of different sectors of the economy. Industrial resources are represented in the model by a number of different factors. The population makes a contribution to industrial resources through its participation in the labor force. Other industrial resources are available from external sources, including imports of industrial materials (as described earlier) financed by industrial investment or assistance from other countries.[4] Finally, Egypt's industrial capacity -- energy production, transportation, and capital goods production -- represents another major industrial resource.

Egypt has a wide range of choices for allocating industrial resources. Figure II-1 diagrams the most important options: military capacity (e.g., tanks, aircraft, and soldiers), agricultural capacity (e.g., tractors and farmers), water control (e.g., irrigation and drainage facilities), consumer goods capacity (e.g., factories and industrial workers), and industrial capacity itself (e.g., construction equipment, power generating facilities, and industrial workers). Allocation of industrial resources to industrial capacity substitutes an investment in future growth for immediate gains in economic sectors that satisfy consumption requirements. Investment in water control projects may also contribute to industrial growth by increasing Egypt's hydro-electric capacity, or it may join with agricultural investments to increase agricultural capacity. As will be described shortly, improvements in consumer goods capacity may immediately stimulate industry if the sector produces for export (thereby facilitating increased capital goods imports), or contribute little in the short run to industrial growth if the sector's output is allocated to domestic consumption. Once again, allocation of industrial resources to military capacity represents a drain on the rest of the economy.

The third allocation decision diagrammed in Figure II-1 concerns the division of consumer goods capacity between production for export and production for domestic consumption. The resulting influences on the balance of the economy are indirect, but quite important. Production of consumer goods for exports, or to substitute for imported consumer-goods, can meet a short-term need for foreign exchange to finance a variety of imports. Production and importation of consumer goods for domestic consumption have longer-term implications, since the resulting gains in standard of living may play an important role in reducing Egypt's birth rate. Over the course of many years, the resulting differences in the size of the population could dramatically affect requirements for food and consumer goods production, and determine whether Egypt can ever achieve self-sufficiency.[5]

Given the complicated and indirect consequences of consumer goods allocation decisions, no <u>a priori</u> judgment can be made of whether production for internal use or export best serves Egypt's long-term interests. This uncertainty is a useful illustration of the important role the computer simulation model will play in understanding the consequences of alternative resource allocation policies.

The fourth allocation decision diagrammed in Figure II-1 involves the division of agricultural capacity between food grown for domestic consumption and food and fibers grown primarily for export. Agricultural resources include labor and machinery from the industrial sector, water, fertilizer, and land area itself. The allocation of these resources responds to the internal requirements of the country, as well as to government policy decisions.

As with consumer goods, the consequences of agricultural allocation decisions for economic growth are indirect, but quite important. A self-sufficiency strategy, for example, would place the highest priority on meeting food needs internally. In the short term, this strategy might meet the food needs of the population and provide a well-nourished, productive labor force. Longer term, such a strategy might limit the Egyptians' options if continued population growth strains the country's domestic food capacity. Once again, the project's simulation model should help evaluate the consequences of alternative strategies.

This chapter's overview of the "system" determining Egypt's economic and social development provides a useful context for considering the role of the water sector. The resources available to develop the country's water sector, and the demands placed upon the water sector, depend upon the interaction of the major forces diagrammed in Figure II-1. Industrialization strategies may limit the resources available to develop the water sector, stalling further improvements in drainage and irrigation that may be necessary to raise agricultural capacity. Agricultural development strategies may require parallel efforts to develop water resources. Population trends will directly affect consumption and use of the Nile river, and indirectly affect the water sector through requirements for consumer goods and agricultural production. Succeeding chapters of this report treat each major sector of the Egyptian population/economic/water "system" individually.

III. WATER

The water sector of the Egypt model is the focus of this study and occupies a central position among the economic and demographic sectors. The water sector has been developed to support the analysis of a wide range of issues pertinent to Egypt's future growth. Among these issues are the adequacy of available water, salinity, water-logging, drainage and irrigation. Figure III-1 summarizes the role of water resources in the development of Egypt's population and economy, and establishes the point of view for the water sector's design.

There are five key outputs from the water sector. First, water (from the Nile or from wells) is required to irrigate Egypt's agricultural lands. Soil moisture must be maintained within a tolerable range for successful agriculture. Too little water will result in dry soil and wilted plants; too much can lead to water-logging and plant disease. Second, the water sector affects the fertility of the soil. Too little water, inadequate to leach salts, leaves salt in the root zone; too much water can also concentrate salt in the soil, through water-logging and surface evaporation. Third, proper amounts and treatment of water are required to maintain public health. The water sector affects public health not only through the availability of water for domestic use, but also through schistosomiasis and other water-borne diseases. Fourth, the Nile serves as a convenient means of transportation. Finally, the water sector of Egypt is an important source of energy, in the form of hydroelectricity.

To achieve and maintain its benefits, the water sector requires three key inputs. First, capital investment is required in the form of dams, barrages, canals, pumps, generating equipment, piping, drilling rigs, drain tiles, and valves. Second, energy is required to operate much of the equipment.

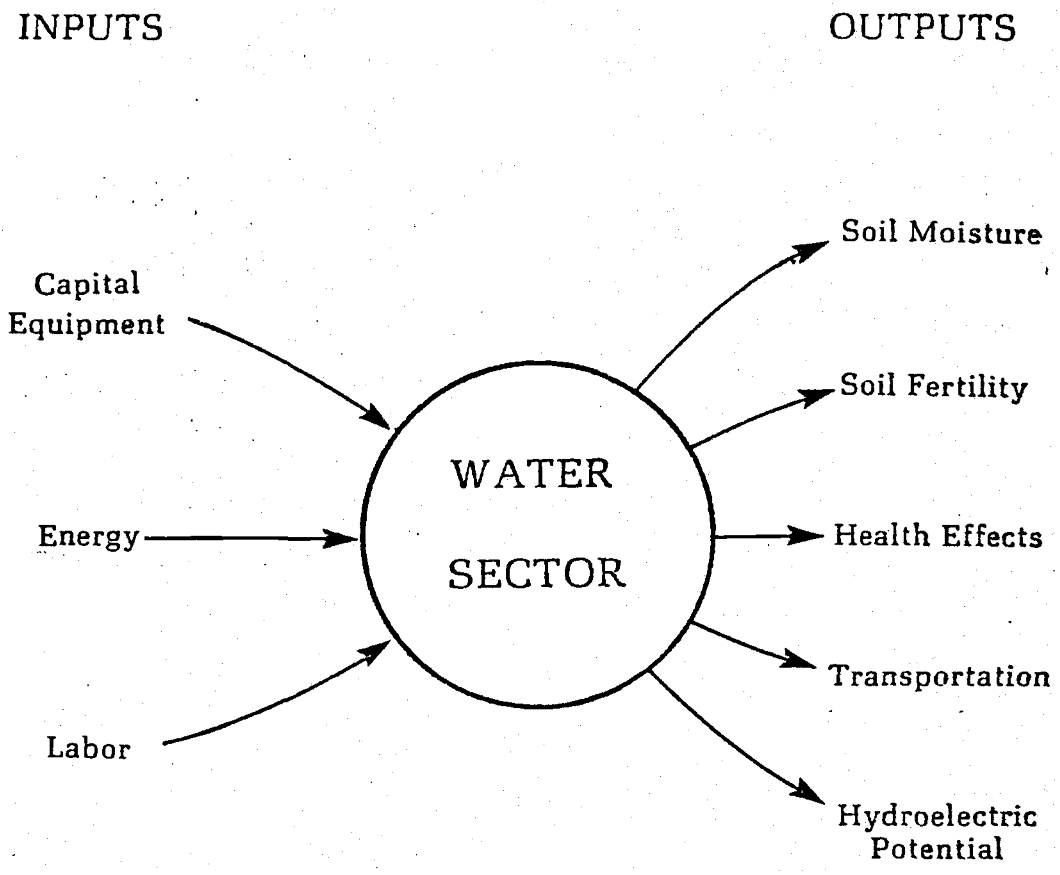


Figure III-1: The Role of the Water Sector

Even though the water sector itself might be the ultimate source of its own energy, the requirements of the water sector detract from what is available for use elsewhere in the economy. Finally, the water sector requires human labor for the maintenance and operation of irrigation and drainage facilities.

A discussion of the model's water sector divides naturally into two parts. The first concerns the flows of water itself, including the accumulation of water in Lake Nasser, the flows of water through the Nile River and associated irrigation facilities, and the build-up of phreatic water beneath farmlands. These subjects are discussed in Section III-A. The second issue concerns time flows of dissolved precipitated salts that accompany the water flows. These important salt issues are discussed in Section III-B.

III-A. THE HYDROLOGY OF EGYPT

The inputs and outputs of the water sector discussed above are linked by the interaction of water with the physical, chemical, and meteorological conditions of Egypt. Figure III-2 shows the basic flows of water in the Nile valley. The cross-section of the Nile Valley shown in Figure III-2 is based on the actual cross-section at Luxor,[1] but the basic shape is characteristic of much of the Nile north of Aswan. The flood plain at the bottom of the valley is about 15 km. wide; the valley is about 200 meters deep (Figure III-2 is drawn with an exaggerated vertical scale, for clarity). The entire Nile Valley in Egypt is, on the average, quite flat, sloping very gently downhill away from the river and toward the Delta to the north. Between Aswan and the Mediterranean, the Nile drops an average of only one meter for each 12,000 meters length.[2]

The flood plain is generally composed of alluvial deposits of sand, gravel and clay, often in distinct layers of different porosity and permeability. The permeable layers formed by the alluvial deposits are bounded below by less permeable basement rock.[3] The permeable layers form a groundwater aquifer which underlies the Nile Valley and Delta to a depth of about 300 meters.[4] The aquifer between Aswan and the Delta has a capacity of about 500 billion cubic meters; the Nile Delta aquifer has a capacity of about 500 billion cubic meters.[5] In addition, an extensive aquifer underlines the Western Desert, with an estimated capacity of 78,000 billion cubic meters.[6] This aquifer is a potential source of water for the New Valley project.

In general, the porous layer underlying the agricultural regions is divided into two zones, according to the amount of water in the aquifer and its movement. Near the surface is the zone of aeration, in which the

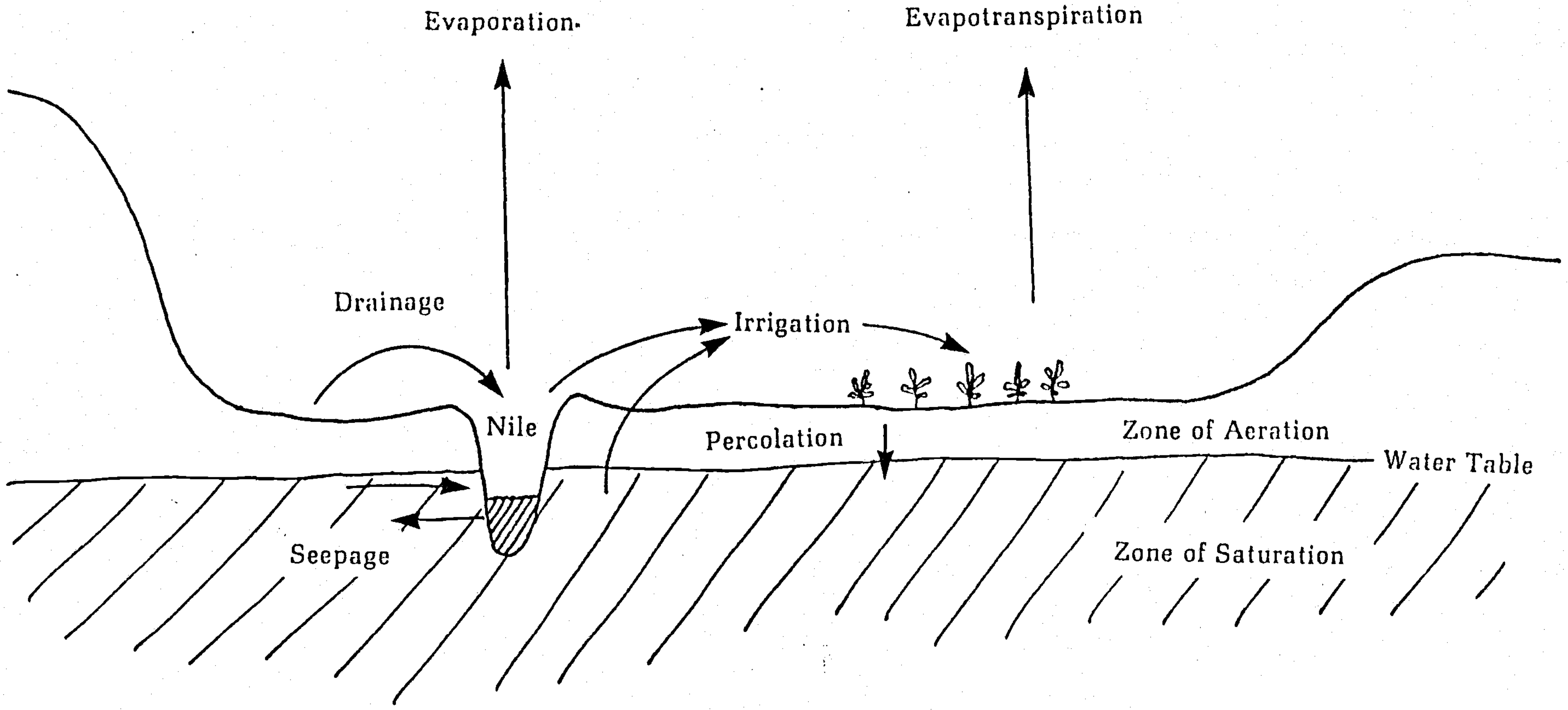


Figure III-2: The Hydrology of Egypt spaces between soil and rock particles are filled with air or with mixtures of air and water bound to the soil by capillary forces. Below the zone of aeration lies the zone of saturation, in which the spaces in the soil and rock are filled completely with water. The surface which divides the two zones is called the water table. The total water in the zones of aeration and saturation, and the water at the surface are collectively defined here as the phreatic water.[7]

The moisture content of the soil is determined by the quantities of Nile water and phreatic water, and the flows associated with them. Water may be diverted from the Nile, or pumped from the phreatic layers, and applied to the surface for the irrigation of crops. Of the water so applied, some evaporates from the surface, some is absorbed by plants, and the rest remains in the soil, percolating toward the zone of saturation. The water taken up by plants is for the most part transpired into the atmosphere. The combination of surface evaporation and plant transpiration is called evapotranspiration.

The control of the Nile, culminating in the High Dam, has led to an increasing reliance on perennial irrigation. Perennial irrigation, first begun over a century ago, now has completely replaced other forms of irrigation north of Aswan. The resulting frequent and year-around diversion of Nile water onto the surface of the Nile Valley has led to an increase in the amount of phreatic water and a corresponding rise in the water table. A high water table causes "water-logging" of the agricultural lands, with the zone of saturation encompassing much of the root zone of the crops growing in the valley. The water-saturated soil damages the plants both directly and indirectly (through side effects such as parasites that thrive in the wet environment and the concentration of salt through surface evaporation). Therefore, where the natural seepage flows do not adequately drain the agricultural land, drainage systems and pumps must be introduced, creating a controlled flow of water through the root zone. Most of the drainage water is discharged into the Nile, the lakes bordering on the Mediterranean, or the Mediterranean itself.

Where the surface water (primarily the Nile) is above the zone of saturation, water seeps horizontally and downward into the phreatic zones. When the surface water is below the water table, a reverse seepage occurs. In the region surrounding Lake Nasser, the direction of seepage is primarily from the lake into the aquifer. In the Nile downstream from Aswan, the river level is low, and seepage from the phreatic water into the Nile predominates.

In addition to the vertical and cross-sectional flows described above, there are important longitudinal flows of water along the Nile Valley both at the surface and underground. The surface flow is limited primarily to the Nile itself and adjoining canals. It is relatively fast and easy to measure. A second longitudinal flow occurs within the phreatic water, which slowly flows underground toward the Mediterranean and the lakes near the northern coast. The ground water under the Western Desert also flows slowly to the North.

III-B. SALINITY OF SOIL AND WATER

Associated with the flows of water are corresponding flows of salt and suspended solids. At present, rising concentrations of salt in agricultural soil are a serious problem, even though the salt concentration in the Nile itself is low, and the concentration of salt in well water is tolerable. Several mechanisms operate to concentrate the salt in the root zone of the crops growing in the Nile Valley. Surface evaporation removes water from the root zone, but leaves behind salt. Similarly, the plant roots themselves remove water from the root zone, and leave most of the salt. This salt will not present a problem if the water table is sufficiently low, so the accumulated salt can be leached from the root zone by the application of excess water. However, if the water table is high, irrigation water remains near the surface. In the short term, the new water dilutes the salt while leaving it in place in the root zone. Over a longer time span the irrigation water evaporates, adding its own salt to the salt already in the soil. As a result, the concentration of salt in the root zone is even higher than before.

III-C. STRUCTURE OF THE WATER SECTOR OF THE MODEL

The dominant impacts of water on Egypt's population and economy are associated with the basic processes described above: Nile flow, irrigation from the Nile, irrigation by pumping, seepage, drainage, evapotranspiration, percolation, water-table height, and salinity. These processes may be represented in a simulation model with almost any degree of detail desired.

For example, one might create a very detailed model which computes the water table and salinity conditions separately for each feddan of land in Egypt. If the data were available to create such a model, it could be a very accurate representation of Egypt's water table. On the other hand, such a model would be prohibitively large and expensive. More importantly, a very detailed picture of the water table would provide little insight into the broad strategic issues addressed by this study.

It has been important, therefore, to choose the perspective of the simulation model and its level of detail according to its intended purpose. In this study, we are concerned not with detailed variations in water table height or soil conditions, but more with the overall average conditions in Egypt's water system, as they affect the aggregate efficiency of the agricultural and industrial sectors. Therefore, we conceptualized the model to address the basic processes listed above at about the same level of detail with which they have been discussed.

Specifically, the water sector represents changes in average annual flows, rather than seasonal or shorter variations. The annual perspective is consistent with the level of detail of the population and economic portions of the model. The model focuses, for example, on the average water table over a large region and the degree of water-logging, rather than specifying which particular parcels of land are wet and which are dry.

The major components of the water sector are summarized in Figure III-3. Three important categories of water are represented. First, the amount of water in Lake Nasser is represented by the box in the upper left of the figure. The distribution of water via the Nile is shown in the lower left. Finally, the water in and below agricultural land, collectively referred to as "phreatic water", is represented in the right side of Figure III-3. The three categories of water are linked by flows of water, represented by solid arrows. Dashed arrows represent additional constraints and influences on water flows.

As shown in Figure III-3, the water sector concentrates on the overall interactions of water in Lake Nasser, water in the Nile, and water in the soil, taken as aggregate wholes. Water in Lake Nasser is augmented by the natural, uncontrolled flow from the upper Nile ("Source Flow", in the figure), and depleted by three major outflows. Two of these outflows -- seepage and evaporation -- are natural, uncontrolled processes; the third (the flow of water released into the Nile) is almost completely controlled by the High Dam at Aswan. The flow into the Nile is governed by two major considerations, represented by dashed arrows at the left of Figure III-3. First, water is released to maintain the Nile flow used downstream for agricultural and human use; second, additional water may be released to generate hydroelectricity.

Two major sources of water contribute to the flow of the Nile: water released from Lake Nasser and water pumped from agricultural drainage. (Under some conditions, seepage through the banks of the Nile may also contribute.) The bulk of the Nile flow is removed in a controlled manner, for

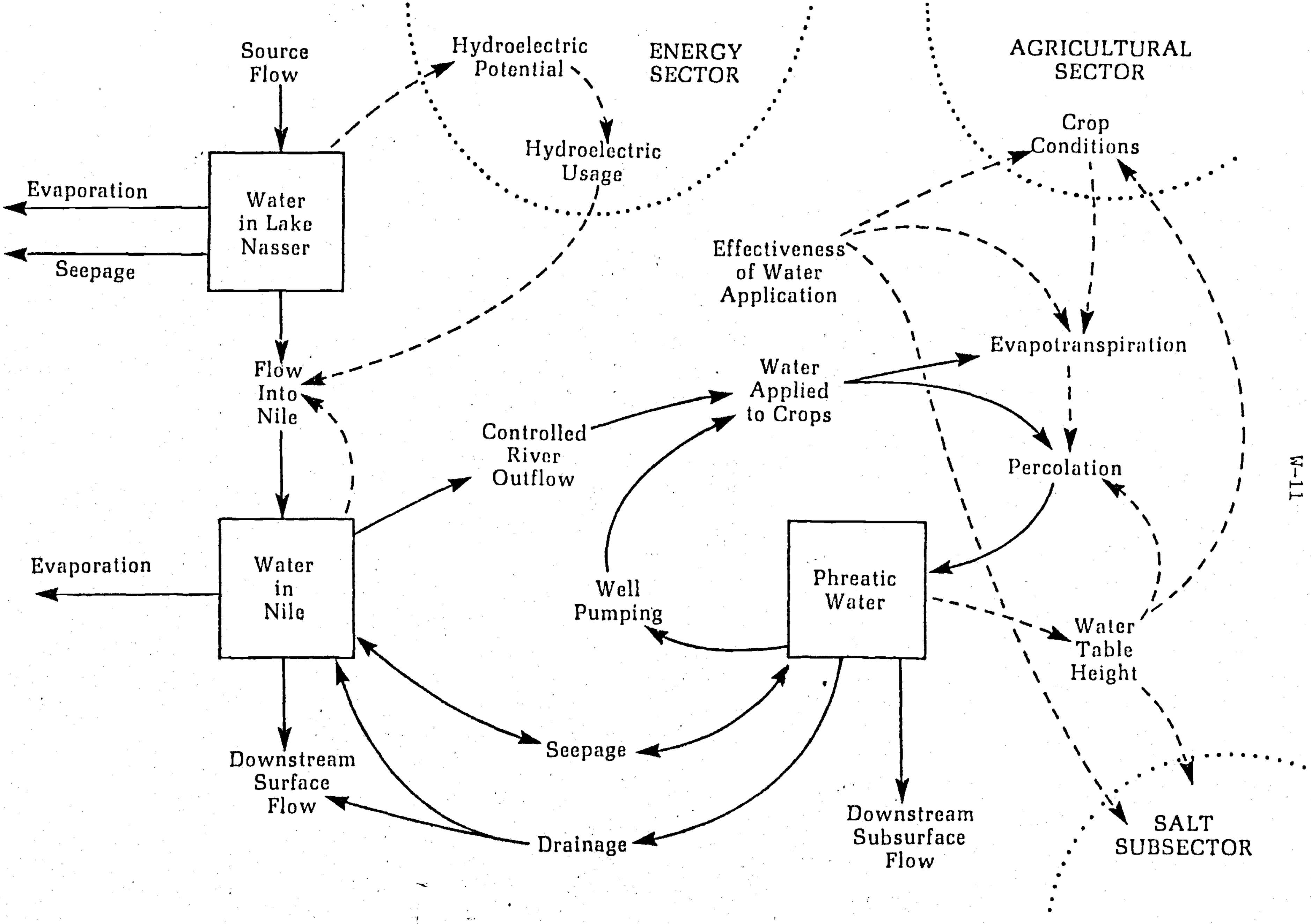


Figure III-3: The Water Sector of the Model use in agriculture, industry, and homes. In addition, water is removed from the Nile by evaporation, and released "downstream" into the Mediterranean Sea.

The right-hand side of Figure III-3 shows the fate of water applied to crops, and other influences on ground and surface water. Much of the water applied to the surface either evaporates directly into the air, or indirectly (transpiration) through uptake by plants. The remaining water, except for surface runoff, becomes, by definition, phreatic water. Phreatic water may be removed naturally, by underground flow and seepage, or by human intervention in the form of surface drainage and ground-water pumping. The quantity of phreatic water determines the height of the water table (see the right-hand side of Figure III-3). The water table, in turn, has important implications for soil salinity and waterlogging, as indicated by links to the salt subsector and agricultural sector shown in the Figure.[8]

III-D. EQUATIONS OF THE WATER SECTOR

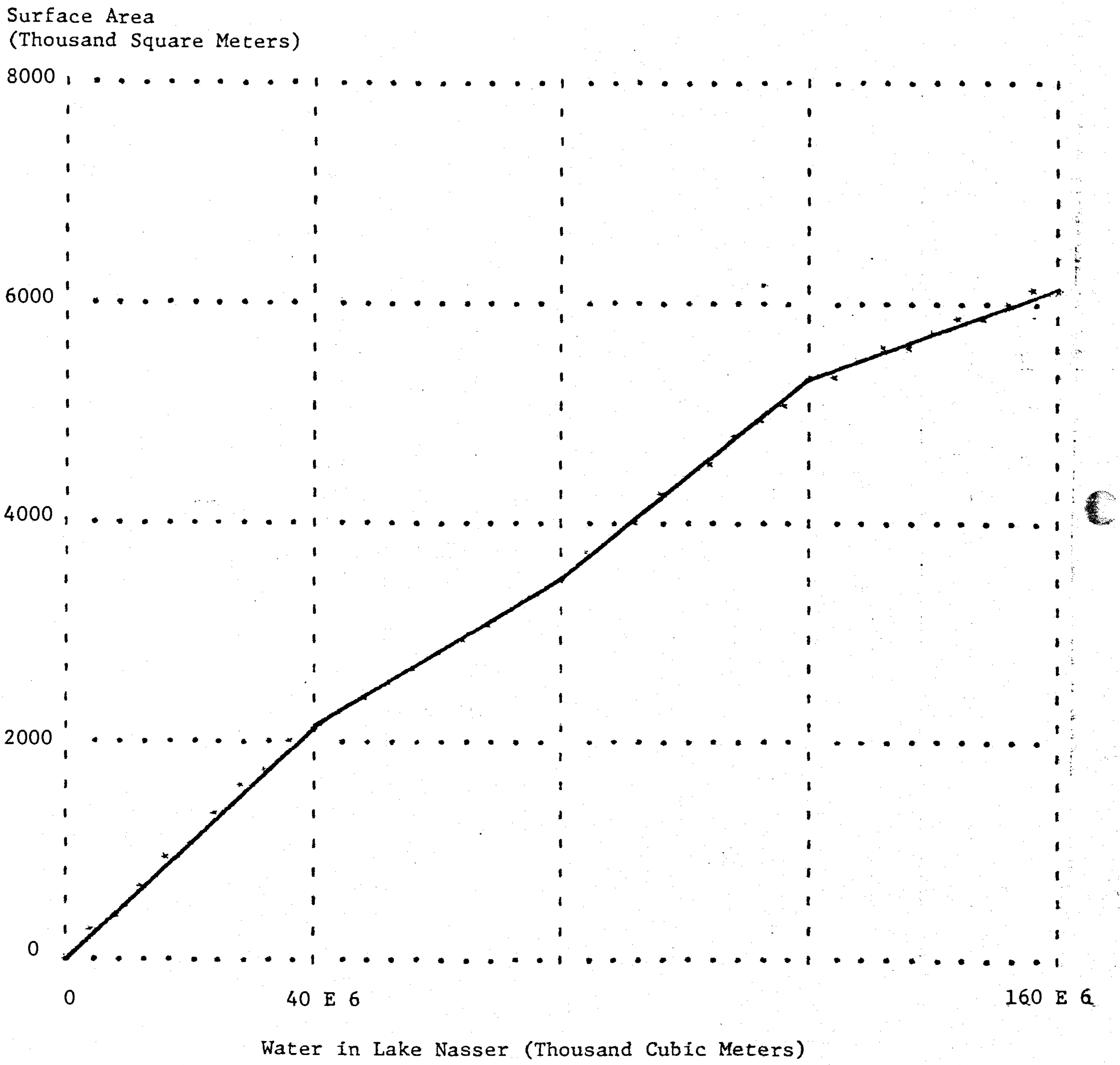
The preceding discussion addressed the overall conceptual basis of the Egypt model's water sector. The following paragraphs describe the detailed structure of the water sector. The sector is divided into eight subsectors: Lake Nasser, Controlled Release of Water at the High Dam, Requests for Water, Distribution of Water for Agriculture, Hydroelectric Power, Phreatic Water, Drainage, and Salinity.

At the end of the description of each subsector are listed the equations which define the model. The model equations described in this and subsequent chapters are written according to the convention of the DYNAMO computer simulation langauge. This language was especially developed for simulating complex social and economic systems.

Lake Nasser Subsector -- The amount of water in Lake Nasser (WLN) is affected by one inflow and four outflows. The flow into Lake Nasser (WFILN) is exogenous to the model, based on past data through 1976, and assuming a future average flow of 84 billion cubic meters per year.[9] Alternative future trends in the annual Nile source flows may also be represented (WASB), including weather changes, higher Sudanese requirements for Nile water, or upstream conservation projects.

The amount of water in Lake Nasser (WLN) largely determines seepage losses from the reservoir (WLNS). The annual fraction of the water lost by seepage (WAFSLN) is taken as five percent,[10] with a gradual reduction to three percent as deposits of silt block the pores in the lake bed. The amount of water also determines the surface area of the lake (WSALN), which in turn affects the rate of evaporation loss (WLNE). The surface area is determined by the amount of water in Lake Nasser, as shown in Figure III-4[11] Implicit

Figure III-4:
Surface Area of Lake Nasser



in the figure is the shape of the bottom of Lake Nasser. The rapid rise in surface area for small amounts of water is due to the relatively flat bottom of the Nile Valley south of Aswan. Further additions of water add less surface area as the edges of the lake encounter the steeper sides of the Valley. Sunshine and winds may also effect the rate of evaporation; such additional effects are incorporated in the exogenous average potential evaporation (WAPE). The net average evaporation from the lake is taken as 2.7 meters per year.[12]

The remaining outflows from Lake Nasser represent the flow of water in the Nile downstream from Aswan. The controlled release of water from Lake Nasser (WCRLN) represents the intentional release of water through the High Dam to satisfy the water requirements of agriculture, hydroelectric generation, industry, and households. This controlled release is discussed in the next section. The forced release of water from Lake Nasser (WFRLN) represents the spillover or release of water past the High Dam due to the limited reservoir capacity.

The forced release includes three possible conditions. First, before the High Dam is built, all flow past Aswan is defined to be "forced". Second, as the water in the reservoir approaches its capacity, water must be released to maintain a flood-control margin of reservoir capacity. Finally, should the reservoir for some reason actually become full, then spillover (or forced release to avoid spillover) may occur. All three cases are approximated in the model by considering the potential net inflow to Lake Nasser (WNILN), which is the excess (if any) of the net natural inflow to the lake (WNNIL) over the controlled release from Lake Nasser (WCRLN). The excess (WNILN) will cause an increase in the water in Lake Nasser or a spillover, depending on whether the reservoir is full. To avoid overfilling of the reservoir, therefore, some fraction of the net inflow (WNILN) is released if the lake is nearing its drained capacity. Figure III-5 shows the assumed relationship. If the lake is full, all of the potential net inflow is released; if the lake is at 60% or less of its capacity, no forced release occurs.

The capacity of Lake Nasser (WCLN) is determined, as a function of time, by the stage of completion of the High Dam. The model represents the capacity starting at zero in 1964, and rising to 162 billion cubic meters[13] by 1974 (See Figure III-6). Before the High Dam, the capacity of Lake Nasser is zero, as is the amount of water in Lake Nasser. Therefore, there is no "unused capacity" (WFCLU) in which to accumulate water, so all inflow is considered to be forced release (WFRLN), with no controlled release (WCRLN). As the capacity of the lake increases, the Nile flow becomes dominated by the controlled release, and forced release occurs only in extraordinary conditions.

Figure III-5: Control of Lake Nasser Reserves

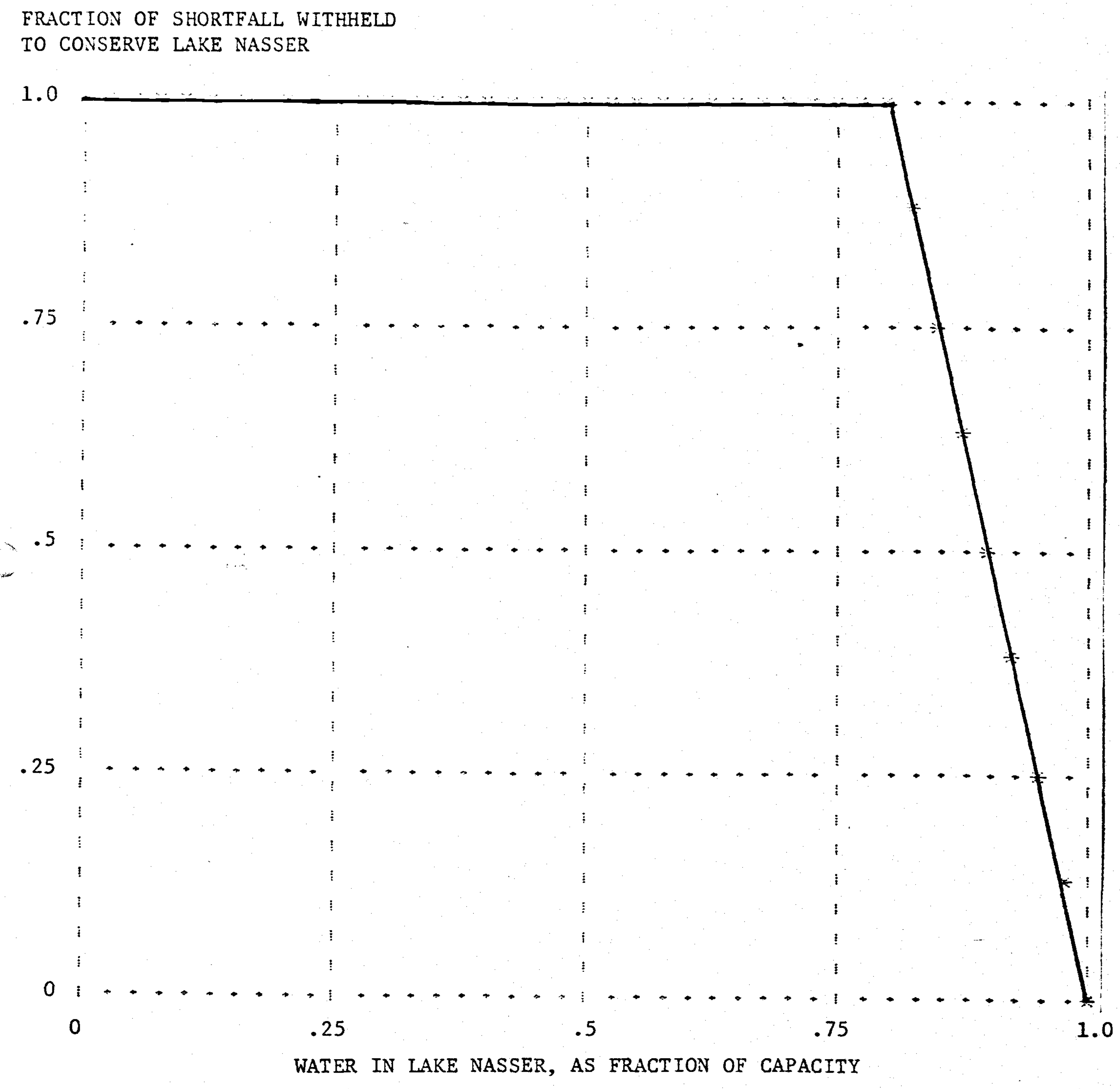
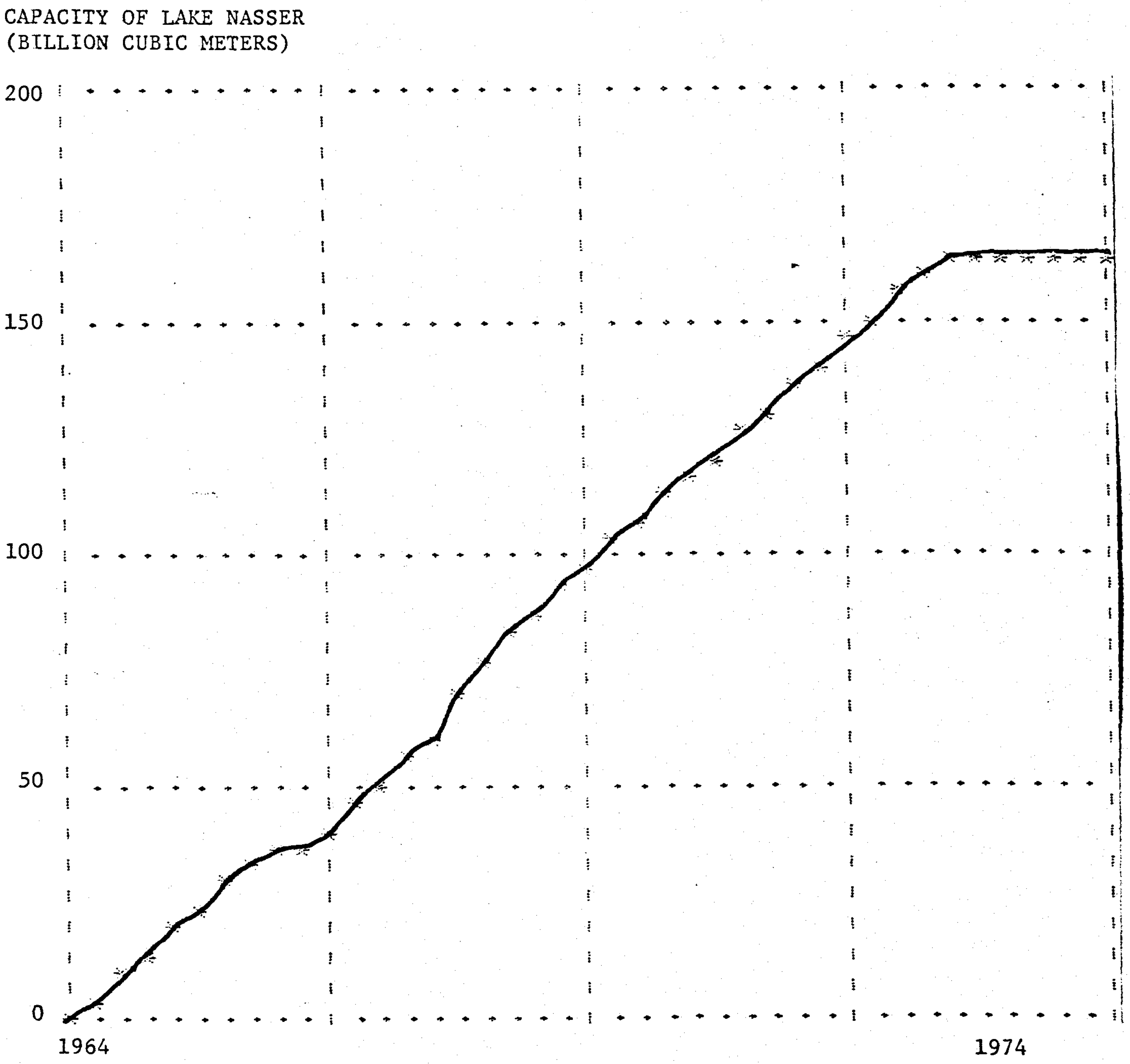


FIGURE III-6



DATE

```
   LAKE NASSER

WLN.K=WLN.J+DT*(WNNIL.J-WFRLN.J-WCRLN.J)                    1, L
WLN=0                                                       1.1, N
    WLN     - WATER IN LAKE NASSER (KCM) <1.1>
    WNNIL   - NET NATURAL INFLOW TO LAKE NASSER (KCM/YR)
                <2>
    WFRLN   - FORCED RELEASE FROM LAKE NASSER (KCM/YR)
                <3>
    WCRLN   - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
                YR) <14>

WNNIL.K=WFILN.K-WLNS.K-WLNE.K                               2, A
    WNNIL   - NET NATURAL INFLOW TO LAKE NASSER (KCM/YR)
                <2>
    WFILN   - FLOW INTO LAKE NASSER (KCM/YR) <3>
    WLNS    - SEEPAGE FROM LAKE NASSER (KCM/YR) <5>
    WLNE    - LAKE NASSER EVAPORATION (KCM/YR) <7>

WFILN.K=SAMPLE(TABHL(WFILNT,TIME.K,1960,1980,1),1,          3, A
  78.5)*1E6+FIFGE(0,WASB,1980,TIME.K)
WFILNT=78.5/99.3/88.3/85.1/110.6/86.1/71.5/92.7/            3.3, T
  74.1/74.8/79.2/82.1/57.3/69.0/87.2/99.6/84/84/84/
  84/84
WASB=0                                                      3.9, C
    WFILN   - FLOW INTO LAKE NASSER (KCM/YR) <3>
    WFILNT  - TABLE FOR FLOW INTO LAKE NASSER (KCM/YR)
                <3.3>
    WASB    - ADDITIONAL WATER FROM SWAMP BYPASS (KCM/YR)
                <3.9>

WLNS.K=WLN.K*WAFSLN.K                                       5, A
    WLNS    - SEEPAGE FROM LAKE NASSER (KCM/YR) <5>
    WLN     - WATER IN LAKE NASSER (KCM) <1.1>
    WAFSLN  - ANNUAL FRACTION OF WATER SEEPING FROM LAKE
                NASSER <6>

WAFSLN.K=TABHL(WAFSLNT,TIME.K,1960,2010,10)                 6, A
WAFSLNT=.05/.05/.04/.03/.03/.03                             6.2, T
    WAFSLN  - ANNUAL FRACTION OF WATER SEEPING FROM LAKE
                NASSER <6>
    WAFSLNT- TABLE FOR FRACTION OF WATER SEEPING FROM
                LAKE NASSER <6.2>

WLNE.K=WSALN.K*WAPE*WFEOW                                   7, A
WAPE=2.7 M/YR                                               7.2, C
WFEOW=.7                                                    7.4, C
    WLNE    - LAKE NASSER EVAPORATION (KCM/YR) <7>
    WSALN   - SURFACE AREA OF LAKE NASSER (KSM) <8>
    WAPE    - AVERAGE POTENTIAL EVAPORATION <7.2>
    WFEOW   - FRACTION OF MAXIMUM EVAPORATION EXPERIENCED
                OVER OPEN WATER <7.4>
```

```
PAGE 3        WATER SECTOR     4/05/78


WSALN.K=TABLE(WSALNT,WLN.K,0,16E6,40E6)                      8, A
WSALNT=0/2.2E6/3.5E6/5.3E6/6.2E6                             8.2, T
    WSALN  - SURFACE AREA OF LAKE NASSER (KSM) <8>
    WSALNT - TABLE FOR SURFACE AREA OF LAKE NASSER (KSM)
               <8.2>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>

WFRLN.K=WNILN.K+WFNIR.K+MAX(0,(WLN.K-WCLN.K)/DT)           9, A
    WFRLN  - FORCED RELEASE FROM LAKE NASSER (KCM/YR)
               <9>
    WNILN  - NET INFLOW TO LAKE NASSER (KCM/YR) <10>
    WFNIR  - FRACTION OF NATURAL INFLOW RELEASED FROM
               LAKE NASSER <11>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>
    WCLN   - CAPACITY OF LAKE NASSER (KCM) <13>

WNILN.K=MAX(0,WNNIL.K-WCRLN.K)                               10, A
    WNILN  - NET INFLOW TO LAKE NASSER (KCM/YR) <10>
    WNNIL  - NET NATURAL INFLOW TO LAKE NASSER (KCM/YR)
               <2>
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
               YR) <14>

WFNIR.K=TABHL(WFNIRT,WFLCU.K,0,.4,.1)                        11, A
WFNIRT=1/.75/.5/.25/0                                        11.2, T
    WFNIR  - FRACTION OF NATURAL INFLOW RELEASED FROM
               LAKE NASSER <11>
    WFNIRT - TABLE FOR FRACTION OF NATURAL INFLOW
               RELEASED FROM LAKE NASSER <11.2>
    WFLCU  - FRACTION OF LAKE NASSER CAPACITY UNUSED
               <12>

WFLCU.K=(WCLN.K-WLN.K)/POS(WCLN.K)                           12, A
    WFLCU  - FRACTION OF LAKE NASSER CAPACITY UNUSED
               <12>
    WCLN   - CAPACITY OF LAKE NASSER (KCM) <13>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>

WCLN.K=TABHL(WCLNT,TIME.K,1964,1980,1)*WCLNC                 13, A
WCLNC=162E6                                                  13.2, C
WCLNT=0/.1/.2/.25/.35/.5/.6/.7/.8/.9/1/1/1/1/1/1/1           13.4, T
    WCLN   - CAPACITY OF LAKE NASSER (KCM) <13>
    WCLNT  - TABLE FOR CAPACITY OF LAKE NASSER <13.4>
    WCLNC  - CAPACITY OF LAKE NASSER <13.2>
```

Controlled Release from Lake Nasser -- The controlled release of water from Lake Nasser (WCRLN) represents the intentional flow of water past the High Dam to meet agricultural, domestic-industrial, and hydroelectric requirements for water. These three components determine the total requested controlled release (WRCR). If the availability of water from Lake Nasser (WALN) is adequate, then all of the requested water is released for use downstream.

The availability of water from Lake Nasser is determined by two considerations. First, the requested release will be made if the current annual net inflow (WNNIL) is sufficient to meet the downstream request. Second, if the request cannot be met by the current flow, then it may be met by drawing down Lake Nasser. The extent to which the reservoir is depleted to meet current requests depends on the amount of water in the reservoir (WLN). If the lake is full, then all of the shortfall is met by lowering the lake. If the lake is less then 80% full, then the water is conserved to maintain the lake itself, and the controlled release is determined by the net natural inflow.

```
   CONTROLLED RELEASE FROM LAKE NASSER

WCRLN.K=WRCR.K*WALN.K*FIFGE(0,1,0,WCLN.K)                14, A
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
                YR) <14>
    WRCR   - REQUESTED CONTROLLED RELEASE FROM LAKE
                NASSER (KCM/YR) <16>
    WALN   - AVAILABILITY OF WATER FROM LAKE NASSER <15>
    WCLN   - CAPACITY OF LAKE NASSER (KCM) <13>

                                                         15, A
WALN.K=1-WFSIF.K*WFSUR.K
    WALN   - AVAILABILITY OF WATER FROM LAKE NASSER <15>
    WFSIF  - POTENTIAL FRACTIONAL SHORTFALL DUE TO
                INSUFFICIENT FLOW <18>
    WFSUR  - FRACTION OF SHORTFALL UNMET BY LAKE NASSER
                RESERVES <19>

WFSIF.K=TABHL(WFSIFT,WNNIL.K/POS(WRCR.K),0,2,1)          18, A
WFSIFT=1/0/0                                             18.3, T
    WFSIF  - POTENTIAL FRACTIONAL SHORTFALL DUE TO
                INSUFFICIENT FLOW <18>
    WFSIFT - TABLE FOR FRACTIONAL SHORTFALL DUE TO
                INSUFFICIENT FLOW (DEFINITIONAL) <18.3>
    WNNIL  - NET NATURAL INFLOW TO LAKE NASSER (KCM/YR)
                <2>
    WRCR   - REQUESTED CONTROLLED RELEASE FROM LAKE
                NASSER (KCM/YR) <16>

WFSUR.K=TABHL(WFSURT,WLN.K/POS(WCLN.K),0,1,.1)*          19, A
  FIFGE(0,1,1974,TIME.K)
WFSURT=1/1/1/1/1/1/1/1/1/.5/0                            19.3, T
    WFSUR  - FRACTION OF SHORTFALL UNMET BY LAKE NASSER
                RESERVES <19>
    WFSURT - TABLE FOR FRACTION OF SHORTFALL UNMET BY
                LAKE NASSER RESERVES <19.3>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>
    WCLN   - CAPACITY OF LAKE NASSER (KCM) <13>
```

Requests for Nile Water -- The requested release of water from Lake Nasser (WRCR), as mentioned above, comprises three factors. First, agricultural needs motivate a flow from Lake Nasser (WFRA). In addition, water is requested for population and industrial use (WRPIU). Water released for these two purposes may also be used to generate electricity, as it flows through turbines at the High Dam. However, the seasonal pattern dictated by agricultural requirements does not match the seasonal pattern of demand for hydroelectricity. During the low part of the seasonal cycle, therefore, additional water may be requested for power generation (WARPG).

The release from Lake Nasser requested for agriculture (WFRA), and the underlying water requested for the Nile for agricultural use (WRA), are based on the amount of water required by the agricultural crops growing in all of Egypt (AWO). This basic request is reduced by the amount of water available from three sources other than Lake Nasser. Water may be available from ground wells in the New Valley project (WNVSP), from ground wells in the old valley (WGWPI), or from the reuse of drainage water (WDAR). On the other hand, the basic requirement must be augmented by expected water losses between the High Dam and the crops: seepage and evaporation losses from the Nile itself (WESEN), and similar losses from the irrigation canals outside the Nile (WELSR and WEACL).

The flow of water requested for population and industrial use (WRPIU) is taken to be proportional to the total population, and to the volume of production of Egyptian industry.

REQUESTS AND DISTRIBUTION OF NILE WATER

```
WRCR.K=SMOOTH(MAX(0,WFRA.K+WRPIU.K+WARPG.K),WTPWN)   16, A
WTPWN=.2 YEAR                                        16.2, C
    WRCR    - REQUESTED CONTROLLED RELEASE FROM LAKE
                NASSER (KCM/YR) <16>
    WFRA    - LAKE NASSER OUTFLOW REQUESTED FOR
                AGRICULTURE <17>
    WRPIU   - WATER REQUESTED FOR POPULATION AND
                INDUSTRIAL USE (KCM/YR) <26>
    WARPG   - ADDITIONAL REQUESTED RELEASE FROM LAKE
                NASSER FOR POWER GENERATION (KCM/YR) <47>
    WTPWN   - TIME TO PERCEIVE WATER NEEDS <16.2>

WFRA.K=WRA.K+WESEN.K-WDAR.K-WGWPI.K                  17, A
    WFRA    - LAKE NASSER OUTFLOW REQUESTED FOR
                AGRICULTURE <17>
    WRA     - WATER REQUESTED FROM NILE FOR AGRICULTURAL
                USE (KCM/YR) <21>
    WESEN   - EXPECTED SEEPAGE AND EVAPORATION LOSSES IN
                NILE (KCM/YR)TABLE FOR FRACTION OF
                SHORTFALL UNMET BY RESERVES <20.1>
    WDAR    - DRAINAGE WATER AVAILABLE FOR AGRICULTURE
                (KCM/YR) <38>
    WGWPI   - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                <59>

WESEN.K=SMOOTH(WNS.K+WNE.K,1)                        20, A
WESEN=8E6 KCM/YR                                     20.1, N
    WESEN   - EXPECTED SEEPAGE AND EVAPORATION LOSSES IN
                NILE (KCM/YR)TABLE FOR FRACTION OF
                SHORTFALL UNMET BY RESERVES <20.1>
    WNS     - SEEPAGE FROM NILE (KCM/YR) <43>
    WNE     - NILE SURFACE EVAPORATION (KCM/YR) <44>

WRA.K=(AWO.K-WNVSP.K)*WBRA.K+WEACL.K+WELSR.K         21, A
    WRA     - WATER REQUESTED FROM NILE FOR AGRICULTURAL
                USE (KCM/YR) <21>
    AWO     - WATER REQUESTED (KCM/YEAR) <233>
    WNVSP   - NEW VALLEY WATER SUPPLIED BY GROUND WATER
                PUMPING <22>
    WBRA    - BIAS IN WATER REQUESTS FOR AGRICULTURE <27>
    WEACL   - EXPECTED AGRICULTURAL CONVEYANCE LOSSES
                (KCM/YR) <25.1>
    WELSR   - EXPECTED LOSS DUE TO SURFACE RUNOFF (KCM/
                YR) <24.1>
```

```
WNVSP.K=(NF.K/AF.K)*AWQ.K*WNVSPF.K                              22, A
    WNVSP  - NEW VALLEY WATER SUPPLIED BY GROUND WATER
               PUMPING <22>
    NF     - PRODUCTIVE FEDDANS IN NEW VALLEY REGIONS
               <287>
    AF     - FEDDANS AVAILABLE FOR AGRICULTURE <209>
    AWQ    - WATER REQUESTED (KCM/YEAR) <233>
    WNVSPF - FRACTION OF NEW VALLEY WATER SUPPLIED BY
               PUMPING <23>

WNVSPF.K=1                                                      23, A
    WNVSPF - FRACTION OF NEW VALLEY WATER SUPPLIED BY
               PUMPING <23>

WELSR.K=SMOOTH(WSRD.K,3)                                        24, A
WELSR=4 KCM/YR                                                  24.1, N
    WELSR  - EXPECTED LOSS DUE TO SURFACE RUNOFF (KCM/
               YR) <24.1>
    WSRD   - SURFACE RUNOFF DOWNSTREAM (KCM/YR) <57>

WEACL.K=SMOOTH(WELC.K+WSLC.K,1)                                 25, A
WEACL=5E6                                                       25.1, N
    WEACL  - EXPECTED AGRICULTURAL CONVEYANCE LOSSES
               (KCM/YR) <25.1>
    WELC   - EVAPORATIVE LOSS IN CONVEYANCE OF
               IRRIGATION WATER (KCM/YR) <39>
    WSLC   - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
               WATER IN <41>

WRPIU.K=P.K*WRPC+(UP.K+GP.K)*WRPLP                              26, A
WRPC=.027 KCM/PERSON-YEAR                                       26.2, C
WRPLP=.53E-3 KCM/POUND                                          26.4, C
    WRPIU  - WATER REQUESTED FOR POPULATION AND
               INDUSTRIAL USE (KCM/YR) <26>
    WRPC   - DOMESTIC PER CAPITA WATER REQUIREMENTS
               <26.2>
    UP     - CONSUMER GOODS PRODUCTION <351>
    GP     - CAPITAL GOODS PRODUCTION <365>
    WRPLP  - WATER REQUIREMENTS FOR INDUSTRIAL
               PRODUCTION <26.4>

WBRA.K=TABLE(WBRAT,TIME.K,1960,2010,10)                         27, A
WBRAT=1/1/1/1/1/1                                               27.2, T
    WBRA   - BIAS IN WATER REQUESTS FOR AGRICULTURE <27>
    WBRAT  - TABLE FOR BIAS IN WATER REQUESTS FOR
               AGRICULTURE <27.2>
```

Distribution of Nile Water for Agriculture -- The controlled flow of water from the Nile for agriculture (WCNOA) may be constrained by either the amount requested for agriculture (WRA) discussed above) or by the perceived availability of water for agricultural use (WAAUP). The perceived availability is, in turn, based on the actual availability of water for agricultural use (WAAU). If the actual availability is growing, a portion of the increase is assumed to be foregone or wasted during the time it takes for the distribution system to be upgraded to handle the increased volume of water. Decreases in availability, of course, become immediately effective as a physical shortage of water.

The water available for agricultural use (WAAU) represents the annual flow into the distribution canals which can be supported by the combination of Nile, ground-water wells, and reclaimed drainage water, less any seepage (WNS) or evaporation (WNE) from the Nile. Seepage and evaporation losses are assumed to depend on the rate of flow of the Nile, as it affects the height and surface area of the water in the Nile. No reliable data on the magnitude of Nile seepage was found; in fact, the direction of seepage is controversial. Therefore, the rate of Nile seepage is initially set at zero, but the structure remains in the model for sensitivity testing and possible subsequent updating.

The fraction of the annual Nile flow usable by agriculture depends on the degree to which the seasonal variation in flow can be controlled to match the seasonal requirements of crops. Therefore, the contributions of controlled and forced releases from Aswan are treated separately. Only 55% of force-released Nile flow (as before the High Dam, for example) is assumed available for agricultural use.[14] The amount of controlled-release water available for agriculture (WAACNR) is in turn dependent on the degree to which the flow is allocated for hydroelectric use. If agriculture is given absolute priority over power generation, the maximum flow available for agriculture (WFXAU) is simply the annual controlled release (WCRLN), less the requirements for domestic and industrial water (WRPIU).

The water usable by crops (WAS) is determined by the controlled Nile outflow for agriculture (WCNOA), less losses due to surface runoff (WSRD) and evaoporation (WELC) and seepage (WSLC) from the distribution system. The latter losses are assumed to sum to 20% of the initial flow, with 80% actually reaching the fields. An additional 15% is lost due to surface runoff.[15]

```
WCNOA.K=MIN(WRA.K,WAAUP.K)                                35, A
    WCNOA  - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
               USE (KCM/YR) <35>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WRA    - WATER REQUESTED FROM NILE FOR AGRICULTURAL
               USE (KCM/YR) <21>
    WAAUP  - PERCEIVED WATER AVAILABLE FOR AGRICULTURAL
               USE <36>

WAAUP.K=MIN(WAAU.K,SMOOTH(WAAU.K,WAAUPT))                 36, A
WAAUPT=4                                                  36.2, C
    WAAUP  - PERCEIVED WATER AVAILABLE FOR AGRICULTURAL
               USE <36>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WAAU   - WATER AVAILABLE FROM NILE FOR AGRICULTURAL
               USE (KCM/YR) <28>
    WAAUPT - TIME TO PERCEIVE THE AVAILABILITY OF EXTRA
               WATER (YEARS) <36.2>

WAAU.K=WAACNR.K+(WFRLN.K*WFRAA)-WNE.K-WNS.K+              28, A
  WGWPI.K+WDAR.K
WFRAA=.55                                                 28.2, C
    WAAU   - WATER AVAILABLE FROM NILE FOR AGRICULTURAL
               USE (KCM/YR) <28>
    WAACNR - WATER AVAILABLE FOR AGRICULTURE FROM
               CONTROLLED RELEASE FROM LAKE NASSER <29>
    WFRLN  - FORCED RELEASE FROM LAKE NASSER (KCM/YR)
               <9>
    WFRAA  - FRACTION OF FORCED RELEASE AVAILABLE FOR
               AGRICULTURE <28.2>
    WNE    - NILE SURFACE EVAPORATION (KCM/YR) <44>
    WNS    - SEEPAGE FROM NILE (KCM/YR) <43>
    WGWPI  - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
               <59>
    WDAR   - DRAINAGE WATER AVAILABLE FOR AGRICULTURE
               (KCM/YR) <38>

WFSALR.K=TABHL(WFSALRT,TIME.K,1960,2010,10)               58, A
WFSALRT=.15/.15/.15/.15/.15/.15                           58.2, T
    WFSALR - FRACTION OF SURFACE APPLICATION LOST TO
               RUNOFF <58>
    WFSALRT- TABLE FOR THE FRACTION OF SURFACE
               APPLICATION LOST TO RUNOFF <58.2>

WNS.K=WSAN.K*WSFN                                         43, A
WSFN=0 METERS/YEAR                                        43.2, C
    WNS    - SEEPAGE FROM NILE (KCM/YR) <43>
    WSAN   - SURFACE AREA OF NILE (KSM) <45>
    WSFN   - SEEPAGE FACTOR FOR NILE WATER <43.2>
```

```
WNE.K=WSAN.K*WAPE*WFEOW                                        44, A
    WNE     - NILE SURFACE EVAPORATION (KCM/YR) <44>
    WSAN    - SURFACE AREA OF NILE (KSM) <45>
    WAPE    - AVERAGE POTENTIAL EVAPORATION <7.2>
    WFEOW   - FRACTION OF MAXIMUM EVAPORATION EXPERIENCED
                OVER OPEN WATER <7.4>

WSAN.K=TABLE(WSANT,WNFLN.K/WNFLNN,0,2,.5)*WSANN                45, A
WSANT=0/.8/1/1.3/1.5                                           45.2, T
WSANN=.6E3 KSM                                                 45.4, C
WNFLNN=84E6 KCM/YR                                             45.6, C
    WSAN    - SURFACE AREA OF NILE (KSM) <45>
    WSANT   - TABLE FOR SURFACE AREA OF THE NILE <45.2>
    WNFLN   - NILE FLOW FROM LAKE NASSER (KCM/YR) <46>
    WNFLNN  - NORMAL NILE FLOW FROM UPSTREAM <45.6>
    WSANN   - NORMAL SURFACE AREA OF THE NILE (KSM)
                <45.4>

WNFLN.K=WFRLN.K+WCRLN.K                                        46, A
    WNFLN   - NILE FLOW FROM LAKE NASSER (KCM/YR) <46>
    WFRLN   - FORCED RELEASE FROM LAKE NASSER (KCM/YR)
                <9>
    WCRLN   - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
                YR) <14>

WAACNR.K=WFMAU.K+(WFXAU.K-WFMAU.K)*(1-WFAHE.K)                 29, A
    WAACNR  - WATER AVAILABLE FOR AGRICULTURE FROM
                CONTROLLED RELEASE FROM LAKE NASSER <29>
    WFMAU   - MINIMUM FLOW AVAILABLE FOR AGRICULTURE <31>
    WFXAU   - MAXIMUM FLOW AVAILABLE FOR AGRICULTURE <30>
    WFAHE   - FLOW ALLOCATION FOR HYDROELECTRIC OUTPUT
                <55>

WFXAU.K=MAX(WCRLN.K-WRPIU.K,0)                                 30, A
    WFXAU   - MAXIMUM FLOW AVAILABLE FOR AGRICULTURE <30>
    WCRLN   - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
                YR) <14>
    WRPIU   - WATER REQUESTED FOR POPULATION AND
                INDUSTRIAL USE (KCM/YR) <26>

WFMAU.K=WAASM.K+WAASX.K                                        31, A
    WFMAU   - MINIMUM FLOW AVAILABLE FOR AGRICULTURE <31>
    WAASM   - WATER AVAILABLE FOR AGRICULTURE AT SEASONAL
                MINIMUMS <32>
    WAASX   - WATER AVAILABLE AT SEASONAL MAXIMUMS <33>
```

```
WAASM.K=MIN(WCRLN.K.WRA.K*WFOFM)*WFYSM                        32. A
    WAASM  - WATER AVAILABLE FOR AGRICULTURE AT SEASONAL
               MINIMUMS <32>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
               YR) <14>
    WRA    - WATER REQUESTED FROM NILE FOR AGRICULTURAL
               USE (KCM/YR) <21>
    WFOFM  - FRACTION OF AVERAGE AGRICULTURAL FLOW AT
               SEASONAL MINIMUM <47.3>
    WFYSM  - FRACTION OF YEAR AT SEASONAL MINIMUM <47.5>

WAASX.K=MIN(WCRLN.K,WFXEIP.K)*(1-WFYSM)+                      33, A
  MAX(WCRLN.K-MAX(WFXEIP.K,WAASM.K),0)
    WAASX  - WATER AVAILABLE AT SEASONAL MAXIMUMS <33>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
               YR) <14>
    WFXEIP - MAXIMUM FLOW TO MEET ENERGY, INDUSTRIAL,
               AND POPULATION NEEDS <34>
    WFYSM  - FRACTION OF YEAR AT SEASONAL MINIMUM <47.5>
    WAASM  - WATER AVAILABLE FOR AGRICULTURE AT SEASONAL
               MINIMUMS <32>

WFXEIP.K=MAX(WRPIU.K,EDPO.K/FOS(WECWL.K))                     34, A
    WFXEIP - MAXIMUM FLOW TO MEET ENERGY, INDUSTRIAL.
               AND POPULATION NEEDS <34>
    WRPIU  - WATER REQUESTED FOR POPULATION AND
               INDUSTRIAL USE (KCM/YR) <26>
    EDPO   - DESIRED POWER OUTPUT FROM LAKE NASSER (KWH/
               YR) <50>
    WECWL  - ENERGY CONTENT OF WATER RELEASED FROM LAKE
               NASSER <49>

WDAR.K=WDRN.K*WFDR                                            38, A
WFDR=.5                                                       38.2, C
    WDAR   - DRAINAGE WATER AVAILABLE FOR AGRICULTURE
               (KCM/YR) <38>
    WDRN   - DRAINAGE WATER RETURNED TO NILE (KCM/YR)
               <69>
    WFDR   - FRACTION OF DRAINAGE WATER REUSED <38.2>

WAS.K=WCNOA.K-WELC.K-WSLC.K-WSRD.K                            37, A
WAS=50E6                                                      37.1, N
    WAS    - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
               (KCM/YR) <37.1>
    WCNOA  - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
               USE (KCM/YR) <35>
    WELC   - EVAPORATIVE LOSS IN CONVEYANCE OF
               IRRIGATION WATER (KCM/YR) <39>
    WSLC   - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
               WATER IN <41>
    WSRD   - SURFACE RUNOFF DOWNSTREAM (KCM/YR) <57>
```

```
                                                           39, A
WELC.K=WELCF.K*WCNOA.K
    WELC    - EVAPORATIVE LOSS IN CONVEYANCE OF
                 IRRIGATION WATER (KCM/YR) <39>
    WELCF   - FRACTION FOR EVAPORATION LOSS OF CONVEYANCE
                 WATER <40>
    WCNOA   - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
                 USE (KCM/YR) <35>

WELCF.K=TABHL(WELCFT,TIME.K,1960,2010,10)                  40, A
WELCFT=.1/.1/.1/.1/.1/.1                                   40.2, T
    WELCF   - FRACTION FOR EVAPORATION LOSS OF CONVEYANCE
                 WATER <40>
    WELCFT  - TABLE FOR THE FRACTION FOR EVAPORATION LOSS
                 OF CONVEYANCE WATER <40.2>

                                                           41, A
WSLC.K=WSLCF.K*WCNOA.K
    WSLC    - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
                 WATER IN <41>
    WSLCF   - FRACTION FOR SEEPAGE LOSS OF CONVEYANCE
                 WATER <42>
    WCNOA   - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
                 USE (KCM/YR) <35>

WSLCF.K=TABHL(WSLCFT,TIME.K,1960,2010,10)                  42, A
WSLCFT=.1/.1/.1/.1/.1/.1                                   42.2, T
    WSLCF   - FRACTION FOR SEEPAGE LOSS OF CONVEYANCE
                 WATER <42>
    WSLCFT  - TABLE FOR THE FRACTION FOR SEEPAGE LOSS OF
                 CONVEYANCE WATER CANALS AND DITCHES (KCM/
                 YR) <42.2>


WSRD.K=(WCNOA.K-WELC.K-WSLC.K)*WFSALR.K                    57, A
    WSRD    - SURFACE RUNOFF DOWNSTREAM (KCM/YR) <57>
    WCNOA   - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
                 USE (KCM/YR) <35>
    WELC    - EVAPORATIVE LOSS IN CONVEYANCE OF
                 IRRIGATION WATER (KCM/YR) <39>
    WSLC    - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
                 WATER IN <41>
    WFSALR  - FRACTION OF SURFACE APPLICATION LOST TO
                 RUNOFF <58>
```

Hydroelectric Power -- Most of the water release from Lake Nasser is governed by agricultural requirements. A by-product of this release is the generation of electric power by the twelve High Dam hydroelectric turbines and generators. As mentioned previously, however, there is a significant difference between the seasonal patterns of agricultural and hydroelectric demands for water.

Agriculture requirements vary in a seasonal pattern, with a minimum during the winter months. However, the demand for electricity is more nearly constant, such that the flow of water required for hydroelectric power during the winter usually exceeds the agricultural requirements. Therefore, during the seasonal minimum of agricultural requirements, an additional requirement for water release for power generation (WARPG) occurs. The magnitude of the additional flow is determined by the gap between the water flow required for power and that required for other uses; the duration of the additional requirements extends only over the fraction of the year during which agricultural requirements are low (WFYSM). Because the model deals in annual flows, the seasonal requirements must be deduced from the corresponding 12-month averages. The winter minimum agricultural requirement is assumed to last .15 year, and is taken as .3 of the average annual flow.[16] The hydroelectric yield of the released water is taken as 144 kilowatt-hours per thousand cubic meters, based on the operating specifications of the turbines under average conditions.[17]

The conflict between agricultural and power requirements may be resolved in another way. In addition to releasing extra water in the low demand season, it is possible to reduce the controlled flow in the peak season. The net result of the two actions together would be to satisfy more of the power requirement without increasing the total annual use of water. Crop growth, however, would tend to suffer from such a policy. In the base case, the model assumes that priority for water release is given to agriculture. Nevertheless, the model has the capability to represent scenarios in which priority is instead given to hydroelectric power generation. This tradeoff is incorporated in the flow allocation for hydroelectric output (WFAHE).

```
   HYDROELECTRIC POWER

WARPG.K=MAX(0,WRCFP.K-WRPIU.K-WFDFM*(WRA.K+                 47, A
  WESEN.K))*WFYSM
WFDFM=.3                                                    47.3, C
WFYSM=.15                                                   47.5, C
     WARPG   - ADDITIONAL REQUESTED RELEASE FROM LAKE
                 NASSER FOR POWER GENERATION (KCM/YR) <47>
     WRCFP   - DESIRED RELEASE FROM LAKE NASSER FOR POWER
                 GENERATION <48>
     WRPIU   - WATER REQUESTED FOR POPULATION AND
                 INDUSTRIAL USE (KCM/YR) <26>
     WFDFM   - FRACTION OF AVERAGE AGRICULTURAL FLOW AT
                 SEASONAL MINIMUM <47.3>
     WRA     - WATER REQUESTED FROM NILE FOR AGRICULTURAL
                 USE (KCM/YR) <21>
     WESEN   - EXPECTED SEEPAGE AND EVAPORATION LOSSES IN
                 NILE (KCM/YR)TABLE FOR FRACTION OF
                 SHORTFALL UNMET BY RESERVES <20.1>
     WFYSM   - FRACTION OF YEAR AT SEASONAL MINIMUM <47.5>

WRCFP.K=EDPO.K/POS(WECWL.K)                                 48, A
     WRCFP   - DESIRED RELEASE FROM LAKE NASSER FOR POWER
                 GENERATION <48>
     EDPO    - DESIRED POWER OUTPUT FROM LAKE NASSER (KWH/
                 YR) <50>
     WECWL   - ENERGY CONTENT OF WATER RELEASED FROM LAKE
                 NASSER <49>

WECWL.K=TABLE(WECWLT,WLN.K,0,160E6,20E6)                    49, A
WECWLT=0/80/144/144/144/144/144/144/144                     49.2, T
     WECWL   - ENERGY CONTENT OF WATER RELEASED FROM LAKE
                 NASSER <49>
     WECWLT  - TABLE FOR ENERGY CONTENT OF WATER RELEASED
                 FROM LAKE NASSER (KWH/KCM) <49.2>
     WLN     - WATER IN LAKE NASSER (KCM) <1.1>

EDPO.K=MAX(0,EPR.K-EPPGL.K)*WFERH.K                         50, A
     EDPO    - DESIRED POWER OUTPUT FROM LAKE NASSER (KWH/
                 YR) <50>
     EPR     - REQUESTED ENERGY PRODUCTION <384>
     EPPGL   - POTENTIAL PRODUCTION OF ENERGY FROM CAPITAL
                 AND LABOR
     WFERH   - FRACTION OF ENERGY REQUESTS TO BE SATISFIED
                 BY HYDROELECTRICITY <51>
```

```
WFERH.K=FIFGE(0,1,40E6,WLN.K)                               51, A
    WFERH  - FRACTION OF ENERGY REQUESTS TO BE SATISFIED
               BY HYDROELECTRICITY <51>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>

WHEO.K=MIN(EDPO.K,WHEA.K)                                   52, A
WHEO=0                                                      52.1, N
    WHEO   - HYDROELECTRIC ENERGY OUTPUT (KWH/YR) <52.1>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    EDPO   - DESIRED POWER OUTPUT FROM LAKE NASSER (KWH/
               YR) <50>
    WHEA   - HYDROELECTRIC ENERGY AVAILABLE <53.1>

WHEA.K=SMOOTH(WECWL.K*(WFMHE.K+(WCRLN.K-WFMHE.K)*     53, A
  WFAHE.K)),.5)
WHEA=0                                                      53.1, N
    WHEA   - HYDROELECTRIC ENERGY AVAILABLE <53.1>
    WECWL  - ENERGY CONTENT OF WATER RELEASED FROM LAKE
               NASSER <49>
    WFMHE  - MINIMUM WATER FLOW FOR HYDROELECTRIC OUTPUT
               <54>
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
               YR) <14>
    WFAHE  - FLOW ALLOCATION FOR HYDROELECTRIC OUTPUT
               <55>

WFMHE.K=WRPIU.K+MIN(WCRLN.K-WRPIU.K,WFRA.K)*WFDFM+  54, A
  (MAX(0,WCRLN.K-WRPIU.K-WFRA.K)/WFYSM)
    WFMHE  - MINIMUM WATER FLOW FOR HYDROELECTRIC OUTPUT
               <54>
    WRPIU  - WATER REQUESTED FOR POPULATION AND
               INDUSTRIAL USE (KCM/YR) <26>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WCRLN  - CONTROLLED RELEASE FROM LAKE NASSER (KCM/
               YR) <14>
    WFRA   - LAKE NASSER OUTFLOW REQUESTED FOR
               AGRICULTURE <17>
    WFDFM  - FRACTION OF AVERAGE AGRICULTURAL FLOW AT
               SEASONAL MINIMUM <47.3>
    WFYSM  - FRACTION OF YEAR AT SEASONAL MINIMUM <47.5>

WFAHE.K=TABHL(WFAHET,TIME.K,1960,2010,10)                   55, A
WFAHET=0/0/0/0/0/0                                          55.2, T
    WFAHE  - FLOW ALLOCATION FOR HYDROELECTRIC OUTPUT
               <55>
    WFAHET - TABLE FOR FLOW ALLOCATION FOR HYDROELECTRIC
               OUTPUT <55.2>
```

Phreatic Water Subsector -- The third major category of water represented in the model is the phreatic water (WPW), defined as the water on, in, and under the agricultural land.[18] The phreatic system is influenced both by surface effects and by underground flows. The most important surface effect is evapotranspiration. Water evapotranspiration (WET) is unique among the flows of phreatic water in that it removes water from the soil but leaves behind any salt dissolved in the water. Physical evaporation, of course, carries no dissolved solids into the air. Growing plants absorb water and transpire it into the atmosphere, but the salts which cause soil salinity are largely rejected by the roots of the plants.

Evaporation and plant transpiration are closely related, as both depend on soil moisture and atmospheric conditions in similar ways. In the model, the two are considered together as a single "flow" of water into the atmosphere. Due to the constancy of atmospheric conditions in Egypt, the model represents evapotranspiration as depending on soil moisture. The more moisture in the soil at or near the surface, the greater the rate of evapotranspiration.

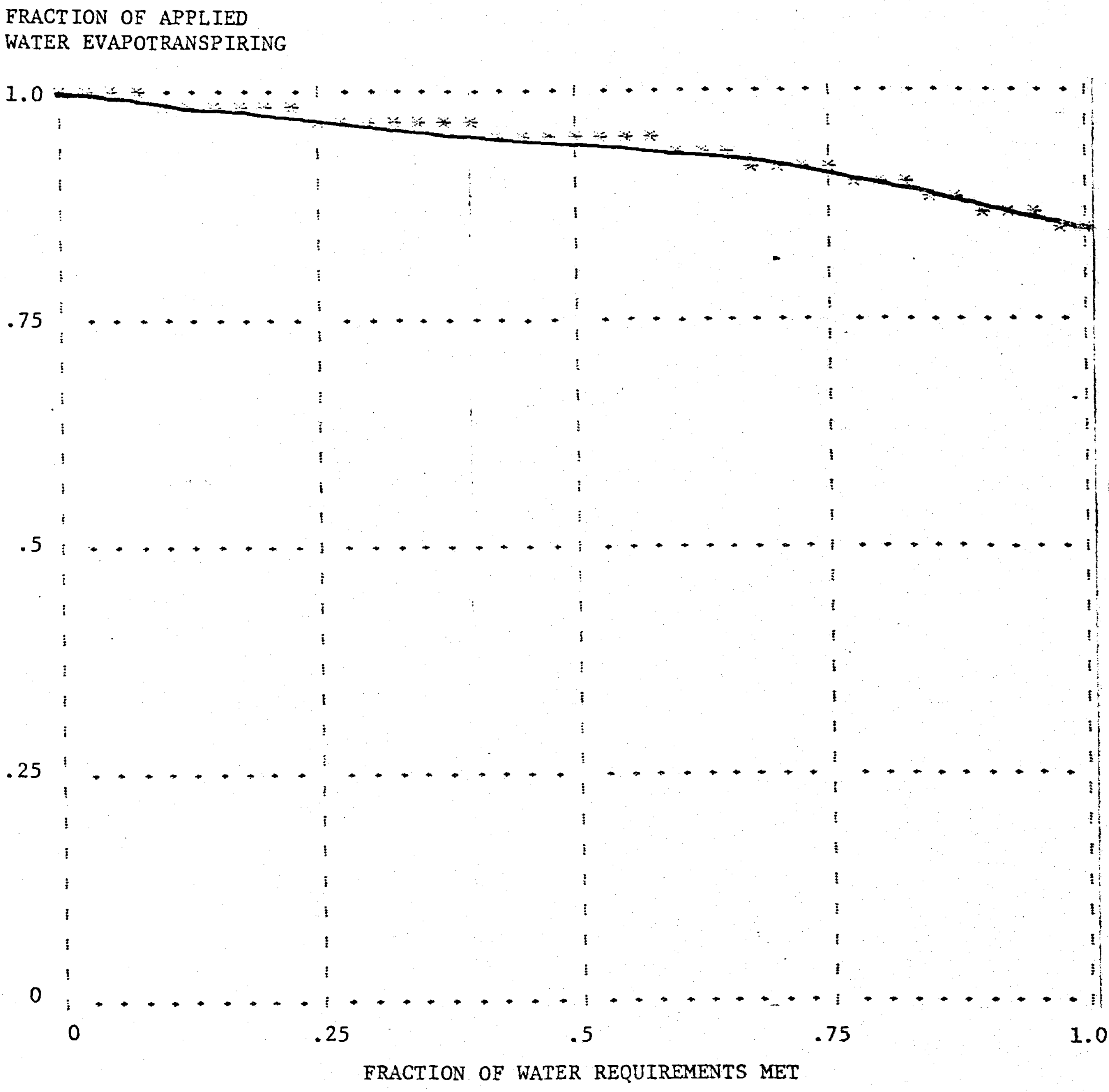
Moisture can infiltrate the soil from both below and above the ground. First, moisture rises from the water table below by capillary action and by diffusion. The higher the water table (WT) the greater the moisture of the surface soil, and the higher the rate of evapotranspiration due to soil water (WESW). In addition to this base level of soil moisture, water applied from above temporarily increases the moisture of the soil as it stands on the surface and percolates toward the water table. In an arid environment such as Egypt, the bulk of water applied to the surface will evaporate, or transpire through crops, with a small fraction reaching the water table (perhaps to rise later). The fraction of irrigation water evapotranspirating (WFIWE) is variable, and depends on the quantity, timing, and method of water application.

The model assumes the dominant influence to be the comparison of the annual rate of application (WAS) with the requirements by the growing crops (AWO). Full application of water will briefly saturate the soil, pushing some water down to the water table. Light application on the other hand, will more readily evaporate at the parched surface, and be more eagerly absorbed by the thirsty roots of plants. Figure III-7 shows the exact relationship used in the model.

The remaining surface contributions to the phreatic water are the rates of seepage from the Nile (WNS) and from seepage losses in the irrigation canals (WSLC). The phreatic system may also yield water to the surface through pumped drainage (WDRN) and ground water wells (WGWPI).

Finally, the phreatic system includes two important underground flows. The phreatic flow from upstream (WPFU) represents underground flows from the south and seepage into the aquifer from the bed of Lake Nasser. In addition, a principal escape of water from the phreatic system is due to a slow but massive underground flow north into the Mediterranean. This outflow is called the "phreatic flow downstream" (WPFD). Should the percolation of irrigation water plus the seepage from Lake Nasser into the phreatic system exceed the underground outflow, the water table (WT) will rise. The relationship between the height of the water table (measured by the number of meters between the land surface and the water-saturated ground beneath) depends on the depth and area of the phreatic zone (WPWA) and its porosity (WPZP).[19]

FIGURE III-7


FRACTION OF APPLIED
WATER EVAPOTRANSPIRING
1.0
.75
.5
.25
0
0
.25
.5
.75
1.0
FRACTION OF WATER REQUIREMENTS MET

```
  PHREATIC WATER

WPW.K=WPW.J+DT*(WPFU.J-WPFD.J-WDRN.J+WNS.J+WAS.J-      56, L
  WET.J-WGWPI.J+WSLC.J)
WPW=WPWI                                               56.2, N
WPWI=645E6 KCM                                         56.4, C
    WPW     - PHREATIC WATER <56.0>
    WPFU    - PHREATIC FLOW FROM UPSTREAM (KCM/YR) <68>
    WPFD    - PHREATIC FLOW DOWNSTREAM (KCM/YR) <65>
    WDRN    - DRAINAGE WATER RETURNED TO NILE (KCM/YR)
                <69>
    WNS     - SEEPAGE FROM NILE (KCM/YR) <43>
    WAS     - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                (KCM/YR) <37.1>
    WET     - EVAPOTRANSPIRATION (KCM/YR) <60>
    WGWPI   - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                <59>
    WSLC    - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
                WATER IN <41>
    WPWI    - INITIAL PHREATIC WATER <56.4>

WGWPI.K=WGWPIC                                         59, A
WGWPIC=0                                               59.2, C
    WGWPI   - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                <59>
    WGWPIC  - CONSTANT GROUND WATER PUMPED FOR IRRIGATION
                <59.2>


 WET.K=MIN(WAS.K*WFIWE.K+WESW.K,WMXES.K)                60, A
     WET     - EVAPOTRANSPIRATION (KCM/YR) <60>
     MIN     - NORMAL PRIORITY OF  ILITARY SECTOR <410.2>
     WAS     - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                 (KCM/YR) <37.1>
     WFIWE   - FRACTION OF IRRIGATION WATER
                 EVAPOTRANSPIRING <63>
     WESW    - EVAPORATION FROM STANDING WATER (KCM/YR)
                 <64>
     WMXES   - MAXIMUM EVAPORATION FROM SOIL (KCM/YR) <61>

 WMXES.K=WARZ.K*WAPE
                                                        61, A
     WMXES   - MAXIMUM EVAPORATION FROM SOIL (KCM/YR) <61>
     WARZ    - AREA OF ROOT ZONE (KCM) <62>
     WAPE    - AVERAGE POTENTIAL EVAPORATION <7.2>

WARZ.K=AFO.K*KSMPF
                                                        62, A
KSMPF=4.2 KSM/FEDDAN                                    62.2, C
    WARZ    - AREA OF ROOT ZONE (KCM) <62>
    AFO     - OLD VALLEY AGRICULTURAL AREA <230>
    KSMPF   - THOUSAND SQUARE METERS PER FEDDAN <62.2>
```

```
WFIWE.K=TABLE(WFIWET,WAS.K/AWOOV.K,0,1,.2)                   63, A
WFIWET=1/.98/.96/.94/.9/.85                                  63.2, T
    WFIWE  - FRACTION OF IRRIGATION WATER
               EVAPOTRANSPIRING <63>
    WFIWET - TABLE FOR FRACTION OF IRRIGATION WATER
               EVAPOTRANSPIRING <63.2>
    WAS    - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
               (KCM/YR) <37.1>
    AWOOV  - WATER REQUESTED FOR OLD VALLEY LANDS <235>

WESW.K=WMXES.K*WSATRZ.K*WFESS                                64, A
WFESS=.2                                                     64.2, C
    WESW   - EVAPORATION FROM STANDING WATER (KCM/YR)
               <64>
    WMXES  - MAXIMUM EVAPORATION FROM SOIL (KCM/YR) <61>
    WSATRZ - SATURATION OF ROOT ZONE <103>
    WFESS  - FRACTION OF MAXIMUM POTENTIAL EVAPORATION
               REALIZED FROM SATURATED SOIL WITH PLANT
               COVER <64.2>

WPFD.K=WPW.K/WTPFD                                           65, A
WTPFD=80 YEARS                                               65.2, C
    WPFD   - PHREATIC FLOW DOWNSTREAM (KCM/YR) <65>
    WPW    - PHREATIC WATER <56.2>
    WTPFD  - TIME FOR PHREATIC WATER TO FLOW DOWNSTREAM
               <65.2>


WT.K=(WPWC-WPW.K)/(WPWA*WPZP)                                66, A
WPWC=700E6 KCM                                               66.2, C
WPZP=.25                                                     66.5, C
WPWA=WPWAN+WPWAD                                             66.7, N
WPWAN=15*1.2E6 KSM                                           66.9, N
WPWAD=11E6 KSM                                               67.2, C
    WT     - WATER TABLE (METERS BELOW SURFACE) <66>
    WPWC   - PHREATIC WATER CAPACITY, CORRESPONDING TO
               SATURATED LAND <66.2>
    WPW    - PHREATIC WATER <56.2>
    WPWA   - PHREATIC WATER ZONE AREA (KSM) <66.7>
    WPZP   - PHREATIC ZONE POROSITY <66.5>
    WPWAN  - PHREATIC WATER ZONE AREA FOR NILE VALLEY
               (KSM) <66.9>
    WPWAD  - PHREATIC WATER ZONE AREA FOR NILE DELTA
               (KSM) <67.2>

WPFU.K=WLNS.K*WFNSFD+WNPFU                                   68, A
WFNSFD=1                                                     68.2, C
WNPFU=0                                                      68.4, C
    WPFU   - PHREATIC FLOW FROM UPSTREAM (KCM/YR) <68>
    WLNS   - SEEPAGE FROM LAKE NASSER (KCM/YR) <5>
    WFNSFD - FRACTION OF LAKE NASSER SEEPAGE FLOWING
               DOWNSTREAM <68.2>
    WNPFU  - NATURAL PHREATIC FLOW FROM UPSTREAM (KCM/
               YR) <68.4>
```

Drainage -- The flow of drainage water from agricultural land (WDRN) represents the collection of water in the tile drains at the bottom of the root zone, and the pumping of that water back into the irrigation distribution system or north into the sea. Drainage requires three conditions. First, the drainage tiles and pumps must be in place, as measured by the number of feddans drained (WFD). Second, there must be excess water in the soil to be drained. This effect is expressed by the maximum pumping rate (WMPR), which depends on the height of the water table as it affects saturation of the root zone (WSBRZ). Finally, energy is required to operate the pumps. The efficiency of pumping due to energy availability (WEDE) expresses the fraction of the pumping capacity which can be supported by the energy sector of the Egyptian economy.

Energy is supplied to the drainage facilities in competition with other energy-consuming sectors. The energy required is taken as proportional to the pumping capacity, at 3 kilowatt-hours of energy per thousand cubic meters of water pumped.[20]

The installation of drainage facilities may arise from two sources. Internal construction (WFDA) represents drainage projects financed within Egypt. It depends on the domestic production (WGD) or paid importation (WGQ) of the necessary tiles and pumps. In addition, the model can represent the consequences of externally-donated drainage facilities (WFEA), which adds to the feddans drained at no cost to Egypt. The total drainage program is planned and guided by a governmental target addition rate for drained feddans (WFDAT). The plan strives to add 250 thousand feddans of drainage per year, until complete drainage is achieved.[21] The actual rate of addition, of course, is determined by the availability of capital goods in the economy as a whole, and the relative priority of the drainage program.

```
DRAINAGE

WDRN.K=WFD.K*WMPR.K*WEDE.K                                69, A
    WDRN     - DRAINAGE WATER RETURNED TO NILE (KCM/YR)
                 <69>
    WFD      - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                 MEANS <74.1>
    WMPR     - MAXIMUM PUMPING RATE ((KCM/YEAR)/FEDDAN)
                 <70>
    WEDE     - EFFICIENCY OF DRAINAGE DUE TO ENERGY
                 AVAILABILITY <71>

WMPR.K=TABHL(WMPRT,AFO.K*WSBRZ.K/POS(WFD.K),0,2,.5)       70, A
WMPRT=0/1/2/2/2                                           70.2, T
    WMPR     - MAXIMUM PUMPING RATE ((KCM/YEAR)/FEDDAN)
                 <70>
    WMPRT    - TABLE FOR MAXIMUM PUMPING RATE <70.2>
    AFO      - OLD VALLEY AGRICULTURAL AREA <230>
    WSBRZ    - SATURATION AT BOTTOM OF ROOT ZONE <99>
    WFD      - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                 MEANS <74.1>

WEDE.K=WDE.K/POS(WDER.K)                                  71, A
    WEDE     - EFFICIENCY OF DRAINAGE DUE TO ENERGY
                 AVAILABILITY <71>
    WDE      - WATER-DRAINAGE ENERGY <73.1>
    WDER     - WATER-DRAINAGE ENERGY REQUIREMENTS (KWH/HA-
                 YR) <72>

WDER.K=WFD.K*WMPR.K*WDERF                                 72, A
WDERF=3 KWH/KCM                                           72.2, C
    WDER     - WATER-DRAINAGE ENERGY REQUIREMENTS (KWH/HA-
                 YR) <72>
    WFD      - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                 MEANS <74.1>
    WMPR     - MAXIMUM PUMPING RATE ((KCM/YEAR)/FEDDAN)
                 <70>
    WDERF    - WATER DRAINAGE ENERGY REQUIREMENTS PER
                 FEDDAN                                <72.2>

WDE.K=SHARE(WDER.K,EPN.K,WDIE.K,EWR.K,WIN.K)              73, A
WDE=WDER                                                  73.1, N
    WDE      - WATER-DRAINAGE ENERGY <73.1>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    WDER     - WATER-DRAINAGE ENERGY REQUIREMENTS (KWH/HA-
                 YR) <72>
    EPN      - SHORTFALL IN PRODUCTION OF ENERGY
    EWR      - WEIGHTED REQUESTS FOR ENERGY <385>
    WIN      - NORMAL PRIORITY OF DRAINAGE FOR CAPITAL
                 GOODS <82>
```

```
WFD.K=WFD.J+(DT)(WFDA.J+WFEA.J-WFDW.J)                      74, L
WFD=0                                                       74.1, N
    WFD     - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                MEANS <74.1>
    WFDA    - ADDITION OF NEW TILE-DRAINED FEDDANAGE
                (FEDDANS/YEAR) <77>
    WFEA    - DRAINAGE FUNDED FROM EXTERNAL ASSISTANCE
                <75>
    WFDW    - WEAROUT OF DRAINAGE FACILITIES <76>

WFEA.K=MIN(WFR.K-WFD.K,FIFGE(0,WFEAC,WFDTT,TIME.K)) 75, A
WFEAC=0                                                     75.2, C
    WFEA    - DRAINAGE FUNDED FROM EXTERNAL ASSISTANCE
                <75>
    MIN     - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WFR     - DRAINAGE FACILITIES REQUESTED <87>
    WFD     - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                MEANS <74.1>
    WFEAC   - AMOUNT OF EXTERNAL DRAINAGE ASSISTANCE
                <75.2>
    WFDTT   - TIME TO CHANGE TARGET FOR DRAINAGE PROGRAM
                <86.2>

WFDW.K=WFD.K/WFDL                                           76, A
WFDL=50                                                     76.2, C
    WFDW    - WEAROUT OF DRAINAGE FACILITIES <76>
    WFD     - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                MEANS <74.1>
    WFDL    - LIFETIME OF DRAINAGE FACILITIES (YEARS)
                <76.2>

WFDA.K=(WGD.K+(WGQ.K/SGXOR.K))/WFDP.K                       77, A
    WFDA    - ADDITION OF NEW TILE-DRAINED FEDDANAGE
                (FEDDANS/YEAR) <77>
    WGD     - DELIVERIES OF CAPITAL GOODS FOR DRAINAGE
                (POUNDS/YEAR) <79>
    WGQ     - IMPORTS OF CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <88>
    SGXOR   - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
                <349>
    WFDP    - COST FOR NEW TILE DRAINAGE (POUNDS/FEDDAN)
                <78>

WFDP.K=TABHL(WFDPT,WFDF.K,0,.5,.1)                          78, A
WFDPT=250/250/250/250/250/250                               78.2, T
    WFDP    - COST FOR NEW TILE DRAINAGE (POUNDS/FEDDAN)
                <78>
    WFDPT   - TABLE FOR THE COST FOR NEW TILE DRAINAGE
                <78.2>
    WFDF    - FRACTION OF LAND AREA DRAINED <108>
```

```
WGD.K=DELAY3P(WGC.K,POS(WGCT.K),WGUC.K)                    79, A
     WGD     - DELIVERIES OF CAPITAL GOODS FOR DRAINAGE
                 (POUNDS/YEAR) <79>
     WGC     - COMMITMENTS OF CAPITAL GOODS TO DRAINAGE
                 (POUNDS/YEAR) <84.1>
     WGCT    - CONSTRUCTION TIME FOR DRAINAGE CAPITAL
                 (YEARS) <80.1>
     WGUC    - WATER CONTROL FACILTIES UNDER CONSTRUCTION

WGCT.K=WGUC.K/POS(WGCA.K)                                  80, A
WGCT=WGCTN                                                 80.1, N
WGCTN=2                                                    80.3, C
     WGCT    - CONSTRUCTION TIME FOR DRAINAGE CAPITAL
                 (YEARS) <80.1>
     WGUC    - WATER CONTROL FACILTIES UNDER CONSTRUCTION
     WGCA    - CONSTRUCTION ACTIVITY FOR DRAINAGE CAPITAL
                 (POUNDS/YEAR) <81>
     WGCTN   - NORMAL CONSTRUCTION TIME FOR DRAINAGE
                 FACILITIES <80.3>

WGCA.K=SHARE(WGCR.K,GPN.K,WIGC.K,GPWR.K,WIN.K)             81, A
     WGCA    - CONSTRUCTION ACTIVITY FOR DRAINAGE CAPITAL
                 (POUNDS/YEAR) <81>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     WGCR    - CONSTRUCTION REQUESTED FOR DRAINAGE CAPITAL
                 (POUNDS/YEAR) <83>
     GPN     - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
     GPWR    - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
     WIN     - NORMAL PRIORITY OF DRAINAGE FOR CAPITAL
                 GOODS <82>

WIN.K=TABHL(WINT,TIME.K,1960,2010,10)                      82, A
WINT=.1/.1/.1/.1/.1/.1                                     82.2, T
     WIN     - NORMAL PRIORITY OF DRAINAGE FOR CAPITAL
                 GOODS <82>
     WINT    - TABLE FOR NORMAL PRIORITY FOR WATER
                 PROJECTS <82.2>

WGCR.K=WGUC.K/WGCTN                                        83, A
     WGCR    - CONSTRUCTION REQUESTED FOR DRAINAGE CAPITAL
                 (POUNDS/YEAR) <83>
     WGUC    - WATER CONTROL FACILTIES UNDER CONSTRUCTION
     WGCTN   - NORMAL CONSTRUCTION TIME FOR DRAINAGE
                 FACILITIES <80.3>
```

```
WGC.K=SHARE(WGO.K,GON.K,WIGO.K,GOWR.K,WIN.K)                  84, A
WGC=0                                                        84.1, N
    WGC     - COMMITMENTS OF CAPITAL GOODS TO DRAINAGE
                (POUNDS/YEAR) <84.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    WGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                DRAINAGE (POUNDS/YEAR) <85>
    GON     - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR    - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    WIN     - NORMAL PRIORITY OF DRAINAGE FOR CAPITAL
                GOODS <83>

WGO.K=MAX(0,MIN(WFR.K-WFD.K-(WGUC.K/WFDP.K),                  85, A
  WFDAT.K))*WFDP.K
    WGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                DRAINAGE (POUNDS/YEAR) <85>
    MIN     - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    WFR     - DRAINAGE FACILITIES REQUESTED <87>
    WFD     - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                MEANS <74.1>
    WGUC    - WATER CONTROL FACILTIES UNDER CONSTRUCTION
    WFDP    - COST FOR NEW TILE DRAINAGE (POUNDS/FEDDAN)
                <78>
  WFDAT   - TARGET ADDITION RATE FOR DRAINED FEDDANS
                <86>

WFDAT.K=FIFGE(FIFGE(0,WFDATC1,1970,TIME.K),WFDATC2,  86, A
  WFDTT,TIME.K)
WFDTT=1980                                                   86.2, C
WFDATC1=250E3                                                86.4, C
WFDATC2=250E3                                                86.6. C
    WFDAT   - TARGET ADDITION RATE FOR DRAINED FEDDANS
                <86>
    WFDATC1- CONSTANT FOR TARGET ADDITION RATE TO
                DRAINED FEDDANS (1970-1980) <86.4>
    WFDATC2- CONSTANT FOR TARGET ADDITION RATE TO
                DRAINED FEDDANS (AFTER 1980) <86.6>
    WFDTT   - TIME TO CHANGE TARGET FOR DRAINAGE PROGRAM
                <86.2>


WFR.K=AFO.K*WSBRZ.K                                         87, A
    WFR     - DRAINAGE FACILITIES REQUESTED <87>
    AFO     - OLD VALLEY AGRICULTURAL AREA <230>
    WSBRZ   - SATURATION AT BOTTOM OF ROOT ZONE <99>
```

```
WGG.K=DELAY3P(WGGC.K,SGGOT,WGGD.K)                        88, A
    WGG     - IMPORTS OF CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <88>
    WGGC    - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
                DRAINAGE (FOREX/YEAR) <89.1>
    SGGOT   - DELIVERY TIME FOR IMPORTED CAPITAL (YEARS)
                <348.2>
    WGGD    - IMPORTED WATER CONTROL FACILITIES BEING
                DELIVERED

WGGC.K=SHARE(WGGO.K,GXN.K,WIS.K,GXWR.K,WIN.K)              89, A
WGGC=0                                                     89.1, N
    WGGC    - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
                DRAINAGE (FOREX/YEAR) <89.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    WGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <90>
    GXN     - SHORTFALL IN FOREIGN EXCHANGE FOR IMPORTING
                CAPITAL (FOREX/YEAR) <377>
    GXWR    - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <379>
    WIN     - NORMAL PRIORITY OF DRAINAGE FOR CAPITAL
                GOODS <82>

WGGO.K=WGGOS.K*SGXQR.K*QEXA.K                              90, A
    WGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <90>
    WGGOS   - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
                FOR DOMESTIC SHORTFALL <91>
    SGXQR   - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
                <349>
    QEXA    - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                REQUESTS FOR IMPORTS <485>

WGGOS.K=SMOOTH(WGGOSF.K*(WGO.K-WGC.K),SGGOAT)              91, A
    WGGOS   - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
                FOR DOMESTIC SHORTFALL <91>
    WGGOSF  - FRACTION FOR DRAINAGE IMPORT ORDERS TO
                REPLACE DOMESTIC CAPITAL GOODS SHORTFALL
                <92>
    WGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                DRAINAGE (POUNDS/YEAR) <85>
    WGC     - COMMITMENTS OF CAPITAL GOODS TO DRAINAGE
                (POUNDS/YEAR) <84.1>
    SGGOAT  - TIME TO ADJUST IMPORT ORDERS TO DOMESTIC
                SHORTFALL (YEARS) <348.4>

WGGOSF.K=TABLE(WGGOSFT,TIME.K,1970,2010,5)                  92, A
WGGOSFT=.25/.25/.25/.25/.25/.25/.25/.25/.25                92.3, T
    WGGOSF  - FRACTION FOR DRAINAGE IMPORT ORDERS TO
                REPLACE DOMESTIC CAPITAL GOODS SHORTFALL
                <92>
    WGGOSFT- TABLE FOR FRACTION FOR DRAINAGE IMPORT
                ORDERS <92.3>
```

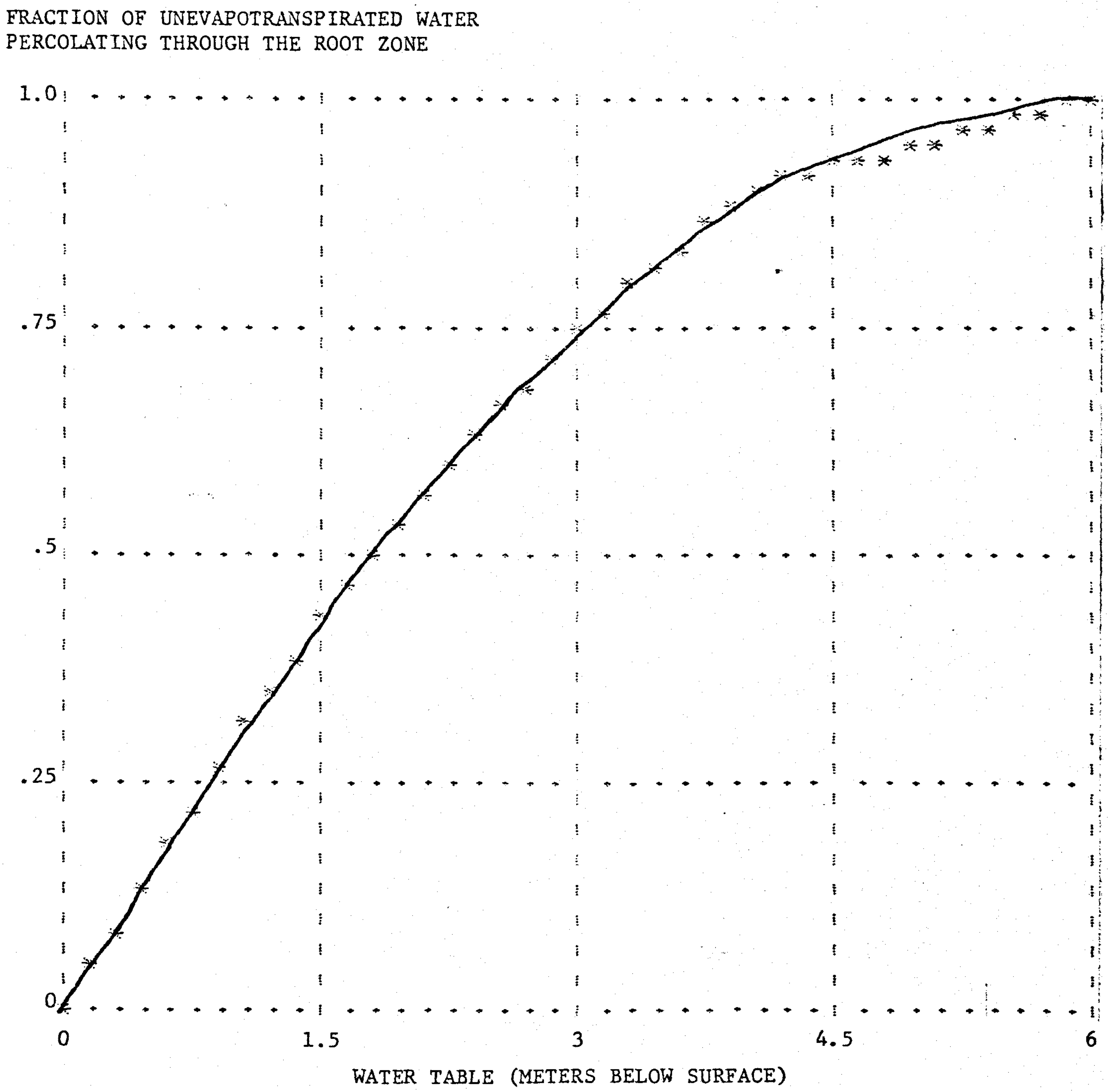
Salinity -- The water flowing into the Nile Valley from upstream carries with it dissolved salts. Although the salt in the water entering Lake Nasser is dilute, evaporation may concentrate the salt in the Nile and in the agricultural soil. Because of the large impact of soil salinity on agricultural production, the model represents the amount of salt in the all-important root zone (WSRZ) separately from the amount in the ground water (WSGW).

Salt may be added to the root zone by two sources. First, most of the salt dissolved in water applied to the surface (WAS) is deposited in the root zone, since neither evaporation nor plant growth remove significant quantities of salt. Second, under conditions of a high and rising water table, ground water may rise into the root zone (WRGR), carrying with it dissolved salt.

Salt is removed from the root zone only by the downward leaching of water through the root zone (WLRZ). Leaching can occur in three ways. Natural leaching relies on the percolation of water from the root zone into the ground water (WPRG). Percolation will not occur unless application of irrigation water (WAS) is great enough that a substantial fraction of it remains unevaporated. Second, percolation is possible only if the water table is well below the root zone. If the water table is low, the flow of water leaching the root zone is determined by the quantity applied and the porosity of the soil. In the annual perspective of the model, such a flow is practically instantaneous. However, if the water table is high , the natural flow of water (and salt) out of the root zone is limited to the sluggish underground flow north to the Mediterranean (WFRG). Figure III-8 show the effect of the water table on percolation.

The flow of water from the root zone to the ground aquifer (WFRG), by definition, occurs only where percolation (WPRG) does not occur: specifically, in regions where the water table has risen to saturate the bottom of the root

FIGURE III-8


FRACTION OF UNEVAPOTRANSPIRATED WATER PERCOLATING THROUGH THE ROOT ZONE
1.0
.75
.5
.25
0
0
1.5
3
4.5
6
WATER TABLE (METERS BELOW SURFACE)

zone (WSBRZ). The flow can be augmented by pumping ground water from the aquifer (WGWPI), but seepage losses from canals (WSLC) tend to inhibit the undergound flow, as they add to the quantity of water in the aquifer without passing through the root zone. The most direct way to achieve the necessary leaching under high-water-table conditions is to pump water from just below the root zone, via drainage tiles (WDRN). This method was discussed in the earlier section on drainage.

The quantity of salt in the root zone is determined by the flows of water discussed above. The effect of salt on plant growth, however, depends on the concentration of salt in the root zone. Numerous experiments suggest that an adequate measure of soil salinity is the salt concentration of the fluid extracted from a sample of soil which has been carefully saturated with water.[22] The model computes the average salinity of the root zone, therefore, by comparing the quantity of salt in the root zone (WSRZ) with the capacity of the root zone to hold water (WCRZ).

```
   SALINITY SUBSECTOR

WSCN.K=(WSCLN*WNFLN.K+WSCDR.K*WDAR.K)/(WNFLN.K+         93, A
  WDAR.K)
WSCN=WSCLN                                                 93.1, N
      WSCN    - SALT CONCENTRATION IN NILE  (KT/KCM) <93.1>
      WSCLN   - SALT CONCENTRATION OF LAKE NASSER (KT/KCM)
                  <94.8>
      WNFLN   - NILE FLOW FROM LAKE NASSER (KCM/YR) <46>
      WSCDR   - SALT CONCENTRATION IN DRAINAGE WATER
                  RETURNED TO NILE (KT/KCM) <95.1>
      WDAR    - DRAINAGE WATER AVAILABLE FOR AGRICULTURE
                  (KCM/YR) <38>

WSGW.K=WSGW.J+DT*(WPFU.J*WSCPWU-(WPFD.J+WGWPI.J)*      94, L
  WSCGW.J+WLRZ.J*WSCRZ.J)
WSGW=WSGWI                                                 94.2, N
WSGWI=WPW*((WPFU*WSCPWU+WLRZ*WSCRZ)/(WPFU+WLRZ))          94.4, N
WSCPWU=200E-6 KT/KCM                                       94.6, C
WSCLN=400E-6 KT/KCM                                        94.8, C
      WSGW    - SALT IN GROUND WATER (KT) <94.2>
      WPFU    - PHREATIC FLOW FROM UPSTREAM (KCM/YR) <68>
      WSCPWU  - SALT CONCENTRATION OF PHREATIC WATER FROM
                  UPSTREAM <94.6>
      WPFD    - PHREATIC FLOW DOWNSTREAM (KCM/YR) <65>
      WGWPI   - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                  <59>
      WSCGW   - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
                  <102>
      WLRZ    - WATER LEACHING THE ROOT ZONE (KCM/YR) <97>
      WSCRZ   - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
                  <104>
      WSGWI   - INITIAL SALT IN GROUND WATER (KT) <94.4>
      WPW     - PHREATIC WATER <56.2>
      WSCLN   - SALT CONCENTRATION OF LAKE NASSER (KT/KCM)
                  <94.8>

WSCDR.K=SMOOTH(WSCRZ.K,.5)                                 95, A
WSCDR=WSCGW                                                95.1, N
      WSCDR   - SALT CONCENTRATION IN DRAINAGE WATER
                  RETURNED TO NILE (KT/KCM) <95.1>
      WSCRZ   - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
                  <104>
      WSCGW   - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
                  <102>
```

```
WSRZ.K=WSRZ.J+DT*(WAS.J*WSCWAS.J+                              96, L
  WLRZ.J*WSCRZ.J+WRGR.J*WSCGW.J)
WSRZ=WSCWAS*WCRZ*(WAS/WLRZ)                                   96.2, N
    WSRZ   - SALT IN ROOT ZONE (KT) <96.2>
    WAS    - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
               (KCM/YR) <37.1>
    WSCWAS - SALT CONCENTRATION IN WATER APPLIED TO
               SURFACE (KT/KCM) <107.1>
    WNS    - SEEPAGE FROM NILE (KCM/YR) <43>
    WSCRZ  - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
               <104>
    WLRZ   - WATER LEACHING THE ROOT ZONE (KCM/YR) <97>
    WRGR   - WATER RISING FROM GROUND AQUIFER TO ROOT
               ZONE (KCM/YR) <101>
    WSCGW  - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
               <102>
    WCRZ   - CAPACITY OF ROOT ZONE (KCM) <106>

WLRZ.K=WPRG.K+WDRN.K+WFRG.K                                     97, A
    WLRZ   - WATER LEACHING THE ROOT ZONE (KCM/YR) <97>
    WPRG   - WATER PERCOLATING FROM SURFACE TO PHREATIC
               ZONE (KCM/YR) <98>
    WDRN   - DRAINAGE WATER RETURNED TO NILE (KCM/YR)
               <69>
    WFRG   - WATER FLOW FROM ROOT ZONE TO GROUND AQUIFER
               <100>

WPRG.K=MAX(0,WAS.K-WET.K)*(1-WSBRZ.K)                           98, A
    WPRG   - WATER PERCOLATING FROM SURFACE TO PHREATIC
               ZONE (KCM/YR) <98>
    WAS    - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
               (KCM/YR) <37.1>
    WET    - EVAPOTRANSPIRATION (KCM/YR) <60>
    WSBRZ  - SATURATION AT BOTTOM OF ROOT ZONE <99>

WSBRZ.K=TABHL(WSBRZT,WT.K,0,6,1)                                99, A
WSBRZT=1/.7/.45/.25/.1/.05/0                                  99.2, T
    WSBRZ  - SATURATION AT BOTTOM OF ROOT ZONE <99>
    WSBRZT - TABLE FOR SATURATION AT BOTTOM OF ROOT ZONE
               <99.2>
    WT     - WATER TABLE (METERS BELOW SURFACE) <66>

WFRG.K=MAX(0,WGWPI.K+WPFD.K-WPFU.K-WSLC.K)*WSBRZ.K  100, A
    WFRG   - WATER FLOW FROM ROOT ZONE TO GROUND AQUIFER
               <100>
    WGWPI  - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
               <59>
    WPFD   - PHREATIC FLOW DOWNSTREAM (KCM/YR) <65>
    WPFU   - PHREATIC FLOW FROM UPSTREAM (KCM/YR) <68>
    WSLC   - SEEPAGE LOSS FROM CONVEYANCE OF IRRIGATION
               WATER IN <41>
    WSBRZ  - SATURATION AT BOTTOM OF ROOT ZONE <99>
```

```
WRGR.K=MAX(0,WPFU.K-WPFD.K-WGWPI.K)*WSBRZ.K                101, A
     WRGR     - WATER RISING FROM GROUND AQUIFER TO ROOT
                   ZONE (KCM/YR) <101>
     WPFU     - PHREATIC FLOW FROM UPSTREAM (KCM/YR) <58>
     WPFD     - PHREATIC FLOW DOWNSTREAM (KCM/YR) <65>
     WGWPI    - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                   <59>
     WSBRZ    - SATURATION AT BOTTOM OF ROOT ZONE <99>

WSCGW.K=WSGW.K/WPW.K                                        102, A
     WSCGW    - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
                   <102>
     WSGW     - SALT IN GROUND WATER (KT) <94.2>
     WPW      - PHREATIC WATER <56.2>

WSATRZ.K=TABHL(WSATRZT,WT.K,0,6,1)                          103, A
WSATRZT=1/.5/.3/.15/.05/0/0                                 103.2, T
     WSATRZ - SATURATION OF ROOT ZONE <103>
     WSATRZT- TABLE FOR FRACTION OF LAND WITH SATURATED
                   ROOT ZONE <103.2>
     WT       - WATER TABLE (METERS BELOW SURFACE) <66>

WSCRZ.K=WSRZ.K/WCRZ.K                                       104, A
     WSCRZ    - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
                   <104>
     WSRZ     - SALT IN ROOT ZONE (KT) <95.2>
     WCRZ     - CAPACITY OF ROOT ZONE (KCM) <106>

WSCECE.K=WFSCC*WSCRZ.K                                      105, A
WFSCC=750 MILLIMHOS-KCM/CM-KT                               105.4, C
     WSCECE - SALT CONCENTRATION, MEASURED BY
                   CONDUCTIVITY OF SATURATED SOIL EXTRACT
                   (MILLIMHOS/CM) <105>
     WFSCC    - FACTOR FOR SALT CONCENTRATION MEASUREMENT
                   CONVERSION <105.4>
     WSCRZ    - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
                   <104>

WCRZ.K=WDRZ*WPRZ*WPWA                                       106, A
WPRZ=.25                                                    106.2, C
WDRZ=1.5                                                    106.4, C
     WCRZ     - CAPACITY OF ROOT ZONE (KCM) <106>
     WDRZ     - DEPTH OF ROOT ZONE (METERS)(KT/KCM) <106.4>
     WPRZ     - POROSITY OF ROOT ZONE <106.2>
     WPWA     - PHREATIC WATER ZONE AREA (KSM) <66.7>
```

```
WSCWAS.K=((WCNOA.K-WGWPI.K)*WSCN.K+WGWPI.K*WSCGW.K) 107, A
  /(WCNOA.K-WELC.K)
WSCWAS=WCNOA*WSCN/(WCNOA-WELC)                          107.1, N
    WSCWAS - SALT CONCENTRATION IN WATER APPLIED TO
               SURFACE (KT/KCM) <107.1>
    WCNOA  - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
               USE (KCM/YR) <35>
    WGWPI  - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
               <59>
    WSCN   - SALT CONCENTRATION IN NILE  (KT/KCM) <93.1>
    WSCGW  - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
               <102>
    WELC   - EVAPORATIVE LOSS IN CONVEYANCE OF
               IRRIGATION WATER (KCM/YR) <39>
```

Supplementary Water Equations -- The remainder of the water sector defines additional variables which do not affect the behavior of the model, but which are convenient for analyzing the results of simulations.

```
    SUPPLEMENTAL OUTPUT VARIABLES FROM WATER SECTOR

WFDF.K=WFD.K/AFO.K                                         108, A
    WFDF    - FRACTION OF LAND AREA DRAINED <108>
    WFD     - FEDDANS DRAINED BY TILE DRAINS AND OTHER
                MEANS <74.1>
    AFO     - OLD VALLEY AGRICULTURAL AREA <230>

WNFD.K=WNFLN.K+WDRN.K-(WCNOA.K-WGWPI.K)-WNS.K-WNE.K 109, S
    WNFD    - NILE FLOW DOWNSTREAM (KCM/YR) <109>
    WNFLN   - NILE FLOW FROM LAKE NASSER (KCM/YR) <46>
    WDRN    - DRAINAGE WATER RETURNED TO NILE (KCM/YR)
                <69>
    WCNOA   - CONTROLLED NILE OUTFLOW FOR AGRICULTURAL
                USE (KCM/YR) <35>
    WGWPI   - GROUND WATER PUMPED FOR IRRIGATION (KCM/YR)
                <59>
    WNS     - SEEPAGE FROM NILE (KCM/YR) <43>
    WNE     - NILE SURFACE EVAPORATION (KCM/YR) <44>

WTN.K=-WT.K                                                110, S
    WTN     - NEGATIVE WATER TABLE FOR PLOTS (METERS)
                <110>
    WT      - WATER TABLE (METERS BELOW SURFACE) <66>

WAWN.K=WAS.K/AWOOV.K                                       111, S
    WAWN    - AVAILABILITY OF WATER FROM THE NILE <111>
    WAS     - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                (KCM/YR) <37.1>
    AWOOV   - WATER REQUESTED FOR OLD VALLEY LANDS <235>

WSWAS.K=WAS.K*WSCWAS.K                                     112, S
    WSWAS   - SALT IN WATER APPLIED TO SURFACE (KT/YR)
                <112>
    WAS     - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                (KCM/YR) <37.1>
    WSCWAS  - SALT CONCENTRATION IN WATER APPLIED TO
                SURFACE (KT/KCM) <107.1>
```

```
WSLRZ.K=WLRZ.K*WSCRZ.K                                  113, S
    WSLRZ  - SALT IN WATER LEACHING ROOT ZONE (KT/YR)
                <113>
    WLRZ   - WATER LEACHING THE ROOT ZONE (KCM/YR) <97>
    WSCRZ  - SALT CONCENTRATION IN ROOT ZONE (KT/KCM)
                <104>

WSRGR.K=WRGR.K*WSCGW.K                                  114, S
    WSRGR  - SALT IN WATER RISING FROM GROUND WATER TO
                ROOT ZONE (KT/YR) <114>
    WRGR   - WATER RISING FROM GROUND AQUIFER TO ROOT
                ZONE (KCM/YR) <101>
    WSCGW  - SALT CONCENTRATION IN GROUND WATER (KT/KCM)
                <102>

     HISTORICAL SERIES FOR CALIBRATION OF WATER SECTOR

WLNA.K=TABHL(WLNAT,TIME.K,1964,1977,1)*1E6              115, A
WLNAT=-1E6/9.8/-1E6/-1E6/41.1/-1E6/-1E6/78.5/-1E6/      115.1, T
  -1E6/-1E6/-1E6/115.0/-1E6
    WLNAT  - ACTUAL WLN FROM WATERBURY, XXII #3, PAGE 6
                <115.1>

WNFLNA.K=TABHL(WNFLNAT,TIME.K,1960,1975,1)*1E6          116, A
WNFLNAT=78.0/98.4/87.5/66.0/109.0/82.7/60.2/75.5/       116.2, T
  53.8/53.5/54.7/55.9/55.0/56.3/56.1/54.4/-1E6
    WNFLNA - ACTUAL NILE FLOW FROM LAKE NASSER (KCM/YR)
                <116>
    WNFLNAT- TABLE FOR ACTUAL FLOW FROM LAKE NASSER
                <116.2>
```

IV. POPULATION

At the heart to Egypt's economic and social development problems is a rapidly growing population. Food requirements are already sufficiently larger in comparison with domestic food production that Egypt must import a large fraction of its food supplies. The requirements of the growing population for immediate consumption of other goods threatens to absorb the surplus necessary for investment and growth. Limited government attempts to decrease the country's birth rate have had little ovservable effect.

The implications for the water resources sector of this continuing population growth are considerable. The population exerts a direct pressure on the water sector through requirements for consumption and personal use, requirements that are expected to rise from the current one billion cubic meters annually to four billion cubic meters by the turn of the century. The water sector is also the recipient of large amounts of population-generated waste. The population exerts an indirect pressure through the agriculture sector, since attempts to increase food production will require more and more water over the coming decades.

The population sector has an important supply relationship with the system's economic sectors. The labor force supplied by the population sector depends on the size and the age distribution of the population. Age distribution determines the balance between productive and non-productive Egyptians. Another important factor in labor supply is the geographical distribution of the population: the access of agriculture to a rural workforce, and the access of industrial and service employers to an urban workforce. The productivity of the workforce is related to nutritional adequacy (another link with the agricultural sector) and the prevalence of disease (particularly schistosomaisis, a consequence of developments in the water sector).

Egypt's population has been growing at an average annual rate of 2% to 2.1 1/2% for the past 10 or 20 years. The birth rate held steady at 40-43 births per thousand throughout the 1950's and 1960's, and only recently has shown signs of falling to the range of 37-39 births per thousand. Egypt's death rate has been rather constant at 13-17 deaths per thousand. Future trends in the country's net growth rate will likely be determined by additional changes in the birth rate.

A wide variety of social and economic factors influence Egypt's net birth rate: the population's degree of urbanization, material standard of living, birth control, and trends regarding education and modernization of social values. Each of these factors is discussed in turn below.

The term "urbanization" is used here to describe the distribution of the population between small rural villages on the one hand, and cities and larger country towns on the other. The factors responsible for the migration of the rural population to urban areas will be discussed shortly; for purposes of addressing Egypt's birth rate, it is important to enumerate the major differences between rural and urban life. Among the most important of these differences between rural and urban life. Among the most important of these differences are the employment opportunities and living arrangements available for children. In the urban regions of Egypt, there are important disincentives for bearing children that arise from living space limitations and a lack of useful work for young children to perform. In contrast, rural children, even the very young, can assist with farming, and the flexibility of rural living quarters eases any space problems as children are added. In addition to these economic impacts, urban residents are generally more sophisticated about family planning and birth control matters than their rural counterparts. For example, use of birth control pills has been reported to be four times greater among urban couples than rural couples. On the whole, these economic and social factors provide more incentives and opportunities for large families in rural areas than in urban areas.

The effect of standard of living (including income) on the birth rate is also the result of a combination of social and economic factors. In the simulation model, standard of living measures the population's consumption of manufactured consumer goods and use of household capital (housing, hospitals, schools, etc). Standard of living thus serves as a surrogate for rising affluence, the accumulation of goods beyond the basic necessities of life. Rising standards of living also contribute to cultural changes in the population, as adults adjust their values in response to their greater material well-being. The resulting mind-set influences a married couple's attitudes toward children and family planning.

The first two birth rate influences -- urbanization and standard of living -- affect married couples' intentions for childbirth and family size. The third influence -- birth control practices -- affects their success in achieving their intentions. Modern birth control methods, such as birth contorl pills and IUD's, provide the means for translating planning for fewer children into an actual reduction in the birth rate. Within the simulation model, we assume differing degrees of birth control effectiveness between adults practicing modern methods and adults practicing the more traditional methods of abstention, <u>coitus interruptus</u>, and the like.

The final birth rate influence consists of cultural and social changes that may occur in the future in ways not explained by the economic and demographic sectors of the model. This factor is to represent assumptions about weakening commitment to traditional Islamic values, exposure to new ideas about family planning, emergence of alternative roles for women, and other cultural changes that may develop during the next 25-35 years.

Future variations in Egypt's death rate are likely to be much less pronounced than variations in the birth rate, since the Egyptians appear to have successfully conquered the most serious contributors to excessive adult mortality. Egypt's current 55-58 year life expectancy could probably be raised to the low 60's of the country were successful in reducing the current high infant mortality rate. The major determinants of death rates include nutrition (protein and calory consumption), persistent diseases (e.g., schistosomiasis), and medical care. Nutrition is a major link between the population and the agriculture sectors; persistent disease is a similarly important inter-relationship between the population and the water control sectors.

Egypt's population enjoys a satisfactory degree of overall nutrition, both by comparison with other developing countries and by comparison with FAO recommendations. In particular, the average Egyptian calorie consumption of 2800 calories per day is well above the FAO recommendation of 2250 calories per day. Protein consumption may suffer slightly from the limited contribution meat makes to the Egyptian diet. In general, the current Egyptian diet seems capable of supporting normal life expectancies. The influence of nutrition on death rates is included in the model primarily to ensure proper system behavior in the event of a future food shortage brought on by a growing population or a loss of food imports.

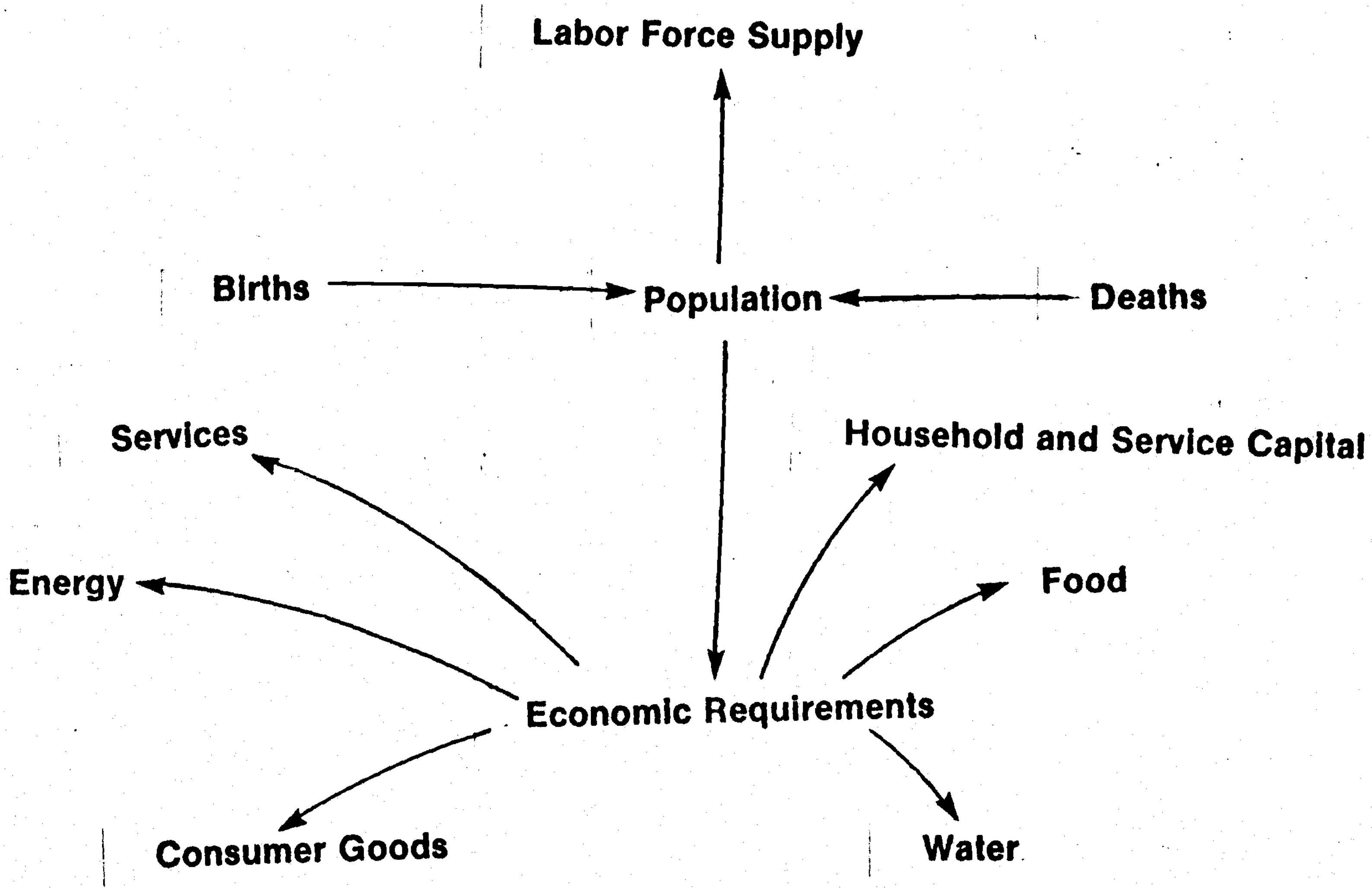
Besides the overall population size created by birth and death rate trends, another important variable is the average labor force productivity. Like the birth rate and death rates, productivity is the locus of important inter-relationships between the population sector and other sectors of the model. In particular, productivity is importantly influenced by nutrition (a relationship with the agriculture sector) and disease (a relationship with the water control sector). In turn, labor productivity affects the performance of every segment of the Egyptian economy.

Earlier portions of this chapter have referred to the influence of urbanization on birth rates, on labor force factors, on the spread of water-borne diseases, and on other population variables. In the computer simulation model, urbanization is represented by treating the rural and urban population separately. Birth and death rates are calculated separately for the two sub-populations, in response to differing urban and rural standards of living, ratios of service personnel to population, etc. In addition, the model represents migration between the two areas, and incorporate those demographic shifts in its calculation of rural and urban populations.

A number of consumption relationships link the population sector to the model's economic sectors. The urban and rural populations consuming grains, fruits and vegetables, and meats from the agricultural sector; water from the water sector; and energy, consumer goods, and capital from the respective industrial sectors. In addition, the population requires service labor from the labor pool it provides to the economy. Both populations compete for these economic goods with the other sectors of the economy that also require them. Thus, the growth of the population sector (as projected by the simulation model), and its direct and indirect competition for resources, will have an important influence on the ability of the other sectors to meet the demands placed upon them.

The roles of the model's population sector are diagrammed in Figure IV-1. At the center of the figure, the size of the population itself is determined by trends in births and deaths. In the model, births and deaths are determined by the interactions of the population sector with other sectors of the model, as described in Section IV-A. The population's requirements for six different goods are represented explicitly in the model: 1) food, 2) services, 3) consumer goods, 4) household and service capital, 5) energy, and 6) water. Section IV-B describes the model's handling of these requirements, and the manner in which the availability of economic goods is determined by competition between the population sector and other sectors of the model. The age and geographical distribution of the population, as well as certain productivity considerations, determine Egypt's labor force. This is described in Section IV-C. Finally, migration from rural to urban areas discussed in Section IV-D.

Figure IV-I:
The Role of Population in the Egypt Model



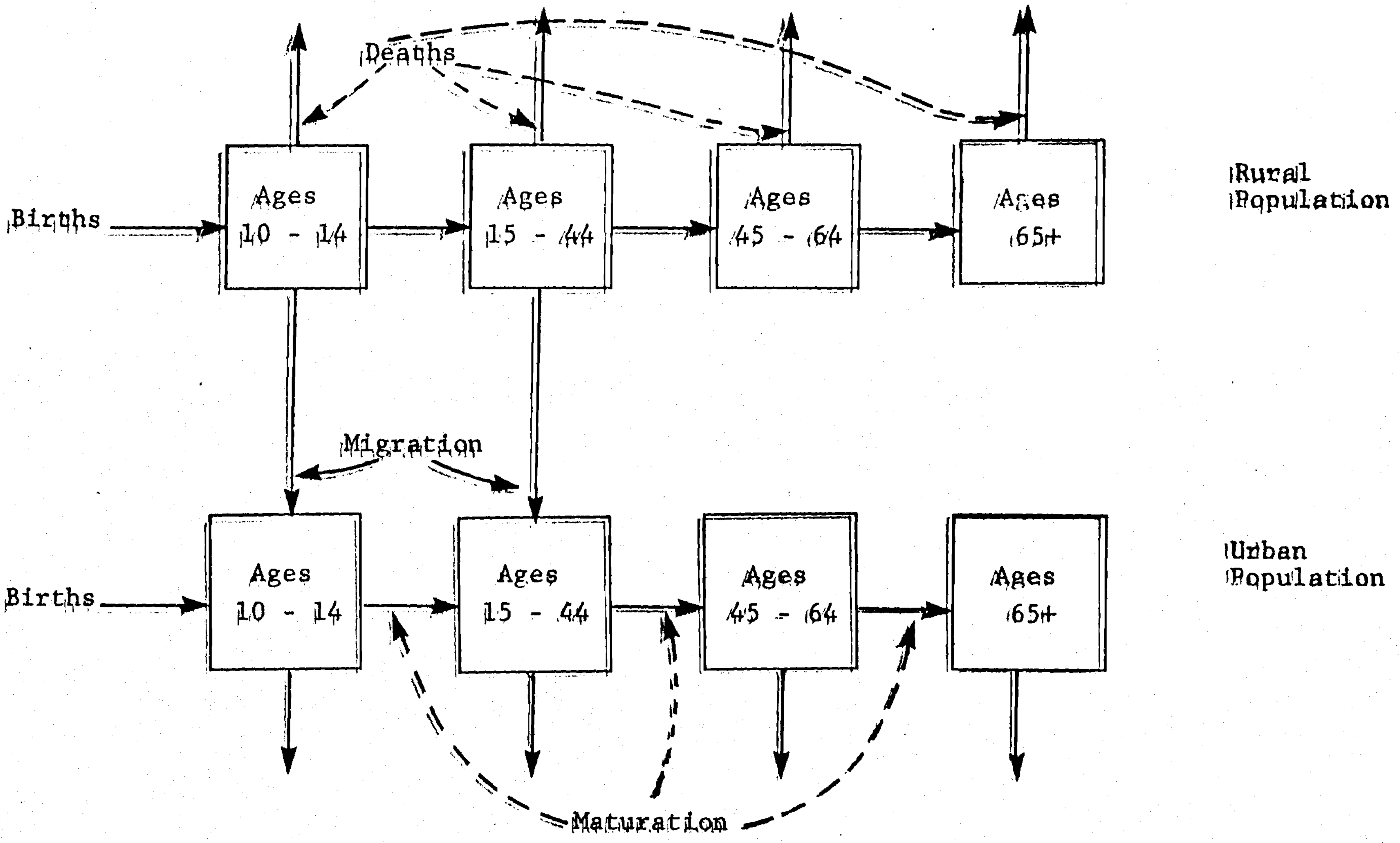
IV-A. DEMOGRAPHICS

The Egypt model distinguishes between eight different population categories, based upon geographic and age considerations. In terms of geography, the model treats the urban and rural populations as two completely separate entities, with their own distinct internal dynamics. Each of the two geographical populations is broken down into four sub-groups -- ages 0-14, 15-44, 45-64, and 65 and over. This population aggregation is diagrammed in Figure IV-2.

Geographical Disaggregation -- The model's urban/rural disaggregation allows the exploration of a number of crucial demographic aspects of Egypt's future economic development. First, consumption requirements for foods and consumer goods typically differ between urban and rural areas.[1] Therefore, the continuing rapid growth of urban areas, combined with the slow growth of rural areas, suggest an ever-increasing per capita burden on Egypt's economy. The model's explicit and separate treatment of urban and rural populations allows accurate estimates of the consequences of these demands on the economy.

A second important aspect of the urban/rural geographical disaggregation concerns Egypt's labor force and employment needs. In particular, urban job creation is losing the race with urban population growth, and underemployment or unemployment problems loom in the future.[2] Furthermore, mechanization of agriculture to boost food output would create an additional reserve of working age adults to compete for industrial and service employment opportunities. Again, the model's disaggregation between urban and rural areas allows an investigation on the balance between labor force and jobs in both regions.

Figure IV-2:
Age and Geographical Disaggregation



Finally, developing countries typically show significant differences between urban and rural fertility. This phenomenon has not yet surfaced in Egypt,[3] an observation that will be discussed in more detail later in this section. However, different urban and rural fertilities may develop in the future, and the model's geographical disaggregation will allow an examination of the implications of such a trend.

Age Disaggregation -- The age disaggregation in the Egypt model reflects the importance of birth rate and employment factors. Thus, the first age group -- 0-14 year olds -- comprises those members of the Egyptian population that are both too young to reproduce and (generally) too young to work.[4] The second age group -- 15-44 year olds -- includes all the members of the population that are likely to reproduce, as well as the bulk of the country's labor force. The third age group -- ages 45-64 -- comprises those adults that are too old to reproduce, but still young enough to participate in the country's labor force. The final age group -- ages 65 and over -- includes those people who are too old for both reproduction and employment.

In the model, deaths, maturation (i.e., moving up to the next age group), and migration are calculated separately for each age group. The annual number of deaths for an individual age group is determined by the geographical population's life expectancy (with a separate life expectancy calculated for the urban population and the rural population). The assumptions in the model for annual mortality are shown in the table below, where the numbers indicate the fraction of the age group population assumed to die each year.

Determination of Age Specific Death Rates from Life Expectancy[5]

Age Group	Life Expectancy 20	30	40	50	60	70	80
0-14	.057	.037	.024	.016	.008	.002	.001
15-44	.027	.017	.011	.0065	.004	.0016	.0008
45-64	.056	.037	.025	.017	.012	.008	.006
65+	.130	.110	.090	.070	.060	.050	.040

The DYNAMO computer language software performs a linear interpolation between the data points shown in the table above to calculate intervening values. Thus, the death rate for the 45-64 year old age group at a sixty-five year life expectancy would be .010, midway between the death rates for a 60 and 70 year life expectancy. The model's calculation of a life expectancy for each population is described later in this chapter.

To calculate maturation rates for each age group, the model assumes a flat distribution of ages throughout the age group population. Therefore, the maturation rate for each age group can be approximated as the total population of that age group divided by the number of years spanned by that group's age classification. For example, maturation for the 0-14 year age group (expressed in terms of people per year) would be calculated as one-fifteenth of the total age group population. Maturation from the eldest age group, of course, would be zero, with deaths being the only outflow from that pool.

To implement the death rate, maturation rate, and age-specific population calculations described above, the Egypt model includes a standard "building block" that is reproduced in the model for each urban and rural age group. In DYNAMO terminology, such a building block is called a MACRO. Thus, each geographical population would include four replications of the "age MACRO", one for each of the four age disaggregations. The equations for the age-group MACRO are listed below. The total age-group population (POP) is increased by any inflows (INFLOW) from the preceding age group or migration from the corresponding age group in the other geographical area. The population is decreased by the outflow (OUTFLOW) that includes death (DEATHS) and maturation (MATUR).

```
   AGE MACRO

MACRO     POP(INFLOW,POPI,MIGRATE,DEATHTB,LIFEXP,           .1
  AGESPAN,DEATHS,MATURE)
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    DEATHS  - DEATHS IN AGE GROUP (PEOPLE/YEAR) <3>
    MATURE  - MATURATION OUT OF AGE GROUP (PEOPLE/YEAR)
                <4>

INTRN     OUTFLOW                                           .3
    OUTFLOW- OUTFLOW FROM AGE GROUP (PEOPLE/YEAR) <2>

POP.K=POP.J+(DT)(INFLOW.J-OUTFLOW.J)                        1, L
POP=POPI                                                    1.1, N
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    OUTFLOW- OUTFLOW FROM AGE GROUP (PEOPLE/YEAR) <2>

OUTFLOW.K=DEATHS.K+MATURE.K+MIGRATE.K                       2, A
    OUTFLOW- OUTFLOW FROM AGE GROUP (PEOPLE/YEAR) <2>
    DEATHS  - DEATHS IN AGE GROUP (PEOPLE/YEAR) <3>
    MATURE  - MATURATION OUT OF AGE GROUP (PEOPLE/YEAR)
                <4>

DEATHS.K=POP.K*TABHL(DEATHTB,LIFEXP.K,20,80,10)             3, A
    DEATHS  - DEATHS IN AGE GROUP (PEOPLE/YEAR) <3>
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>

MATURE.K=POP.K/AGESPAN                                      4, A
    MATURE  - MATURATION OUT OF AGE GROUP (PEOPLE/YEAR)
                <4>
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>

MEND
```

The basic structures of the demographic processes for Egypt's urban and rural populations are quite similar. Within each geographical population, birth rates and life expectancies respond to the same fundamental influences (although the strengths of these influences and, hence, their impacts can vary substantially between the urban and rural environments). Each population (albeit, to a differing extent) accumulates household capital and requires consumer goods, energy, services, water, and food. Labor supply considerations will likewise be structurally similar for each population.

Because the basic structures associated with both geographical populations are so similar, the Egypt model incorporates a standard "building block" of equations to represent them. This building block has been called the "area MACRO", where 'area' refers to a geographical subdivision of the overall Egyptian population. The area population MACRO is vastly more complex than the age-group MACRO, treating as it does a wide range of demographic and economic factors.

The remainder of this chapter is devoted to a detailed description of the structural and parametric assumptions for the area population building block. As suggested above, the structural assumptions for the urban and rural populations are identical. There are, however, important differences in the parameters used for the two populations; these differences will be highlighted in the forthcoming discussion. The building block discussion will treat the following eight subjects in turn:

(1) births,
(2) life expectancy,
(3) food availability,
(4) services,
(5) consumer goods,
(6) household and service capital,
(7) energy, and
(8) labor supply.

The model equations for each of these eight subjects will immediately follow the descriptive material, so the reader may examine how the descriptive material and assumptions accumulated for the study were translated into mathematical form for the simulation model.

The area population building block begins with equations that calculate the total area population (AREA) by adding the populations for the four age groups (PQ, PX, PY, PZ). The age-group populations are in turn defined through the use of the age-group building block described earlier in this section. The age-group blocks are connected by the maturation flows between them, so that maturation out of the 0-14 year pool (PQM) becomes a flow into the 15-44 year pool. Deaths for the area population (PD) are calculated by summing the deaths from each age group (PQD, PXD, PYD, PZD). Births (PB) are calculated by a separate piece of model structure, which is discussed next.

Initial values for the number of people in each age group are required to provide a starting point for the model simulations. To facilitate historical validation of the model, simulations are initiated in 1960. The starting values for each area population age group are shown below.

1960 Population Values(Millions)[6]

	0-14	15-44	45-64	65+	Total
Urban	4.18	3.94	1.25	.39	9.76
Rural	6.99	6.59	2.10	.65	16.33
Total	11.17	10.53	3.35	1.04	26.09

```
   POPULATION

AREA.K=PQ.K+PX.K+PY.K+PZ.K                                    3, A
    AREA    - TOTAL AREA POPULATION (PEOPLE) <3>
    PQ      - POPULATION AGED 0-14 (PEOPLE) <4>
    PX      - POPULATION AGED 15-44 (PEOPLE) <5>
    PY      - POPULATION AGED 45-64 (PEOPLE) <6>
    PZ      - POPULATION AGED OVER 64(PEOPLE) <7>

PQ.K=POP(PB.K,PQI,PQNM.K,PQDT,PLE.K,15,PQD.K,PQM.K) 4, A
    PQ      - POPULATION AGED 0-14 (PEOPLE) <4>
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    PB      - BIRTHS (PEOPLE/YEAR) <10>
    PQNM    - NET RURAL-URBAN MIGRATION OF 0-14 YEAR OLDS
    PQDT    - TABLE FOR DEATH RATES FOR 0-14 YEAR OLDS
                <118>
    PLE     - LIFE EXPECTANCY (YEARS) <24>
    PQD     - DEATHS OF 0-14 YEAR OLDS
    PQM     - MATURATION OF 0-14 YEAR OLDS

PX.K=POP(PQM.K,PXI,PXNM.K,PXDT,PLE.K,30,PXD.K,              5, A
  PXM.K)
    PX      - POPULATION AGED 15-44 (PEOPLE) <5>
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    PQM     - MATURATION OF 0-14 YEAR OLDS
    PXI     - INITIAL AREA POPULATION AGED 15-44
    PXNM    - NET RURAL-URBAN MIGRATION OF 15-44 YEAR
                OLDS
    PXDT    - TABLE FOR DEATH RATES FOR 15-44 YEAR OLDS
                <118.2>
    PLE     - LIFE EXPECTANCY (YEARS) <24>
    PXD     - DEATHS OF 15-44 YEAR OLDS
    PXM     - MATURATION OF 15-44 YEAR OLDS

PY.K=POP(PXM.K,PYI,PYNM.K,PYDT,PLE.K,20,PYD.K,              6, A
  PYM.K)
    PY      - POPULATION AGED 45-64 (PEOPLE) <6>
    POP     - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    PXM     - MATURATION OF 15-44 YEAR OLDS
    PYI     - INITIAL AREA POPULATION AGED 45-64
    PYNM    - NET RURAL URBAN MIGRATION OF 45-64 YEAR
                OLDS
    PYDT    - TABLE FOR DEATH RATES FOR 45-64 YEAR OLDS
                <118.4>
    PLE     - LIFE EXPECTANCY (YEARS) <24>
    PYD     - DEATHS OF 45-64 YEAR OLDS
    PYM     - MATURATION OF 45-64 YEAR OLDS
```

```
PZ.K=POP(PYM.K,PZI,PZNM.K,PZDT,PLE.K,1E12,PZD.K,            7, A
  PZM.K)
    PZ        - POPULATION AGED OVER 64(PEOPLE) <7>
    POP       - POPULATION IN AGE GROUP (PEOPLE) <1.1>
    PYM       - MATURATION OF 45-64 YEAR OLDS
    PZI       - INITIAL AREA POPULATION AGED OVER 65
    PZNM      - NET RURAL-URBAN MIGRATION OF 65+ YEAR OLDS
    PZDT      - TABLE FOR DEATH RATES FOR AGES OVER 64
                  <118.6>
    PLE       - LIFE EXPECTANCY (YEARS) <24>
    PZD       - DEATHS OF AGES OVER 65

PD.K=PGD.K+PXD.K+PYD.K+PZD.K                                8, A
    PD        - TOTAL DEATHS (PEOPLE/YEAR) <8>
    PGD       - DEATHS OF 0-14 YEAR OLDS
    PXD       - DEATHS OF 15-44 YEAR OLDS
    PYD       - DEATHS OF 45-64 YEAR OLDS
    PZD       - DEATHS OF AGES OVER 65

PINN.K=TABHL(PINNT,TIME.K,1960,2010,10)                     9, A
    PINN      - NORMAL POPULATION PRIORITY
```

Births -- The annual births for both the urban and rural populations in the Egypt model are important dynamic, endogenous variables. By dynamic and endogenous, we mean that the two birth rates respond to internal conditions -- for example, standard of living, services delivery, and perceived child mortality -- that are calculated elsewhere within the model. This representation of annual births greatly enriches the model's treatment of demographic issues, since it reduces the number of separate (and, potentially, inconsistent) external assumptions the analyst must make about future trends in such important variables as the standard of living. Thus, one need not assume some future trend in standard of living, and input that standard of living estimate to the projection for annual births. Instead, one need only assume the impact of differing standards of living on the overall birth rate, and the model itself will supply projections of the material standard of living for different economic scenarios. This dynamic, endogenous representation allows the model to properly capture the two-way interdependency between births and standard of living.

In the model, the total annual births (PB) for an area population is determined by three other demographic factors. The first is the maximum possible number of births (PBM) for the area population, which depends upon the number of fertile adults, the fraction of the population that is married, and estimates of maximum possible fertility. The second factor is the model's estimate of the area population's desired annual births (PBD). Unlike the maximum possible births, which is a biological concept, the population's desired births is a sociological variable -- dependent on the average desired family size. The third major determinant of annual births is the area population's birth control effectiveness (PBCE). This determines whether annual births fall closer to desired births or to maximum births. Each of these three influences will be discussed in turn shortly.

The calculation of annual births from these three major demographic influences is diagrammed below. Desired births (PBD) and maximum births (PBM) form the two extremes of a wide possible range for the area population's actual births (PB). The location of actual births within this range is determined by the population's birth control effectiveness (PBCE). Birth control effectiveness is represented in the model as an index ranging in value from 0 to 1, where zero connotes complete ineffectiveness in limiting births and one connotes complete success. Thus, an area population with a .50 birth control effectiveness would find its actual births falling midway between desired births and maximum births. Effectiveness values closer to one would move actual births closer to desired births.

```
    BIRTHS

PB.K=FIFGE(PBD.K+(PBM.K-PBD.K)*(1-PBCE.K),PBM.K,      10, A
  PBM.K,PBD.K)
    PB       - BIRTHS (PEOPLE/YEAR) <10>
    PBD      - DESIRED BIRTHS (PEOPLE/YEAR) <12>
    PBM      - MAXIMUM BIRTHS (PEOPLE/YEAR) <11>
    PBCE     - BIRTH CONTROL EFFECTIVENESS <21>
```

Maximum Births — Maximum births (PBM) are calculated within the model as the product of the number of married couples in the area population (PMMC) and an estimated maximum fertility (PMF). The assumed value for maximum fertility, forty births per 100 fertile women per year, is an average across the entire fertile age span of ages 15-44.[7]

The number of married couples depends on the size of the 15 to 44 year age group (PX) and the fraction of the population within that age group which is married (PFM). The fraction of the population married is determined from an estimate supplied to the model of the average marriage age (PMA) for the urban and rural areas. It is assumed that the average marriage age for the rural population will typically be two years less than the marriage age for the urban population,[8] as diagrammed in Figure IV-3. The implications of alternative projections for future marriage trends can be easily determined by adjusting the marriage age assumptions provided to the model.

```
PBM.K=PMMC.K*PMF                                              11, A
    PBM      - MAXIMUM BIRTHS (PEOPLE/YEAR) <11>
    PMMC     - MARRIED COUPLES (COUPLES) <13>
    PMF      - MAXIMUM FERTILITY (BIRTHS/YEAR PER FERTILE
                 WOMAN) <118.8>

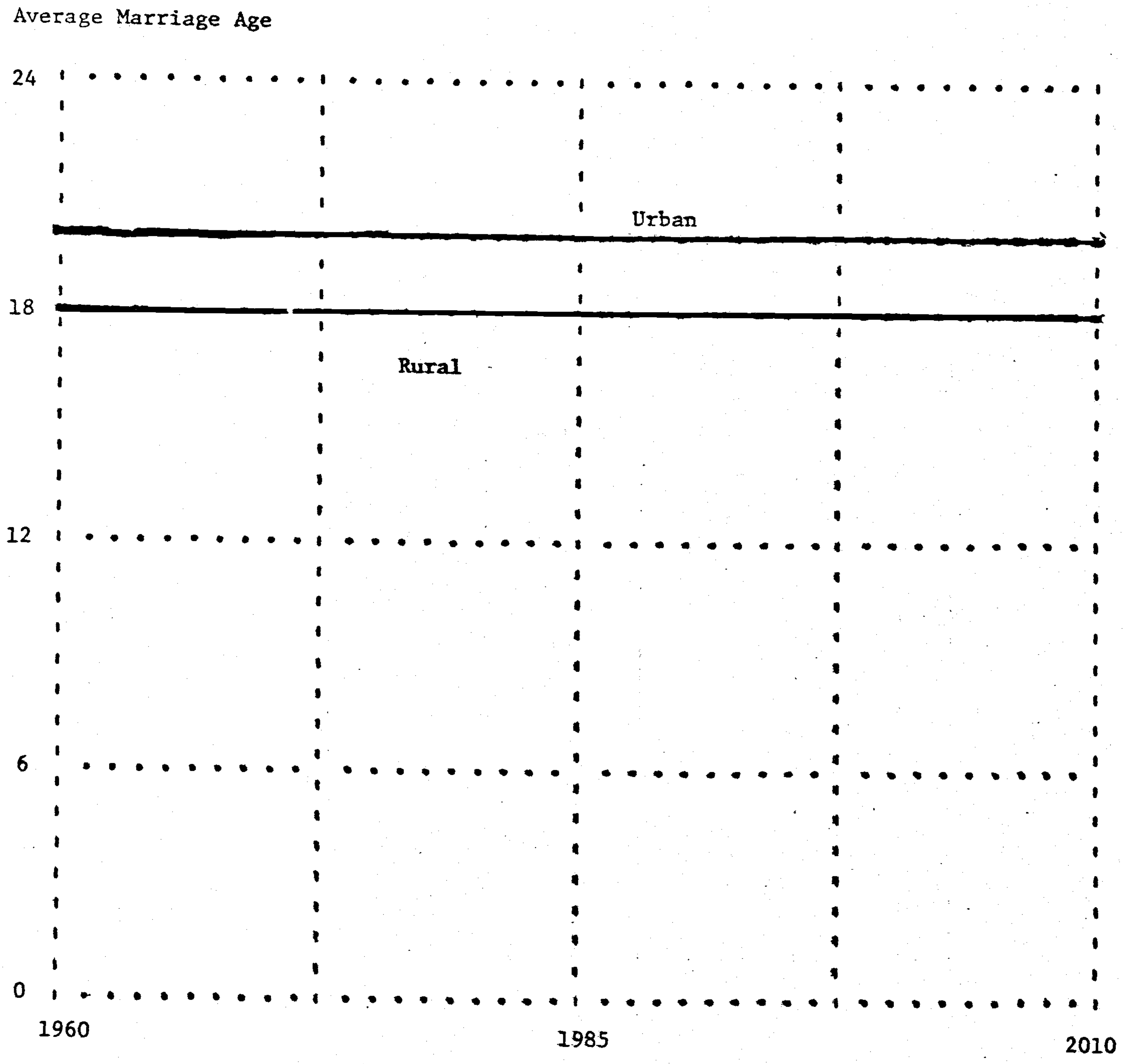
PBD.K=PMMC.K*(PDLB.K/(45-PMA.K))                              12, A
    PBD      - DESIRED BIRTHS (PEOPLE/YEAR) <12>
    PMMC     - MARRIED COUPLES (COUPLES) <13>
    PDLB     - DESIRED LIFETIME BIRTHS (PEOPLE/COUPLE)
                 <16>
    PMA      - AVERAGE MARRIAGE AGE (YEARS) <15>


PMMC.K=PX.K*.5*PFM.K                                          13, A
    PMMC     - MARRIED COUPLES (COUPLES) <13>
    PX       - POPULATION AGED 15-44 (PEOPLE) <5>
    PFM      - FRACTION OF POPULATION MARRIED <14>

PFM.K=(45-PMA.K)/30                                           14, A
    PFM      - FRACTION OF POPULATION MARRIED <14>
    PMA      - AVERAGE MARRIAGE AGE (YEARS) <15>

PMA.K=TABHL(PMAT,TIME.K,1960,2010,10)                         15, A
    PMA      - AVERAGE MARRIAGE AGE (YEARS) <15>
    PMAT     - TABLE FOR POPULATION AVERAGE MARRIAGE AGE
                 (YEARS)
```

Figure IV-3:
Marriage Ages

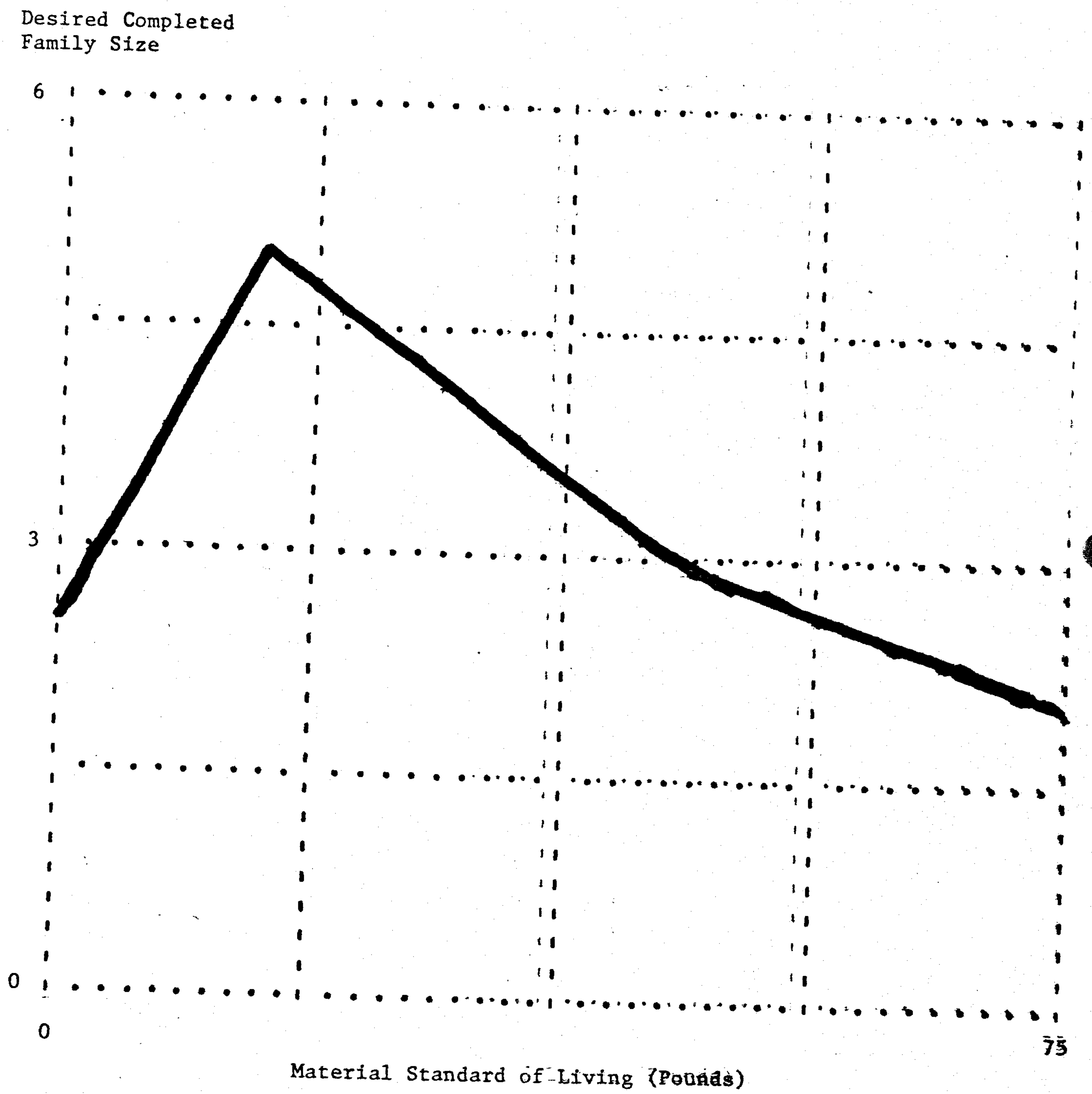


Desired Births -- The desired births (PBD) for an area population is determined by the area's married couples (PMMC, whose calculation was described above) and the total desired lifetime births (PDLB) per couple. For ease of calculation, it is assumed that married couples will distribute their desired lifetime births evenly over the time interval between the average marriage age (PMA) and the onset of infertility at age 45.

Desired lifetime births, in turn, arise from the population's desired completed family size (PDCFS) and its perceptions of child mortality (PPCM). The desired completed family size represents the number of children each married couple would like to see survive into adulthood, and is assumed to depend upon the population's standard of living. The assumed dependence of family size on standard of living (PSL) is diagrammed in Figure IV-4. The shape was estimated from descriptive material on Egyptian demographic trends, and incorporates the observation that the peak desired family size occurs at low, but non-zero, standards of living.[9] Below this family size peak, numerous children are too great a financial burden for limited family incomes, so excessive childbirth is discouraged. Beyond the peak family size, rising incomes and the associated social value changes are assumed to reduce the desire of married couples for extra children.

Besides the influence of standard of living on desired family size, the model also includes an exogenous factor (PDCFSN). This factor is used to represent the differing rural and urban incentives for children[10] including the economic role of children in the two areas, and living space considerations. In the model, the assumed standard of living incentives for urban births during the past 15 years are balanced by exogenous incentives for rural births, yielding a roughly equal birth rate for the two areas. In addition, the exogenous factor incorporates the possibility for changes in social values over

Figure IV-4: Effect of Material Standard of Living



the next several decades that might also influence desired family sizes.[11] Figure IV-5 diagrams the values for this exogenous family size effect that are incorporated into the model.

Desired lifetime births (PDLB), as noted above, depends on both desired completed family size and perceived child mortality (PPCM). It has been observed in other developing societies that desired births are influenced by infant and child mortality, so that parents attempt to compensate for the deaths of their children by having extra births.[12] In the model, perceived child mortality is a lagged recognition of the actual child mortality (PCM), the comparison of child deaths (PQD) with the total population aged 0-14 (PQ). The larger the perceived child mortality, the greater will be the excess of desired births over desired completed family size.

```
PDLB.K=PDCFS.K/(1-PPCM.K)                                16, A
    PDLB    - DESIRED LIFETIME BIRTHS (PEOPLE/COUPLE)
                <16>
    PDCFS   - DESIRED COMPLETED FAMILY SIZE (PEOPLE/
                COUPLE) <19>
    PPCM    - PERCEIVED CHILD MORTALITY <17>

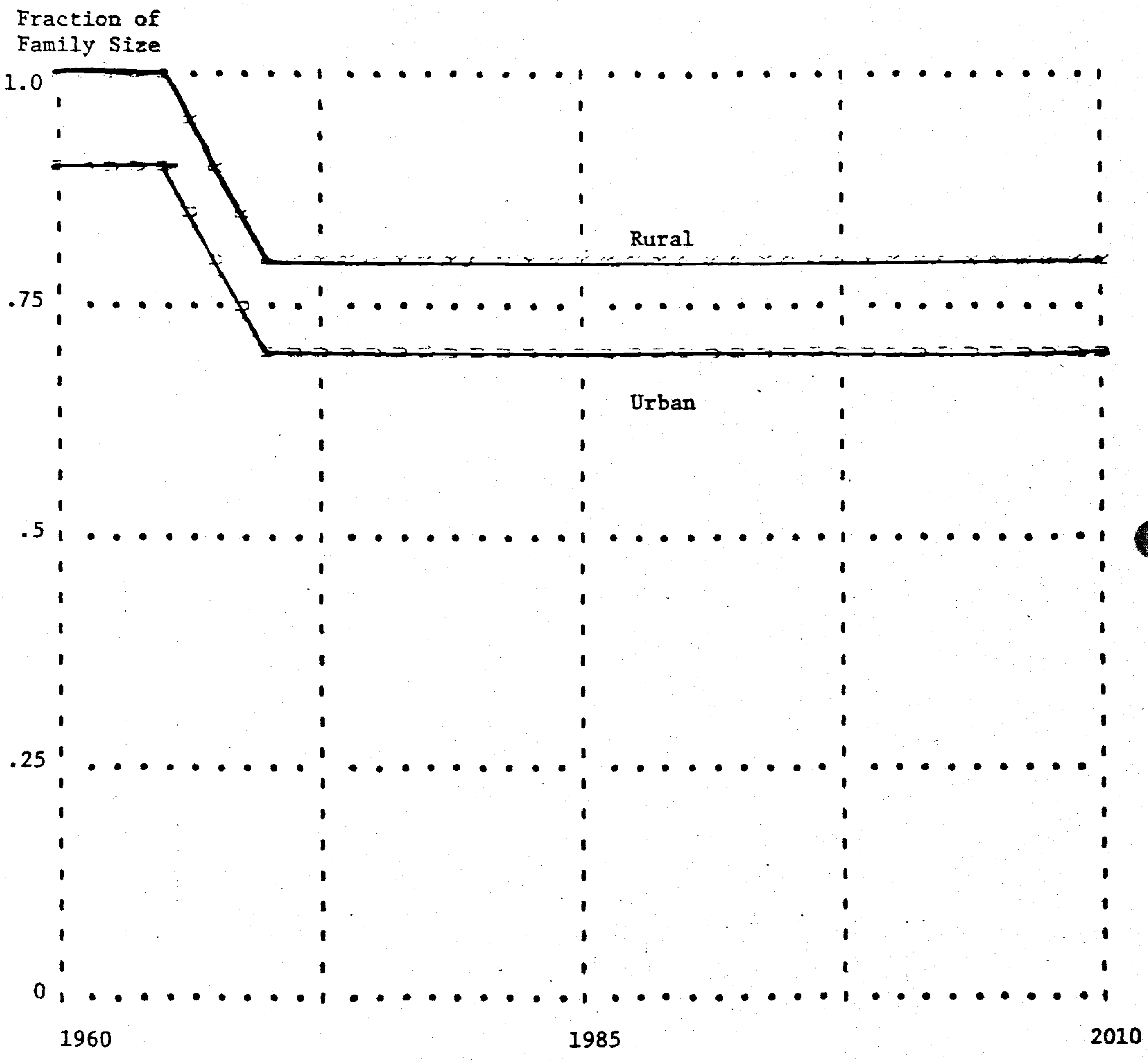
PPCM.K=SMOOTH(PCM.K,PCMAT)                               17, A
    PPCM    - PERCEIVED CHILD MORTALITY <17>
    PCM     - CHILD MORTALITY <18>
    PCMAT   - TIME TO PERCEIVE CHANGES IN CHILD MORTALITY
                (YEARS) <119.1>

PCM.K=1-(EXP(15*LOGN(1-(PQD.K/PQ.K))))                   18, A
    PCM     - CHILD MORTALITY <18>
    PQD     - DEATHS OF 0-14 YEAR OLDS
    PQ      - POPULATION AGED 0-14 (PEOPLE) <4>

PDCFS.K=PDCFSN.K*TABHL(PDFST,PSL.K,0,75,15)              19, A
    PDCFS   - DESIRED COMPLETED FAMILY SIZE (PEOPLE/
                COUPLE) <19>
    PDCFSN  - FAMILY SIZE TRENDS <20>
    PDFST   - TABLE FOR POPULATION DESIRED FAMILY SIZE
    PSL     - STANDARD OF LIVING (POUNDS/YEAR) <44>

PDCFSN.K=TABHL(PDFSNT,TIME.K,1960,2010,5)                20, A
    PDCFSN  - FAMILY SIZE TRENDS <20>
```

Figure IV-5:
Trends in Desired Family Sizes

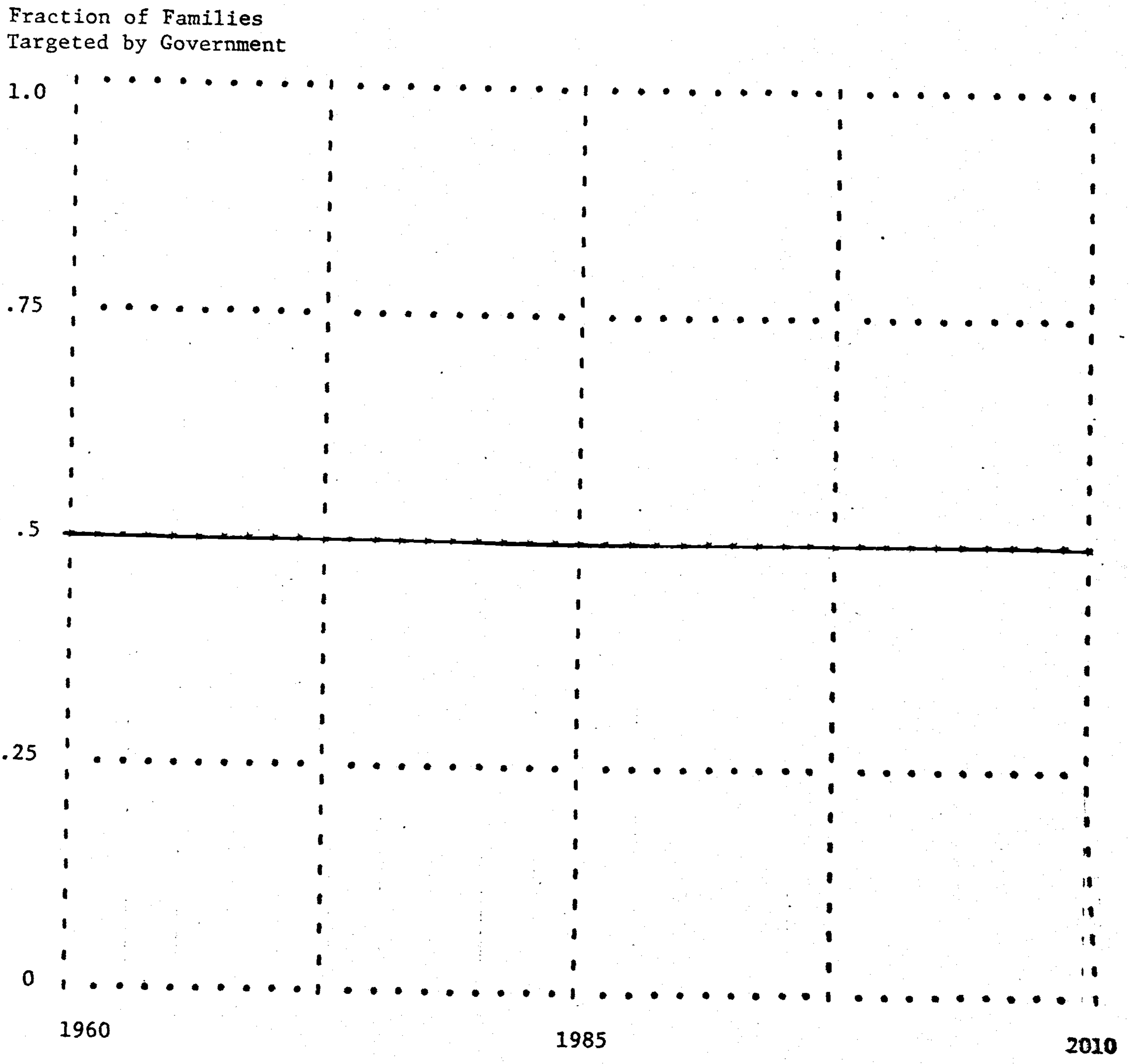


Birth Control Effectiveness -- The ability of an area population to limit its births to some desired figure will depend upon the methods of birth control that population practices. Even the most primitive populations are capable of practicing what we might call "traditional" birth control methods. These traditional methods would include abstinence, coitis interruptus, and other non-technological procedures for avoiding conception.[13] In practice, such methods have a limited effectiveness. Contrasted with these traditional birth control methods are the more modern birth control pills, IUDs, and, in the extreme, sterilizations. These modern techniques, when properly used, are much more effective in controlling births.

For each population area, the model calculates the fraction of the married couples using modern birth control methods (PFCMB); it is assumed that the balance of the population is using traditional birth control methods. Thus, the area population's overall birth control effectiveness is a weighted average of the two approaches, i.e., the fraction of the population using modern methods times the effectiveness of modern methods (PEMBCM, an assumed effectiveness of .9) plus the fraction of the population using traditional methods times the effectiveness of traditional birth control methods (PETBCM, assumed to be .5).[14]

The fraction of married couples using modern birth control methods is modeled as resulting from: 1) government programs to encourage modern birth control methods; and 2) the ability of the government to carry out these programs through the service labor force. The model receives external inputs for each area population that represent assumed government birth control programs over the 1960 to 2010 period (the base assumption is diagrammed in Figure IV-6).[15] The government programs are expressed as an index from 0 to 1, representing the fraction of the adult population in each area the government attempts to convert to the use of modern birth control devices.

Figure IV-6:
Government Birth Control Effort



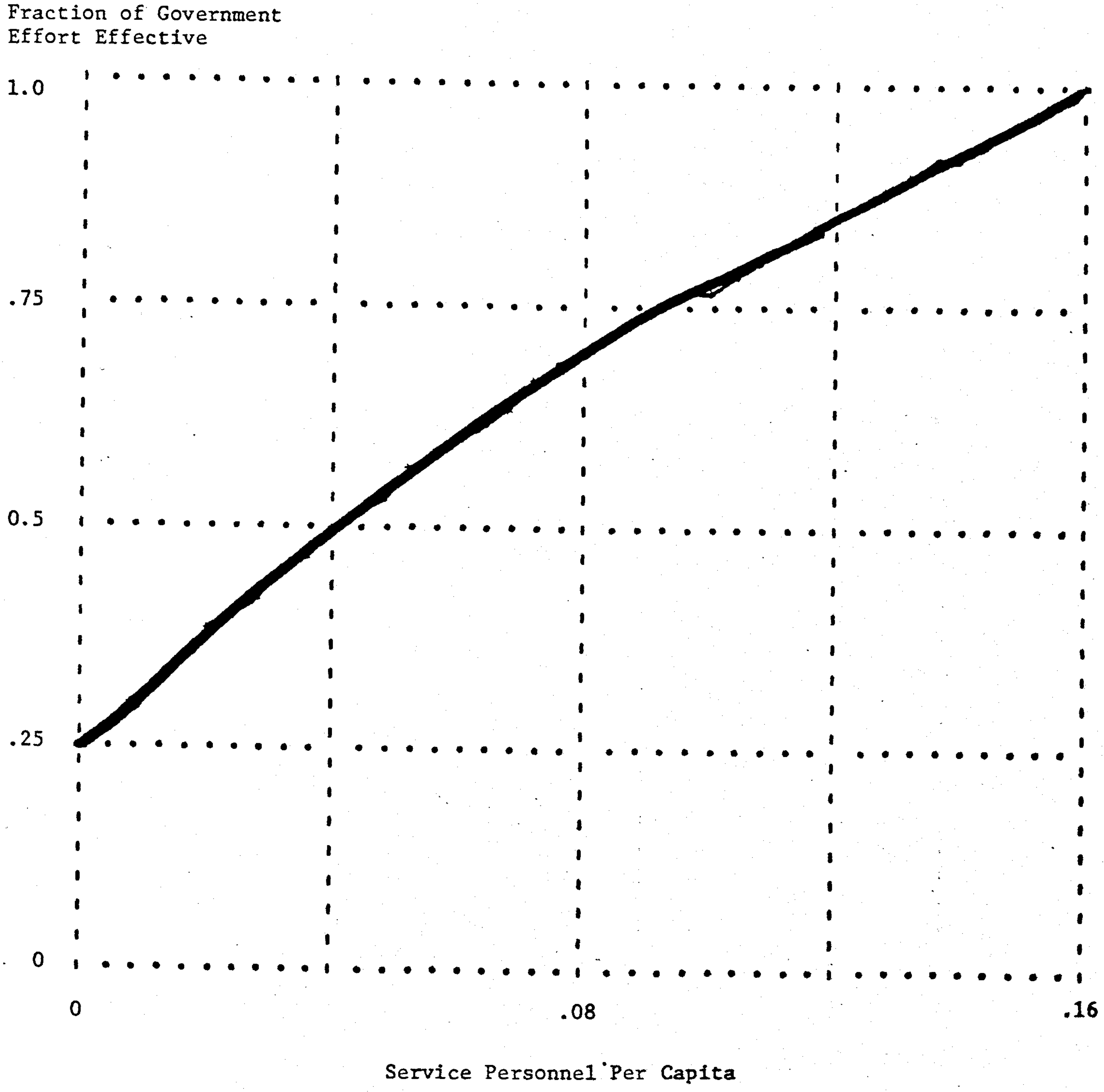
Whether this target group will actually convert to modern birth control depends upon the effect of services delivery on the fraction of married couples using modern birth control (PFCMBS). The greater the ratio of the service personnel to the total population, the closer the government is assumed to come to achieving its target fraction for modern birth control usage.[16] In the model, services per capita (PGSC) is the variable for the range of social and business services provided to the population by the service labor force. Thus, it represents a surrogate for the combination of medical and educational personnel that determines the ability of the government to reach and instruct the population in both urban and rural areas. The assumed effect of services delivery is diagrammed in Figure IV-7.

```
PBCE.K=PETBCM*(1-PFCMB.K)+PEMBCM*PFCMB.K                  21, A
    PBCE   - BIRTH CONTROL EFFECTIVENESS <21>
    PETBCM - EFFECTIVENESS OF TRADITIONAL BIRTH CONTROL
                METHODS <119.5>
    PFCMB  - FRACTION OF MARRIED COUPLES USING MODERN
                BIRTH CONTROL <22>
    PEMBCM - EFFECTIVENESS OF MODERN BIRTH CONTROL
                METHODS <119.7>

PFCMB.K=TABHL(PFCMBT,TIME.K,1960,2010,10)*PFCMBS.K   22, A
    PFCMB  - FRACTION OF MARRIED COUPLES USING MODERN
                BIRTH CONTROL <22>
    PFCMBT - TABLE FOR FRACTION OF MARRIED COUPLES THE
                GOVERNMENT IS ATTEMPTING TO CONVERT TO
                MODERN BIRTH CONTROL METHODS <119.9>
    PFCMBS - EFFECT OF SERVICES DELIVERY ON FRACTION OF
                MARRIED COUPLES USING MODERN BIRTH
                CONTROL <23>

PFCMBS.K=TABLE(PFCMBST,PGSC.K,0,.16,.04)                  23, A
    PFCMBS - EFFECT OF SERVICES DELIVERY ON FRACTION OF
                MARRIED COUPLES USING MODERN BIRTH
                CONTROL <23>
    PFCMBST- EFFECT OF SERVICES DELIVERY ON GOVERNMENT
                ATTEMPTS TO CONVERT MARRIED COUPLES TO
                MODERN BIRTH CONTROL METHODS <120.3>
    PGSC   - GOVERNMENT SERVICES PER CAPITA (SERVICE
                UNITS) <47>
```

Figure IV-7:
Effect of Services Delivery on Birth Control Programs

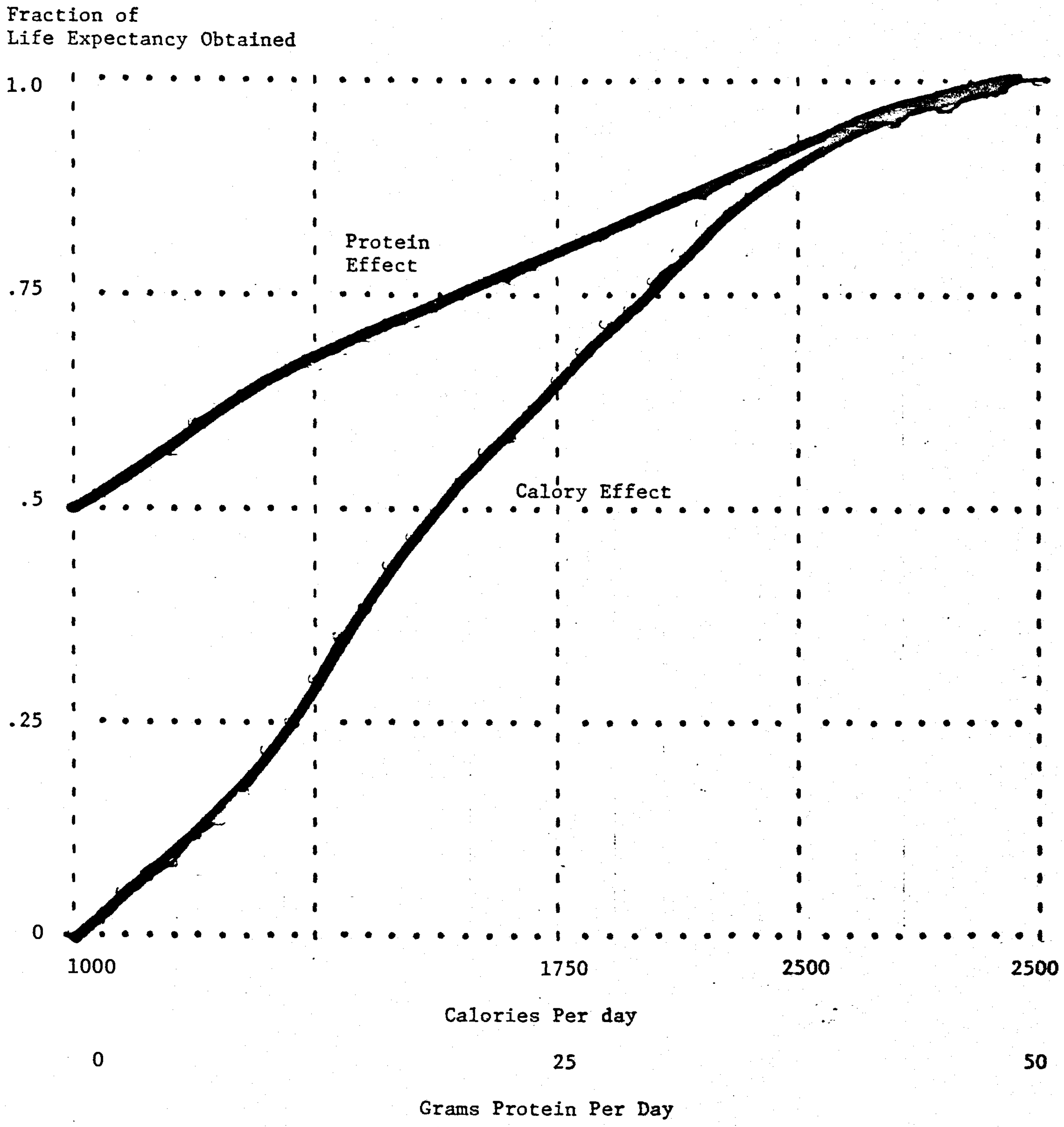


Life Expectancy -- An earlier section of this chapter described the dependence of individual age-group mortality on the overall life expectancy for an area population. In the Egypt model, an area population's life expectancy is determined by four factors -- calorie consumption, protein consumption, persistent diseases, and government medical support. The effect on life expectancy of each of the four influences is calculated separately in the model, and the combined effects determine an overall life expectancy. Because the four effects are somewhat independent, an extreme condition for any one effect can have a severe impact on life expectancy, no matter how beneficial the other effects.

The life expectancy for an area population (PLE) is calculated in the model by reference to a hypothetical "normal" life expectancy (PLEN). This normal life expectancy is defined as the average life expectancy at birth for a population with adequate calorie and protein consumption, minimal persistent disease, and full medical support. In the model, this hypothetical life expectancy is assumed to be 75 years.[17] Each of the four effects in the model, as described in turn below, act on life expectancy in a fractional manner. That is, a certain level of calorie consumption is assumed to reduce the life expectancy by some percentage (for example, 20%) from what the life expectancy otherwise would be with an adequate caloric intake.

The calculation of the calorie consumption (PELEC) and protein consumption (PELEP) effects on life expectancy illustrates this process. Figure IV-8 diagrams the nutritional effects on life expectancy for varying levels of calorie and protein consumption. At the extreme of no calorie consumption, life expectancies are assumed to drop near zero. Very low protein consumption levels are also assumed to have severe impacts, although life expectancy remains above zero. Average adult comsumption of 2,250 calories per day and 35

Figure IV-8:
Effect of Nutrition on Life Expectancy



grams of protein per day are assumed to be sufficient to achieve normal life expectancy.[18] Protein and calorie consumptions between these two extremes are assumed to have intermediate effects on life expectancy, as shown in the Figure.

There currently exists little hard research evidence regarding the exact dependence of life expectancy on average calorie consumption.[19] Thus, the shapes of the curves for nutritional effects in Figure IV-8 are estimates that are based on assumed or defined values for the left and right hand end-points for the curves. The gradual slope of the two curves acknowledges the distributional inadequacies that are likely to exist in the food supply system in Egypt. Thus, if the average calorie consumption in Egypt is 2000 calories per day, there are likely to be individual urban areas and villages where the calorie consumption is much lower -- so low, in fact, that malnutrition emerges as a contributor to death. These distributional inadequacies explain why the calorie and protein effect curves (which apply to an entire area population) fall smoothly with reduced calorie consumption, even though an individual experiencing a 10% drop in calorie consumption might suffer no ill effects.

An important element of the life expectancy calculations is the assumed mutual reinforcement of the four determining influences. Thus, a drop in calorie consumption sufficient to cause a 20% drop in life expectancy, combined with a drop in protein consumption sufficient to cause a 10% drop in life expectancy, would lead to an overall reduction in life expectancy of 28% (.8 calorie effect x .9 protein effect = .72 for the combined effect, a 28% reduction from the hypothetical maximum of 1.0).

The effect of disease incidence on life expectancy (PELED) in the model reflects the influence of such things as widespread schistosomiasis on overall life expectancy. Schistosomiasis itself is seldom a direct cause of death. However, the disease does weaken the resistence of the human body to other causes of death, and therefore can be assumed to have an influence on life expectancy.[20] The model makes a calculation of the fraction of an area population suffering from persistent diseases (PFSPD), based upon conditions in the water sector that describe irrigation practices. This estimate of the extent of schistosomiasis determines the effect of diseases on life expectancy, in the manner diagrammed in Figure IV-9.

The final influence on life expectancy represented in the model is the effect of government services (PELES). The model calculates the ratio of all government and business service personnel to the total area population. This ratio can serve as a surrogate for the adequacy of medical services available to the area population. As shown in Figure IV-10, it is assumed that very low levels of government service produce up to a 50% reduction in the areas population's life expectancy; the addition of service personnel provides a gradual improvement in life expectancy. It should be noted that the Egyptians have already achieved a considerable amount of health care for their population.[21] The low range of Figure IV-10 is included in the model only to assess the consequences of possible severe reductions in service personnel that might occur in various future scenarios for Egypt's development.

```
   LIFE EXPECTANCY

PLE.K=PLEN*PELEC.K*PELEP.K*PELED.K*PELES.K                24, A
    PLE     - LIFE EXPECTANCY (YEARS) <24>
    PLEN    - NORMAL LIFE EXPECTANCY (YEARS) <120.6>
    PELEC   - EFFECT OF CALORY CONSUMPTION ON LIFE
                 EXPECTANCY <25>
    PELEP   - EFFECT OF PROTEIN CONSUMPTION ON LIFE
                 EXPECTANCY <26>
    PELED   - EFFECT OF DISEASE INCIDENCE ON LIFE
                 EXPECTANCY <27>
    PELES   - EFFECT ON LIFE EXPECTANCY OF GOVERNMENT
                 SERVICES <28>
```

Figure IV-9: Effect of Disease on Life Expectancy

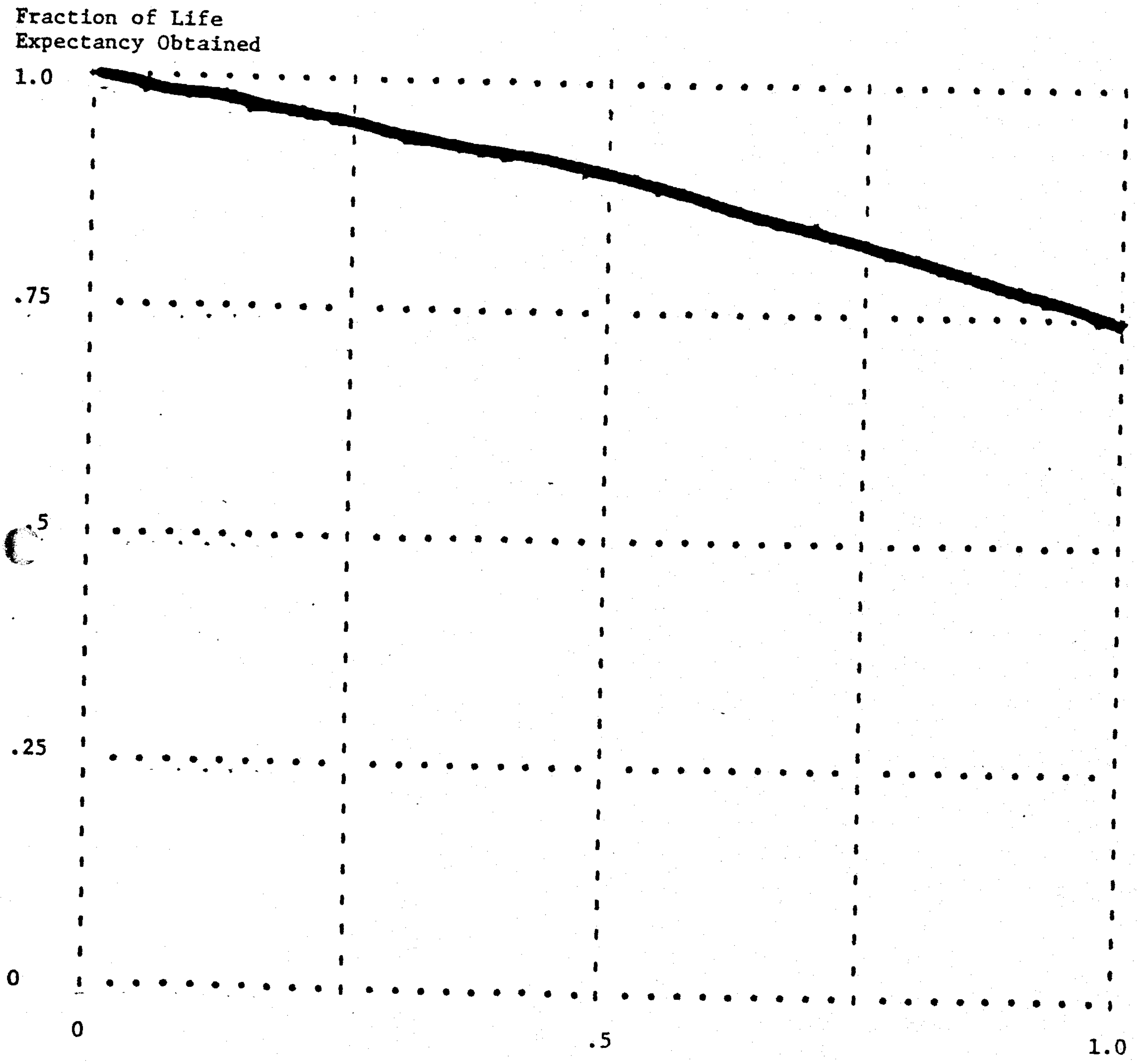
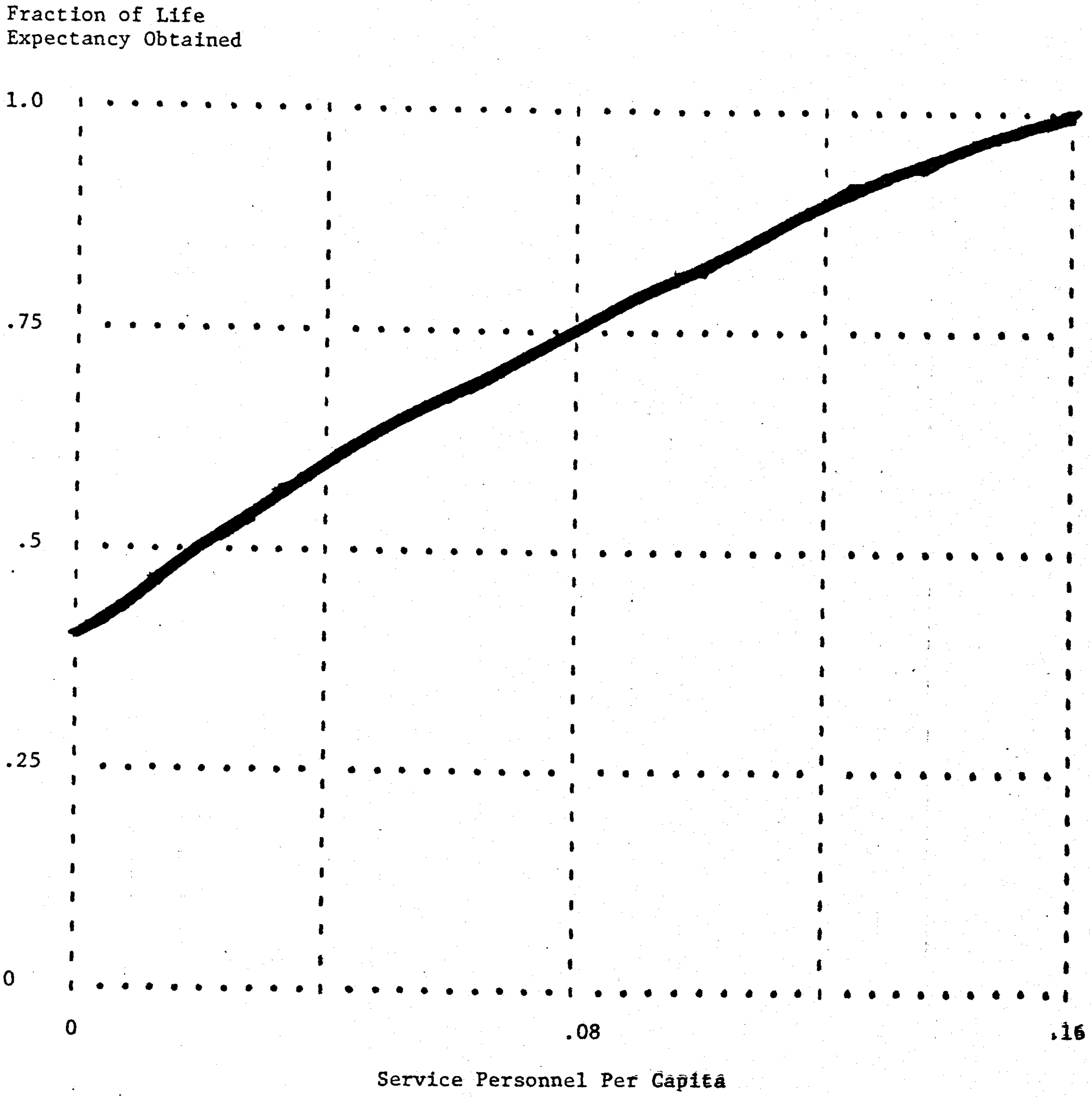


Figure IV-10: Effect of Services on Life Expectancy



```
PELEC.K=TABHL(PELECT,PCCC.K,1000,2500,250)                   25, A
    PELEC  - EFFECT OF CALORY CONSUMPTION ON LIFE
                EXPECTANCY <25>
    PELECT - TABLE FOR THE EFFECT OF CALORY CONSUMPTION
                ON LIFE EXPECTANCY <120.8>
    PCCC   - DAILY CALORY CONSUMPTION PER CAPITA <74>

PELEP.K=TABHL(PELEPT,PPCC.K,0,50,10)                         26, A
    PELEP  - EFFECT OF PROTEIN CONSUMPTION ON LIFE
                EXPECTANCY <26>
    PELEPT - TABLE FOR THE EFFECT OF PROTEIN CONSUMPTION
                ON LIFE EXPECTANCY <121.2>
    PPCC   - DAILY PROTEIN CONSUMPTION PER CAPITA <75>

PELED.K=TABLE(PELEDT,PFSPC.K,0,1,.25)                        27, A
    PELED  - EFFECT OF DISEASE INCIDENCE ON LIFE
                EXPECTANCY <27>
    PELEDT - TABLE FOR THE EFFECT OF DISEASE INCIDENCE
                ON LIFE EXPECTANCY <121.5>

PELES.K=TABHL(PELEST,PGSC.K,0,.16,.04)                       28, A
    PELES  - EFFECT ON LIFE EXPECTANCY OF GOVERNMENT
                SERVICES <28>
    PELEST - TABLE FOR THE EFFECT OF SERVICES DELIVERY
                ON LIFE EXPECTANCY <121.8>
    PGSC   - GOVERNMENT SERVICES PER CAPITA (SERVICE
                UNITS) <47>
```

IV-B. ECONOMIC GOODS REQUIREMENTS

As discussed at the beginning of Chapter IV, Egypt's urban and rural populations require a range of goods and services from the country's economy. In the model, these varied requirements are treated explicitly in the area population building block, where specific needs are calculated and passed along to the relevant economic sectors. The balance of supply and demand for each economic sector will determine how much of the population's needs are satisfied.

Food Requirements -- Food supplies in the Egypt model are specified in terms of four general categories:

meat products
fruits and vegetables
rice
other grains.

These food categories were selected to embrace the most important sources of calories in the Egyptian diet,[22] and for consistency with the disaggregation used in the agriculture sector (see Chapter V). Per capita calory consumption (PCCC) and protein consumption (PPCC) for each area population are determined by combining the nutritional contributions from each of the four food groups.

Per capita food requirements for meat products (PMRC), fruits and vegetables (PORC), and rice (PRRC) are each specified separately for both population groups. That is, the model makes no attempt to explain why either population tries to consume certain amounts of fruits and vegetables, or why the urban and rural populations should have different food desires. Instead, the model accepts the current food preferences as "givens," although the preferences are expressed in the model as external factors that can be varied over time to determine the consequences of changes in dietary habits. The assumed urban and rural requirements for these three food categories are provided below.

ASSUMED DAILY ADULT CONSUMPTION REQUIREMENTS[23]

(Grams/Day)

	RICE	MEATS	FRUITS & VEGETABLES
Urban	300	50	350
Rural	60	10	125

The calculation of requirements for grains (except rice) is handled differently from the calculation of other food requirements. It is assumed in the model that each area population has a target per capita calorie consumption requirement (PCCR). These figures — 3,000 calories per day in urban areas and 2,700 calories per day in rural areas -- reflect the overall nutritional desires of the population. (The higher urban target reflects the preferential treatment accorded to urban areas by the Egyptian Central Government.[24]) In the model, any gap between total desired calorie consumption and the total calories available from actual consumption of meats, fruits, vegetables, and rice is assumed to be made up in requested grain consumption. That is to say, if the urban population falls short by 400 calories per capita per day in its total desired nutrition, it will request sufficient grains (PNRC) to supply this 400 calories per capita. Requested grain consumption, therefore, may vary over the course of the simulation, depending upon the availability of the other three food categories.

The urban and rural populations compete with each other for the agricultural production of the four different food categories. In addition, domestic consumption of food also competes with export requirements for rice, and fruits and vegetables. The model's standard allocation logic (see Chapter VII) calculates what fraction of each area population's food requirements will be met in the event that agricultural production is inadequate to meet total needs. This determines the total meat consumption (PMC), fruits and vegetables consumption (POVC), grain consumption (PNC), and rice consumption (PRC) for each area.

```
PMC.K=SHARE(PMR.K,AMPN.K,PIM.K,AMPWR.K,PINN.K)          59, A
    PMC     - MEAT CONSUMPTION (TONNES/YEAR) <59>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    PMR     - MEAT CONSUMPTION REQUESTED (TONS/YEAR) <60>
    AMPN    - SHORTFALL IN MEAT PRODUCTION <344>
    AMPWR   - WEIGHTED REQUESTS FOR MEAT PRODUCTION <345>
    PINN    - NORMAL POPULATION PRIORITY

PMR.K=PW.K*365*PMRC.K
                                                        60, A
    PMR     - MEAT CONSUMPTION REQUESTED (TONS/YEAR) <60>
    PW      - POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>
    PMRC    - MEAT CONSUMPTION REQUESTED PER CAPITA <61>

PMRC.K=TABLE(PMRCT,TIME.K,1960,2010,10)/1E3             61, A
    PMRC    - MEAT CONSUMPTION REQUESTED PER CAPITA <61>
    PMRCT   - TABLE FOR DESIRED CONSUMPTION OF MEAT

POC K=SHARE(POR.K,AOPN.K,PIO.K,AOWR.K,PINN.K)           62, A
    POC     - FRUIT AND VEGETABLE CONSUMPTION (TONNES/
                YEAR) <62>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    POR     - FRUIT AND VEGETABLE CONSUMPTION REGUESTED
                (TONNES/YEAR) <63>
    AOPN    - SHORTFALL IN PRODUCTION OF F&V
    AOWR    - WEIGHTED REQUESTS FOR F&V PRODUCTION <197>
    PINN    - NORMAL POPULATION PRIORITY
```

```
POR.K=PW.K*365*PORC.K                                         63, A
    POR     = FRUIT AND VEGETABLE CONSUMPTION REQUESTED
                (TONNES/YEAR) <63>
    PW      = POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>
    PORC    = FRUIT AND VEGETABLE CONSUMPTION REQUESTED
                PER CAPITA ((TONNES/YEAR)/PERSON) <64>

PORC.K=TABLE(PORCT,TIME.K,1960,2010,10)/1E3                   64, A
    PORC    = FRUIT AND VEGETABLE CONSUMPTION REQUESTED
                PER CAPITA ((TONNES/YEAR)/PERSON) <64>
    PORCT   = TABLE FOR DESIRED CONSUMPTION OF FRUITS AND
                VEGETABLES

PRC.K=SHARE(PRR.K,ARPN.K,PIR.K,ARWR.K,PINN.K)                 65, A
    PRC     = RICE CONSUMPTION (TONNES/YEAR) <65>
    SHARE   = ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    PRR     = DESIRED RICE CONSUMPTION (TONNES/YEAR) <66>
    ARPN    = SHORTFALL IN PRODUCTION OF RICE
    ARWR    = WEIGHTED REQUESTS FOR RICE PRODUCTION <181>
    PINN    = NORMAL POPULATION PRIORITY

PRR.K=PW.K*365*PRRC.K                                         66, A
    PRR     = DESIRED RICE CONSUMPTION (TONNES/YEAR) <66>
    PW      = POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>
    PRRC    = RURAL RICE CONSUMPTION (TONNES/YEAR)

PRRC.K=TABLE(PRRCT,TIME.K,1960,2010,10)/1E3                   67, A
    PRRC    = RURAL RICE CONSUMPTION (TONNES/YEAR)
    PRRCT   = TABLE FOR DESIRED CONSUMPTION OF RICE

PNC.K=SHARE(PNR.K,ANPNQ.K,PIN.K,ANWP.K,PINN.K)                68, A
    PNC     = GRAIN CONSUMPTION (TONNES/YEAR) <68>
    SHARE   = ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    PNR     = REQUESTED GRAIN CONSUMPTION (TONNES/YEAR)
                <69>
    ANPNQ   = GRAIN PRODUCTION SHORTFALL AFTER IMPORTS
                <171>
    ANWR    = WEIGHTED REQUESTS FOR GRAIN PRODUCTION
                <170>
    PINN    = NORMAL POPULATION PRIORITY

PNR.K=MAX(0,(PRCC.K-PCCM.K-PCCF.K-PCCR.K)/ACCG)               69, A
    PNR     = REQUESTED GRAIN CONSUMPTION (TONNES/YEAR)
                <69>
    PRCC    = REQUESTED CALORY CONSUMPTION (KCAL/YEAR)
                <70>
    PCCM    = CALORY CONSUMPTION FROM MEAT (KCAL/YEAR)
                <71>
    PCCF    - CALORY CONSUMPTION FROM FRUITS AND
                VEGETABLES (KCAL/YEAR) <72>
    PCCR    = CALORY CONSUMPTION FROM RICE <73>
    ACCG    - CALORY CONTENT OF WHEAT <146.5>
```

```
PRCC.K=PW.K*365*TABLE(PRCCT,TIME.K,1960,2010,10)         70, A
    PRCC    - REQUESTED CALORY CONSUMPTION (KCAL/YEAR)
                <70>
    PW      - POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>
    PRCCT   - TABLE FOR DESIRED CALORY CONSUMPTION

PCCM.K=PMC.K*ACCM
                                                          71, A
    PCCM    - CALORY CONSUMPTION FROM MEAT (KCAL/YEAR)
                <71>
    PMC     - MEAT CONSUMPTION (TONNES/YEAR) <59>
    ACCM    - CALORY CONTENT OF MEAT (AVERAGE OF PORK AND
                SHEEP -- KCAL/TONNE) <145.2>

PCCF.K=POC.K*ACCO
                                                          72, A
    PCCF    - CALORY CONSUMPTION FROM FRUITS AND
                VEGETABLES (KCAL/YEAR) <72>
    POC     - FRUIT AND VEGETABLE CONSUMPTION (TONNES/
                YEAR) <62>
    ACCO    - CALORY CONTENT OF FRUITS AND VEGETABLES
                (KCAL/TONNE) <146.1>

PCCR.K=PRC.K*ACCR
                                                          73, A
    PCCR    - CALORY CONSUMPTION FROM RICE <73>
    PRC     - RICE CONSUMPTION (TONNES/YEAR) <65>
    ACCR    - CALORY CONTENT OF RICE (KCAL/TONNE) <145.6>

PCCC.K=(PCCF.K+PCCM.K+PCCR.K+PNC.K*ACCG)/(PW.K*365) 74, A
    PCCC    - DAILY CALORY CONSUMPTION PER CAPITA <74>
    PCCF    - CALORY CONSUMPTION FROM FRUITS AND
                VEGETABLES (KCAL/YEAR) <72>
    PCCM    - CALORY CONSUMPTION FROM MEAT (KCAL/YEAR)
                <71>
    PCCR    - CALORY CONSUMPTION FROM RICE <73>
    PNC     - GRAIN CONSUMPTION (TONNES/YEAR) <68>
    ACCG    - CALORY CONTENT OF WHEAT <146.5>
    PW      - POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>

PPCC.K=(PMC.K*APCM+POC.K*APCO+PRC.K*APCR+PNC.K*       75, A
  APCG.K)/(PW.K*365)
    PPCC    - DAILY PROTEIN CONSUMPTION PER CAPITA <75>
    PMC     - MEAT CONSUMPTION (TONNES/YEAR) <59>
    APCM    - PROTEIN CONTENT OF MEAT (GMS/TONNE) <145.4>
    POC     - FRUIT AND VEGETABLE CONSUMPTION (TONNES/
                YEAR) <62>
    APCO    - PROTEIN CONTENT OF FRUITS AND VEGETABLES
                (GMS/TONNE) <146.3>
    PRC     - RICE CONSUMPTION (TONNES/YEAR) <65>
    APCR    - PROTEIN CONTENT OF RICE (GMS/TONNE) <145.8>
    PNC     - GRAIN CONSUMPTION (TONNES/YEAR) <68>
    APCG    - PROTEIN CONTENT OF WHEAT <147>
    PW      - POPULATION WEIGHTED FOR CALORY (AND
                PROTEIN) REQUIREMENTS <76>
```

```
W.K=.89*PQ.K+1.05*PX.K+PY.K+.91*PZ.K                              76, A
   PW       - POPULATION WEIGHTED FOR CALORY (AND
               PROTEIN) REQUIREMENTS <76>
   PQ       - POPULATION AGED 0-14 (PEOPLE) <4>
   PX       - POPULATION AGED 15-44 (PEOPLE) <5>
   PY       - POPULATION AGED 45-64 (PEOPLE) <6>
   PZ       - POPULATION AGED OVER 64(PEOPLE) <7>
```

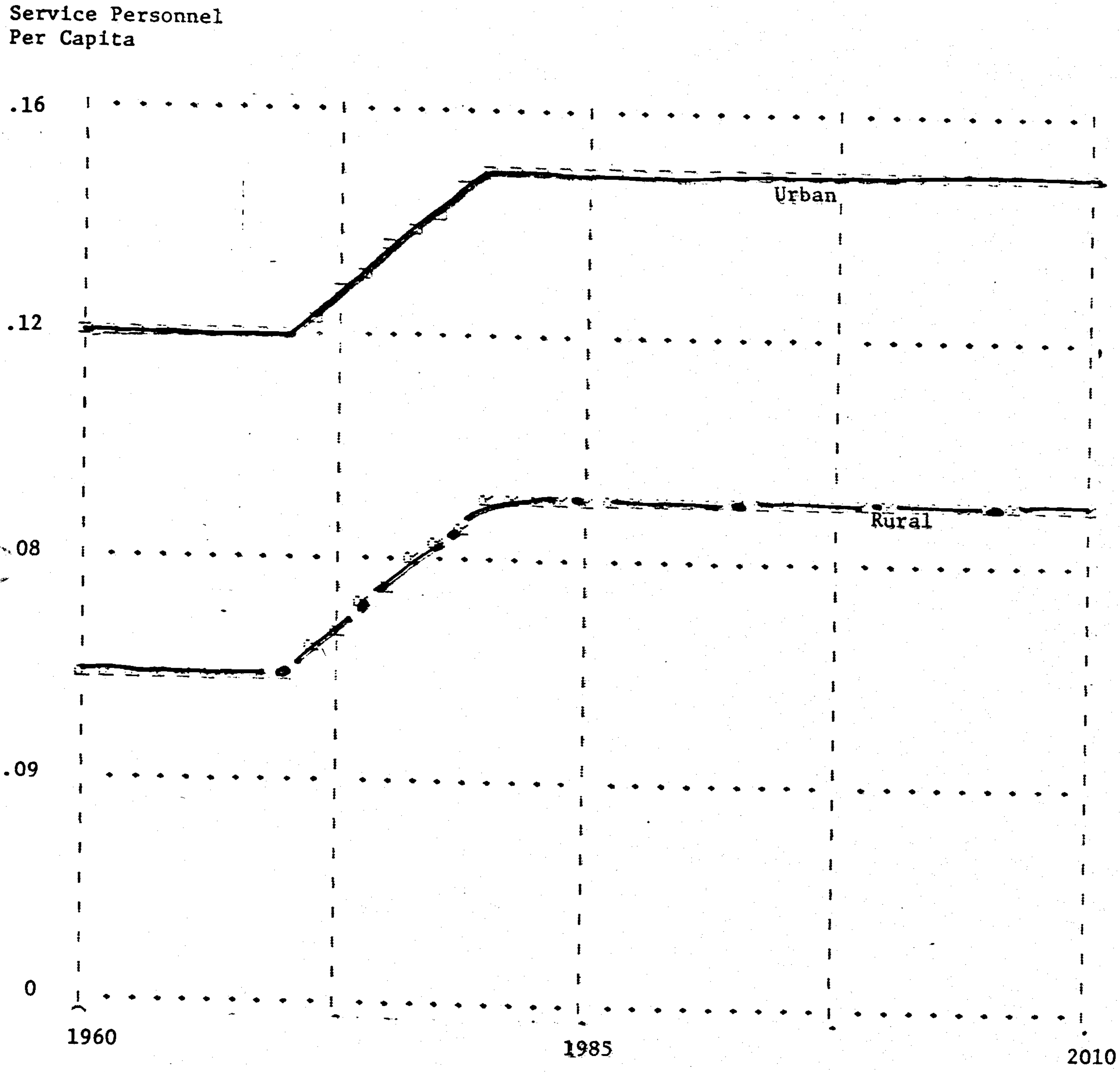
Service Requirements--Services in the Egypt model are a surrogate for the range of government and business services provided to both the urban and rural populations. The service requirements of the population establish a target for the number of labor force workers allocated to service employment, as opposed to employment in other industrial or agricultural activity.

The model calculates the government services per capita (PGSC) by comparing the service labor force (PLS) with the total area population (AREA). A conversion factor (PLSP) denotes the productivity of service labor, and can be varied over time to investigate improvements in services delivery per service worker. The service labor force responds to the service labor force desired (PLSR), although the overall availability of labor will determine how much of this request can be satisfied.

The service labor desired is determined by the desired services per capita (PGSCD) and the total area population. The desired services per capita is introduced in the model as an external factor that can change over time, to investigate the consequences for Egypt's economy of a rising demand for services. The model's base assumptions for service requirements are diagrammed in Figure IV-11.[25]

```
PGSC.K=(PLS.K*PLSP.K)/AREA.K                              47, A
    PGSC    - GOVERNMENT SERVICES PER CAPITA (SERVICE
                UNITS) <47>
    PLS     - SERVICE LABOR (MEN) <48>
    PLSP    - PRODUCTIVITY OF SERVICE LABOR (SERVICE
                UNITS/WORKER) <124>
    AREA    - TOTAL AREA POPULATION (PEOPLE) <3>
```

Figure IV-II: Service Requirements



```
PLS.K=SMOOTH(PLSI.K,PLTT)                                          48, A
     PLS     - SERVICE LABOR (MEN) <48>
     PLSI    - SERVICE LABOR INDICATED (MEN) <49>
     PLTT    - TRANSFER TIME FOR LABOR (YEARS) <124.4>

PLSI.K=SHARE(PLSR.K,PLN.K,PIL.K,PLWR.K,PINN.K)                     49, A
     PLSI    - SERVICE LABOR INDICATED (MEN) <49>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
     PLSR    - SERVICE LABOR DESIRED (MEN) <50>
     PLN     - SHORTFALL IN AREA LABOR FORCE
     PLWR    - WEIGHTED REQUESTS FOR AREA LABOR
     PINN    - NORMAL POPULATION PRIORITY

PLSR.K=(PGSCD.K/PLSP.K)*AREA.K                                     50, A
     PLSR    - SERVICE LABOR DESIRED (MEN) <50>
     PGSCD   - DESIRED SERVICES PER CAPITA (SERVICE UNITS)
                  <51>
     PLSP    - PRODUCTIVITY OF SERVICE LABOR (SERVICE
                  UNITS/WORKER) <124>
     AREA    - TOTAL AREA POPULATION (PEOPLE) <3>

PGSCD.K=TABLE(PGSCDT,TIME.K,1960,2010,10)                          51, A
     PGSCD   - DESIRED SERVICES PER CAPITA (SERVICE UNITS)
                  <51>
     PGSCDT  - TABLE FOR DESIRED GOVERNMENT SERVICES
```

Consumer Goods Requirements--Consumer goods in the Egypt model are defined to include all of the non-food, non-capital-goods material output from Egypt's industry. The urban and rural populations compete for deliveries of consumer goods (PUD) with each other, and with the need for making consumer goods available for export. Requested consumer goods for the population (PUR) are calculated in the model from a backlog of demand (PUB) that exists within each area population. This backlog reflects two important factors. The first is the annual consumer goods requirements, or "orders", of the population (PUO). These requirements represent a reference consumption level, and include an external factor that can vary over time to investigate the consequences of rising demands for consumer goods within Egypt's population.[26]

The second important factor determining the current backlog of consumer goods demand is the extent of built-up demand unsatisfied in past years. The model assumes the demand for consumer goods can be deferred, that a sort of "savings" takes place whereby requested deliveries from one year persist into the next year if the economy is incapable of satisfying them. The result is a backlog of consumer goods requirements (PUB) that can build up and increase the pressure on the consumer goods sector.

The model does include something of a safety valve to insure that the pressure of deferred consumer goods requests does not assume unreasonable proportions. The effect of delivery delay on consumer goods orders (PUOED) serves to choke off new consumer goods orders as the backlog of unfilled demand approaches five years of normal requirements.

The deliveries of consumer goods to the population, as well as the capital investment in place (discussed shortly), are combined to measure the area population's standard of living (PSL). In the model, a rising standard of living is indicative of the social and cultural changes such increasing affluence usually generates. It should be emphasized that standard of living in the model does not measure overall income, but rather the accumulation and consumption of material goods. We assume that the material affluence represented by these trends is a more important determinant of social and cultural change than a simple rise in money income.

In the model, the material standard of living is calculated by adding together deliveries of consumer goods to the area population (PUD) and a factor representing usage of household and service capital. The "wearout" (or depreciation) of household and service capital (PGW) is used in the model as a measure of capital use, since it can be counted upon to rise as the total amount of capital goods available to the population rises. The sum of the consumer goods and capital goods effects is divided by the area population (AREA) so the standard of living can measured in per capita terms.

```
PUOED.K=TABLE(PUOEDT,PUDTP.K,0,5,1)                    42, A
    PUOED  - EFFECT OF DELIVERY TIME ON CONSUMER GOODS
                ORDERS <42>
    PUOEDT - EFFECT OF DELIVERY TIME ON CONSUMER GOODS
                ORDERS <123.2>
    PUDTP  - PERCEIVED DELIVERY TIME FOR CONSUMER GOODS
                (YEARS) <43>

PUDTP.K=SMOOTH(PUB.K/PUD.K,PUODAT)                     43, A
    PUDTP  - PERCEIVED DELIVERY TIME FOR CONSUMER GOODS
                (YEARS) <43>
    PUB    - URBAN BIRTHS
    PUD    - URBAN DEATHS
    PUODAT - TIME TO PERCEIVE CHANGES IN CONSUMER GOODS
                DELIVERY TIME (YEARS) <123.4>

PSL.K=(PUD.K+PGW.K)/AREA.K                             44, A
    PSL    - STANDARD OF LIVING (POUNDS/YEAR) <44>
    PUD    - URBAN DEATHS
    PGW    - WEAROUT OF POPULATION CAPITAL (POUNDS/YEAR)
                <30>
    AREA   - TOTAL AREA POPULATION (PEOPLE) <3>
```

```
PUD.K=SHARE(PUR.K,UPN.K,PIU.K,UWR.K,PINN.K)             38, A
    PUD      - URBAN DEATHS
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    PUR      - REQUESTED CONSUMER GOODS FOR THE POPULATION
                 (POUNDS/YEAR) <39>
    UPN      - SHORTFALL IN PRODUCTION OF CONSUMER GOODS
    UWR      - WEIGHTED REQUESTS FOR CONSUMER GOODS <354>
    PINN     - NORMAL POPULATION PRIORITY

PUR.K=PUB.K/PUTN                                        39, A
    PUR      - REQUESTED CONSUMER GOODS FOR THE POPULATION
                 (POUNDS/YEAR) <39>
    PUB      - URBAN BIRTHS
    PUTN     - ORDERING TIME FOR CONSUMERGOODS (YEARS)
                 <122.9>

PUB.K=PUB.J+(DT)(PUO.J-PUD.J)                           40, L
PUB=AREA*TABLE(PUOT,TIME,1960,2010,10)*PUTN             40.1, N
    PUB      - URBAN BIRTHS
    PUO      - POPULATION CONSUMER GOODS ORDERS (POUNDS/
                 YEAR) <41>
    PUD      - URBAN DEATHS
    AREA     - TOTAL AREA POPULATION (PEOPLE) <3>
    PUOT     - TABLE FOR POPULATION CONSUMER GOODS ORDERS
    PUTN     - ORDERING TIME FOR CONSUMERGOODS (YEARS)
                 <122.9>

PUO.K=AREA.K*PUOED.K*TABLE(PUOT,TIME.K,1960,2010,     41, A
  10)
    PUO      - POPULATION CONSUMER GOODS ORDERS (POUNDS/
                 YEAR) <41>
    AREA     - TOTAL AREA POPULATION (PEOPLE) <3>
    PUOED    - EFFECT OF DELIVERY TIME ON CONSUMER GOODS
                 ORDERS <42>
    PUOT     - TABLE FOR POPULATION CONSUMER GOODS ORDERS
```

Household and Services Capital Goods Required -- Like the industrial sectors of Egypt's economy, the urban and rural population sectors accumulate capital investment. These capital goods satisfy two basic needs. First, there is capital investment accumulated for housing and related residential purposes. Second, there is a wide variety of capital accumulated for services, including schools, roads, religious facilities, and retail and other business services. In the model, this wide range of capital investment in the population sector is combined into a single variable called population capital (PG).

The logic for the model's treatment of the accumulation of household and service capital for the urban and rural populations is quite similar to the logic for accumulation of industrial capital. Chapter VI describes the industrial capital accumulation logic in considerable detail. Therefore, only a brief description of the capital investment process for population is provided here, and the reader is referred to Chapter VI for further details.

Household and service capital (PG) is increased by construction from the capital goods sector (PGD) and diminished by the wearing out of the current capital investment in place (PGW). Population sector household and service capital is assumed to have a serviceable lifetime of fifty years (PGWL). The population sector competes with the other sectors of the economy for the limited construction capability of the capital goods sector, and this competition determines what fraction of the population sector's orders (PGO) for capital goods will be translated into commitments (PGC) of capital to the population sector.

The requested capital for the population sector (PGR) is calculated in the model by multiplying the area population (AREA) by an assumed per capita capital requirement. This assumed requirement was estimated by comparing total initial capital investment with the total initial population for each sector. In addition, an external factor (PGRT) has been included in the model to investigate the consequences of rising per capita demands for capital investment. The 1960 amounts of capital investment are estimated to be 350 million pounds for the urban sector (PUGI) and 450 million pounds for the rural sector (PRGI).[27]

```
PGR.K=AREA.K*(PGI/(PGI+PXI+PYI+PZI))*TABLE(PGRT,      37, A
  TIME.K,1960,2010,10)
    PGR     - REQUESTED CAPITAL FOR POPULATON SECTOR
                (POUNDS) <37>
    AREA    - TOTAL AREA POPULATION (PEOPLE) <3>
    PGI     - INITIAL POPULATION HOUSEHOLD AND SERVICE
                CAPITAL
    PXI     - INITIAL AREA POPULATION AGED 15-44
    PYI     - INITIAL AREA POPULATION AGED 45-64
    PZI     - INITIAL AREA POPULATION AGED OVER 65
    PGRT    - TABLE FOR REQUESTED POPULATION CAPITAL
                GOODS

PG.K=PG.J+(DT)(PGD.J-PGW.J)
                                                        29, L
PG=PGI                                                  29.1, N
    PG      - POPULATION SECTOR HOUSEHOLD AND SERVICE
                CAPITAL (POUNDS) <29.1>
    PGD     - DELIVERIES OF CAPITAL TO POPULATION SECTOR
                (POUNDS/YEAR) <31>
    PGW     - WEAROUT OF POPULATION CAPITAL (POUNDS/YEAR)
                <30>
    PGI     - INITIAL POPULATION HOUSEHOLD AND SERVICE
                CAPITAL

PGW.K=PG.K/PGWL
                                                        30, A
    PGW     - WEAROUT OF POPULATION CAPITAL (POUNDS/YEAR)
                <30>
    PG      - POPULATION SECTOR HOUSEHOLD AND SERVICE
                CAPITAL (POUNDS) <29.1>
    PGWL    - LIFETIME OF HOUSEHOLD CAPITAL (YEARS)
                <122.1>

PGD.K=DELAY3P(PGC.K,POS(PGCT.K),PGUC.K)                 31, A
    PGD     - DELIVERIES OF CAPITAL TO POPULATION SECTOR
                (POUNDS/YEAR) <31>
    PGC     - COMMITMENTS OF CAPITAL TO POPULATION SECTOR
                (POUNDS/YEAR) <35.1>
    PGCT    - CONSTRUCTION TIME FOR POPULATION SECTOR
                CAPITAL (YEARS) <32.1>
    PGUC    - SERVICE AND HOUSEHOLD CAPITAL UNDER
                CONSTRUCTION
```

```
PGCT.K=PGUC.K/PGCA.K                                             32, A
PGCT=PGCTN                                                       32.1, N
    PGCT     - CONSTRUCTION TIME FOR POPULATION SECTOR
                 CAPITAL (YEARS) <32.1>
    PGUC     - SERVICE AND HOUSEHOLD CAPITAL UNDER
                 CONSTRUCTION
    PGCA     - CONSTRUCTION ACTIVITY FOR POPUATION SECTOR
                 (POUNDS/YEAR) <33>
    PGCTN    - NORMAL CONSTRUCTION TIME FOR HOUSEHOLD
                 CAPITAL (YEARS) <122.3>

PGCA.K=SHARE(PGCR.K,GPN.K,PIGC.K,GPWR.K,PINN.K)                  33, A
    PGCA     - CONSTRUCTION ACTIVITY FOR POPUATION SECTOR
                 (POUNDS/YEAR) <33>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    PGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                 POPULATION SECTOR (POUNDS/YEAR) <34>
    GPN      - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
    GPWR     - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    PINN     - NORMAL POPULATION PRIORITY

PGCR.K=PGUC.K/PGCTN                                              34, A
    PGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                 POPULATION SECTOR (POUNDS/YEAR) <34>
    PGUC     - SERVICE AND HOUSEHOLD CAPITAL UNDER
                 CONSTRUCTION
    PGCTN    - NORMAL CONSTRUCTION TIME FOR HOUSEHOLD
                 CAPITAL (YEARS) <122.3>

PGC.K=SHARE(PGO.K,GON.K,PIGO.K,GOWR.K,PINN.K)                    35, A
PGC=PGW*PGGFI                                                    35.1, N
    PGC      - COMMITMENTS OF CAPITAL TO POPULATION SECTOR
                 (POUNDS/YEAR) <35.1>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    PGO      - ORDERS OF CAPITAL FOR THE POPULATION SECTOR
                 (POUNDS/YEAR) <36>
    GON      - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR     - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    PINN     - NORMAL POPULATION PRIORITY
    PGW      - WEAROUT OF POPULATION CAPITAL (POUNDS/YEAR)
                 <30>
    PGGFI    - INITIAL GROWTH FACTOR FOR HOUSEHOLD CAPITAL
                 <122.5>
```

```
GO.K=MAX(0,PGW.K+(PGR.K+(PGW.K*PGCTN)-(PG.K+          36, A
 PGUC.K))/PGOT)
   PGO     - ORDERS OF CAPITAL FOR THE POPULATION SECTOR
               (POUNDS/YEAR) <36>
   PGW     - WEAROUT OF POPULATION CAPITAL (POUNDS/YEAR)
               <30>
   PGR     - REQUESTED CAPITAL FOR POPULATON SECTOR
               (POUNDS) <37>
   PGCTN   - NORMAL CONSTRUCTION TIME FOR HOUSEHOLD
               CAPITAL (YEARS) <122.3>
   PG      - POPULATION SECTOR HOUSEHOLD AND SERVICE
               CAPITAL (POUNDS) <29.1>
   PGUC    - SERVICE AND HOUSEHOLD CAPITAL UNDER
               CONSTRUCTION
   PGOT    - ORDERING TIME FOR HOUSEHOLD CAPITAL (YEARS)
               <122.7>
```

Energy--Both area populations compete with the industrial sectors of Egypt's economy for output from the energy sector. The energy requirements for the population sector are assumed to depend upon the amount of household and service capital in place for the population's use. A conversion factor (PEGRN) translates capital investment into energy requirements; this conversion factor was determined by analysis of 1960 energy usage and capital investment.[28]

```
PE.K=SHARE(PER.K,EPN.K,PIE.K,EWR.K,PINN.K)                 45, A
    PE      - ENERGY FOR THE POPULATION (KWH/YEAR) <45>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    PER     - REQUESTED ENERGY FOR THE POPULATION SECTOR
                (KWH/YEAR) <46>
    EPN     - SHORTFALL IN PRODUCTION OF ENERGY
    EWR     - WEIGHTED REQUESTS FOR ENERGY <385>
    PINN    - NORMAL POPULATION PRIORITY

PER.K=PG.K*PEGRN*EDF.K                                     46, A
PEGRN=PEI/PGI                                              46.2, N
    PER     - REQUESTED ENERGY FOR THE POPULATION SECTOR
                (KWH/YEAR) <46>
    PG      - POPULATION SECTOR HOUSEHOLD AND SERVICE
                CAPITAL (POUNDS) <29.1>
    PEGRN   - NORMAL POPULATION ENERGY/CAPITAL RATIO
                <46.2>
    EDF     - ENERGY DEMAND FACTOR <391>
    PEI     - INITIAL POPULATION ENERGY USAGE
    PGI     - INITIAL POPULATION HOUSEHOLD AND SERVICE
                CAPITAL
```

IV-C. LABOR FORCE

Besides consuming output from the Egyptian economy, the population sector also provides an important production input to the economy. This production input is the economy's labor force, which is distributed by the model's resource allocation logic across the competing requirements of various economic sectors.

In the model, the effective labor force (PLF) available to work from an area population is determined by the number of people in each of the three youngest age groups, the employment fraction for each age group, and the effects of calorie consumption and disease on labor force productivity. The model calculates the total number of workers available from each age group, and introduces productivity effects from calorie consumption and disease (specifically, schistosomiasis) to determine the effective number of workers available for employment.

The employment fractions for the three age groups in each area population are provided to the model as external inputs (summarized below). Therefore, the model can be used to examine the consequences of changes in labor force participation rates for Egypt's economic development.

Labor Force Participation Rates[29]

(Assumed Fraction of Total Age Population Available for Work)

	0-14	15-44	45-64
Urban	.05	.54	.5
Rural	.1	.5	.45

The effects of calorie consumption (PLFEC) and disease (PLFED) on labor force effectiveness are expressed in the model in the form of indices denoting the fraction of the potential productive labor currently available from the area workforce. These indices are diagrammed in Figures IV-12 and IV-13, and described in detail below.

The nutrition effect on productivity (PLFEC) includes both medical and social aspects. On the medical side, limited calorie consumption has a detrimental effect on strength and coordination, reducing the amount of useful work an adult can perform.[30] On the social side, reduced consumption versus past dietary standards contributes to unrest among the population that appears to increase the prevalence of strikes and social disorder.[31] The simulation model combines both of these aspects into a single effect of nutrition on productivity. This effect is diagrammed in Figure IV-12, which illustrates how a declining average calorie consumption reduces the fraction of potential productive labor that is available for use in the economy.

The disease effect on productivity (PLFED), like the disease effect on the death rate, traces directly to the spread of schistosomiasis. Victims of the disease are often incapable of assuming normal workloads, so their average output suffers.[32] Figure IV-13 illustrates how increases in the fraction of the population suffering from persistent diseases (PFSPD) are assumed to reduce the fraction of the potential effort available from the population.

```
PLF.K=(PQ.K*PQE.K+PX.K*PXE.K+PY.K*PYE.K)*PLFEC.K*    52. A
  PLFED.K
    PLF     - EFFECTIVE LABOR FORCE <52>
    PQ      - POPULATION AGED 0-14 (PEOPLE) <4>
    PQE     - EMPLOYMENT FRACTION FOR 0-15 YEAR OLDS <53>
    PX      - POPULATION AGED 15-44 (PEOPLE) <5>
    PXE     - EMPLOYMENT FRACTION FOR 15-44 YEAR OLDS
                <54>
    PY      - POPULATION AGED 45-64 (PEOPLE) <6>
    PYE     - EMPLOYMENT FRACTION FOR 45-60 YEAR OLDS
                <55>
    PLFEC   - EFFECT OF CALORY CONSUMPTION ON LABOR
                EFFECTIVENESS <56>
    PLFED   - EFFECT OF DISEASE ON LABOR EFFECTIVENESS
                <57>
```

Figure IV-12: Effect of Calorie Consumption on Productivity

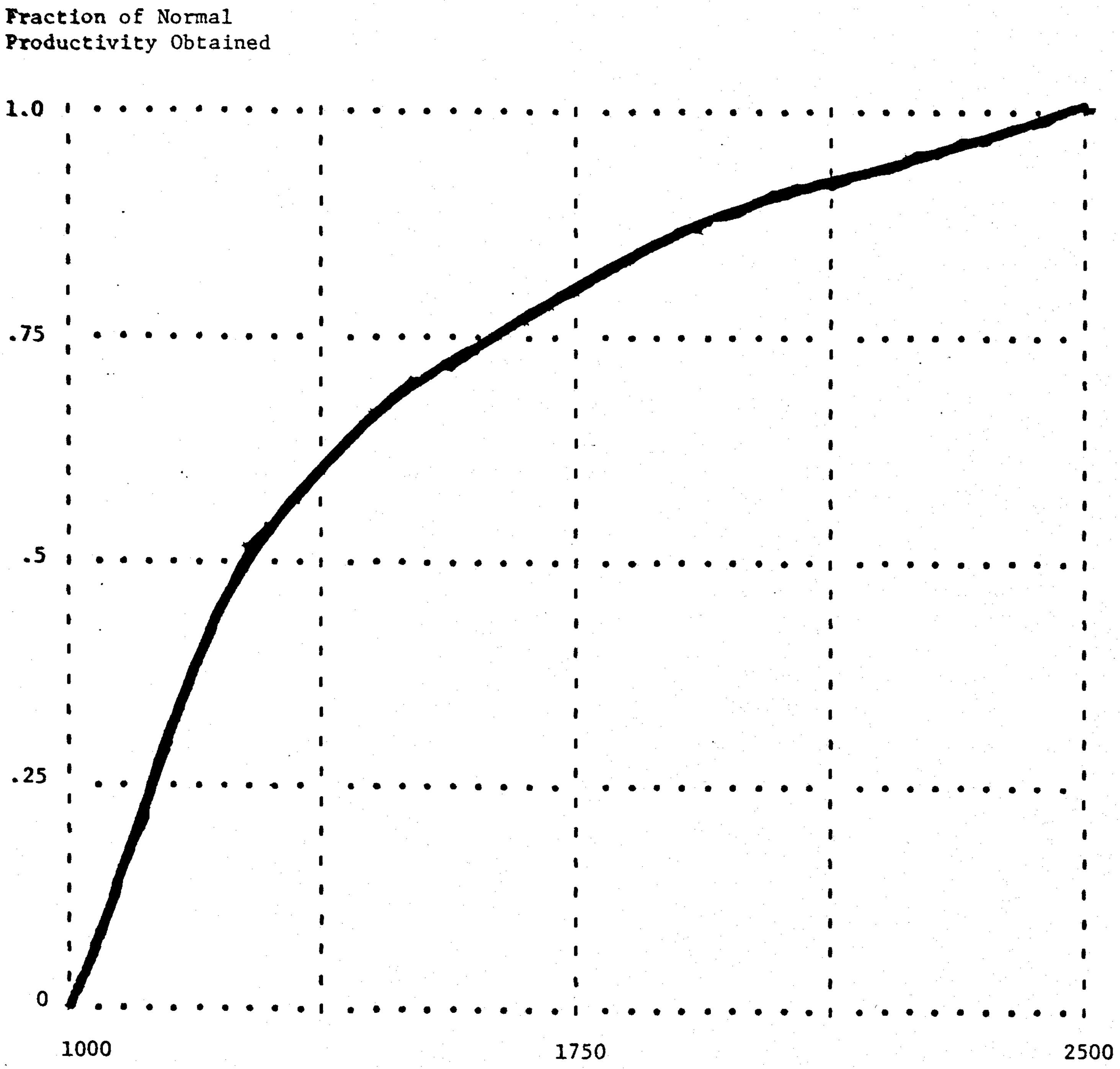
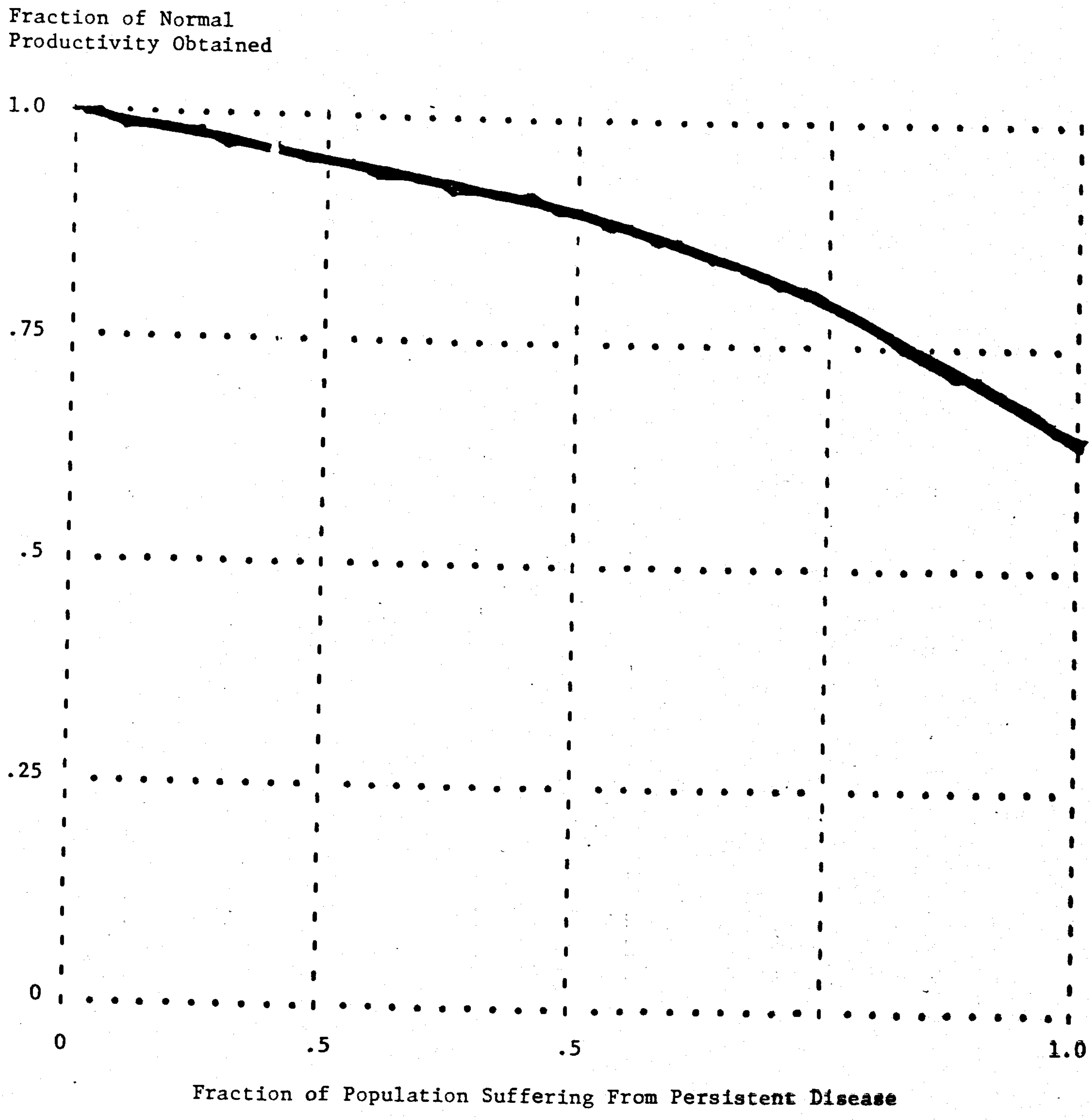


Figure IV-13: Effect of Diseases on Productivity



```
PQE.K=TABLE(PQET,TIME.K,1960,2010,10)                       53, A
    PQE     - EMPLOYMENT FRACTION FOR 0-15 YEAR OLDS <53>
    PQET    - TABLE FOR EMPLOYMENT PERCENTAGE OF 0-14
                YEAR OLDS

PXE.K=TABLE(PXET,TIME.K,1960,2010,10)                       54, A
    PXE     - EMPLOYMENT FRACTION FOR 15-44 YEAR OLDS
                <54>
    PXET    - TABLE FOR EMPLOYMENT PERCENTAGE OF 15-44
                YEAR OLDS

PYE.K=TABLE(PYET,TIME.K,1960,2010,10)                       55, A
    PYE     - EMPLOYMENT FRACTION FOR 45-60 YEAR OLDS
                <55>
    PYET    - TABLE FOR EMPLOYMENT PERCENTAGE OF 45-64
                YEAR OLDS

PLFEC.K=TABHL(PLFECT,PCCC.K,1000,2500,250)                  56, A
    PLFEC   - EFFECT OF CALORY CONSUMPTION ON LABOR
                EFFECTIVENESS <56>
    PLFECT  - EFFECT OF CALORY CONSUMPTION ON
                PRODUCTIVITY <124.6>
    PCCC    - DAILY CALORY CONSUMPTION PER CAPITA <74>

PLFED.K=TABLE(PLFEDT,PFSPD.K,0,1,.25)                       57, A
    PLFED   - EFFECT OF DISEASE ON LABOR EFFECTIVENESS
                <57>
    PLFEDT  - EFFECT OF PERSISTENT DISEASES ON
                PRODUCTIVITY <124.8>

PLN.K=MAX(PLR.K-PLF.K,0)                                    58, A
    PLN     - SHORTFALL IN AREA LABOR FORCE
    PLR     - REQUESTED AREA LABOR
    PLF     - EFFECTIVE LABOR FORCE <52>
```

The following equations implement the area population "building block" for the rural and urban populations. They specify the parameter values common to each population, as well as the values that distinguish one population from another. They are listed here for reference.

```
   PARAMETERS COMMON TO ALL USES OF AREA MACRO

PQDT=.057/.037/.024/.016/.008/.002/.001                118, T
PXDT=.027/.017/.011/.0065/.004/.0016/.0008             118.2, T
PYDT=.056/.037/.025/.017/.012/.008/.006                118.4, T
PZDT=.13/.11/.09/.07/.06/.05/.04                       118.6, T
PMF=.30                                                118.8, C
PCMAT=15                                               119.1, C
PDFST=2.5/5/4/3/2.5/2                                  119.3, T
PETBCM=.5                                              119.5, C
PEMBCM=.9                                              119.7, C
PFCMBT=.5/.5/.5/.5/.5/.5                               119.9, T
PFCMBST=.25/.5/.7/.85/1                                120.3, T
PLEN=75                                                120.6, C
PELECT=0/.15/.45/.65/.85/.95/1                         120.8, T
PELEPT=.5/.65/.75/.85/.95/1                            121.2, T
PELEDT=1/.95/.9/.83/.75                                121.5, T
PELEST=.4/.6/.75/.9/1                                  121.8, T
PGWL=50                                                122.1, C
PGCTN=1                                                122.3, C
PGGFI=2.5                                              122.5, C
PGDT=1                                                 122.7, C
PUTN=1                                                 122.9, C
PUOEDT=1/1/.8/.4/.1/0                                  123.2, T
PUODAT=1                                               123.4, C
    PQDT    - TABLE FOR DEATH RATES FOR 0-14 YEAR OLDS
                <118>
    PXDT    - TABLE FOR DEATH RATES FOR 15-44 YEAR OLDS
                <118.2>
    PYDT    - TABLE FOR DEATH RATES FOR 45-64 YEAR OLDS
                <118.4>
    PZDT    - TABLE FOR DEATH RATES FOR AGES OVER 64
                <118.6>
    PMF     - MAXIMUM FERTILITY (BIRTHS/YEAR PER FERTILE
                WOMAN) <118.8>
    PCMAT   - TIME TO PERCEIVE CHANGES IN CHILD MORTALITY
                (YEARS) <119.1>
    PDFST   - TABLE FOR POPULATION DESIRED FAMILY SIZE
    PETBCM  - EFFECTIVENESS OF TRADITIONAL BIRTH CONTROL
                METHODS <119.5>
    PEMBCM  - EFFECTIVENESS OF MODERN BIRTH CONTROL
                METHODS <119.7>
```

```
     PFCMBT = TABLE FOR FRACTION OF MARRIED COUPLES THE
                GOVERNMENT IS ATTEMPTING TO CONVERT TO
                MODERN BIRTH CONTROL METHODS <119.9>
     PFCMBST= EFFECT OF SERVICES DELIVERY ON GOVERNMENT
                ATTEMPTS TO CONVERT MARRIED COUPLES TO
                MODERN BIRTH CONTROL METHODS <120.3>
     PLEN   = NORMAL LIFE EXPECTANCY (YEARS) <120.6>
     PELECT = TABLE FOR THE EFFECT OF CALORY CONSUMPTION
                ON LIFE EXPECTANCY <120.8>
     PELEPT = TABLE FOR THE EFFECT OF PROTEIN CONSUMPTION
                ON LIFE EXPECTANCY <121.2>
     PELEDT = TABLE FOR THE EFFECT OF DISEASE INCIDENCE
                ON LIFE EXPECTANCY <121.5>
     PELEST = TABLE FOR THE EFFECT OF SERVICES DELIVERY
                ON LIFE EXPECTANCY <121.8>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    PGWL    = LIFETIME OF HOUSEHOLD CAPITAL (YEARS)
                <122.1>
    PGCTN   = NORMAL CONSTRUCTION TIME FOR HOUSEHOLD
                CAPITAL (YEARS) <122.3>
    PGGFI   = INITIAL GROWTH FACTOR FOR HOUSEHOLD CAPITAL
                <122.5>
    PGOT    = ORDERING TIME FOR HOUSEHOLD CAPITAL (YEARS)
                <122.7>
    PUTN    = ORDERING TIME FOR CONSUMERGOODS (YEARS)
                <122.9>
    PUOEDT = EFFECT OF DELIVERY TIME ON CONSUMER GOODS
                ORDERS <123.2>
    PUODAT = TIME TO PERCEIVE CHANGES IN CONSUMER GOODS
                DELIVERY TIME (YEARS) <123.4>

PLSP.K=TABHL(PLSPT,TIME.K,1960,2010,10)                    124, A
PLSPT=1/1/1/1/1/1                                          124.2, T
PLTT=1                                                     124.4. C
PLFECT=0/.5/.7/.8/.9/.95/1                                 124.6, T
PLFEDT=1/.95/.9/.8/.65                                     124.8. T
    PLSP    - PRODUCTIVITY OF SERVICE LABOR (SERVICE
                UNITS/WORKER) <124>
    PLSPT   - TABLE FOR PRODUCTIVITY OF SERVICE LABOR
                <124.2>
    PLTT    = TRANSFER TIME FOR LABOR (YEARS) <124.4>
    PLFECT = EFFECT OF CALORY CONSUMPTION ON
                PRODUCTIVITY <124.6>
    PLFEDT = EFFECT OF PERSISTENT DISEASES ON
                PRODUCTIVITY <124.8>
```

```
   URBAN POPULATION

PU.K=AREA(PUQI.PUXI,PUYI.PUZI,-PQRUM,-PXRUM,0,0,          126, A
  PUMAT,PUDFSNT,PUGI,PUINNT.PUGRT.PUUOT.PUEI.
  PUGSCDT,PUQET,PUXET.PUYET.PULR.PULWR.K,PUMRCT,
  PUORCT,PURRCT,PURCCT,PUQ,PUX,PUY,PUZ.PUR,PUDLB,
  PURCE.PUMMC,PUD.PULE.PUSL.PURCC.PUCCC,PUPCC,
  PUFSPD,PUG.PUGCP.PUGO.PUUD.PUUR.PUE,PUER,PUGSC,
  PULSR.PULF.PULN,PUMC.PUMR.PUOC.PUOR,PURC,PURR,
  PUNC,PUNR,PUIGC,PUIGO,PUIU,PUIE.PUIL,PUIM,PUIC,
  PUIR,PUIN)
PUQI=4.18E6                                                  127.5, C
PUXI=3.94E6                                                  127.7, C
PUYI=1.25E6                                                  127.9, C
PUZI=.39E6                                                   128.2, C
PUMAT=20/20/20/20/20/20                                      128.4, T
PUDFSNT=.9/.9/.7/.7/.7/.7/.7/.7/.7/.7/.7                     128.6, T
PUGI=350E6                                                   128.8, C
PUINNT=.2/.2/.2/.2/.2/.2                                     129.1, T
PUGRT=1/1/1/1/1/1                                            129.3, T
PUUOT=15/15/15/15/15/15                                      129.5, T
PUEI=237E6                                                   129.7, C
PUGSCDT=.12/.12/.15/.15/.15/.15                              129.9, T
PUQET=.05/.05/.05/.05/.05/.05                                130.3, T
PUXET=.54/.54/.54/.54/.54/.54                                130.5, T
PUYET=.5/.5/.5/.5/.5/.5                                      130.7, T
PUMRCT=.075/.075/.075/.075/.075/.075                         130.9, T
PUORCT=1.75/1.75/1.75/1.75/1 .75/1.75                        131.2, T
PURRCT=.300/.300/.300/.300/.300/.300                         131.5, T
PURCCT=3000/3000/3000/3000/3000/3000                         131.7, T
    PU      - URBAN POPULATION <126>
    AREA    - TOTAL AREA POPULATION (PEOPLE) <3>
    PUQI    - INITIAL URBAN POPULATION AGED 0-14 <127.5>
    PUXI    - INITIAL URBAN POPULATION AGED 15-44 <127.7>
    PUYI    - INITIAL URBAN POPULATION AGED 45-64 <127.9>
    PUZI    - INITIAL URBAN POPULATION AGED OVER 64
                <128.2>
    PQRUM   - RURAL-URBAN MIGRATION OF 0-14 YEAR OLDS
                (MEN/YEAR) <155>
    PXRUM   - RURAL-URBAN MIGRATION OF 15-44 YEAR OLDS
                (MEN/YEAR) <148>
    PUMAT   - TABLE FOR URBAN MARRIAGE AGE (YEARS)
                <128.4>
    PUDFSNT- TABLE FOR EFFECT OF LIVING STANDARD ON
                DESIRED FAMILY SIZE <128.6>
    PUGI    - INITIAL URBAN HOUSEHOLD AND SERVICE CAPITAL
                (POUNDS) <128.8>
    PUINNT - NORMAL PRIORITY FOR THE URBAN POPULATION
                <129.1>
    PUGRT   - TABLE FOR DESIRED HOUSEHOLD CAPITAL PER
                CAPITA <129.3>
    PUUOT   - TABLE FOR DESIRED CONSUMER GOODS PER CAPITA
                (POUNDS/YEAR) <129.5>
    PUEI    - INITIAL URBAN POPULATION ENERGY USAGE (KWH/
                YEAR) <129.7>
    PUGSCDT- TABLE FOR DESIRED SERVICE PRODUCTION PER
                CAPITA (SERVICE UNITS/YEAR) <129.9>
```

PUQET = TABLE FOR EMPLOYMENT OF URBAN 0-15 YEAR-OLDS <130.3>
PUXET = TABLE FOR EMPLOYMENT OF URBAN 15-44 YEAR OLDS <130.5>
PUYET = TABLE FOR EMPLOYMENT OF URBAN 45-64 YEAR OLDS <130.7>
PULR = URBAN LABOR REQUESTED <132>
PULWR = WEIGHTED REQUESTS FOR URBAN LABOR <133>
PUMRCT = TABLE FOR DESIRED URBAN MEAT CONSUMPTION (KILOS/DAY) <130.9>
PUORCT = TABLE FOR DESIRED URBAN CONSUMPTION OF FRUITS AND VEGETABLES (KILOS/DAY) <131.2>
PURRCT = TABLE FOR URBAN REQUESTED RICE CONSUMPTION ((KG/PERSON)/DAY) <131.5>
PURCCT = TABLE FOR DESIRED URBAN CALORY CONSUMPTION (KCAL/DAY) <131.7>
PUQ = URBAN POPULATION AGED 0-14
PUX = URBAN POPULATION AGED 15-44
PUY = URBAN POPULATION AGED 45-64
PUZ = URBAN POPULATION AGED 65 AND OVER
PUB = URBAN BIRTHS
PUDLB = URBAN DESIRED LIFETIME BIRTHS PER MARRIED COUPLE
PUBCE = URBAN BIRTH CONTROL EFFECTIVENESS
PUMMC = URBAN MARRIED COUPLES
PUD = URBAN DEATHS
PULE = URBAN LIFE EXPECTANCY
PUSL = URBAN STANDARD OF LIVING
PURCC = URBAN REQUESTED CALORY CONSUMPTION
PUCCC = URBAN CALORY CONSUMPTION PER ADULT (CALORIES/DAY)
PUPCC = URBAN PROTEIN CONSUMPTION PER ADULT (GRAMS/DAY)
PUESPD = FRACTION OF URBAN POPULATION SUFFERING FROM PERSISTENT DISEASE
PUG = URBAN HOUSEHOLD AND SERVICE CAPITAL
PUGCR = CONSTRUCTION REQUESTED FOR URBAN HOUSEHOLD AND SERVICE CAPITAL
PUGO = URBAN ORDERS FOR HOUSEHOLD AND SERVICE CAPITAL
PUUD = CONSUMER GOODS DELIVERIES FOR URBAN POPULATION (POUNDS/YEAR)
PUUR = CONSUMER GOODS REQUESTED FOR URBAN POPULATION (POUNDS/YEAR)
PUE = URBAN ENERGY CONSUMPTION (KWH/YEAR)
PUER = URBAN ENERGY CONSUMPTION REQUESTED (KWH/YEAR)
PUGSC = GOVERNMENT AND SERVICE PERSONNEL WORKING IN URBAN AREAS
PULSR = REQUESTED SERVICE LABOR FOR URBAN AREAS
PULF = URBAN LABOR FORCE
PULN = SHORTFALL IN URBAN LABOR
PUMC = URBAN MEAT CONSUMPTION (TONNES/YEAR)
PUMR = REQUESTED URBAN MEAT CONSUMPTION (TONNES/YEAR)

```
    PURC    - URBAN RICE CONSUMPTION (TONNES/YEAR)
    PURR    - REQUESTED URBAN RICE CONSUMPTION (TONNES/
                YEAR)
    PUNC    - URBAN GRAIN CONSUMPTION (TONNES/YEAR)
    PUNR    - REQUESTED URBAN GRAIN CONSUMPTION (TONNES/
                YEAR)
    PUIGC   - URBAN PRIORITY FOR CAPITAL GOODS
                CONSTRUCTION
    PUIGO   - URBAN PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    PUIU    - URBAN PRIORITY FOR CONSUMER GOODS
    PUIE    - URBAN PRIORITY FOR ENERGY
    PUIL    - URBAN PRIORITY FOR (SERVICE) LABOR

PULR.K=PULSR.K+VLR.K+ULR.K+MLR.K+GLR.K                   132, A
    PULR    - URBAN LABOR REQUESTED <132>
    PULSR   - REQUESTED SERVICE LABOR FOR URBAN AREAS
    ULR     - LABOR REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    MLR     - MILITARY LABOR REQUESTED <411>
    GLR     - LABOR REQUESTED FOR CAPITAL GOODS
                PRODUCTION

PULWR.K=(PULSR.K/PUIL.K)+(VLR.K/VIL.K)+(ULR.K/           133, A
  UIL.K)+(MLR.K/MIL.K)+(GLR.K/GIL.K)
    PULWR   - WEIGHTED REQUESTS FOR URBAN LABOR <133>
    PULSR   - REQUESTED SERVICE LABOR FOR URBAN AREAS
    PUIL    - URBAN PRIORITY FOR (SERVICE) LABOR
    ULR     - LABOR REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    UIL     - CONSUMER GOODS PRIORITY FOR LABOR
    MLR     - MILITARY LABOR REQUESTED <411>
    GLR     - LABOR REQUESTED FOR CAPITAL GOODS
                PRODUCTION
    GIL     - CAPITAL GOODS PRIORITY FOR LABOR

PUFSPD.K=PUFRPD*PRFSPD.K                                 134, A
PUFRPD=.7                                                134.2, C
    PUFSPD - FRACTION OF URBAN POPULATION SUFFERING FROM
                PERSISTENT DISEASE
    PUFRPD - URBAN FRACTION SUFFERING FROM PERSISTANT
                DISEASE, RELATIVE TO RURAL POPULATION
                <134.2>
    PRFSPD - FRACTION OF RURAL POPULATION SUFFERING FROM
                PERSISTENT DISEASE
```

```
   RURAL POPULATION

PR.K=AREA(PRQI,PRXI,PRYI,PRZI,PQRUM,PXRUM,0,0,               135, A
  PRMAT,PRDFSNT,PRGI,PRINNT,PRGRT,PRUOT,PREI,
  PRGSCDT,PRQET,PRXET,PRYET,PRLR,PRLMR.K,PRMRCT,
  PRORCT,PRRRCT,PRRCCT,PRQ,PRX,PRY,PRZ,PRB,PRDLB,
  PRBCE,PRMMC,PRD,PRLE,PRSL,PRRCC,PRCCC,PRPCC,
  PRFSPD,PRG,PRGCR,PRGO,PRUD,PRUR,PRE,PRER,PRGSC,
  PRLSR,PRLF,PRLN,PRMC,PRMR,PROC,PROR,PRRC,PRRR,
  PRNC,PRNR,PRIGC,PRIGO,PRIU,PRIE,PRIL,PRIM,PRIO,
  PRIR,PRIN)
PRQI=6.99E6                                                   136.5, C
PRXI=6.59E6                                                   136.7, C
PRYI=2.1E6                                                    136.9, C
PRZI=.65E6                                                    137.2, C
PRMAT=18/18/18/18/18/18                                       137.4, T
PRDFSNT=1/1/.8/.8/.8/.8/.8/.8/.8/.8/.8                        137.6, T
PRGI=450E6                                                    137.9, C
PRINNT=.1/.1/.1/.1/.1/.1                                      138.2, T
PRGRT=1/1/1/1/1/1                                             138.4, T
PRUOT=9/9/9/9/9/9                                             138.6, T
PREI=304E6                                                    138.9, C
PRGSCDT=.06/.06/.09/.09/.09/.09                               139.2, T
PRQET=.1/.1/.1/.1/.1/.1                                       139.5, T
PRXET=.5/.5/.5/.5/.5/.5                                       139.7, T
PRYET=.45/.45/.45/.45/.45/.45                                 139.9, T
PRMRCT=.015/.015/.015/.015/.015/.015                          140.2, T
PRORCT=.58/.58/.58/.58/.58/.58                                140.5, T
PRRRCT=.060/.060/.060/.060/.060/.060                          140.8, T
PRRCCT=2700/2700/2700/2700/2700/2700                          141.1, T
    PR      - RURAL POPULATION <135>
    AREA    - TOTAL AREA POPULATION (PEOPLE) <3>
    PRQI    - INITIAL RURAL POPULATION AGED 0-14 <136.5>
    PRXI    - INITIAL RURAL POPULATION AGED 15-44 <136.7>
    PRYI    - INITIAL RUAL POPULATION AGED 45-64 <136.9>
    PRZI    - INITIAL RURAL POPULATION AGED OVER 64
                <137.2>
    PQRUM   - RURAL-URBAN MIGRATION OF 0-14 YEAR OLDS
                (MEN/YEAR) <155>
    PXRUM   - RURAL-URBAN MIGRATION OF 15-44 YEAR OLDS
                (MEN/YEAR) <148>
    PRMAT   - TABLE FOR RURAL DESIRED MARRIAGE AGE
                (YEARS) <137.4>
    PRDFSNT- TABLE FOR THE EFFECT OF RURAL LIVING
                STANDARD ON MARRIAGE AGE <137.6>
    PRGI    - INITIAL RURAL HOUSEHOLD CAPITAL (POUNDS)
                <137.9>
    PRINNT - NORMAL RURAL PRIORITY <138.2>
    PRGRT   - TABLE FOR DESIRED RURAL CAPITAL PER CAPITA
                <138.4>
```

PRUOT - TABLE FOR DESIRED RURAL CONSUMER GOODS PER CAPITA (POUNDS/YEAR) <138.6>

PREI - INITIAL RURAL POPULATION ENERGY USAGE (KWH/YEAR) <138.9>

PRGSCDT- TABLE FOR DESIRED RURAL SERVICE PRODUCTION PER CAPITA (SERVICE UNITS/YEAR) <139.2>

PRQET - TABLE FOR EMPLOYMENT OF RURAL 0-15 YEAR OLDS <139.5>

PRXET - TABLE FOR EMPLOYMENT OF RURAL 15-44 YEAR OLDS <139.7>

PRYET - TABLE FOR EMPLOYMENT OF RURAL 45-64 YEAR OLDS <139.9>

PRLR - REQUESTED RURAL LABOR <142>

PRLWR - WEIGHTED REQUESTS FOR URBAN LABOR <143>

PRMRCT - TABLE FOR DESIRED RURAL MEAT CONSUMPTION PER CAPITA (KILOS/DAY) <140.2>

PRORCT - TABLE FOR DESIRED RURAL FRUITS AND VEGETABLES CONSUMPTION PER CAPITA (KILOS/DAY) <140.5>

PRRRCT - TABLE FOR RURAL REQUESTED RICE CONSUMPTION ((KG/PERSON)/DAY) <140.8>

PRRCCT - TABLE FOR DESIRED RURAL CALORY CONSUMPTION PER CAPITA (KCAL/DAY) <141.1>

PRQ - RURAL POPULATION AGED 0-14

PRX - RURAL POPULATION AGED 15-44

PRY - RURAL POPULATION AGED 45-64

PRZ - RURAL POPULATION AGED 65 AND OVER

PRB - RURAL BIRTHS

PRDLB - RURAL DESIRED LIFETIME BIRTHS PER MARRIED COUPLE

PRBCE - RURAL BIRTH CONTROL EFFECTIVENESS

PRMMC - RURAL MARRIED COUPLES

PRD - RURAL DEATHS

PRLE - RURAL LIFE EXPECTANCY

PRSL - RURAL STANDARD OF LIVING

PRRCC - RURAL REQUESTED CALORY CONSUMPTION

PRCCC - RURAL CALORY CONSUMPTION PER ADULT (CALORIES/DAY)

PRPCC - RURAL PROTEIN CONSUMPTION PER ADULT (GRAMS/DAY)

PRFSPD - FRACTION OF RURAL POPULATION SUFFERING FROM PERSISTENT DISEASE

PRG - RURAL HOUSEHOLD AND SERVICE CAPITAL

PRGCR - CONSTRUCTION REQUESTED FOR RURAL HOUSEHOLD AND SERVICE CAPITAL

PRGO - RURAL ORDERS FOR HOUSEHOLD AND SERVICE CAPITAL

PRUD - CONSUMER GOODS DELIVERIES FOR RURAL POPULATION (POUNDS/YEAR)

PRUR - CONSUMER GOODS REQUESTED FOR RURAL POPULATION (POUNDS/YEAR)

PRE - RURAL ENERGY CONSUMPTION (KWH/YEAR)

PRER - RURAL ENERGY CONSUMPTION REQUESTED (KWH/YEAR)

```
    PRGSC   - GOVERNMENT AND SERVICE PERSONNEL WORKING IN
                RURAL AREAS
    PRLSR   - REQUESTED SERVICE LABOR FOR RURAL AREAS
    PRLF    - RURAL LABOR FORCE
    PRLN    - SHORTFALL IN RURAL LABOR
    PRMC    - RURAL MEAT CONSUMPTION (TONNES/YEAR)
    PRMR    - REQUESTED RURAL MEAT CONSUMPTION (TONNES/
                YEAR)
    PROC    - RURAL FRUITS AND VEGETABLE CONSUMPTION
                (TONNES/YEAR)
    PROR    - REQUESTED RURAL FRUITS AND VEGETABLE
                CONSUMPTION (TONNES/YEAR)

    PRRC    - RURAL RICE CONSUMPTION (TONNES/YEAR)
    PRRR    - REQUESTED RURAL RICE CONSUMPTION (TONNES/
                YEAR)
    PRNC    - RURAL GRAIN CONSUMPTION (TONNES/YEAR)
    PRNR    - REQUESTED RURAL GRAIN CONSUMPTION (TONNES/
                YEAR)
    PRIGC   - RURAL PRIORITY FOR CAPITAL GOODS
                CONSTRUCTION
    PRIGO   - RURAL PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    PRIU    - RURAL PRIORITY FOR CONSUMER GOODS
    PRIE    - RURAL PRIORITY FOR ENERGY
    PRIL    - RURAL PRIORITY FOR (SERVICE) LABOR

PRLR.K=PRLSR.K+ALR.K                                 142, A
    PRLR    - REQUESTED RURAL LABOR <142>
    PRLSR   - REQUESTED SERVICE LABOR FOR RURAL AREAS
    ALR     - AGRICULTURE LABOR REQUESTED <250>

PRLWR.K=(PRLSR.K/PRIL.K)+(ALR.K/AIL.K)               143, A
    PRLWR   - WEIGHTED REQUESTS FOR URBAN LABOR <143>
    PRLSR   - REQUESTED SERVICE LABOR FOR RURAL AREAS
    PRIL    - RURAL PRIORITY FOR (SERVICE) LABOR
    ALR     - AGRICULTURE LABOR REQUESTED <250>

PRFSPD.K=TABHL(PRFSPDT,TIME.K,1960,2010,10)          144, A
PRFSPDT=.6/.6/.6/.6/.6/.6                            144.2, T
PRCCC=PRCCCI                                         144.5, N
PRCCCI=2600                                          144.6, C
    PRFSPD  - FRACTION OF RURAL POPULATION SUFFERING FROM
                PERSISTENT DISEASE
    PRFSPDT- TABLE FOR THE FRACTION OF THE RURAL
                POPULATION SUFFERING FROM PERSISTENT
                DISEASE <144.2>
    PRCCC   - RURAL CALORY CONSUMPTION PER ADULT
                (CALORIES/DAY)
    PRCCCI  - INITIAL RURAL CALORY CONSUMPTION PER CAPITA
                <144.6>
```

```
   FOOD NUTRIENT CONTENTS

ACCM=1.08E6                                                       145.2, C
APCM=110E3                                                        145.4, C
ACCR=3.62E6                                                       145.6, C
APCR=67.0E3                                                       145.8, C
ACCO=450E3                                                        146.1, C
APCO=25E3                                                         146.3, C
ACCG=3.24E6                                                       146.5, C
    ACCM   - CALORY CONTENT OF MEAT (AVERAGE OF PORK AND
               SHEEP -- KCAL/TONNE) <145.2>
    APCM   - PROTEIN CONTENT OF MEAT (GMS/TONNE) <145.4>
    ACCR   - CALORY CONTENT OF RICE (KCAL/TONNE) <145.6>
    APCR   - PROTEIN CONTENT OF RICE (GMS/TONNE) <145.8>
    ACCO   - CALORY CONTENT OF FRUITS AND VEGETABLES
               (KCAL/TONNE) <146.1>
    APCO   - PROTEIN CONTENT OF FRUITS AND VEGETABLES
               (GMS/TONNE) <146.3>
    ACCG   - CALORY CONTENT OF WHEAT <146.5>

APCG.K=122E3                                                      147, A
    APCG   - PROTEIN CONTENT OF WHEAT <147>
```

IV-D. MIGRATION

Linking together the urban and rural area populations is the model's calculation of migration between the two. These demographic shifts are incorporated into the model's calculation of year by year changes in rural and urban populations.

The primary impetus to rural/urban migration appears to be underemployment in the rural regions.[33] The extraordinarily intensive farming practices in Egypt leave little room on existing farmlands for the hundreds of thousands of young adults who enter the rural workforce each years. The result of this crowding is a push of young people out of rural areas and into the cities.

In the model, the rural/urban migration of 15 to 44 year olds (PXRUM) is based upon the number of adults aged 15-44 (PRX) and an effect of rural employment (PXRUME). The effect of rural employment is to establish a base fraction for the portion of 15-44 year age group that migrates to the cities each year. As shown in Figure IV-14, this fraction is assumed to be quite low (but still non-zero) under conditions of extreme labor force shortages in rural areas, and rises rapidly as the rural population makes a transition from labor force shortage to labor force excess.

Besides the base migration rate determined by rural employment conditions, four other factors are modeled as influencing the migration of unemployed rural adults. Two of these effects--the effect of services on rural/urban migration (PXRUMS) and the effect of income on rural/urban migration (PXRUMI)—are determined by a comparison of conditions in the cities with conditions in rural areas. Thus, superior services delivery in urban areas relative to rural areas,[34] or superior standards of living in urban areas relative to rural areas,[35] are assumed to be capable of increasing the rate of rural-urban migration, in the manner shown in Figures IV-15. The third

Figure IV-14: Effect of Rural Employment on Migration

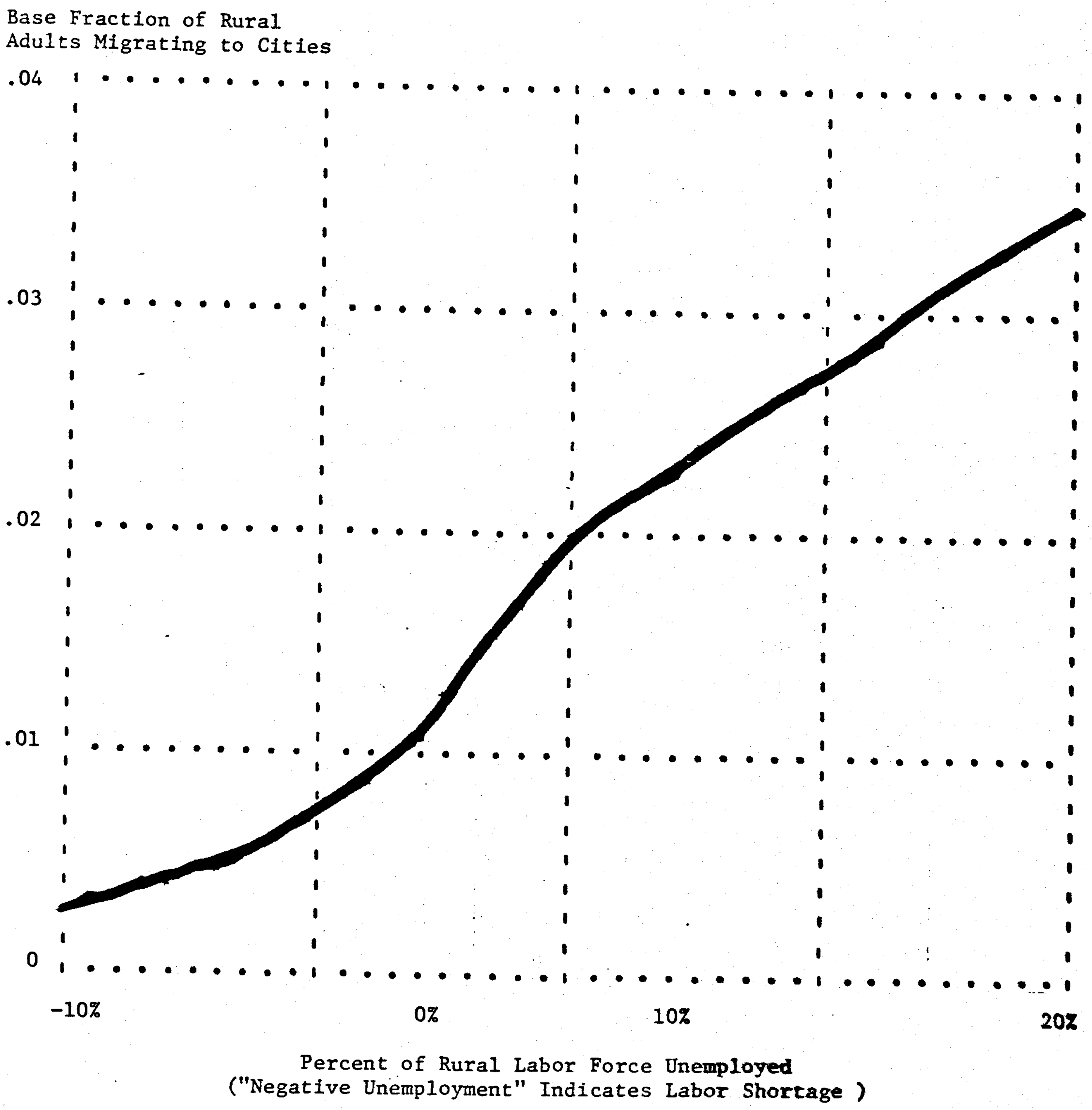
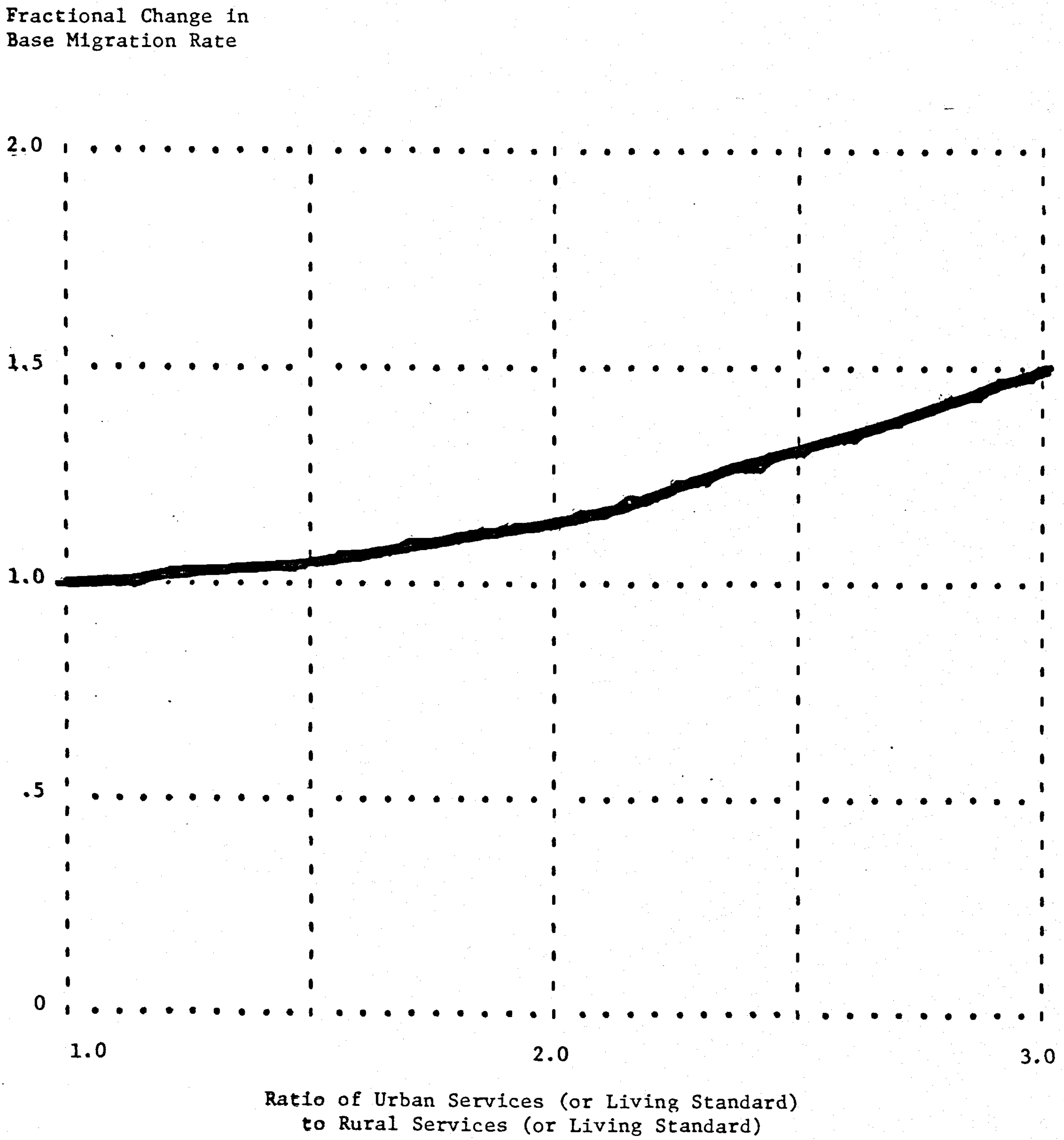


Figure IV-15: Effect of Services and Living Standards on Migration



effect concerns urban employment (PXRUMU), and incorporates an assumption that labor shortages in urban areas will also boost rural/urban migration (although labor surpluses are assumed to have no effect). This influence is diagrammed in Figure IV-16.

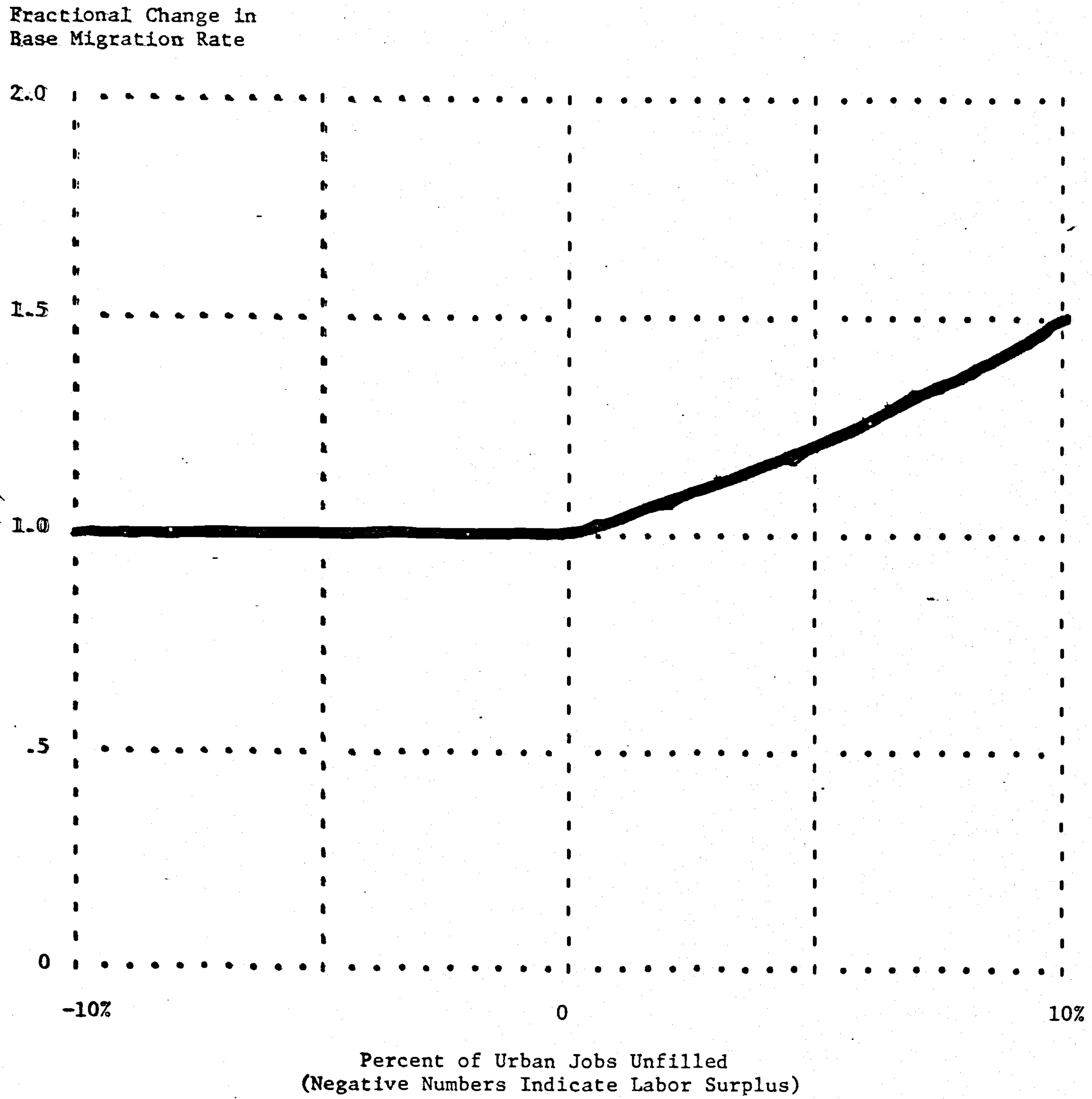
In addition to the three endogenous influences on rural-urban migration, a fourth exogenous influence is also included. This exogenous influence (PXRUMX) allows the model user to assess the consequences of government programs or social changes that act to increase or decrease migration.

The final adjustment to the migration calculation concerns the role of wives and children who migrate with unemployed male adults. The model includes an adjustment factor (PXRUMM) incoporating an assumption that 50% of the unemployed males who migrate to urban areas bring their wives along with them. This factor is included in the model as an external input that can be varied over time. Rural urban migration of 0-14 year olds (PQRUM) is calculated from the number of married couples migrating (PMCRUM). Since the adults migrating to rural areas are typically quite young,[36] the married couples migrating to the cities would have fewer children to bring along for the move. In the model, this bias factor (PACMFB) representing the fraction of the average children per family that is associated with migrating parents is assigned a value of .3.

```
 MIGRATION

PXRUM.K=PRX.K*PXRUME.K*PXRUMS.K*PXRUMI.K*PXRUMM.K*   148, A
  PXRUMU.K*PXRUMX.K
    PXRUM  - RURAL-URBAN MIGRATION OF 15-44 YEAR OLDS
               (MEN/YEAR) <148>
    PRX    - RURAL POPULATION AGED 15-44
    PXRUME - EFFECT OF RURAL EMPLOYMENT ON RURAL-URBAN
               MIGRATION <149>
    PXRUMS - EFFECT OF SERVICES ON RURAL-URBAN MIGRATION
               <150>
    PXRUMI - EFFECT OF INCOME ON RURAL-URBAN MIGRATION
               <151>
    PXRUMM - EFFECT OF MARRIAGE ON RURAL-URBAN MIGRATION
               <152>
    PXRUMU - EFFECT OF URBAN EMPLOYMENT ON RURAL-URBAN
               MIGRATION <153>
    PXRUMX - EXOGENOUS INFLUENCES ON RURAL URBAN
               MIGRATION <154>
```

Figure IV-16: Effect of Urban Employment on Migration



```
PXRUME.K=TABHL(PXRUMET,(PRLF.K-PRLR.K)/PRX.K,-.1,     149, A
  .2,.05)
PXRUMET=.003/.005/.01/.02/.025/.03/.035                 149.2, T
    PXRUME - EFFECT OF RURAL EMPLOYMENT ON RURAL-URBAN
               MIGRATION <149>
    PXRUMET- TABLE FOR THE EFFECT OF EMPLOYMENT ON
               RURAL-URBAN MIGRATION <149.2>
    PRLF   - RURAL LABOR FORCE
    PRLR   - REQUESTED RURAL LABOR <142>
    PRX    - RURAL POPULATION AGED 15-44

PXRUMS.K=TABHL(PXRUMST,PUGSC.K/PRGSC.K,1,3,.5)          150, A
PXRUMST=1/1.05/1.15/1.3/1.5                             150.2, T
    PXRUMS - EFFECT OF SERVICES ON RURAL-URBAN MIGRATION
               <150>
    PXRUMST- TABLE FOR THE EFFECT OF SERVICES ON RURAL-
               URBAN MIGRATION <150.2>
    PUGSC  - GOVERNMENT AND SERVICE PERSONNEL WORKING IN
               URBAN AREAS
    PRGSC  - GOVERNMENT AND SERVICE PERSONNEL WORKING IN
               RURAL AREAS

PXRUMI.K=TABHL(PXRUMIT,PUSL.K/PRSL.K,1,3,.5)            151, A
PXRUMIT=1/1.05/1.15/1.3/1.5                             151.2, T
    PXRUMI - EFFECT OF INCOME ON RURAL-URBAN MIGRATION
               <151>
    PXRUMIT- TABLE FOR THE EFFECT OF INCOME ON RURAL-
               URBAN MIGRATION <151.2>
    PUSL   - URBAN STANDARD OF LIVING
    PRSL   - RURAL STANDARD OF LIVING

PXRUMM.K=TABLE(PXRUMMT,TIME.K,1960,2010,10)             152, A
PXRUMMT=1.5/1.5/1.5/1.5/1.5/1.5                         152.2, T
    PXRUMM - EFFECT OF MARRIAGE ON RURAL-URBAN MIGRATION
               <152>
    PXRUMMT- TABLE FOR THE EFFECT OF MARRIAGE ON RURAL-
               URBAN MIGRATION <152.2>

PXRUMU.K=TABLE(PXRUMUT,(PULR.K-PULF.K)/POS(PULF.K),     153, A
  -.1,.1,.05)
PXRUMUT=1/1/1/1.2/1.5                                   153.2, T
    PXRUMU - EFFECT OF URBAN EMPLOYMENT ON RURAL-URBAN
               MIGRATION <153>
    PXRUMUT- TABLE FOR THE EFFECT OF URBAN EMPLOYMENT ON
               RURAL-URBAN MIGRATION <153.2>
    PULR   - URBAN LABOR REQUESTED <132>
    PULF   - URBAN LABOR FORCE
```

V. AGRICULTURE

Egyptian agriculture is the largest single consumer of water from the Nile River. The ebb and flow of the Nile water for centuries determined when the crops would be planted and how successful the harvest would be. The annual flooding of the rich river valley soil enabled an intensive cultivation of various cereal crops, and Egypt for many centuries was a breadbasket for the Middle East.

In modern times, however, two major changes have occurred. First, the rapidly growing Egyptian population strained and then exceeded the capabilities for domestic food production, and by the 1960's the country was a net importer of food. Second, control of the Nile with the Aswan High Dam has greatly expanded the potential for Egyptian agricultural production. Controlled release of the Nile water allows year-round cultivation, almost doubling the country's effective agricultural land area. Water can be carried from the Nile to new lands never before available for cultivation, further increasing Egypt's arable land resources. In addition, control of the Nile largely frees Egypt from the dangers of excessive or inadequate water when the Nile flood varies from its average flow.

In spite of the opening of the Aswan High Dam in 1965, Egypt's agricultural position in the mid-1970 is little better than in the early 1960's. The country still imports considerable amounts of food, because the increased agricultural production from control of the Nile water has not kept pace with the 30% population increase over the past ten years. And while control of the Nile has expanded the land area available for cultivation, it has necessarily increased the country's reliance on other production factors (fertilizer, motive power from draft animals and mechinery, etc.)

and introduced the prospect of serious yield losses from increased soil salinity and rising water tables. All of these trends affect the ability of Egypt's agricultural sector to supply the surplus necessary for industrialization.

Two major considerations motivated the decision to develop a detailed agriculture sector for this study of water resources. First, Egypt's current access to water resources exceeds the water needs determined by the country's current mix of other agricultural production factors. In the short term, therefore, Egypt's success in increasing agricultural production will be influenced very little by the availability of water, but very much by the way that water is used and by the impact of other production factors. Second, there exist long-term prospects for significant agricultural production gains in Egypt, given the wide variety of production factors amenable to improvement by some combination of social and economic change. In the future, therefore, water availability may emerge as one of the key constraints on agricultural production, if enough other production factors are adjusted to raise the country's base agricultural capacity. It would be quite desirable to anticipate when water availability might become an important limitation, and what developments in agricultural production might be most likely to bring about that result.

To thoroughly explore the role of Nile water in Egyptian agriculture in the coming decades, and to evaluate the prospects for self-sufficiency or disaster (and the spectrum of outcomes in between), considerable detail is invested in the simulation model's treatment of agricultural production. The list of production inputs and influences included in the model is lengthly and allows analysis of a number of different programs for boosting harvests of various crops. In addition, the model disaggregates agricultural production among five different categories of crops, thereby providing a basis for analyzing the mix, as well as the overall amount, of agricultural production.

The allocation of agricultural production capacity among the five major crop categories is modeled as depending largely upon projections of requirements for individual crops. In the model, the needs for grains, fruits and vegetables, and rice will be determined by the population sector, the needs for cotton, rice, and fruits and vegetables by Egypt's foreign trade position, the need for cotton and other fibers by the economy's consumer goods sector, and the need for fodder by the agricultural sector's livestock population. Land is allocated among the five crops in response to these requirements; the land area allocation and seed strains are the basis for determining each crop's requirements for water, soil nutrients, motive power, and human labor.

For most of the agricultural production inputs, the total demand implied by summing the individual crop requirements will exceed the amount of the resource available. In a free market economy, prices would fluctuate under such shortage situations to allocate scarce resources among competing demands. In Egypt, agricultural production is largely regulated by the central government. The model attempts to represent this regulation with an allocation process that responds to the priority for each crop's production, as well as the amount of production required. To some extent these priorities reflect government policies and programs. For instance, an export development strategy might accord a higher priority to cotton production than to production of various foodstuffs. These official priorities are parameters that can be changed to represent different assumptions about government intentions. In addition to the effect of government policy, priorities may respond to changing agricultural conditions. For instance, increased soil salinity would raise the priority for rice cultivation, since that crop's higher tolerance for salt would allow a more effective use of available production inputs.

A final aspect of agricultural production is the role of livestock. The simulation model distinguishes between livestock maintained primarily for draft pruposes and livestock maintained for food use (although the food contribution from draft livestock will be recognized). Both livestock categories consume fodder, and therefore compete indirectly for agricultural resources with the other four crop categories. Both categories are a source of manure, which serves as an important soil nutrient.

The allocation of fodder between the two livestock types depends upon the competing requirements for motive power in agriculture, versus meat consumption by the population. Increased mechanization would reduce the crop-requriements for draft livestock, which would leave more fodder available for food livestock or would allow a direct reduction of the agricultural resources (land, water, etc.) allocated to fodder cultivation. Meat requirements will be determined by the dietary preferences of the population and the population's absolute size.

The role of livestock in Egyptian agriculture is complicated by several important feedback relationships that make it difficult to anticipate the consequences of alternative policies for managing the livestock population. For example, increased mechanization might increase the land available for cultivation of the five Egyptian crops. However, the increased mechanization would have the indirect effect of decreasing the size of the draft livestock herd. The reduced demand for fodder would limit an important source of soil nutrients, an effect that would be further compounded by the loss of nutrient-rich manure. The simulation model should help determine the net impact on agricultural production of such an interrelated set of factors.

V-A. CROP AGRICULTURE

The agriculture sector of the Egypt model distinguishes among five **separate** categories for crops. These production categories are:

1. **Cotton** and other non-food crops;
2. **Fruits** and vegetables;
3. **Rice**;
4. **Grains** (not including rice); and
5. **Fodder** (mostly clover).

The crop categories listed above were determined by an evaluation of **the production** factor requirements and end-uses of the dozen or so major **Egyptian** crops. An attempt was made to group all crops with similar factor **requirements** and end-uses so that the crops could be modeled as substitutes **for one** another. Thus, cotton and other non-food crops constitute a category **obviously** distinct from the other four cultivation types, which serve as food **for humans** and other livestock. Fruits and vegetables are separated out **because** they have water and labor requirements that are distinct from those **of other** human food crops. Fruits and vegetables also have a different end-use **from** other human foods, since they do not yet occupy a major portion of the **Egyptian** diet and are grown mainly for export.[1] Similarly, rice is different from other grains in that it is an important export crop that is too **expensive** at present for many Egyptians. The water requirements for rice **are also** different from other grains. Fodder is different from other grain crops in its end-use as a feed for livestock and in its ability to replenish important soil nutrients.[2]

The major influences on agricultural production and harvests are similar from crop to crop. Although some crops are more sensitive to certain production influences than others, as mentioned above, generally applicable list of influences can be constructed. This generality suggested the development of a standard building block, or MACRO, to represent the processes of agricultural production and harvest. This standardized building block is reproduced in model for each of the crops.

The Egypt model currently contains twelve separate influences on crop production. These are:

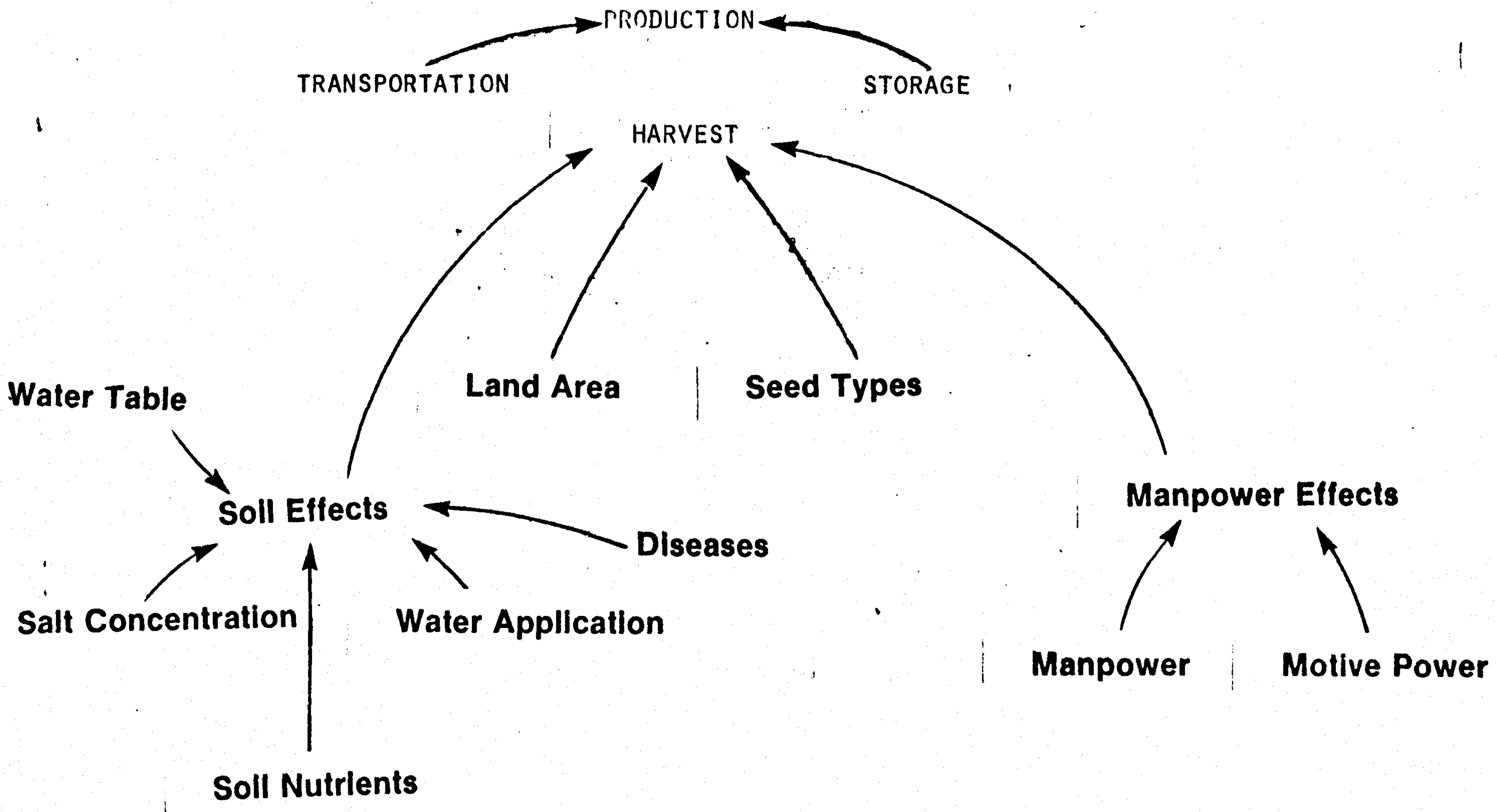
1. Transportation Effects
2. Storage Losses
3. Seed Type
4. Land Area
5. Salt Concentration
6. Water Table Height
7. Water Supply
8. Soil Nutrients
9. Diseases and Pests
10. Labor Supply
11. Machinery
12. Draft Animals

Some of these effects (e.g., water table height) depend directly on other variables in the model, while others (e.g., seed type) are external inputs reflecting assumptions about future trends in practices and technique. Several of the effects are involved in important feedback relationships through a network of connections with other sectors of the model. As noted above, a number of these production influences are more important for some crops than for others.

For ease of explanation, the model's standard crop building block has been subdivied into five sections -- production, harvest, soil effects, manpower effects, and production adequacy (Figure V-1). Each of these will be discussed in turn, followed by a listing of the model equations that implement the descriptive information in the text.

<u>Crop Production</u> -- The quantity of a crop (CROP) available for food, industrial raw materials, or export is modeled as depending upon three separate factors. The first is the actual amount of harvest (AH) that is gathered from the farmland. Not all of this harvest, however, will always be available for consumption. Inadequate facilities for storage or

**Figure V-I:
Crop Agriculure**



or marketing may combine to limit the amount of the harvest that is actually made available for consumption. In the model, the storage and marketing effects are represented as an external factor (ASE) that can be varied over time to investigate the consequences of improved handling of agricultural production. The storage effect is assumed to be different for different crops, as diagrammed in Figure V-2.[3]

A second possible limitation on the amount of harvest that will actually be available for consumption is transportation. The agricultural sector of Egypt's economy must compete with the other industrial sectors for transportation support. The adequacy of transportation for agriculture (ATA), as will be explained later, is the fraction of desired agricultural transportation that is actually supplied. The resulting transportation effect on crop production (ATE) will be different for different crops, since some crops are more vulnerable to the delivery delays associated with inadequate transportation than others. And fodder, which is typically consumed within the same village or region where it is grown, would be unaffected by transportation shortages (Figure V-3).[4]

The transportation requirement for each crop (ATR) is determined by the amount of the crop harvested (AH) and a normal transportation requirement (ATRN) that represents the average shipping distance, in kilometers, for that individual crop harvest.[5] The individual crop transportation requirements are summed to calculate the overall transportation requirement for agriculture.

The model determines the harvest (AH) for an individual crop by totalling the harvests for Old Valley (AHO) and New Valley (AHN) lands. Both sub-harvests are determined by comparing the land area cultivated for the crop (AXF) with the calculated average yield for the crop (AYO,AYN) in each land area.

Figure V-2:
Storage Effect on Crop Production

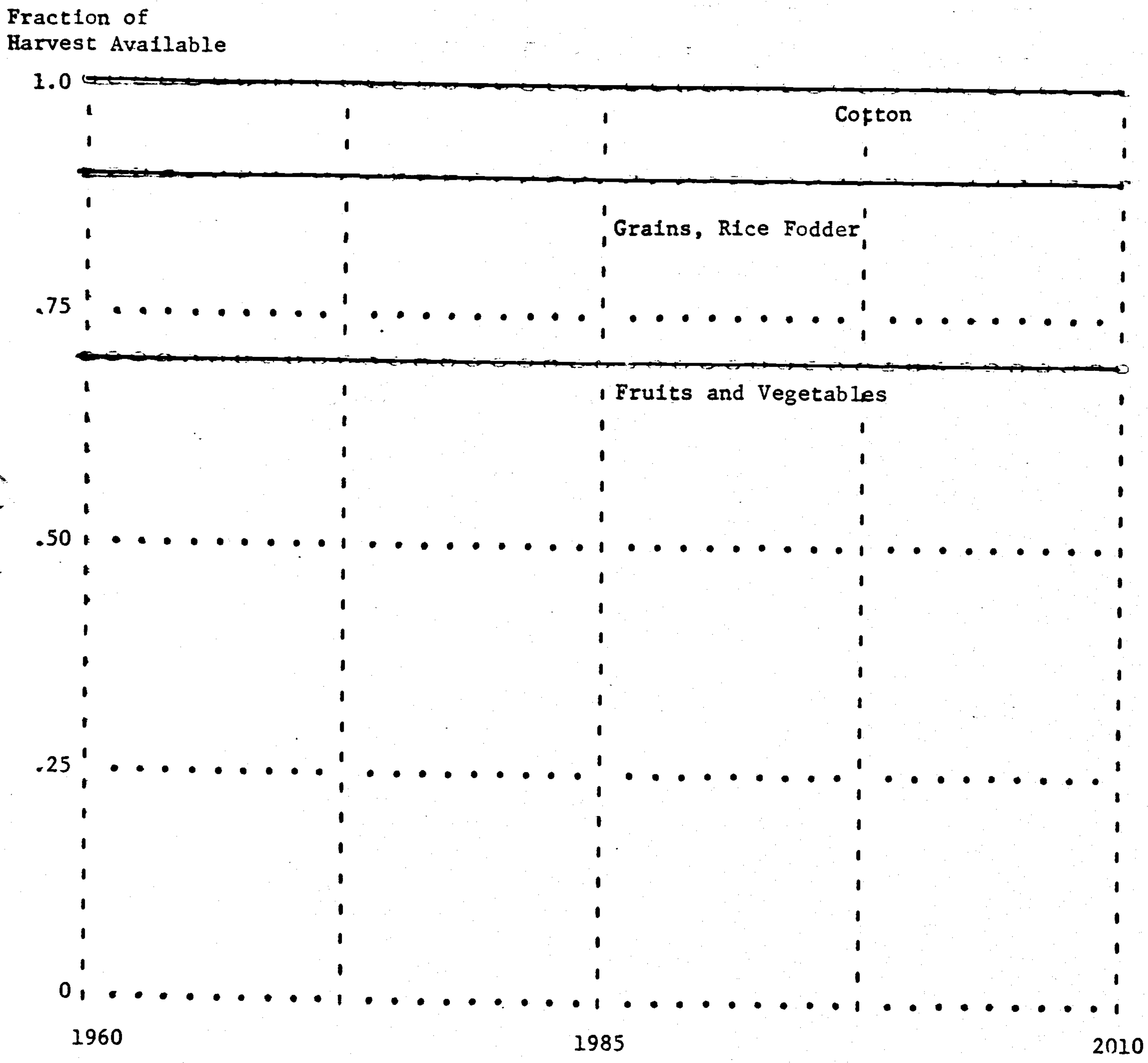
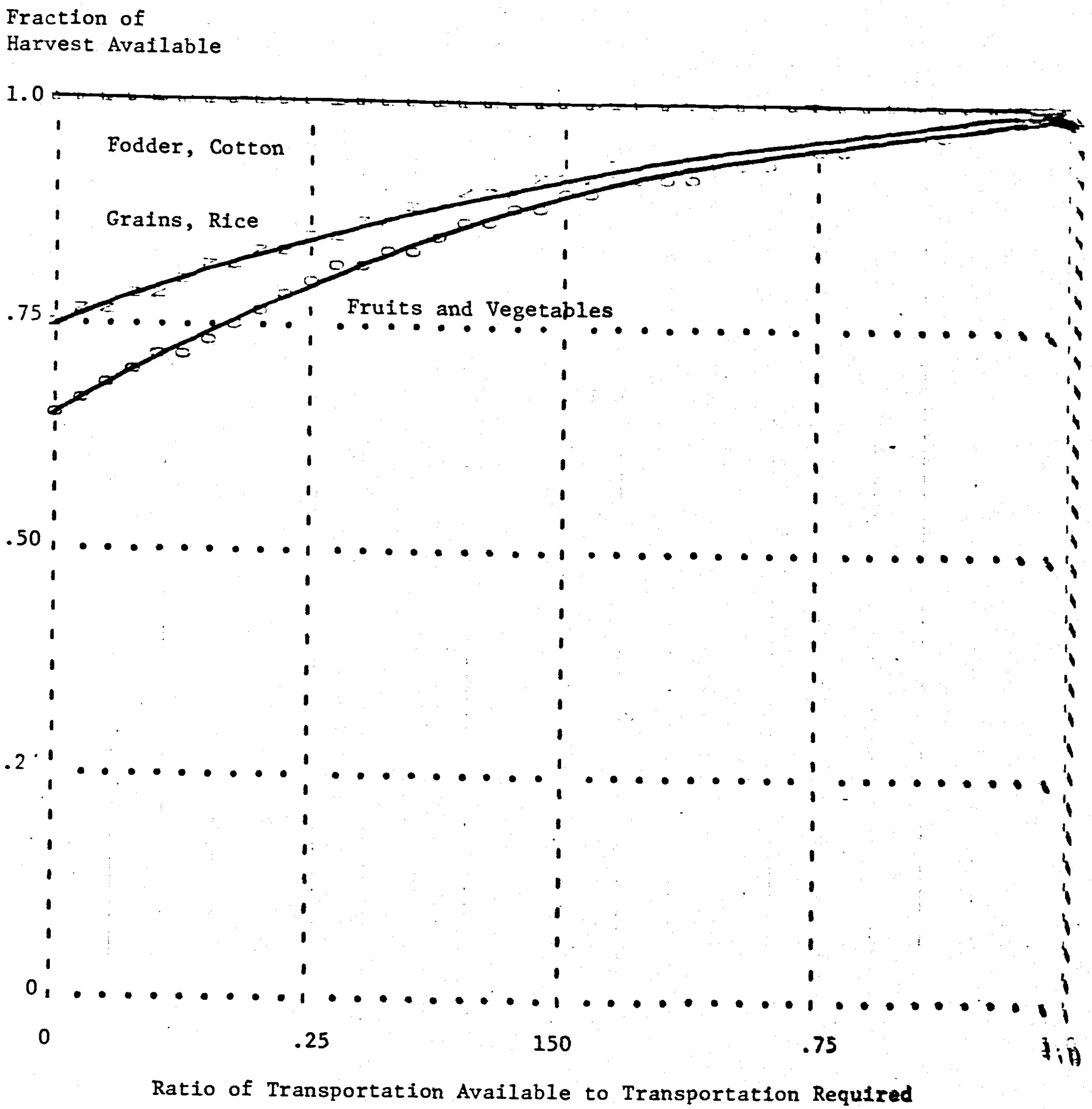


Figure V-3:
Transportation Effect on Crop Production



```
PXRUMX.K=TABHL(PXRUMXT,TIME.K,1960,2010,10)                154, A
PXRUMXT=1/1/1/1/1/1                                        154.2, T
    PXRUMX - EXOGENOUS INFLUENCES ON RURAL URBAN
              MIGRATION <154>
    PXRUMXT- TABLE FOR EXOGENOUS INFLUENCES ON RURAL-
              URBAN MIGRATION <154.2>

PQRUM.K=PMCRUM.K*PACMF.K                                   155, A
    PQRUM  - RURAL-URBAN MIGRATION OF 0-14 YEAR OLDS
              (MEN/YEAR) <155>
    PMCRUM - RURAL-URBAN MIGRATION OF MARRIED COUPLES
              <156>
    PACMF  - AVERAGE CHILDREN PER MIGRATING COUPLE <157>

PMCRUM.K=PXRUM.K*(1-(1/PXRUMM.K))                          156, A
    PMCRUM - RURAL-URBAN MIGRATION OF MARRIED COUPLES
              <156>
    PXRUM  - RURAL-URBAN MIGRATION OF 15-44 YEAR OLDS
              (MEN/YEAR) <148>
    PXRUMM - EFFECT OF MARRIAGE ON RURAL-URBAN MIGRATION
              <152>

PACMF.K=(PRQ.K/PRMMC.K)*PACMFB                             157, A
PACMFB=.3                                                  157.2, C
    PACMF  - AVERAGE CHILDREN PER MIGRATING COUPLE <157>
    PRQ    - RURAL POPULATION AGED 0-14
    PRMMC  - RURAL MARRIED COUPLES
    PACMFB - BIAS FACTOR FOR CHILD MIGRATION <157.2>
```

The average yield in either land area is determined from the seed strains used and a combination of production factors and environmental conditions. The seed strains used determine a reference yield (AYR) that could be obtained with the optimal balance of factors and conditions. This reference yield will seldom be realized in practice, however, since an optimal balance of effects is all but impossible to achieve. In the model, these influences on the yield for Old Valley lands are divided between soil effects (AYGE) and manpower effects (AYHE).

The soil and manpower effects are indices that can range in value between zero and two. They represent the fraction of the reference harvest that can be achieved, given current soil conditions and manpower availability. Thus, a value for the soil effect index of .8 means that 80% of the reference harvest will be available, assuming a manpower effect index of 1.0. The two effects can re-inforce each other or counteract each other. For example, a soil effect index of .8 and a manpower effect index of 1.1 translates to a combined index of .88 -- the actual harvest is reduced below the reference harvest (by -12%), but to a lesser extent than if the soil effect were operating alone. In this example, an excess of manpower (from human labor, draft animals, or machinery) has partially compensated for prospective harvest losses caused by soil effects (inadequate fertilizer, perhaps, or excessive salt).

```
CROP.K=AH.K*ATE.K*ASE.K                                  2, A
    CROP    - CROP PRODUCTION (TONNES/YEAR) <2>
    AH      - AGRICULTURAL HARVEST (TONNES/YEAR) <6>
    ATE     - TRANSPORTATION EFFECT ON CROP PRODUCTION
                <4>
    ASE     - STORAGE EFFECT ON CROP PRODUCTION <3>

ASE.K=TABHL(ASET,TIME.K,1960,2010,10)                    3, A
    ASE     - STORAGE EFFECT ON CROP PRODUCTION <3>
    ASET    - TABLE FOR STORAGE EFFECT ON CROP PRODUCTION
```

```
ATE.K=TABHL(ATET,ATA.K,0,1,.25)                                 4, A
    ATE     - TRANSPORTATION EFFECT ON CROP PRODUCTION
                <4>
    ATET    - TABLE FOR TRANSFORTATION EFFECT ON CROP
                PRODUCTION
    ATA     - ADEQUACY OF TRANSPORTATION SUPPLIED TO
                AGRICULTURE <281.1>

ATR.K=AH.K*ATRN                                                 5, A
    ATR     - TRANSPORTATION REQUIRED (TONNE-MILES/
                SEASON) <5>
    AH      - AGRICULTURAL HARVEST (TONNES/YEAR) <6>
    ATRN    - NORMAL TRANSPORTATION REQUIREMENT (KM)

   CROP HARVEST

AH.K=AHN.K+AHO.K                                                6, A
    AH      - AGRICULTURAL HARVEST (TONNES/YEAR) <6>
    AHN     - HARVEST ON NEW VALLEY LANDS <7>
    AHO     - HARVEST ON OLD VALLEY LANDS <9>

AHN.K=AXF.K*AFFNV.K*AYN.K                                       7, A
    AHN     - HARVEST ON NEW VALLEY LANDS <7>
    AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
    AFFNV   - FRACTION OF AGRICULTURAL LAND IN THE NEW
                VALLEY <229>
    AYN     - YIELD ON NEW VALLEY LANDS <8>

AYN.K=AYR.K*AYNE.K*AYDE.K*AYHE.K                                8, A
    AYN     - YIELD ON NEW VALLEY LANDS <8>
    AYR     - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
    AYNE    - EFFECT OF FERTILIZER ON YIELD <21>
    AYDE    - EFFECT OF DISEASE AND PEST LOSSES ON CROP
                YIELD <25>
    AYHE    - MANPOWER (HUMAN) EFFECT ON SEED YIELD <26>

AHO.K=AXF.K*(1-AFFNV.K)*AYO.K                                   9, A
    AHO     - HARVEST ON OLD VALLEY LANDS <9>
    AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
    AFFNV   - FRACTION OF AGRICULTURAL LAND IN THE NEW
                VALLEY <229>
    AYO     - YIELD ON OLD VALLYE LANDS <10>

AYO.K=AYR.K*AYGE.K*AYHE.K                                      10, A
    AYO     - YIELD ON OLD VALLYE LANDS <10>
    AYR     - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
    AYGE    - SOIL (GROUND) EFFECT ON YIELD <15>
    AYHE    - MANPOWER (HUMAN) EFFECT ON SEED YIELD <26>
```

Land Area and Seed Strains -- The land area allocated to each crop (AXF) is determined by the competition among all five crops for the limited land area available for agriculture.

The land area requested for an individual crop (AFR) is calculated from the land area already allocated to the crop (AXF) and the desired annual change in that crop's production (APDAC). Thus, desired increases in agricultural production are translated into attempts to increase the amount of land devoted to an individual crop. Similarly, planned decreases in agricultural production reduce the requested land allocation.

The transfer of land among crops, however, cannot occur instantaneously. Crops already growing on the land must first be harvested. Considerable preparation may be necessary to shift from the cultivation of one type of crop to cultivation of another. Furthermore, perception and implementation delays will slow the reaction of land allocation to changes in the land area desired. In the model, a delay is introduced (by means of the DYNAMO "SMOOTH" function) between the amount of land indicated (AFI) for an individual crop based on current demand conditions and the actual transfer of land to that crop. This land transfer time (AFTT) is assumed to average three years.[6]

To begin the simulations, the 1960 values for land distribution among the five crops have been provided to the model. The model generates its own calculations for land allocation after 1960. The initial land allocations are provided below:

1960 Land Allocation (Thousand Feddan)[7]

Cotton	Grains (ex. Rice)	Rice	Fodder	Other
1,870	3,830	710	2,850	860

The role of seed strains is represented in the model by the reference crop yield (AYR), a parameter that establishes a likely upper limit on crop production per feddan of land area. As mentioned earlier, the reference yield is the yield that will be maintained with an optimal balance of production inputs and environmental conditions. The reference yields are introduced into the model as parameters that can be varied over time to test the consequences of the introduction of new seed strains for any of the five crop categories. The current model values for reference yield are summarized in the table below.

Reference Yields (Tonnes/Feddan)[8]

Cotton	Grains (ex. Rice)	Rice	Fodder	Other
.45	2.05	3.15	18	21.5

```
AXF.K=SMOOTH(AFI.K,AFTT.K)                                12, A
    AXF     - FEDDANS FOR CROF PRODUCTION (FEDDANS) <12>
    AFI     - INDICATED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <13.1>
    AFTT    - TIME TO TRANSFER AGRICULTURAL LAND (YEARS)
                <158>

AFI.K=SHARE(AFR.K,AFN.K,AIF.K,AFWR.K,AXIN.K)              13, A
AFI=AFII                                                  13.1, N
    AFI     - INDICATED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <13.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    AFR     - REQUESTED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <14>
    AFN     - SHORTFALL IN FEDDANS (FEDDANS) <236>
    AFWR    - WEIGHTED REQUESTS FOR AGRICULTURAL LAND
                <228>
    AXIN    - NORMAL CROP PRIORITY <42.1>
```

```
AFR.K=(1+APDAC.K*AFTT.K)*AXF.K                              14, A
    AFR     - REQUESTED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <14>
    APDAC   - DESIRED ANNUAL CHANGE IN AGRICULTURE
                PRODUCTION <37>
    AFTT    - TIME TO TRANSFER AGRICULTURAL LAND (YEARS)
                <158>
    AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>

AYR.K=TABLE(AYRT,TIME.K,1960,2010,10)                       11, A
    AYR     - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
    AYRT    - TABLE FOR REFERENCE CROP YIELD
```

Soil Effects -- The soil effect (AYGE) in the crop building block is actually a combination of five separate effects on crop yields. These five effects are the effect of salt concentration (AYSE), the effect of water table height (AYTE), the effect of water availability (AYWE), the effect of nutrients (AYNE), and the effect of disease and pest losses (AYDE). Like the combined soil effect, the individual effects are indices (although the range for all is limited to zero to one). The five indices are multiplied together to determine the overall soil effect. These five effects are diagrammed in in Figure V-4, and described in turn below.

The first three effects -- salt concentration, water table height, and water availability -- are determined by developments in the model's water sector. The salt concentration in the root zone (WSCECE) changes over time depending upon irrigation and drainage practices. (The factors contributing to an increase or decrease in soil salt concentrations are described in Section III-C). Although different crops have a different sensitivity to a build-up of salt, we assume that farmers will attempt to compensate for these differences by planting the more tolerant crops in the saltier soil. Thus, all crops would have a similar vulnerability to rising salt conditions, as diagrammed in Figure V-5.

The water table effect (AYTE) is determined by the fraction of agricultural land with a saturated root zone (WSATRZ). The water sector, as described in Chapter III, maintains a constant assessment of the average water table height is the basis for the model's calculation of the fraction of agricultural land that is so saturated with water that crop yields are impaired. At the extreme where all of the land area is flooded, agricultural yields are assumed to fall to a minimal fraction of their potenital value (Figure V-6). Rice alone is assumed to have no significant sensitivity to the problem of water-logging, since the crop typically requires a plentiful water supply for proper maturation.

**Figure V-4:
Soil Effects on Crop Harvests**

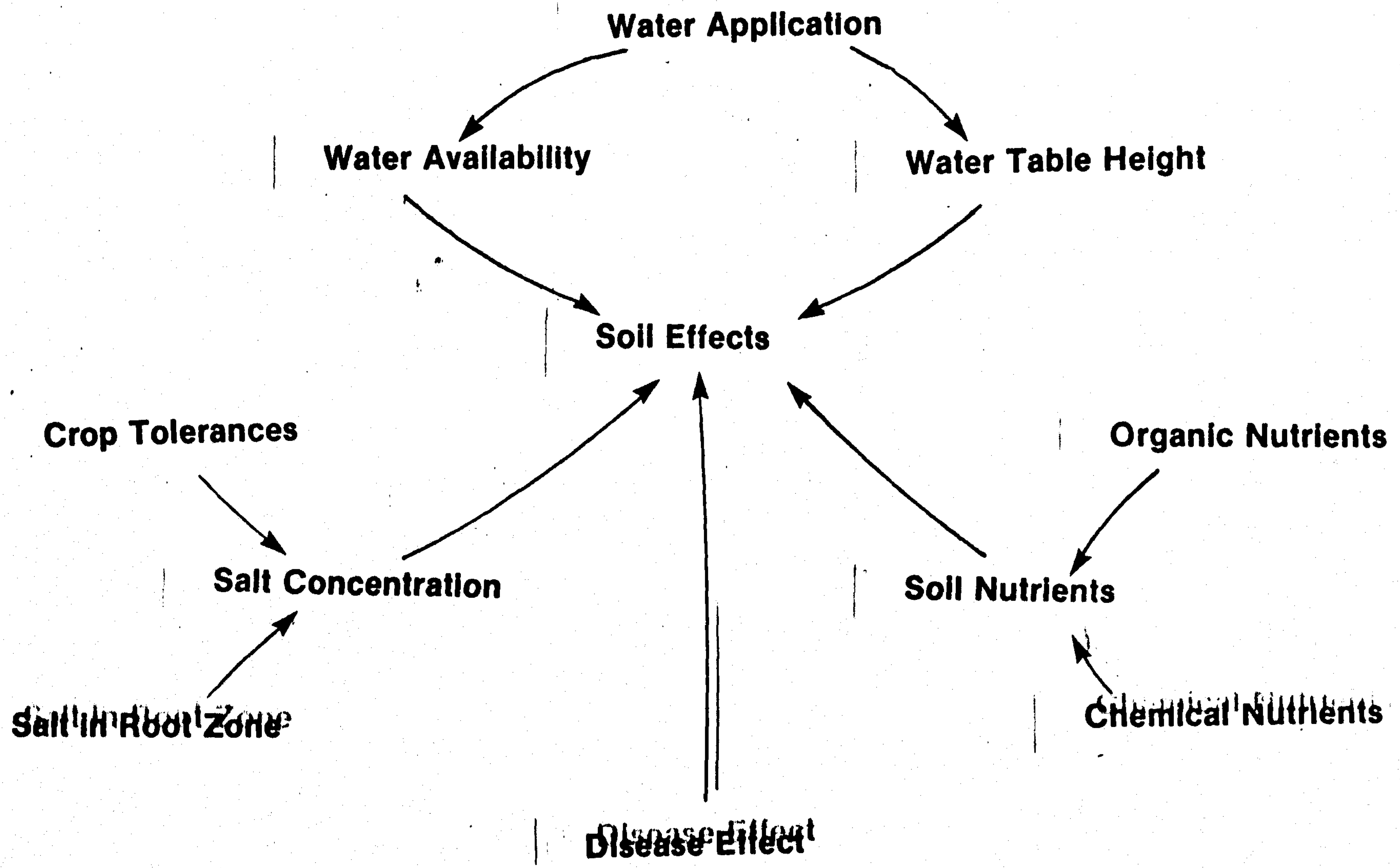


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Figure V-4:
Soil Effects on Crop Harvests

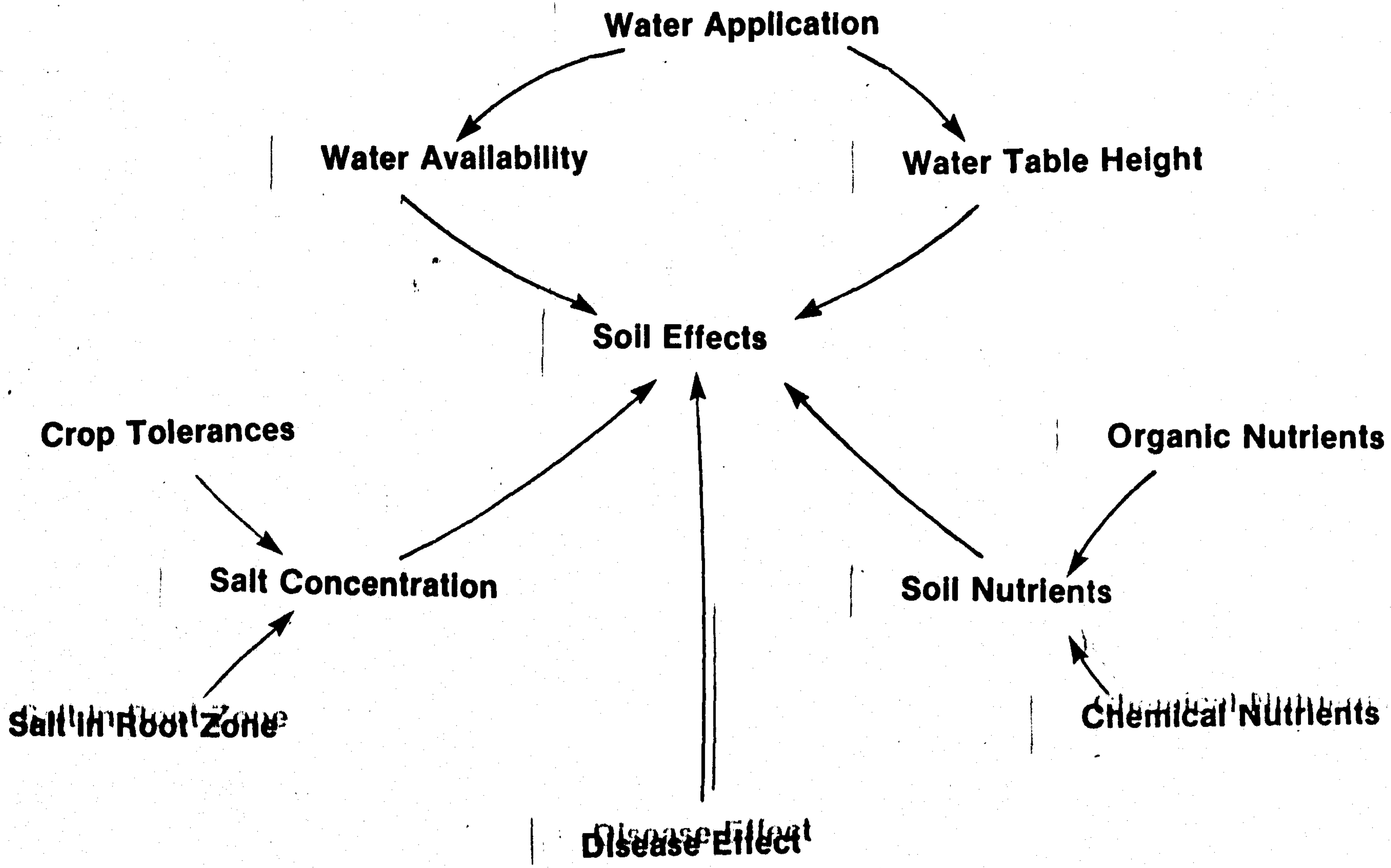


Figure V-5:
Effect of Salt Concentration on Crop Yield

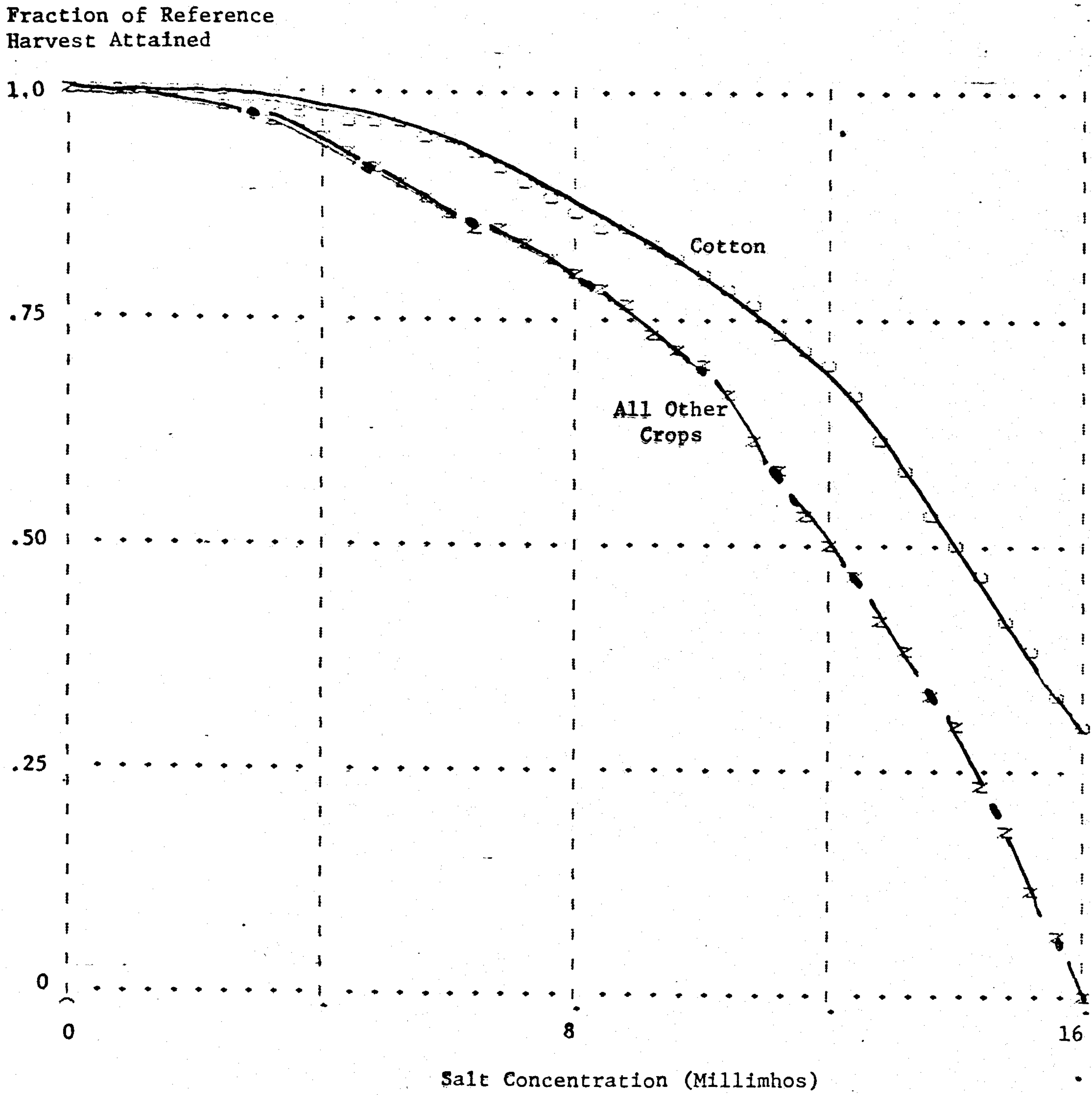
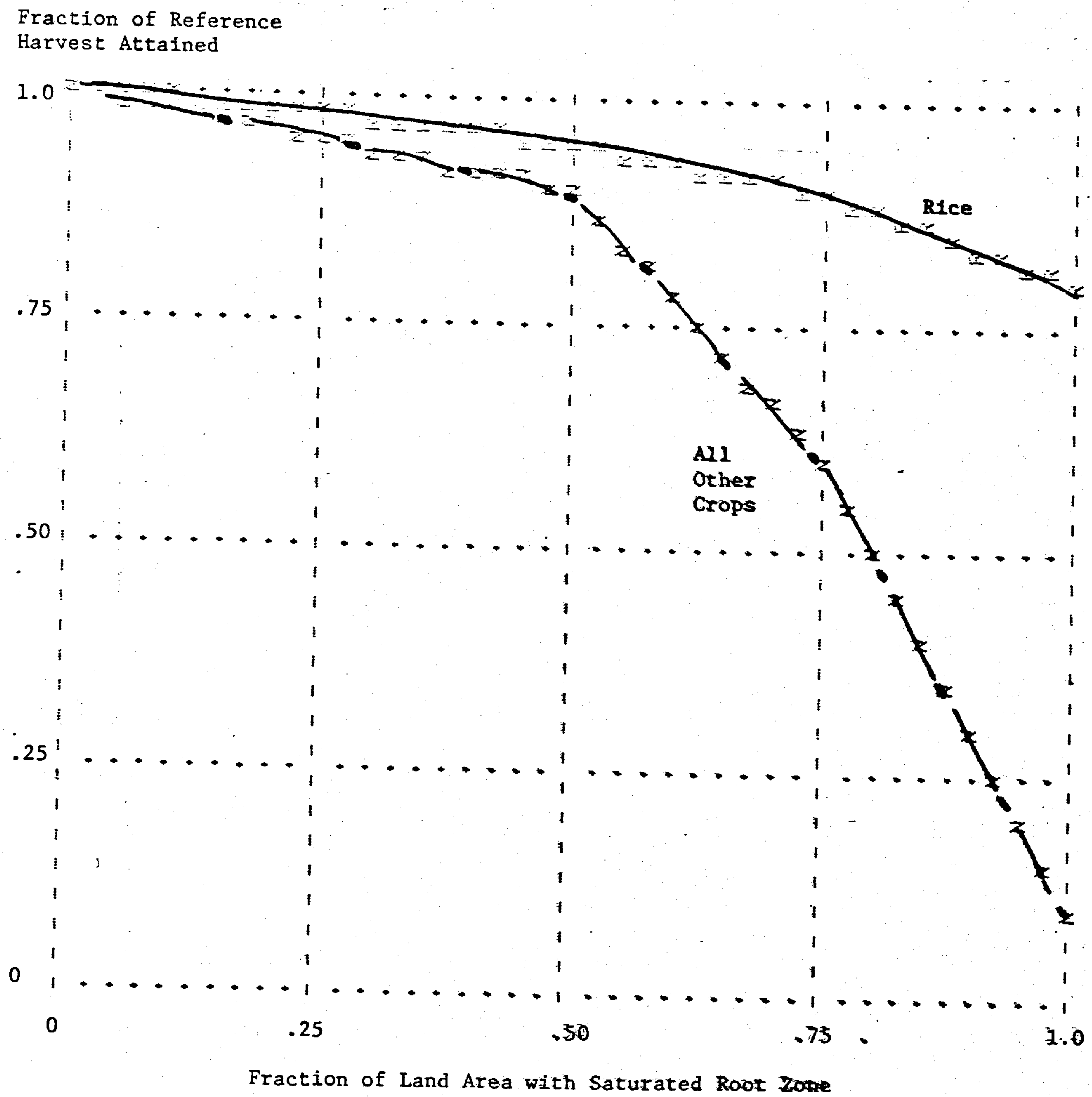


Figure V-6:
Effect of Water Table on Crop Yield



The water availability effect (AYWE) is determined by the ratio of the water available for an individual crop (AW) to the optimal application (XWO) for that crop. The optimal water application depends upon the total land area cultivated for that particular crop (AXF) and the per feddan water requirement of tha crop. The per feddan water requirement is assumed to depend upon the individual needs of the separate crops[10] and the effect of the water table height (AYTE). That is, a zone that reduces the potential harvest for a crop is also assumed to reduce that crop's requirements for additional water (Figure V-7).

The actual amount of water applied to a crop will be determined by the model's allocation logic, dividing the water available for agricultural production among the five competing crops. The water application could conceivably exceed the optimum water application, if a bias in favor of excessive water usage exists among the population. The model's incorporation of such a bias is discussed in Chapter III, but the consequences of that bias for agricultural yields are apparent in Figure V-8, a diagram for the effect of water availability yield (AYWE). Note that the model provides for reduced yields for both inadequate and excessive water application rates.

The fourth soil effect on agricultural yields depends on the adequacy of fertilizer (AYNE). It is calculated in the model from the ratio of nutrients available (AN) for each crop to the nutrients required (ANR) for that crop (Figure V-9). The crop nutrient requirements are dictated by the land allocation (AXF) to the particular crop and the crop's potential yield, as determined by the reference yield (AYR) and the three water sector effects (AYSE, AYTE, AYWE). Figure V-10 diagrams these requirements.[11] The model assumption is that crops whose potential yield is restricted by salt build-up,

Figure V-7:
Crop Water Requirements

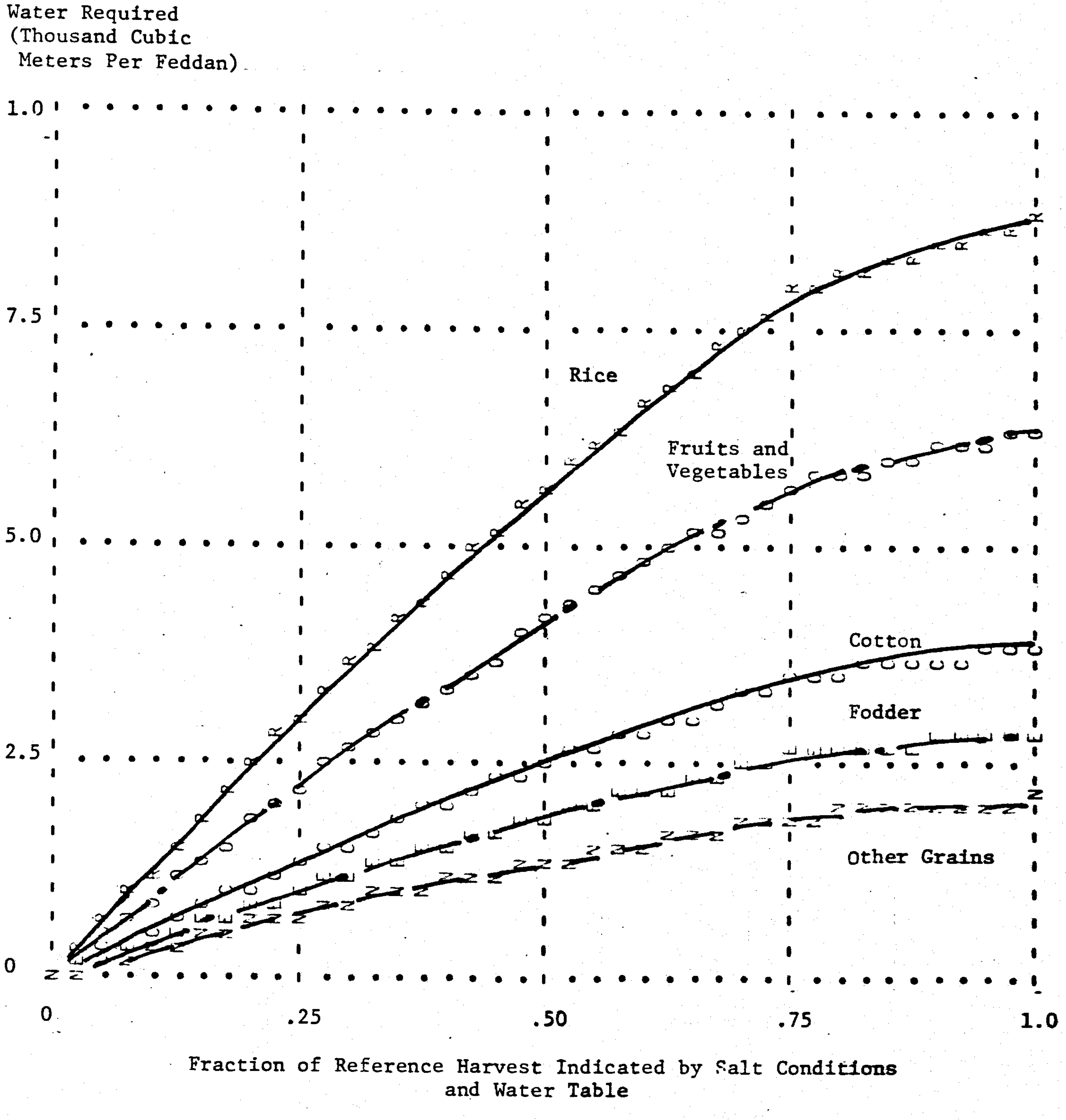


Figure V-8: Effect of Water Availability on Crop Yield

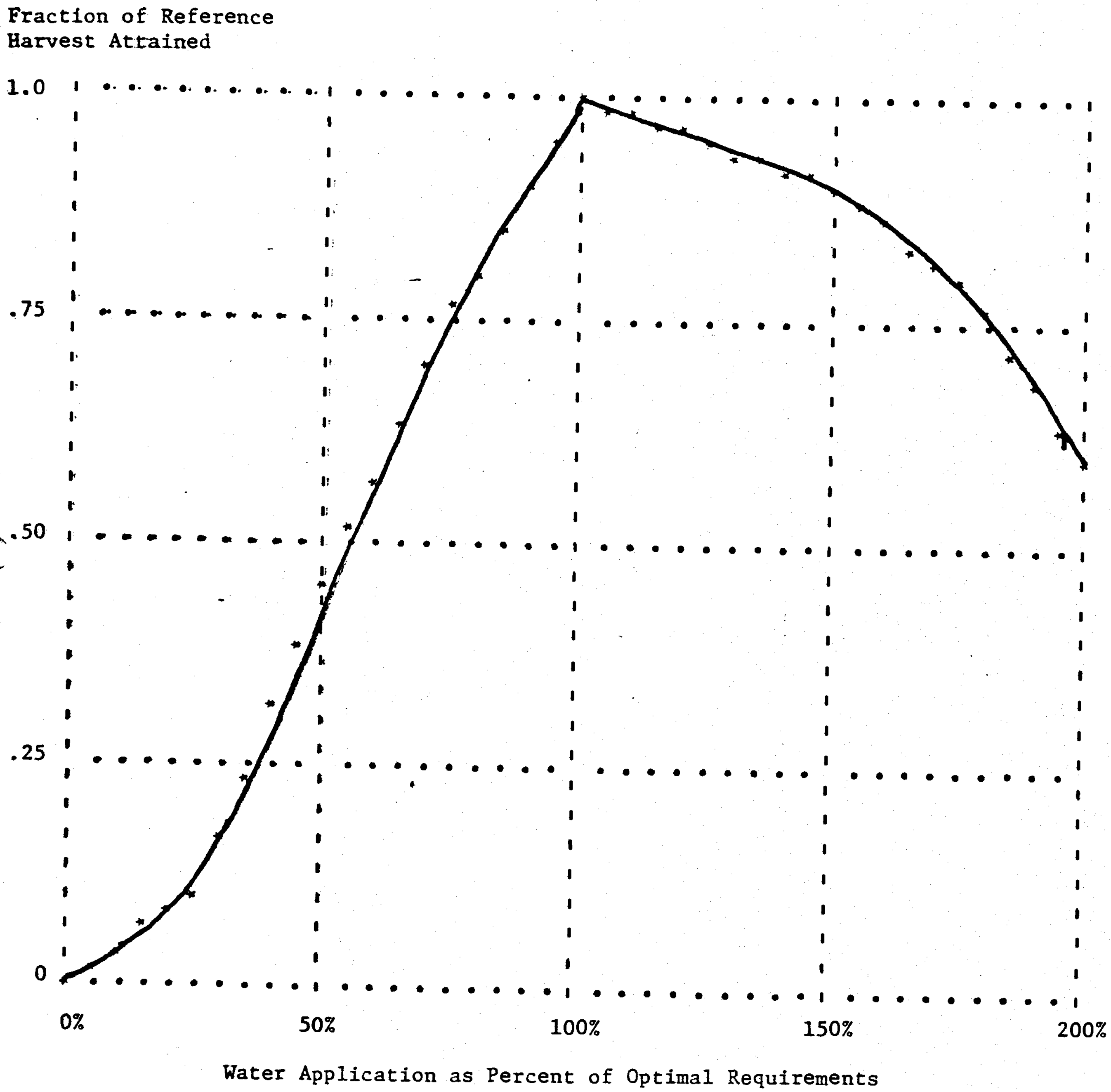


Figure V-9: Effect of Soil Nutrients on Crop Yield

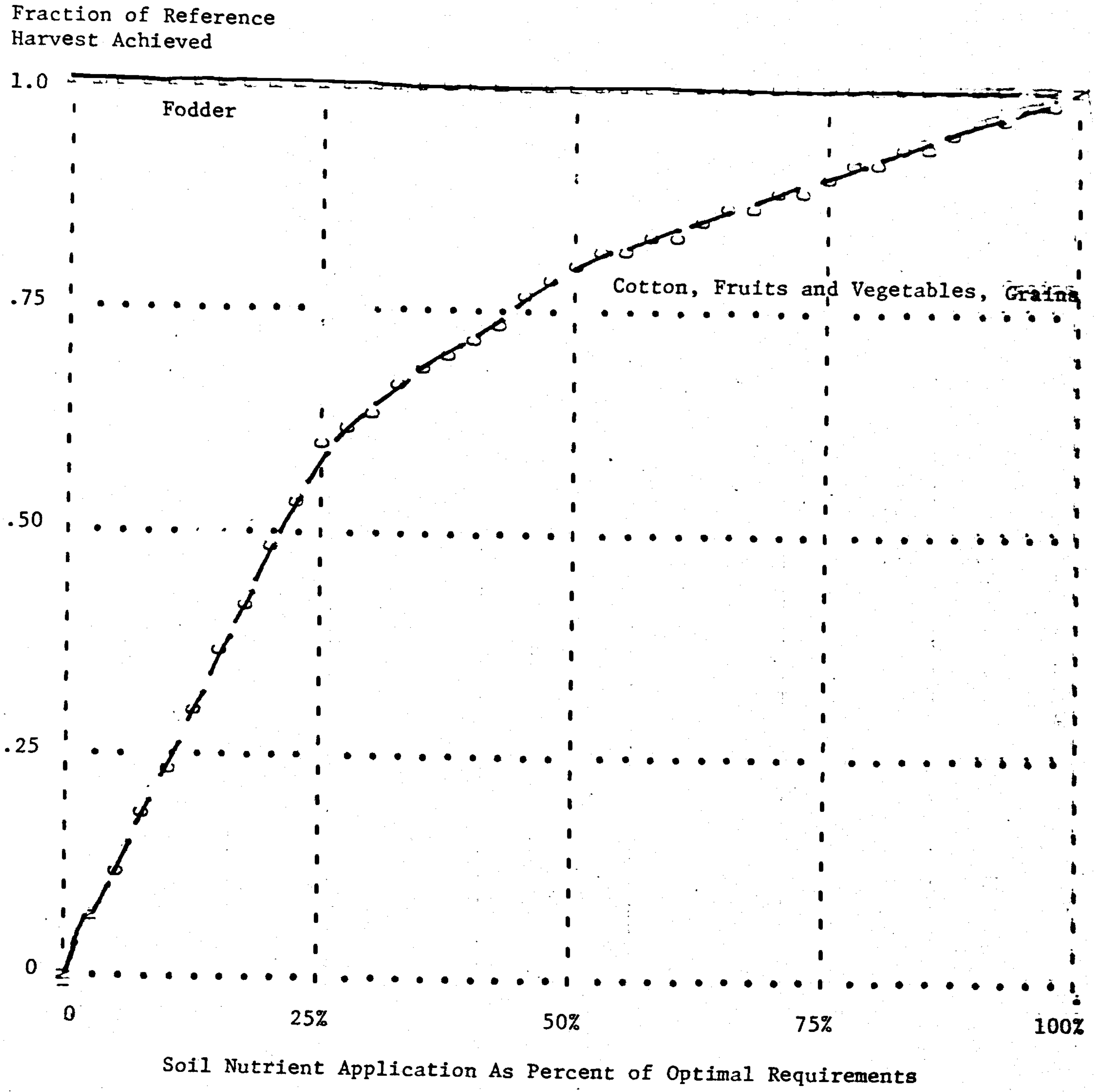
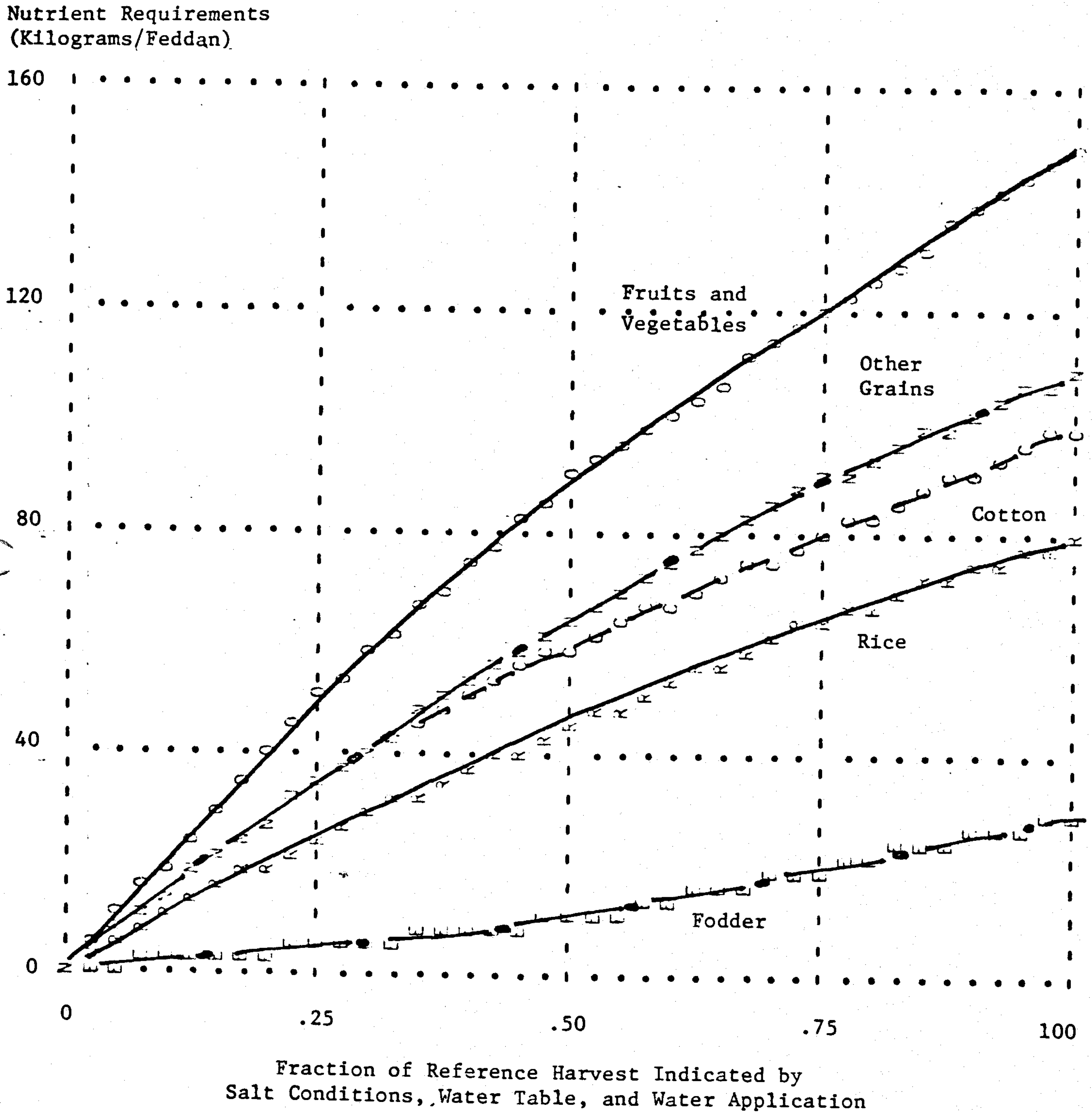


Figure V-10: Soil Nutrient Requirements



root zone saturation, or inadequate or excessive water require less soil nutrients than crops whose potential yield is unrestricted by water sector considerations.

The soil nutrients available to a particular crop (AXN) will be determined by the model's allocation logic. The total nutrients (organic and chemical) available for agricultural use are allocated among the competing needs of the five agricultural crops. Nutrient requirements for crop agriculture are assumed in the model to be a combination of the requirements for nitrates and phosphates. It appears unlikely that future Egyptian agricultural production will be hindered by a shortage of the third important chemical fertilizer, potash.[12]

The impact of disease and pest losses on crop yields is the fifth soil effect. Egypt's dry climate generally spares its agricultural crops from the ravages of pests and disease that are typical of more temperate, and more wet, agricultural areas. Cotton appears to be the only exception, and the model includes an assumption that cotton yields are currently reduced an average 10% from the impact of pest losses.[13] The cotton disease effect, and the disease effects for other crops, are represented in the model as an external factor that can be varied over time to represent the consequences of future changes in the susceptibility of crops to diseases and pests.

```
AYGE.K=AYSE.K*AYTE.K*AYWE.K*AYNE.K*AYDE.K              15, A
    AYGE    - SOIL (GROUND) EFFECT ON YIELD <15>
    AYSE    - $$$ <16>
    AYTE    - EFFECT OF WATER TABLE ON SEED YIELD <17>
    AYWE    - EFFECT OF WATER AVAILABLE ON SEED YIELD
                <18>
    AYNE    - EFFECT OF FERTILIZER ON YIELD <21>
    AYDE    - EFFECT OF DISEASE AND PEST LOSSES ON CROP
                YIELD <25>
```

```
AYSE.K=TABLE(AYSET,WSCECE.K,0,16,2)                         16, A
 /SE=1                                                       16.1, N
    AYSE   - $$$ <16>
    AYSET  - TABLE FOR SALT EFFECT ON CROP YIELD
    WSCECE - SALT CONCENTRATION, MEASURED BY
               CONDUCTIVITY OF SATURATED SOIL EXTRACT
               (MILLIMHOS/CM) <105>

AYTE.K=TABLE(AYTET,WSATRZ.K,0,1,.25)                        17, A
    AYTE   - EFFECT OF WATER TABLE ON SEED YIELD <17>
    AYTET  - TABLE FOR WATER TABLE EFFECT ON CROP YIELD
    WSATRZ - SATURATION OF ROOT ZONE <103>

AYWE.K=TABLE(AYWET,AW.K/(AXWO.K*(1-AFFNV.K)),0,2,       18, A
  .25)
    AYWE   - EFFECT OF WATER AVAILABLE ON SEED YIELD
               <18>
    AYWET  - TABLE FOR WATER AVAILABILITY EFFECT ON CROP
               YIELD
    AW     - WATER AVAILABLE FOR OLD VALLEY LANDS (KCM/
               SEASON) <20>
    AXWO   - OPTIMUM WATER APPLICATION (KCM/SEASON) <19>
    AFFNV  - FRACTION OF AGRICULTURAL LAND IN THE NEW
               VALLEY <229>

AXWO.K=AXF.K*TABLE(AXWOT,AYR.K*AYTE.K,0,AYR.K,          19, A
  AYR.K/4)
    AXWO   - OPTIMUM WATER APPLICATION (KCM/SEASON) <19>
    AXF    - FEDDANS FOR CROF PRODUCTION (FEDDANS) <12>
    AXWOT  - TABLE FOR WATER ORDERED FOR CROP USE
    AYR    - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
    AYTE   - EFFECT OF WATER TABLE ON SEED YIELD <17>

AW.K=SHARE(AXWO.K*(1-AFFNV.K),AWN.K,AIW.K,AWWR.K,       20, A
  AXIN.K)*AWXF.K
    AW     - WATER AVAILABLE FOR OLD VALLEY LANDS (KCM/
               SEASON) <20>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    AXWO   - OPTIMUM WATER APPLICATION (KCM/SEASON) <19>
    AFFNV  - FRACTION OF AGRICULTURAL LAND IN THE NEW
               VALLEY <229>
    AWN    - SHORTFALL IN WATER AVAILABLE (KCM/YEAR)
               <231>
    AWWR   - WEIGHTED REQUESTS FOR AGRICULTURAL WATER
               <236>
    AXIN   - NORMAL CROP PRIORITY <43.1>
    AWXF   - FRACTION FOR EXCESS WATER APPLICATON <234>
```

```
AYNE.K=TABLE(AYNET,(AXN.K+AXF.K*ANNF)/POS(AXND.K)    21, A
  ,0,1,.25)
     AYNE    - EFFECT OF FERTILIZER ON YIELD <21>
     AYNET   - TABLE FOR NUTRIENT EFFECT ON CROP YIELD
     AXN     - SOIL NUTRIENTS (TONNES/YEAR) <23>
     AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
     ANNF    - NATURAL ADDITION OF NUTRIENTS TO FARMLAND
                 ((TONNES/FEDDAN)/YEAR) <158.4>
     AXND    - REQUIRED SOIL NUTRIENTS (TONNES/YEAR) <22>

AXND.K=AXF.K*TABLE(ANRT,AYR.K*AYSE.K*AYTE.K*AYWE.K,  22, A
  0,AYR.K,AYR.K/4)
     AXND    - REQUIRED SOIL NUTRIENTS (TONNES/YEAR) <22>
     AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
     ANRT    - TABLE FOR NUTRIENT REQUIREMENT FOR CROP USE
     AYR     - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
     AYSE    - $$$ <16>
     AYTE    - EFFECT OF WATER TABLE ON SEED YIELD <17>
     AYWE    - EFFECT OF WATER AVAILABLE ON SEED YIELD
                 <18>

AXN.K=SHARE(AXNR.K,ANN.K,AICN.K,ANNWR.K,AXIN.K)        23, A
     AXN     - SOIL NUTRIENTS (TONNES/YEAR) <23>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     AXNR    - REQUESTED SOIL NUTRIENTS (TONNES/YEAR) <24>
     ANN     - SHORTFALL IN NUTRIENT AVAILABILITY <237>
     ANNWR   - WEIGHTED REQUESTS FOR AGRICULTURAL
                 NUTRIENTS <244>
     AXIN    - NORMAL CROP PRIORITY <42.1>

AXNR.K=AXND.K-(AXF.K*ANNF)                             24, A
     AXNR    - REQUESTED SOIL NUTRIENTS (TONNES/YEAR) <24>
     AXND    - REQUIRED SOIL NUTRIENTS (TONNES/YEAR) <22>
     AXF     - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
     ANNF    - NATURAL ADDITION OF NUTRIENTS TO FARMLAND
                 ((TONNES/FEDDAN)/YEAR) <158.4>

AYDE.K=TABLE(AYDET,TIME.K,1960,2010,10)                25, A
     AYDE    - EFFECT OF DISEASE AND PEST LOSSES ON CROP
                 YIELD <25>
     AYDET   - TABLE FOR DISEASE EFFECT ON CROP YIELD
```

Manpower Effects -- In the Egypt model, the manpower effect on crop yield (AYHE) incorporates the contribution to agricultural production of motive power--agricultural machinery and draft animals--and human labor (Figure V-11). The manpower effects are represented with indices similar to the soil effects described above. They are introduced into the model as a motive power effect on yield (AYME) and a labor effect on yield (AYLE). The range for these indices runs from zero to two, to allow for intensive application of manpower to compensate for poor soil conditions.

The motive power effect on crop yields depends upon the adequacy of the motive power--draft animals and machinery--available for each crop (AXM). The motive power desired (AMD) for each crop is determined by the land area (AXF) allocated to the crop, and the potential crop yield indicated by the reference yield (AYR) and the combination of all soil effects (AYGE). Thus, it is assumed that less motive power is required for a crop whose potential yield is depressed by poor water conditions, limited nutrients, or disease and pest losses (Figure V-12).[14] The calculation of the motive power effect on yield is diagrammed in Figure V-13. Note that increases in yield above the potential established by the reference yield and the soil effects are assumed to be possible with an intensive application of motive power. However, the marginal returns to this incremental motive power are assumed to be small, reflecting the inefficiencies using additional motive power to coax more and more crop production out of a fixed land area.

The motive power available for a crop (AXM) is determined by the model's resource allocation logic, with the total motive power available for agriculture distributed among the competing needs of the five crops. The motive power requested for an individual crop (AXMR) will largely be determined by the basic desired motive power application (AMD) discussed above.

Figure V-II:
Manpower Effects on Crop Harvests

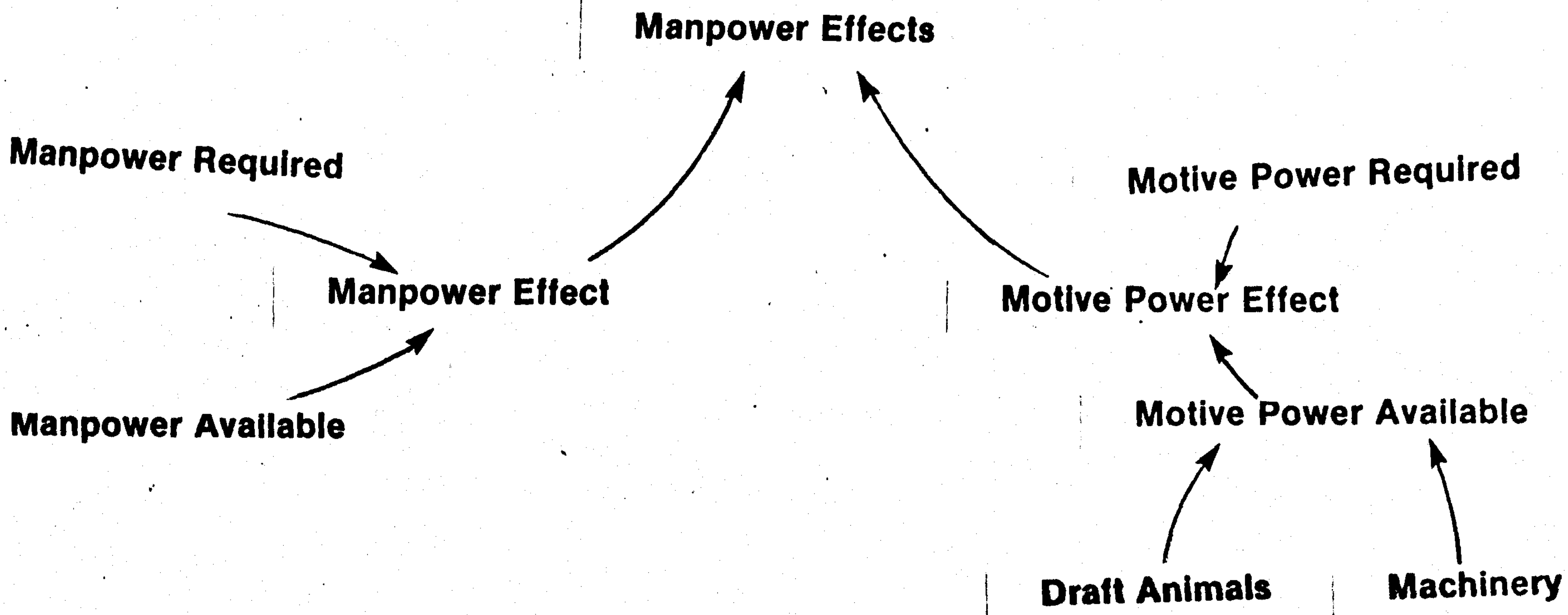


Figure V-12: Motive Power Requirements

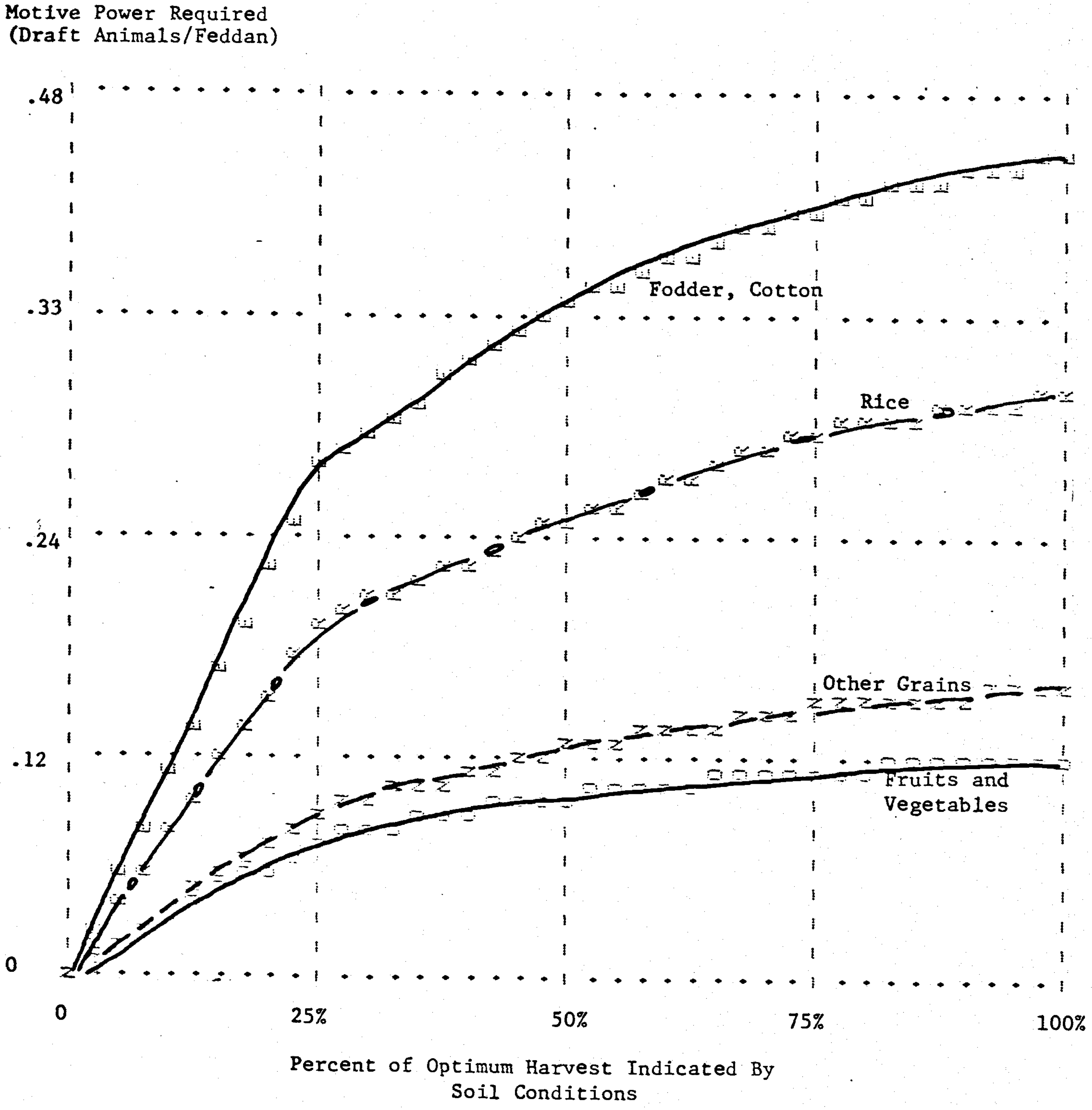
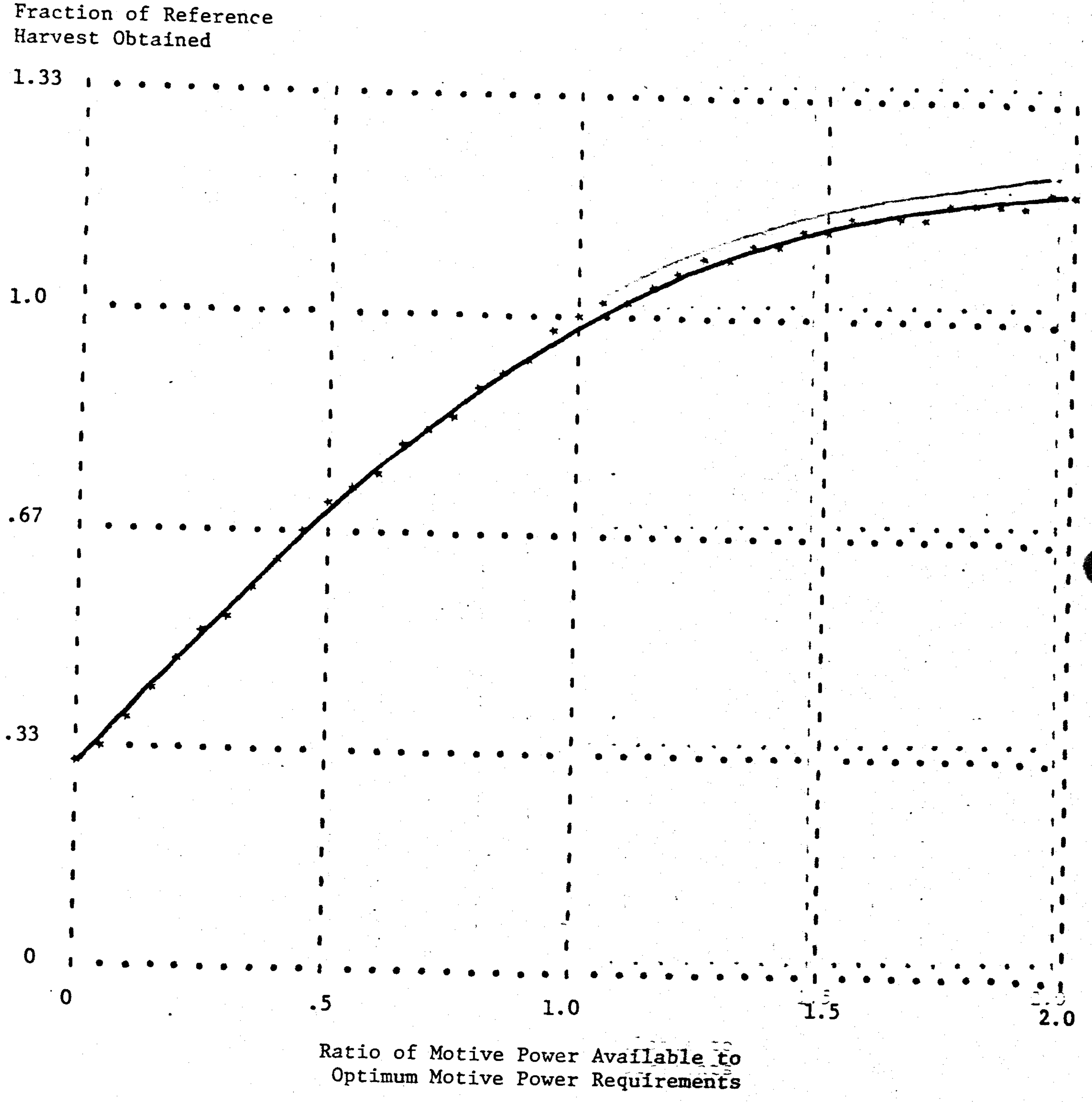


Figure V-13: Effect of Motive Power Availability on Crop Yield



However, the model provides for more intensive application of motive power in the event that rapid increases in crop production are desired. Thus, the desired annual change in crop production (APDAC) is used in the model to adjust the motive power request for each crop.

Section V-B will describe the sources of motive power for crop production. At this point, it should be noted that agricultural capital and draft animals are assumed in the model to be substitutes for one another, so that there is no <u>inherent</u> yield advantage assumed for mechanization, although mechanization can increase production by increasing the number of harvests per year.

The labor effect on crop yield (AYLE) is determined in much the same manner as the motive power effect. The labor requirement (ALD) for a particular crop is determined by the crop's motive power requirement, and is consistent with the differing labor requirements observed in Egypt.[15] Per feddan labor requirements are assumed to decrease with an increasing substitution of machinery for draft animals (ALDEG). The labor available for the crop (AL) will be determined by the model's resource allocation logic, with agricultural labor distributed among the competing requests of the five crops. The labor requested for the crop (AXLR) will largely depend upon the basic desired labor allocation (ALD). As was true for motive power, the model provides for an extra application of labor in the event that rapid increases in crop production are desired.

```
   MANPOWER EFFECTS

AYHE.K=AYME.K*AYLE.K                                          26, A
    AYHE    - MANPOWER (HUMAN) EFFECT ON SEED YIELD <26>
    AYME    - MOTIVE POWER EFFECT ON YIELD <27>
    AYLE    - LABOR EFFECT ON YIELD <32>

AYME.K=TABLE(AYMET,AXM.K/AMD.K,0,2,.25)                       27, A
    AYME    - MOTIVE POWER EFFECT ON YIELD <27>
    AYMET   - TABLE FOR MOTIVE POWER EFFECT ON CROP YIELD
    AXM     - MOTIVE POWER AVAILABLE FOR CROP (UNITS/
                SEASON) <25>
    AMD     - MOTIVE POWER DESIRED FOR CROP <28>
```

```
AMD.K=AXF.K*TABLE(AMDT,AYR.K*AYGE.K,0,AYR.K,AYR.K/
  4)                                                         28, A
    AMD      - MOTIVE POWER DESIRED FOR CROP <28>
    AXF      - FEDDANS FOR CROP PRODUCTION (FEDDANS) <12>
    AMDT     - TABLE FOR MOTIVE POWER REQUIREMENT FOR CROP
                 USE
    AYR      - REFERENCE CROP YIELD (TONNES/FEDDAN) <11>
    AYGE     - SOIL (GROUND) EFFECT ON YIELD <15>

AXM.K=SMOOTH(AMI.K,AMTT)
                                                             29, A
    AXM      - MOTIVE POWER AVAILABLE FOR CROP (UNITS/
                 SEASON) <29>
    AMI      - MOTIVE POWER INDICATED FOR CROP (UNITS/
                 SEASON) <30.1>
    AMTT     - TIME TO TRANSFER AGRICULTURAL MOTIVE POWER
                 (YEARS) <158.6>

AMI.K=SHARE(AXMR.K,AMN.K,AIM.K,AMWR.K,AXIN.K)               30, A
AMI=AMD                                                      30.1, N
    AMI      - MOTIVE POWER INDICATED FOR CROP (UNITS/
                 SEASON) <30.1>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    AXMR     - MOTIVE POWER REQUESTED FOR CROP PRODUCTION
                 (UNITS/SEASON) <31>
    AMN      - SHORTFALL IN MOTIVE POWER <255>
    AMWR     - WEIGHTED REQUESTS FOR AGRICULTURAL MOTIVE
                 POWER <257>
    AXIN     - NORMAL CROP PRIORITY <42.1>
    AMD      - MOTIVE POWER DESIRED FOR CROP <28>

AXMR.K=AMD.K*TABLE(AXMRT,APDAC.K,-.2,.2,.1)                  31, A
    AXMR     - MOTIVE POWER REQUESTED FOR CROP PRODUCTION
                 (UNITS/SEASON) <31>
    AMD      - MOTIVE POWER DESIRED FOR CROP <28>
    AXMRT    - TABLE FOR THE EFFECT OF DESIRED PRODUCTION
                 CHANGE ON CROP MOTIVE POWER REQUESTED
                 <158.8>
    APDAC    - DESIRED ANNUAL CHANGE IN AGRICULTURE
                 PRODUCTION <37>

AYLE.K=TABLE(AYLET,AL.K/ALD.K,0,2,.25)                       32, A
    AYLE     - LABOR EFFECT ON YIELD <32>
    AYLET    - TABLE FOR LABOR EFFECT ON CROP YIELD
    AL       - MEN AVAILABLE FOR CROP (MEN/SEASON) <34>
    ALD      - MEN DESIRED FOR CROP <33>
ALD.K=(AMD.K/AMLRN)*ALDEG.K
                                                             33, A
    ALD      - MEN DESIRED FOR CROP <33>
    AMD      - MOTIVE POWER DESIRED FOR CROP <28>
    AMLRN    - NORMAL MOTIVE POWER/LABOR RATIO <161.1>
    ALDEG    - EFFECT OF SUBSTITUTION OF MACHINERY FOR
                 DRAFT ANIMALS ON LABOR REQUIREMENTS
                 <160.1>
```

```
AL.K=SMOOTH(ALI.K,ALTT)                                        34, A
    AL      - MEN AVAILABLE FOR CROP (MEN/SEASON) <34>
    ALI     - MEN INDICATED FOR CROP (MEN/SEASON) <35.1>
    ALTT    - TIME TO TRANSFER AGRICULTURE LABOR (YEARS)
               <159.2>

ALI.K=SHARE(AXLR.K,ALN.K,AIL.K,ALWR.K,AXIN.K)                 35, A
ALI=ALD                                                       35.1, N
    ALI     - MEN INDICATED FOR CROP (MEN/SEASON) <35.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    AXLR    - MEN REQUESTED FOR CROP (MEN/SEASON) <36>
    ALN     - SHORTFALL IN AGRICULTURE LABOR <249>
    ALWR    - WEIGHTED REQUESTS FOR AGRICULTURAL LABOR
                <254>
    AXIN    - NORMAL CROP PRIORITY <42.1>
    ALD     - MEN DESIRED FOR CROP <33>

AXLR.K=ALD.K*TABLE(AXLRT,APDAC.K,-.2,.2,.1)                    36, A
    AXLR    - MEN REQUESTED FOR CROP (MEN/SEASON) <36>
    ALD     - MEN DESIRED FOR CROP <33>
    AXLRT   - TABLE FOR THE EFFECT OF DESIRED PRODUCTION
                CHANGE ON CROP LABOR REQUESTED <160.7>
    APDAC   - DESIRED ANNUAL CHANGE IN AGRICULTURE
                PRODUCTION <37>
```

Production Adequacy -- The crop building block continuously monitors the demand for each crop's output to determine the adequacy of overall production. A desired annual change in production (APDAC) is calculated whenever a gap exists between the demand for, and supply of, a particular crop. As discussed earlier in this section, the desired annual change determines individual crop requests for land, motive power, and labor. Included in the desired annual change calculation is any attempted direct government influence on the agricultural growth rate (APGI). These government influences are external factors that can vary over time to represent assumptions about government pressures for increases, or decreases, in production of individual crops.

Another determinant of production adequacy is an individual crop's priority for agricultural resources. The model's allocation of resources is directed by the priorities that serve as surrogates for prices, custom, and bureaucratic government policies. In the model, the normal priority for a crop (AXIN) is determined by the base priority (AIB) and the effect of water availability (AIEWA). The base priority is an external parameter that can vary over time to represent changing emphasis on individual crops. The current model values (shown below) reflect descriptions of the current importance of individual crops and the results of simulation analysis with the model (higher numbers indicate higher priorities as described in Chapter VIII). The effect of water availability is to increase the priority for rice for production factors when water is plentiful, since rice is a water intensive crop.

Assigned Base Priorities

Cotton	Fruits and Vegetables	Fodder	Rice	Other Grains
.068	.16	.1	.09	.06

PRODUCTION ADEQUACY

```
APDAC.K=TABLE(APDACT,APIAC.K,-.2,.2,.05)                         37, A
    APDAC   = DESIRED ANNUAL CHANGE IN AGRICULTURE
                PRODUCTION <37>
    APDACT  = TABLE FOR THE DESIRED ANNUAL CHANGE IN
                AGRICULTURAL PRODUCTION <161.3>
    APIAC   = INDICATED ANNUAL CHANGE FOR AGRICULTURE
                PRODUCTION <38>

APIAC.K=SMOOTH(APDFC.K/APTA,APAT)+APGI.K                         38, A
    APIAC   = INDICATED ANNUAL CHANGE FOR AGRICULTURE
                PRODUCTION <38>
    APDFC   = DESIRED FRACTIONAL CHANGE IN AGRICULTURE
                PRODUCTION <39>
    APTA    = ADJUSTMENT TIME FOR AGRICULTURAL PRODUCTION
                (YEARS) <161.5>
    APAT    = TIME TO PERCEIVE CHANGES IN AGRICULTURAL
                PRODUCTION (YEARS) <161.7>
    APGI    = GOVERNMENT INFLUENCE ON AGRICULTURAL GROWTH
                RATE <41>

APDFC.K=(APR.K-CROP.K)/CROP.K                                    39, A
    APDFC   = DESIRED FRACTIONAL CHANGE IN AGRICULTURE
                PRODUCTION <39>
    APR     = REQUESTED CROP PRODUCTION
    CROP    = CROP PRODUCTION (TONNES/YEAR) <2>

APN.K=MAX(0,APR.K-CROP.K)                                        40, A
    APN     = SHORTFALL IN AGRICULTURAL PRODUCTION <40>
    APR     = REQUESTED CROP PRODUCTION
    CROP    = CROP PRODUCTION (TONNES/YEAR) <2>

APGI.K=TABLE(APGIT,TIME.K,1960,2010,10)                          41, A
    APGI    = GOVERNMENT INFLUENCE ON AGRICULTURAL GROWTH
                RATE <41>
    APGIT   = TABLE GOVERNMENT INFLUENCE ON PRODUCTION

AXIN.K=AIB.K*SMOOTH(AIEWA.K,APAT)                                42, A
AXIN=AIB                                                         42.1, N
    AXIN    = NORMAL CROP PRIORITY <42.1>
    AIB     = BASE CROP PRIORITY
    AIEWA   = EFFECT OF WATER AVAILABILITY ON CROP
                PRIORITY <44>
    APAT    = TIME TO PERCEIVE CHANGES IN AGRICULTURAL
                PRODUCTION (YEARS) <161.7>

AIB.K=TABHL(AIBT,TIME.K,1960,2010,10)                            43, A
    AIB     = BASE CROP PRIORITY
```

```
AIEWA.K=TABHL(AIEWAT,AWA.K/AWO.K,.7,1.1,.1)            44, A
    AIEWA   - EFFECT OF WATER AVAILABILITY ON CROP
                PRIORITY <44>
    AWA     - WATER AVAILABLE FOR AGRICULTURE <232>
    AWO     - WATER REQUESTED (KCM/YEAR) <233>
```

The following equations implement the crop "building block" for each of the five agricultural crops. They specify the parameter values common to each crop, as well as the parameter values that distinguish one crop from another. They are listed here for reference.

```
   CONSTANTS APPLICABLE TO ALL USES OF THE CROP MACRO

AFTT.K=TABHL(AFTTT,TIME.K,1960,2010,10)                 158, A
AFTTT=3/3/3/3/3/3                                        158.2, T
ANNF=.010                                                158.4, C
AMTT=1                                                   158.6, C
AXMRT=.7/.9/1/1.15/1.4                                   158.8, T
ALTT=1                                                   159.2, C
    AFTT    - TIME TO TRANSFER AGRICULTURAL LAND (YEARS)
                <158>
    AFTTT   - TABLE FOR TIME TO TRANSFER AGRICULTURAL
                LAND <158.2>
    ANNF    - NATURAL ADDITION OF NUTRIENTS TO FARMLAND
                ((TONNES/FEDDAN)/YEAR) <158.4>
    AMTT    - TIME TO TRANSFER AGRICULTURAL MOTIVE POWER
                (YEARS) <158.6>
    AXMRT   - TABLE FOR THE EFFECT OF DESIRED PRODUCTION
                CHANGE ON CROP MOTIVE POWER REQUESTED
                <158.8>
    ALTT    - TIME TO TRANSFER AGRICULTURE LABOR (YEARS)
                <159.2>

ALDEG.K=SMOOTH(TABLE(ALDEGT,ADL.K/AM.K,0,1,.25),       160, A
  ALTT)
ALDEG=1                                                 160.1, N
ALDEGT=.2/.4/.6/.8/1                                    160.4, T
AXLRT=.7/.9/1/1.3/1.75                                  160.7, T
AMLRN=.75                                               161.1, C
APDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1            161.3, T
APTA=4                                                  161.5, C
APAT=1                                                  161.7, C
  ALDEG  - EFFECT OF SUBSTITUTION OF MACHINERY FOR
             DRAFT ANIMALS ON LABOR REQUIREMENTS
             <160.1>
  ALDEGT - TABLE FOR THE EFFECT OF SUBSTITUTION OF
             MACHINERY FOR DRAFT ANIMALS ON
             AGRICULTURAL LABOR REQUIREMENTS <160.4>
  ADL    - DRAFT LIVESTOCK AVAILABLE <259>
  AM     - MOTIVE POWER AVAILABLE <258>
  ALTT   - TIME TO TRANSFER AGRICULTURE LABOR (YEARS)
             <159.2>
```

GRAIN PRODUCTION

```
ANP.K=CROP(ANSET,ANTET,ANTRN,ANINT,ANYRT,ANYSET,            163, A
  ANYTET,ANYWET,ANWOT,ANYNET,ANNRT,ANYDET,ANYMET,
  ANMDT,ANYLET,ANFR,ANPGIT,ANIEWAT,ANTR,ANH,ANHO,
  ANHN,ANF,ANFR,ANFII,ANYGE,ANYSE,ANYTE,ANYWE,ANWO,
  ANYNE,ANNR,ANYHE,ANYME,ANM,ANMR,ANYLE,ANL,ANLR,
  ANPDAC,ANPN,ANIF,ANIW,ANICN,ANIH,ANIL)
ANSET=.9/.9/.9/.9/.9/.9                                     163.9, T
ANTET=.75/.85/.92/.96/1                                     164.2, T
ANTRN=30                                                    164.5, C
ANINT=.03/.06/.06/.06/.06/.06                               164.7, T
ANYRT=1.8/1.8/2.15/2.15/2.15/2.15                           164.9, T
ANYSET=1/1/.95/.87/.80/.7/.5/.3/0                           165.2, T
ANYSTH=4.25 MILLIMHOS/CM                                    165.3, C
ANYSZY=16 MILLIMHOS/CM                                      165.6, C
ANYTET=1/.95/.9/.6/.1                                       165.9, T
ANYWET=0/.5/.75/.92/1/.95/.9/.8/.6                          166.2, T
ANWOT=0/.73/1.36/1.88/2.09                                  166.4, T
ANFII=3.83E6                                                166.6, C
ANYNET=0/.6/.8/.9/1                                         166.8, T
ANNRT=0/.035/.065/.090/.110                                 167.1, T
ANYDET=.9/.9/.9/.9/.9/.9                                    167.3, T
ANYMET=.3/.5/.7/.85/1/1.08/1.14/1.17/1.2                    167.6, T
ANMDT=0/.09/.125/.15/.16                                    167.8, T
ANYLET=0/.35/.65/.85/1/1.15/1.25/1.3/1.35                   168.2, T
ANPGIT=.05/.05/.05/.05/.05/.05                              168.4, T
ANIEWAT=1/1/1/1/1                                           168.6, T
    ANP     - GRAIN PRODUCTION (TONNES/YEAR) <163>
    CROP    - CROP PRODUCTION (TONNES/YEAR) <2>
    ANSET   - TABLE FOR STORAGE EFFECT ON GRAIN
                PRODUCTION <163.9>
    ANTET   - TABLE FOR THE EFFECT OF TRANSPORTATION
                ADEQUACY ON GRAIN PRODUCTION <164.2>
    ANTRN   - TRANSPORTATION REQUIREMENT FOR GRAIN
                (KILOMETERS) <164.5>
    ANINT   - NORMAL PRIORITY FOR GRAIN <164.7>
    ANYRT   - TABLE FOR REFERENCE GRAIN YIELD (TONNES/
                FEDDAN) <164.9>
    ANYTET  - TABLE FOR THE EFFECT OF WATER TABLE HEIGHT
                ON GRAIN YIELDS <165.9>
    ANYWET  - TABLE FOR THE EFFECT OF WATER APPLICATION
                ON GRAIN YIELD <166.2>
    ANWOT   - TABLE FOR REQUESTED WATER ORDERS FOR GRAIN
                (KCM/FEDDAN) <166.4>
    ANYNET  - TABLE FOR THE EFFECT OF SOIL NUTRIENTS ON
                GRAIN YIELD <166.8>
    ANNRT   - TABLE FOR REQUESTED FERTILIZERS FOR GRAIN
                (TONNES/FEDDAN) <167.1>
    ANYDET  - TABLE FOR THE EFFECT OF DISEASE AND PEST
                LOSSES ON GRAIN YIELDS <167.3>
    ANYMET  - TABLE FOR THE EFFECT OF MOTIVE POWER ON
                GRAIN YIELDS <167.6>
    ANMDT   - TABLE FOR DESIRED MOTIVE POWER FOR GRAIN
                (ANIMAL-UNITS/FEDDAN) <167.8>
    ANYLET  - TABLE FOR THE EFFECT OF LABOR ON GRAIN
                YIELDS <168.2>
```

```
    ANPR     - REQUESTED GRAIN PRODUCTION <169>
    ANPGIT  - TABLE FOR GOVERNMENT INFLUENCE ON DESIRED
                GRAIN PRODUCTION <168.4>
    ANIEWAT- TABLE FOR THE EFFECT OF WATER AVAILABILITY
                ON THE NORMAL PRIORITY FOR GRAIN <168.6>
    ANTR     - TRANSPORTATION REQUIRED FOR GRAIN
    ANH      - HARVEST OF GRAIN (TONNES/YEAR)
    ANHO     - GRAIN HARVEST FROM OLD VALLEY LANDS
    ANHN     - GRAIN HARVEST FROM NEW VALLEY LANDS
    ANF      - FEDDANS ALLOCATED TO GRAIN
    ANFR     - FEDDANS REQUESTED FOR GRAIN
    ANFII    - INITIAL LAND AREA FOR GRAIN <166.6>
    ANYGE    - GROUND EFFECTS ON GRAIN YIELD
    ANYSE    - SALT EFFECT ON GRAIN YIELD
    ANYTE    - WATER TABLE EFFECT ON GRAIN YIELD
    ANYWE    - WATER AVAILABILITY EFFECT ON GRAIN YIELD
    ANWO     - OPTIMAL WATER APPLICATION FOR GRAIN (KCM/
                YEAR)
    ANYNE    - SOIL NUTRIENT EFFECT ON GRAIN YIELD
    ANNR     - GRAIN NUTRIENTS REQUIRED
    ANYHE    - HUMAN EFFECTS ON GRAIN YIELD
    ANYME    - MOTIVE POWER EFFECT ON GRAIN YIELD
    ANM      - MOTIVE POWER FOR GRAIN
    ANMR     - MOTIVE POWER REQUESTED FOR GRAIN
    ANYLE    - LABOR EFFECT ON GRAIN YIELD
    ANL      - LABOR FOR GRAIN
    ANLR     - LABOR REQUESTED FOR GRAIN
    ANPDAC  - DESIRED ANNUAL CHANGE FOR GRAIN PRODUCTION
    ANPN     - SHORTFALL IN PRODUCTION OF GRAIN
    ANIF     - GRAIN PRIORITY FOR FEDDANS
    ANIW     - GRAIN PRIORITY FOR WATER
    ANICN    - GRAIN PRIORITY FOR CHEMICAL NUTRIENTS
    ANIM     - GRAIN PRIORITY FOR MOTIVE POWER
    ANIL     - GRAIN PRIORITY FOR LABOR
    ANYSTH  - THRESHOLD SALT CONCENTRATION FOR YIELD
                EFFECT ON GRAINS (CONDUCTIVITY OF
                SATURATED SOIL EXTRACT) <165.3>
    ANYSZY  - ZERO-YIELD SALT CONCENTRATION FOR GRAINS
                (CONDUCTIVITY OF SATURATED SOIL EXTRACT)
                <165.6>

ANPR.K=PUNR.K+PRNR.K                                       169, A
    ANPR     - REQUESTED GRAIN PRODUCTION <169>
    PUNR     - REQUESTED URBAN GRAIN CONSUMPTION (TONNES/
                YEAR)
    PRNR     - REQUESTED RURAL GRAIN CONSUMPTION (TONNES/
                YEAR)

ANWR.K=(PUNR.K/PUIN.K)+(PRNR.K/PRIN.K)                     170, A
    ANWR     - WEIGHTED REQUESTS FOR GRAIN PRODUCTION
                <170>
    PUNR     - REQUESTED URBAN GRAIN CONSUMPTION (TONNES/
                YEAR)
    PUIN     - URBAN PRIORITY FOR GRAIN
    PRNR     - REQUESTED RURAL GRAIN CONSUMPTION (TONNES/
                YEAR)
    PRIN     - RURAL PRIORITY FOR GRAIN
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ANPNQ.K=MAX(0,ANPN.K-ANQ.K)                                      171, A
    ANPNQ  - GRAIN PRODUCTION SHORTFALL AFTER IMPORTS
               <171>
    ANPN   - SHORTFALL IN PRODUCTION OF GRAIN
    ANQ    - GRAIN IMPORTS (TONNES/YEAR) <172>

ANQ.K=QANXV.K/XANP.K                                             172, A
    ANQ    - GRAIN IMPORTS (TONNES/YEAR) <172>
    QANXV  - POUNDS VALUE OF AGRICULTURE IMPORTS <475>
    XANP   - PRICE FOR IMPORTED GRAIN (POUNDS/TONNE)
               <478>

ANQR.K=ANPN.K                                                    173, A
    ANQR   - REQUESTED GRAIN IMPORTS (TONNES/YEAR) <173>
    ANPN   - SHORTFALL IN PRODUCTION OF GRAIN

   RICE PRODUCTION

ARP.K=CROP(ARSET,ARTET,ARTRN,ARINT,ARYRT,ANYSET,                174, A
  ARYTET,ARYWET,ARWOT,ARYNET,ARNRT,ARYDET,ARYMET,
  ARMDT,ARYLET,ARPR,ARPGIT,ARIEWAT,ARTR,ARH,ARHO,
  ARHN,ARF,ARFR,ARFII,ARYGE,ARYSE,ARYTE,ARYWE,ARWO,
  ARYNE,ARNR,ARYHE,ARYME,ARM,ARMR,ARYLE,ARL,ARLR,
  ARPDAC,ARPN,ARIF,ARIW,ARICN,ARIM,ARIL)
ARSET=.9/.9/.9/.9/.9/.9                                          174.9, T
ARTET=.75/.85/.92/.96/1                                          175.2, T
ARTRN=50                                                         175.5, C
ARINT=.12/.09/.09/.09/.09/.09                                    175.7, T
ARYRT=2.7/2.7/2.7/2.7/2.7/2.7                                    175.9, T
ARYSTH=4.25 MILLIMHOS/CM                                         176.2, C
ARYSZY=16 MILLIMHOS/CM                                           176.5, C
ARYTET=1/.98/.95/.9/.8                                           176.8, T
ARYWET=0/.1/.45/.82/1/.95/.9/.8/.6                               177.1, T
ARWOT=0/3.08/5.72/7.92/8.8                                       177.3, T
ARFII=.71E6                                                      177.5, C
ARYNET=0/.6/.8/.9/1                                              177.7, T
ARNRT=0/.025/.045/.065/.080                                      177.9, T
ARYDET=.9/.9/.9/.9/.9/.9                                         178.2, T
ARYMET=.3/.5/.7/.85/1/1.08/1.14/1.17/1.2                         178.5, T
ARMDT=0/.195/.25/.3/.32                                          178.7, T
ARYLET=0/.35/.65/.85/1/1.15/1.25/1.3/1.35                        179.1, T
ARPGIT=.05/.1/.1/.05/.05/.05                                     179.3, T
ARIEWAT=1/1.1/1.5/2/3                                            179.5, T
    ARP    - RICE PRODUCTION (TONNES/YEAR) <174>
    CROP   - CROP PRODUCTION (TONNES/YEAR) <2>
    ARSET  - TABLE FOR STORAGE EFFECT ON RICE PRODUCTION
               <174.9>
    ARTET  - TABLE FOR THE EFFECT OF TRANSPORTATION
               ADEQUACY ON RICE PRODUCTION <175.2>
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ARTRN - TRANSPORTATION REQUIREMENT FOR RICE (KILOMETERS) <175.5>
ARINT - NORMAL PRIORITY FOR RICE <175.7>
ARYRT - TABLE FOR REFERENCE RICE YIELD (TONNES/FEDDAN) <175.9>
ARYTET - TABLE FOR THE EFFECT OF WATER TABLE HEIGHT ON RICE YIELDS <176.8>
ARYWET - TABLE FOR THE EFFECT OF WATER APPLICATION ON RICE YIELD <177.1>
ARWOT - TABLE FOR REQUESTED WATER ORDERS FOR RICE (KCM/FEDDAN) <177.3>
ARYNET - TABLE FOR THE EFFECT OF SOIL NUTRIENTS ON RICE YIELD <177.7>
ARNRT - TABLE FOR REQUESTED FERTILIZERS FOR RICE (TONNES/FEDDAN) <177.9>
ARYDET - TABLE FOR THE EFFECT OF DISEASE AND PEST LOSSES ON RICE YIELDS <178.2>
ARYMET - TABLE FOR THE EFFECT OF MOTIVE POWER ON RICE YIELDS <178.5>
ARMDT - TABLE FOR DESIRED MOTIVE POWER FOR RICE (ANIMAL-UNITS/FEDDAN) <178.7>
ARYLET - TABLE FOR THE EFFECT OF LABOR ON RICE YIELDS <179.1>
ARPR - REQUESTED RICE PRODUCTION <180>

ARPGIT - TABLE FOR GOVERNMENT INFLUENCE ON DESIRED RICE PRODUCTION <179.3>
ARIEWAT- TABLE FOR THE EFFECT OF WATER AVAILABILITY ON THE NORMAL PRIORITY FOR RICE <179.5>
ARTR - TRANSPORTATION REQUIRED FOR RICE
ARH - HARVEST OF RICE (TONNES/YEAR)
ARHO - RICE HARVEST FROM OLD VALLEY LANDS
ARHN - RICE HARVEST FROM NEW VALLEY LANDS
ARF - FEDDANS ALLOCATED TO RICE
ARFR - FEDDANS REQUESTED FOR RICE
ARFII - INITIAL LAND AREA FOR RICE <177.5>
ARYGE - GROUND EFFECTS ON RICE YIELD
ARYSE - SALT EFFECT ON RICE YIELD
ARYTE - WATER TABLE EFFECT ON RICE YIELD
ARYWE - WATER AVAILABILITY EFFECT ON RICE YIELD
ARWO - OPTIMAL WATER APPLICATION FOR RICE (KCM/YEAR)
ARYNE - SOIL NUTRIENT EFFECT ON RICE YIELD
ARNR - RICE NUTRIENTS REQUIRED
ARYHE - HUMAN EFFECTS ON RICE YIELD
ARYME - MOTIVE POWER EFFECT ON RICE YIELD
ARM - MOTIVE POWER FOR RICE
ARMR - MOTIVE POWER REQUESTED FOR RICE
ARYLE - LABOR EFFECT ON RICE YIELD

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    ARL    - LABOR FOR RICE
    ARLR   - LABOR REQUESTED FOR RICE
    ARPDAC - DESIRED ANNUAL CHANGE FOR RICE PRODUCTION
    ARPN   - SHORTFALL IN PRODUCTION OF RICE
    ARIF   - RICE PRIORITY FOR FEDDANS
    ARIW   - RICE PRIORITY FOR WATER
    ARICN  - RICE PRIORITY FOR CHEMICAL NUTRIENTS
    ARIM   - RICE PRIORITY FOR MOTIVE POWER
    ARIL   - RICE PRIORITY FOR LABOR
    ARYSTH - THRESHOLD SALT CONCENTRATION FOR YIELD
               EFFECT ON RICE (CONDUCTIVITY OF SATURATED
               SOIL EXTRACT) <176.2>
    ARYSZY - ZERO-YIELD SALT CONCENTRATION FOR RICE
               (CONDUCTIVITY OF SATURATED SOIL EXTRACT)
               <176.5>

ARPR.K=PRRR.K+PURR.K+CARR.K                           180, A
    ARPR   - REQUESTED RICE PRODUCTION <180>
    PRRR   - REQUESTED RURAL RICE CONSUMPTION (TONNES/
               YEAR)
    PURR   - REQUESTED URBAN RICE CONSUMPTION (TONNES/
               YEAR)
    CARR   - REQUESTED RICE EXPORTS <462>

ARWR.K=(PRRR.K/PRIR.K)+(PURR.K/PUIR.K)+(CARR.K/       181, A
  CIAR.K)
    ARWR   - WEIGHTED REQUESTS FOR RICE PRODUCTION <181>
    PRRR   - REQUESTED RURAL RICE CONSUMPTION (TONNES/
               YEAR)
    PRIR   - RURAL PRIORITY FOR RICE
    PURR   - REQUESTED URBAN RICE CONSUMPTION (TONNES/
               YEAR)
    PUIR   - URBAN PRIORITY FOR RICE
    CARR   - REQUESTED RICE EXPORTS <462>

    COTTON PRODUCTION

 ACP.K=CROP(ACSET,ACTET,ACTRN,ACINT,ACYRT,ACYSET,      182, A
   ACYTET,ACYWET,ACWCT,ACYNET,ACNRT,ACYDET,ACYMET,
   ACMDT,ACYLET,ACPR.ACPGIT,ANIEWAT,ACTR,ACH,ACHO.
   ACHN.ACF,ACFR,ACFII,ACYGE,ACYSE,ACYTE,ACYWE,ACWO,
   ACYNE,ACNR,ACYHE,ACYME.ACM,ACMR.ACYLE,ACL,ACLR,
   ACPDAC,ACPN,ACIF,ACIW.ACICN,ACIM,ACIL)
 ACSET=1/1/1/1/1/1                                     182.9, T
 ACTET=1/1/1/1/1                                       183.2, T
 ACTRN=210                                             183.5, C
 ACINT=.06/.068/.068/.068/.068/.068                    183.7, T
 ACYRT=.38,.38,.38,.38,.38,.38                         183.9, T
 ACYSET=1/1/.98/.95/.87/.8/.7/.5/.3                    184.2, T
 ACYSTH=5.5 MILLIMHOS/CM                               184.3, C
 ACYSZY=23 MILLIMHOS/CM                                184.6, C
 ACYTET=1/.95/.9/.6/.1                                 184.9, T
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ACYWET=0/.1/.45/.83/1/.95/.9/.8/.6                        185.2, T
 CWOT=0/1.35/2.5/3.47/3.85                                185.4, T
ACFII=1.87E6                                              185.6, C
ACYNET=0/.6/.8/.9/1                                       185.8, T
ACNRT=0/.035/.060/.080/.100                               186.1. T
ACYDET=.9/.9/.9/.9/.9/.9                                  186.3, T
ACYMET=.3/.5/.7/.85/1/1.08/1.14/1.17/1.2                  186.6, T
ACMDT=0/.28/.37/.42/.45                                   186.8, T
ACYLET=0/.35/.65/.85/1/1.15/1.25/1.3/1.35                 187.2, T
ACPGIT=.05/.05/.05/.05/.05/.05                            187.4, T
    ACP     - COTTON PRODUCTION (TONNES/YEAR) <182>
    CROP    - CROP PRODUCTION (TONNES/YEAR) <2>
    ACSET   - TABLE FOR STORAGE EFFECT ON COTTON
                PRODUCTION <182,9>
    ACTET   - TABLE FOR THE EFFECT OF TRANSPORTATION
                ADEQUACY ON COTTON PRODUCTION <183,2>
    ACTRN   - TRANSPORTATION REQUIREMENT FOR COTTON
                (KILOMETERS) <183,5>
    ACINT   - NORMAL PRIORITY FOR COTTON <183,7>
    ACYRT   - TABLE FOR REFERENCE COTTON YIELD (TONNES/
                FEDDAN) <183.9>
    ACYTET  - TABLE FOR THE EFFECT OF WATER TABLE HEIGHT
                ON COTTON YIELDS <184.9>
    ACYWET  - TABLE FOR THE EFFECT OF WATER APPLICATION
                ON COTTON YIELD <185.2>
    ACWOT   - TABLE FOR REQUESTED WATER ORDERS FOR COTTON
                (KCM/FEDDAN) <185.4>
    ACYNET  - TABLE FOR THE EFFECT OF SOIL NUTRIENTS ON
                COTTON YIELD <185.8>
    ACNRT   - TABLE FOR REQUESTED FERTILIZERS FOR COTTON
                (TONNES/FEDDAN) <186.1>
    ACYDET  - TABLE FOR THE EFFECT OF DISEASE AND PEST
                LOSSES ON COTTON YIELDS <186.3>
    ACYMET  - TABLE FOR THE EFFECT OF MOTIVE POWER ON
                COTTON YIELDS <186.6>
    ACMDT   - TABLE FOR DESIRED MOTIVE POWER FOR COTTON
                (ANIMAL-UNITS/FEDDAN) <186.8>
    ACYLET  - TABLE FOR THE EFFECT OF LABOR ON COTTON
                YIELDS <187.2>
    ACPR    - REQUESTED COTTON PRODUCTION <188>
    ACPGIT  - TABLE FOR GOVERNMENT INFLUENCE ON DESIRED
                COTTON PRODUCTION <187.4>
    ANIEWAT- TABLE FOR THE EFFECT OF WATER AVAILABILITY
                ON THE NORMAL PRIORITY FOR GRAIN <168.6>
    ACTR    - TRANSPORTATION REQUIRED FOR COTTON
    ACH     - HARVEST OF COTTON (TONNES/YEAR)
    ACHO    - COTTON HARVEST FROM OLD VALLEY LANDS
    ACHN    - COTTON HARVEST FROM NEW VALLEY LANDS
    ACF     - FEDDANS ALLOCATED TO COTTON
    ACFR    - FEDDANS REQUESTED FOR COTTON
    ACFII   - INITIAL LAND AREA FOR COTTON <185.6>
    ACYGE   - GROUND EFFECTS ON COTTON YIELD
    ACYS    - SALT EFFECT ON COTTON YIELD
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    ACYTE  - WATER TABLE EFFECT ON COTTON YIELD
    ACYWE  - WATER AVAILABILITY EFFECT ON COTTON YIELD
    ACWO   - OPTIMAL WATER APPLICATION FOR COTTON (KCM/
               YEAR)
    ACYNE  - SOIL NUTRIENT EFFECT ON COTTON YIELD
    ACNR   - COTTON NUTRIENTS REQUIRED
    ACYHE  - HUMAN EFFECTS ON COTTON YIELD
    ACYME  - MOTIVE POWER EFFECT ON COTTON YIELD
    ACM    - MOTIVE POWER FOR COTTON
    ACMR   - MOTIVE POWER REQUESTED FOR COTTON
    ACYLE  - LABOR EFFECT ON COTTON YIELD
    ACL    - LABOR FOR COTTON
    ACLR   - LABOR REQUESTED FOR COTTON
    ACPDAC - DESIRED ANNUAL CHANGE FOR COTTON PRODUCTION
    ACPN   - SHORTFALL IN PRODUCTION OF COTTON
    ACIF   - COTTON PRIORITY FOR FEDDANS
    ACIW   - COTTON PRIORITY FOR WATER
    ACICM  - COTTON PRIORITY FOR CHEMICAL NUTRIENTS
    ACIM   - COTTON PRIORITY FOR MOTIVE POWER
    ACIL   - COTTON PRIORITY FOR LABOR
    ACYSTH - THRESHOLD SALT CONCENTRATION FOR YIELD
               EFFECT ON COTTON (CONDUCTIVITY OF
               SATURATED SOIL EXTRACT) <184,3>
    ACYSZY - ZERO-YIELD SALT CONCENTRATION FOR COTTON
               (CONDUCTIVITY OF SATURATED SOIL EXTRACT)
               <184,6>

ACPR.K=UACR.K+CACR.K                                    188, A
    ACPR   - REQUESTED COTTON PRODUCTION <188>
    UACR   - REQUESTED AGRICULTURAL RAW MATERIALS FOR
               CONSUMER GOODS <360>
    CACR   - REQUESTED COTTON EXPORTS <468>

ACWR.K=(UACR.K/UIAC.K)+(CACR.K/CIAC.K)                  189, A
    ACWR   - WEIGHTED REQUESTS FOR COTTON PRODUCTION
               <189>
    UACR   - REQUESTED AGRICULTURAL RAW MATERIALS FOR
               CONSUMER GOODS <360>
    CACR   - REQUESTED COTTON EXPORTS <468>

   F&V PRODUCTION

AOP.K=CROP(AOSET,AOTET,AOTRN,AOINT,AOYRT,ANYSET,        190, A
  AOYTET,AOYWET,AOWOT,AOYNET,AONRT,AOYDET,AOYMET,
  AOMDT,AOYLET,AOPR,AOPGIT,ANIEWAT,AOTR,AOH,AOHO,
  AOHN,AOF,AOFR,AOFII,AOYGE,AOYSE,AOYTE,AOYWE,AOWO,
  AOYNE,AONR,AOYHE,AOYME,AOM,AOMR,AOYLE,AOL,AOLR,
  AOPDAC,AOPN,AOIF,AOIW,AOICM,AOIM,AOIL)
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AOSET=.7/.7/.7/.7/.7/.7                                              190.9, T
AOTET=.65/.8/.9/.95/1                                                191.2, T
 OTRN=20                                                             191.5, C
AOINT=.16/.16/.16/.16/.16/.16                                        191.7, T
AOYRT=20/20/20/20/20/20                                              191.9, T
AOYSTH=4.25 MILLIMHOS/CM                                             192.2, C
AOYSZY=16 MILLIMHOS/CM                                               192.6, C
AOYTET=1/.95/.9/.6/.1                                                192.9, T
AOYWET=0/.1/.45/.75/1/.95/.9/.8/.6                                   193.2, T
AOWOT=0/2.23/4.13/5.72/6.36                                          193.4, T
AOFII=.85E6                                                          193.6, C
AOYNET=0/.6/.8/.9/1                                                  193.8, T
AONRT=0/.050/.090/.120/.150                                          194.1, T
AOYDET=.9/.9/.9/.9/.9/.9                                             194.3, T
AOYMET=.3/.5/.7/.85/1/1.08/1.14/1.17/1.2                             194.6, T
AOMDT=0/.075/.1/.115/.12                                             194.8, T
AOYLET=0/.35/.65/.85/1/1.15/1.25/1.3/1.35                            195.2, T
AOPGIT=.05/.05/.05/.05/.05/.05                                       195.4, T
     AOP     - F&V PRODUCTION (TONNES/YEAR) <190>
     CROP    - CROP PRODUCTION (TONNES/YEAR) <2>
     AOSET   - TABLE FOR STORAGE EFFECT ON F&V PRODUCTION
                  <190.9>
     AOTET   - TABLE FOR THE EFFECT OF TRANSPORTATION
                  ADEQUACY ON F&V PRODUCTION <191.2>
     AOTRN   - TRANSPORTATION REQUIREMENT FOR F&V
                  (KILOMETERS) <191.5>
     AOINT   - NORMAL PRIORITY FOR F&V <191.7>
     AOYRT   - TABLE FOR REFERENCE F&V YIELD (TONNES/
                  FEDDAN) <191.9>
     AOYTET  - TABLE FOR THE EFFECT OF WATER TABLE HEIGHT
                  ON F&V YIELDS <192.9>
     AOYWET  - TABLE FOR THE EFFECT OF WATER APPLICATION
                  ON F&V YIELD <193.2>
     AOWOT   - TABLE FOR REQUESTED WATER ORDERS FOR F&V
                  (KCM/FEDDAN) <193.4>
     AOYNET  - TABLE FOR THE EFFECT OF SOIL NUTRIENTS ON
                  F&V YIELD <193.8>
     AONRT   - TABLE FOR REQUESTED FERTILIZERS FOR F&V
                  (TONNES/FEDDAN) <194.1>
     AOYDET  - TABLE FOR THE EFFECT OF DISEASE AND PEST
                  LOSSES ON F&V YIELDS <194.3>
     AOYMET  - TABLE FOR THE EFFECT OF MOTIVE POWER ON F&V
                  YIELDS <194.6>
     AOMDT   - TABLE FOR DESIRED MOTIVE POWER FOR F&V
                  (ANIMAL-UNITS/FEDDAN) <194.8>
     AOYLET  - TABLE FOR THE EFFECT OF LABOR ON F&V YIELDS
                  <195.2>
     AOPR    - REQUESTED F&V PRODUCTION <196>
     AOPGIT  - TABLE FOR GOVERNMENT INFLUENCE ON DESIRED
                  F&V PRODUCTION <195.4>
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   ANIEWAT- TABLE FOR THE EFFECT OF WATER AVAILABILITY
              ON THE NORMAL PRIORITY FOR GRAIN <168.6>
   AOTR    = TRANSPORTATION REQUIRED FOR F&V
   AOH     = HARVEST OF F&V (TONNES/YEAR)
   AOHO    = FRUITS AND VEGETABLES HARVEST FROM OLD
              VALLEY LANDS
   AOHN    = FRUITS AND VEGETABLES HARVEST FROM NEW
              VALLEY LANDS
   AOF     = FEDDANS ALLOCATED TO F&V
   AOFR    = FEDDANS REQUESTED FOR F&V
   AOFII   = INITIAL LAND AREA FOR F&V <193.6>
   AOYGE   = GROUND EFFECTS ON F&V YIELD
   AOYSE   = SALT EFFECT ON F&V YIELD
   AOYTE   = WATER TABLE EFFECT ON F&V YIELD
   AOYWE   = WATER AVAILABILITY EFFECT ON F&V YIELD
   AOWO    = OPTIMAL WATER APPLICATION FOR F&V (KCM/
              YEAR)
   AOYNE   = SOIL NUTRIENT EFFECT ON F&V YIELD
   AONR    = FRUITS AND VEGETABLES NUTRIENTS REQUIRED
   AOYHE   = HUMAN EFFECTS ON F&V YIELD
   AOYME   = MOTIVE POWER EFFECT ON F&V YIELD
   AOM     = MOTIVE POWER FOR F&V
   AOMR    = MOTIVE POWER REQUESTED FOR F&V
   AOYLE   = LABOR EFFECT ON F&V YIELD
   AOL     = LABOR FOR F&V
   AOLR    = LABOR REQUESTED FOR F&V
   AOPDAC  = DESIRED ANNUAL CHANGE FOR F&V PRODUCTION
   AOPN    = SHORTFALL IN PRODUCTION OF F&V
   AOIF    = F&V PRIORITY FOR FEDDANS
   AOIW    = F&V PRIORITY FOR WATER
   AOICN   = F&V PRIORITY FOR CHEMICAL NUTRIENTS
   AOIM    = F&V PRIORITY FOR MOTIVE POWER
   AOIL    = F&V PRIORITY FOR LABOR
   AOYSTH  = (NO EFFECT)THRESHOLD SALT CONCENTRATION FOR
              YIELD EFFECT ON FRUITS & VEGETABLES
              (CONDUCTIVITY OF SATURATED SOIL EXTRACT)
              <192.2>
   AOYSZY  = ZERO-YIELD SALT CONCENTRATION FOR FRUITS
              AND VEGETABLES (CONDUCTIVITY OF SATURATED
              SOIL EXTRACT) <192.6>

AOPR.K=PUOR.K+PROR.K+CAOR.K                          196, A
   AOPR    = REQUESTED F&V PRODUCTION <196>
   PUOR    = REQUESTED URBAN FRUITS AND VEGETABLE
              CONSUMPTION (TONNES/YEAR)
   PROR    = REQUESTED RURAL FRUITS AND VEGETABLE
              CONSUMPTION (TONNES/YEAR)
   CAOR    = REQUESTED F&V EXPORTS <465>
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OWR.K=(PUOR.K/PUIO.K)+(PROR.K/PRIO.K)+(CAOR.K/        197, A
 CIAO.K)
   AOWR    - WEIGHTED REQUESTS FOR F&V PRODUCTION <197>
   PUOR    - REQUESTED URBAN FRUITS AND VEGETABLE
               CONSUMPTION (TONNES/YEAR)
   PUIO    - URBAN PRIORITY FOR FRUITS AND VEGETABLES
   PROR    - REQUESTED RURAL FRUITS AND VEGETABLE
               CONSUMPTION (TONNES/YEAR)
   PRIO    - RURAL PRIORITY FOR FRUITS AND VEGETABLES
   CAOR    - REQUESTED F&V EXPORTS <465>

  FODDER PRODUCTION

AEP.K=CROP(AESET,AETET,AETRN,AEINT,AEYRT,ANYSET,       198, A
  AEYTET,AEYWET,AEWOT,AEYNET,AENRT,AEYDET,AEYMET,
  AEMDT,AEYLET,AEPR,AEPGIT,ANIEWAT,AETR,AEH,AEHO,
  AEHN,AEF,AEFR,AEFII,AEYGE,AEYSE,AEYTE,AEYWE,AEWO,
  AEYNE,AENR,AEYHE,AEYME,AEM,AEMR,AEYLE,AEL,AELR,
  AEPDAC,AEPN,AEIF,AEIW,AEICN,AEIM,AEIL)
AESET=.9/.9/.9/.9/.5/.9                                 198.9, T
AETET=1/1/1/1/1                                         199.2, T
AETRN=0                                                 199.5, C
AEINT=.1/.1/.1/.1/.1/.1                                 199.7, T
AEYRT=18/18/18/18/18/18                                 199.9, T
EYSTH=4.25 MILLIMHOS/CM                                 200.2, C
EYSZY=16 MILLIMHOS/CM                                   200.5, C
AEYTET=1/.95/.9/.6/.1                                   200.8, T
AEYWET=0/.1/.45/.75/1/.95/.9/.8/.6                      201.1, T
AEWOT=0/1.01/1.88/2.6/2.89                              201.3, T
AEFII=2.85E6                                            201.5, C
AEYNET=1/1/1/1/1                                        201.7, T
AENRT=0/.005/.01/.02/.03                                201.9, T
AEYDET=.9/.9/.9/.9/.9/.5                                202.2, T
AEYMET=.3/.5/.7/.85/1/1.08/1.14/1.17/1.2                202.5, T
AEMDT=0/.28/.37/.42/.45                                 202.7, T
AEYLET=0/.35/.65/.85/1/1.15/1.25/1.3/1.35               203.1, T
AEPGIT=.05/.05/.05/.05/.05/.05                          203.3, T
    AEP     - FODDER PRODUCTION (TONNES/YEAR) <198>
    CROP    - CROP PRODUCTION (TONNES/YEAR) <2>
    AESET   - TABLE FOR STORAGE EFFECT ON FODDER
                PRODUCTION <198.9>
    AETET   - TABLE FOR THE EFFECT OF TRANSPORTATION
                ADEQUACY ON FODDER PRODUCTION <199.2>
    AETRN   - TRANSPORTATION REQUIREMENT FOR FODDER
                (KILOMETERS) <199.5>
    AEINT   - NORMAL PRIORITY FOR FODDER <199.7>
    AEYRT   - TABLE FOR REFERENCE FODDER YIELD (TONNES/
                FEDDAN) <199.9>
    AEYTET  - TABLE FOR THE EFFECT OF WATER TABLE HEIGHT
                ON FODDER YIELDS <200.8>
```

AEYWET - TABLE FOR THE EFFECT OF WATER APPLICATION ON FODDER YIELD <201.1>
AEWOT - TABLE FOR REQUESTED WATER ORDERS FOR FODDER (KCM/FEDDAN) <201.3>
AEYNET - TABLE FOR THE EFFECT OF SOIL NUTRIENTS ON FODDER YIELD <201.7>
AENRT - TABLE FOR REQUESTED FERTILIZERS FOR FODDER (TONNES/FEDDAN) <201.9>
AEYDET - TABLE FOR THE EFFECT OF DISEASE AND PEST LOSSES ON FODDER YIELDS <202.2>
AEYMET - TABLE FOR THE EFFECT OF MOTIVE POWER ON FODDER YIELDS <202.5>
AEMDT - TABLE FOR DESIRED MOTIVE POWER FOR FODDER (ANIMAL-UNITS/FEDDAN) <202.7>
AEYLET - TABLE FOR THE EFFECT OF LABOR ON FODDER YIELDS <203.1>
AEPR - REQUESTED FODDER PRODUCTION <204>
AEPGIT - TABLE FOR GOVERNMENT INFLUENCE ON DESIRED FODDER PRODUCTION <203.3>

ANIEWAT- TABLE FOR THE EFFECT OF WATER AVAILABILITY ON THE NORMAL PRIORITY FOR GRAIN <168.6>
AETR - TRANSPORTATION REQUIRED FOR FODDER
AEH - HARVEST OF FODDER (TONNES/YEAR)
AEHO - FODDER HARVEST FROM OLD VALLEY LANDS
AEHN - FODDER HARVEST FROM NEW VALLEY LANDS
AEF - FEDDANS ALLOCATED TO FODDER
AEFR - FEDDANS REQUESTED FOR FODDER
AEFII - INITIAL LAND AREA FOR FODDER <201.5>
AEYGE - GROUND EFFECTS ON FODDER YIELD
AEYSE - SALT EFFECT ON FODDER YIELD
AEYTE - WATER TABLE EFFECT ON FODDER YIELD
AEYWE - WATER AVAILABILITY EFFECT ON FODDER YIELD
AEWO - OPTIMAL WATER APPLICATION FOR FODDER (KCM/YEAR)
AEYNE - SOIL NUTRIENT EFFECT ON FODDER YIELD
AENR - FODDER NUTRIENTS REQUIRED
AEYHE - HUMAN EFFECTS ON FODDER YIELD
AEYME - MOTIVE POWER EFFECT ON FODDER YIELD
AEM - MOTIVE POWER FOR FODDER
AEMR - MOTIVE POWER REQUESTED FOR FODDER
AEYLE - LABOR EFFECT ON FODDER YIELD
AEL - LABOR FOR FODDER
AELR - LABOR REQUESTED FOR FODDER
AEPDAC - DESIRED ANNUAL CHANGE FOR FODDER PRODUCTION
AEPN - SHORTFALL IN PRODUCTION OF FODDER
AEIF - FODDER PRIORITY FOR FEDDANS
AEIW - FODDER PRIORITY FOR WATER
AEICN - FODDER PRIORITY FOR CHEMICAL NUTRIENTS
AEIM - FODDER PRIORITY FOR MOTIVE POWER

```
    AEIL    - FODDER PRIORITY FOR LABOR
    AEYSTH  - THRESHOLD SALT CONCENTRATION FOR YIELD
                EFFECT ON FODDER (CONDUCTIVITY OF
                SATURATED SOIL EXTRACT) <200.2>
    AEYSZY  - ZERO-YIELD SALT CONCENTRATION FOR FODDER
                (CONDUCTIVITY OF SATURATED SOIL EXTRACT)
                <200.5>

AEPR.K=ADER.K+ABER.K                                       204, A
    AEPR    - REQUESTED FODDER PRODUCTION <204>
    ADER    - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
                YEAR) <314>
    ABER    - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
                YEAR) <332>

AEWR.K=(ADER.K/ADIE.K)+(ABER.K/ABIE.K)                     205, A
    AEWR    - WEIGHTED REQUESTS FOR FODDER PRODUCTION
                <205>
    ADER    - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
                YEAR) <314>
    ABER    - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
                YEAR) <332>
```

V-B. AGRICULTURAL RESOURCES

The preceding description highlighted five major resource inputs that are used to determine agricultural production. These are land area, water, soil nutrients, labor, and motive power. In addition, transportation is an indirect input that determines how much of the crop harvest is available for consumption, and energy is an indirect input that determines the productivity of agricultural machinery. This section describes the model's calculation of the total availability of these resources for use in agriculture.

Feddans -- The major consideration regarding land area as an agricultural resource is the balance between the land area requested for all crops (AFR) and the land area available for cultivation (AFC). The total land area requested for agricultural purposes is determined in a straightforward manner by adding the individual land area requests for each crop. The land area available for cultivation, however, is the more complicated variable, as it reflects a number of different factors. The total potential arable land in Egypt, the competition for land area provided by population and industrial requirements, and the potential for multiple-cropping are all important. These important factors are represented explicitly in the model's treatment of land resources.

The feddans available for cultivation (AFC) are determined in the model by the feddans available for agriculture (AF) and the multiple-cropping potential established by water availability and mechanization. The feddans available for agriculture (AF) are in turn determined by the total potential arable feddans in Egypt (AFP), less the land removed for use by the urban population, the rural population, and industry. The model's estimates for urban per capita land requirements (PUFN), rural per capita land requirements (PRFN), and industrial land requirements (GFN) were determined by an analysis of changes in arable land area over Egypt during the last 15 years.[16]

```
   FEDDANS

AFN.K=MAX(AFR.K-AFC.K,0)                                   206, A
    AFN     - SHORTFALL IN FEDDANS (FEDDANS) <206>
    AFR     - REQUESTED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <14>
    AFC     - FEDDANS AVAILABLE FOR CULTIVATION <208>

AFR.K=ARFR.K+ANFR.K+ACFR.K+AOFR.K+AEFR.K                   207, A
    AFR     - REQUESTED FEDDANS FOR CROP PRODUCTION
                (FEDDANS) <14>
    ARFR    - FEDDANS REQUESTED FOR RICE
    ANFR    - FEDDANS REQUESTED FOR GRAIN
    ACFR    - FEDDANS REQUESTED FOR COTTON
    AOFR    - FEDDANS REQUESTED FOR F&V
    AEFR    - FEDDANS REQUESTED FOR FODDER

AFC.K=AF.K*(1+AFCWE.K*AFCGE.K)                             208, A
    AFC     - FEDDANS AVAILABLE FOR CULTIVATION <208>
    AF      - FEDDANS AVAILABLE FOR AGRICULTURE <209>
    AFCWE   - EFFECT OF WATER SUPPLY ON FEDDANS AVAILABLE
                FOR CULTIVATION <211>
    AFCGE   - EFFECT OF AGRICULTURE CAPITAL ON FEDDANS
                AVAILABLE FOR CULTIVATION <210>

AF.K=AFP.K-(PU.K*PUFN)-((GG.K+UG.K)*GFN)-(PR.K*            209, A
  PRFN)+NF.K
PUFN=.014                                                  209.2, C
PRFN=.014                                                  209.4, C
GFN=4E-4                                                   209.6, C
    AF      - FEDDANS AVAILABLE FOR AGRICULTURE <209>
    AFP     - POTENTIAL ARABLE FEDDANS <215>
    PU      - URBAN POPULATION <126>
    PUFN    - NORMAL URBAN PER CAPITA LAND REQUIREMENT
                <209.2>
    GG      - CAPITAL GOODS IN PLACE FOR CAPITAL GOODS
                PRODUCTION
    UG      - CAPITAL GOODS IN PLACE FOR CONSUMER GOODS
                PRODUCTION
    GFN     - NORMAL INDUSTRY PER UNIT LAND REQUIREMENT
                <209.6>
    PR      - RURAL POPULATION <135>
    PRFN    - NORMAL RURAL PER CAPITA LAND REQUIREMENT
                <209.4>
    NF      - PRODUCTIVE FEDDANS IN NEW VALLEY REGIONS
                <287>
```

The simulation model represents two specific possibilities for increasing the arable land in Egypt. The first is reclamation of land in the Nile Valley area; the second is reclamation of land in the New Valley. The equations for both reclamation programs represent the financial investment required to reclaim land for agriculture and the delays that exist before the land can become fully productive. Reclamation for Nile Valley lands is described below; New Valley lands are treated separately in Section V-C.

The model treatment of potentially arable feddans (AFP) -- land available for agriculture -- distinguishes between established arable land (AFE) and arable land being developed (AFID). Established arable land comprises fully mature acreage, and was assumed to number 7.4 million feddans (including residential, commercial, and industrial land) in 1960. Arable land being developed is newly reclaimed land that requires further trading before it becomes fully developed. This development process between reclamation and full productivity is assumed to take six years (AFTP). During that six year period, newly reclaimed land is assumed to be only 40% (AFPF) as productive as established land.

Reclamation of land (AFRA) requires the allocation of investment resources (AFGD) from the model's capital goods equations. Like the other sectors of the model, the agricultural sector establishes a target for annual investment activity (AFGO), based upon the desired land area reclaimed (AFGOT) and the costs of the reclamation (AFGR, assumed to be 400 Egyptian pounds per feddan). The commitment of capital investment for land reclamation (AFGC) uses the model's resource allocation logic to determine how much of the targeted reclamation will be provided. As in industrial investment (see Chapter VI), the construction activity (AFGLA) that follows the commitment of resources will determine how reapidly (AFGRT) the reclmation process is conccluded.

```
AFP.K=AFE.K+AFID.K*AFPF                                          215, A
AFPF=.4                                                          215.2, C
    AFP     - POTENTIAL ARABLE FEDDANS <215>
    AFE     - ESTABLISHED ARABLE FEDDANS <216.1>
    AFID    - ARABLE FEDDANS BEING DEVELOPED <218.1>
    AFPF    - PRODUCTION FACTOR FOR LAND IN DEVELOPMENT
                <215.2>

AFE.K=AFE.J+(DT)*(AFER.J)                                        216, L
AFE=AFEN                                                         216.1, N
AFEN=7.4E6                                                       216.3, C
    AFE     - ESTABLISHED ARABLE FEDDANS <216.1>
    AFER    - RATE FOR ESTABLISHED ARABLE FEDDANS <217>
    AFEN    - 1960 ESTIMATE OF ESTABLISHED ARABLE FEDDANS
                (INCLUDES RESIDENTIAL, COMMERICAL, AND
                INDSUTRIAL LAND) <216.3>

AFER.K=AFID.K/AFTP                                               217, A
AFTP=6                                                           217.2, C
    AFER    - RATE FOR ESTABLISHED ARABLE FEDDANS <217>
    AFID    - ARABLE FEDDANS BEING DEVELOPED <218.1>
    AFTP    - TIME TO DEVELOP RECLAIMED FEDDANS (YEARS)
                <217.2>

AFID.K=AFID.J+(DT)(AFRA.J-AFER.J)                                218, L
AFID=(AFGO/AFGR)*AFTP                                            218.1, N
    AFID    - ARABLE FEDDANS BEING DEVELOPED <218.1>
    AFRA    - RECLAMATION OF FEDDANS FOR AGRICULTURE
                <219>
    AFER    - RATE FOR ESTABLISHED ARABLE FEDDANS <217>
    AFGO    - DESIRED RECLAMATION ACTIVITY <225>
    AFGR    - INVESTMENT REQUIRED FOR LAND RECLAMATION
                (POUNDS/FEDDAN) <219.2>
    AFTP    - TIME TO DEVELOP RECLAIMED FEDDANS (YEARS)
                <217.2>

AFRA.K=AFGD.K/AFGR                                               219, A
AFGR=400                                                         219.2, C
    AFRA    - RECLAMATION OF FEDDANS FOR AGRICULTURE
                <219>
    AFGD    - COMPLETION OF INVESTMENT FOR RECLAMATION
                <220>
    AFGR    - INVESTMENT REQUIRED FOR LAND RECLAMATION
                (POUNDS/FEDDAN) <219.2>
AFGD.K=DELAY3P(AFGC.K,AFGRT.K,AFGIP.K)                           220, A
    AFGD    - COMPLETION OF INVESTMENT FOR RECLAMATION
                <220>
    AFGC    - INVESTMENT COMMITMENT TO LAND RECLAMATION
                <224.1>
    AFGRT   - TIME FOR COMPLETION OF RECLAMATION PROJECTS
                <221.1>
    AFGIP   - OLD VALLEY LAND RECLAMATION IN PROGRESS
                (FEDDANS)
```

```
AFGRT.K=AFGIP.K/AFGCA.K                                  221, A
AFGRT=AFGRTN                                             221.1, N
    AFGRT  - TIME FOR COMPLETION OF RECLAMATION PROJECTS
               <221.1>
    AFGIP  - OLD VALLEY LAND RECLAMATION IN PROGRESS
               (FEDDANS)
    AFGCA  - ACTIVITY FOR LAND RECLAMATION <222>
    AFGRTN - TIME TP RECLAIM LAND (YEARS) <223.2>

AFGCA.K=SHARE(AFGCR.K,GPN.K,AFIGC.K,GPWR.K,AIN.K)        222, A
    AFGCA  - ACTIVITY FOR LAND RECLAMATION <222>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    AFGCR  - ACTIVITY REQUESTED FOR LAND RECLAMATION
               <223>
    GPN    - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
    GPWR   - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    AIN    - NORMAL PRIORITY FOR AGRICULTURE <253>

AFGCR.K=AFGIP.K/AFGRTN                                   223, A
AFGRTN=1                                                 223.2, C
    AFGCR  - ACTIVITY REQUESTED FOR LAND RECLAMATION
               <223>
    AFGIP  - OLD VALLEY LAND RECLAMATION IN PROGRESS
               (FEDDANS)
    AFGRTN - TIME TP RECLAIM LAND (YEARS) <223.2>

AFGC.K=SHARE(AFGO.K,GON.K,AFIGO.K,GOWR.K,AIN.K)          224, A
AFGC=AFGO                                                224.1, N
    AFGC   - INVESTMENT COMMITMENT TO LAND RECLAMATION
               <224.1>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    AFGO   - DESIRED RECLAMATION ACTIVITY <225>
    GON    - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR   - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    AIN    - NORMAL PRIORITY FOR AGRICULTURE <253>

AFGO.K=FIFGE(AFGO1.K,AFGO2.K,AFGSW,1)                    225, A
AFGSW=2                                                  225.2, C
    AFGO   - DESIRED RECLAMATION ACTIVITY <225>
    AFGO1  - ORDERS FOR INVESTMENT IN LAND RECLAMATION
               (POUNDS/YEAR) <226>
    AFGO2  - RECLAMATION ACTIVITY DESIRED <227>
    AFGSW  - SWITCH FOR TESTING DESIRED RECLAMATION
               ACTIVITY <225.2>

AFGO1.K=TABHL(AFGO1T,TIME.K,1960,2010,10)*1E3*AFGR       226, A
AFGO1T=30/30/30/30/30/30                                 226.2, T
    AFGO1  - ORDERS FOR INVESTMENT IN LAND RECLAMATION
               (POUNDS/YEAR) <226>
    AFGO1T - TABLE FOR INVESTMENT RECLAMATION ORDERS
               (THOUSAND FEDDANS/YEAR) <226.2>
    AFGR   - INVESTMENT REQUIRED FOR LAND RECLAMATION
               (POUNDS/FEDDAN) <219.2>
```

```
AFG02.K=FIFGE(30,AFG02C,1980,TIME.K)*1E3*AFGR          227, A
 G02C=0                                                 227.2, C
    AFG02  = RECLAMATION ACTIVITY DESIRED <227>
    AFG02C = CONSTANT FOR RECLAMATION ACTIVITY DESIRED
               <227.2>
    AFGR   = INVESTMENT REQUIRED FOR LAND RECLAMATION
               (POUNDS/FEDDAN) <219.2>

AFWR.K=(ARFR.K/ARIF.K)+(ANFR.K/ANIF.K)+(ACFR.K/        228, A
  ACIF.K)+(AOFR.K/AOIF.K)+(AEFR.K/AEIF.K)
    AFWR   = WEIGHTED REQUESTS FOR AGRICULTURAL LAND
               <228>
    ARFR   = FEDDANS REQUESTED FOR RICE
    ARIF   = RICE PRIORITY FOR FEDDANS
    ANFR   = FEDDANS REQUESTED FOR GRAIN
    ANIF   = GRAIN PRIORITY FOR FEDDANS
    ACFR   = FEDDANS REQUESTED FOR COTTON
    ACIF   = COTTON PRIORITY FOR FEDDANS
    AOFR   = FEDDANS REQUESTED FOR F&V
    AOIF   = F&V PRIORITY FOR FEDDANS
    AEFR   = FEDDANS REQUESTED FOR FODDER
    AEIF   = FODDER PRIORITY FOR FEDDANS

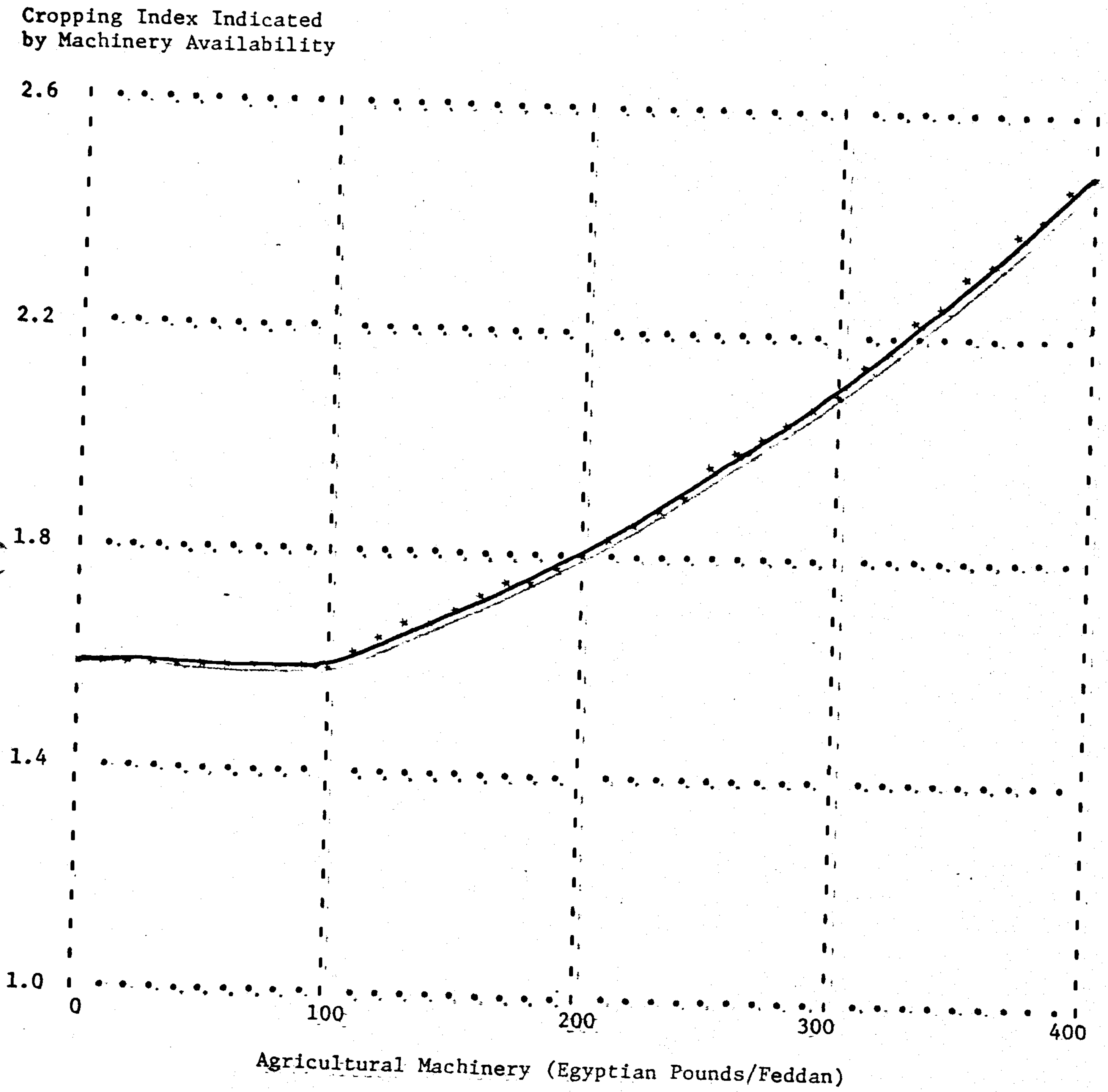
AFFNV.K=NF.K/AF.K                                       229, A
    AFFNV  = FRACTION OF AGRICULTURAL LAND IN THE NEW
               VALLEY <229>
    NF     = PRODUCTIVE FEDDANS IN NEW VALLEY REGIONS
               <287>
    AF     = FEDDANS AVAILABLE FOR AGRICULTURE <209>

AFO.K=AF.K-NF.K                                         230, A
    AFO    = OLD VALLEY AGRICULTURAL AREA <230>
    AF     = FEDDANS AVAILABLE FOR AGRICULTURE <209>
    NF     = PRODUCTIVE FEDDANS IN NEW VALLEY REGIONS
               <287>
```

The cropping index that determines the base productivity of agricultural land is calculated from a water supply effect (AFCWE) and a mechanization effect (AFCGE). Of these two, the water effect is of only historical interest, and relates to the expansion of perennial irrigation to another 8000,000 feddans of Egyptian agricultural lands following the completion of the High Dam in the mid 1960's.[17] The mechanization effect, in contrast, should be much more important in the future, as the accumulation of agricultural machinery enables the Egyptians to reduce the growing season for their crops and squeeze more crops into a given time period. The mechanization effect is calculated in the model by comparing the total agricultural machinery available (AG) with the land area available for agriculture (AF). As shown in Figure V-14, increases in this ratio increase the intensity of land use for crop agriculture. The model assumes a maximum average cropping index for Egyptian agriculture of 2.5 crops per year.[18]

The land resources portion of the model computes two indices to measure the intensity and effectiveness of land use. The cropping index (AFCI) is a ratio of feddans available for cultivation (AFC, actually expressed in terms of crop feddans per year) to feddans available for agriculture (AF). The cropping index affects calculations of labor and machinery availability, and is also available to monitor the model's performance regarding land use. The efficiency index for land use (AFEI) involves a more complicated calculation of the allocation of land among the different crops. Egyptian agriculture operates under a complex crop rotation system that requires a balance between summer crops (rice, cotton, and corn) and winter crops (wheat and fodder). This year round crop rotation increases the productivity of land, motive power, and labor, since it minimizes "downtime" during the off-season. However, these advantages can only be realized if the land areas allocated to the crops

Figure V-14:
Mechanization Effect on Cropping Index



in the model are balanced to reflect the seasonal requirements for cultivation. The land use efficiency index assumes values less than 1.0 if the land area allocation to summer crops strays too far out of balance from the land area allocation to winter crops. The efficiency index is used in labor and motive power portions of the agricultural resources sector of the model to determine the effective amount of both actually available.

```
AFCGE.K=TABLE(AFCGET,AG.K/AF.K,0,400,100)                    210, A
AFCGET=.6/.6/.8/1.1/1.5                                      210.3, T
    AFCGE  - EFFECT OF AGRICULTURE CAPITAL ON FEDDANS
               AVAILABLE FOR CULTIVATION <210>
    AFCGET - TABLE FOR THE EFFECT OF AGRICULTURAL
               CAPITAL ON FEDDANS AVAILABLE FOR
               CULTIVATION <210.3>
    AG     - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AF     - FEDDANS AVAILABLE FOR AGRICULTURE <209>

AFCWE.K=TABLE(AFCWET,AWSR.K,0,2.5,.5)                        211, A
AFCWET=.83/.84/.86/.89/.93/1                                 211.2, T
    AFCWE  - EFFECT OF WATER SUPPLY ON FEDDANS AVAILABLE
               FOR CULTIVATION <211>
    AFCWET - TABLE FOR THE EFFECT OF WATER SUPPLY ON
               FEDDANS AVAILABLE FOR CULTIVATION <211.2>
    AWSR   - WATER SUPPLY RATIO FOR AGRICULTURE <212>

AWSR.K=SMOOTH(WLN.K/AWOOV.K,AWSRAT)                          212, A
AWSRAT=3                                                     212.2, C
    AWSR   - WATER SUPPLY RATIO FOR AGRICULTURE <212>
    WLN    - WATER IN LAKE NASSER (KCM) <1.1>
    AWOOV  - WATER REQUESTED FOR OLD VALLEY LANDS <235>
    AWSRAT - AVERAGING TIME FOR WATER SUPPLY RATIO FOR
               AGRICULTURE (YEARS) <212.2>

AFCI.K=AFC.K/AF.K                                            213, A
    AFCI   - CROPPING INDEX <213>
    AFC    - FEDDANS AVAILABLE FOR CULTIVATION <208>
    AF     - FEDDANS AVAILABLE FOR AGRICULTURE <209>

AFEI.K=1-(MAX(0,MAX((AEF.K-ANF.K)-(ARF.K+ACF.K),             214, A
  (ARF.K+ACF.K)-(AEF.K+ANF.K)))/AFC.K)
    AFEI   - EFFICIENCY INDEX FOR LAND USE <214>
    AEF    - FEDDANS ALLOCATED TO FODDER
    ANF    - FEDDANS ALLOCATED TO GRAIN
    ARF    - FEDDANS ALLOCATED TO RICE
    ACF    - FEDDANS ALLOCATED TO COTTON
    AFC    - FEDDANS AVAILABLE FOR CULTIVATION <208>
```

Water — The adequacy of water for agriculture is determined by the balance between total water requested (AWO) and the water actually applied to the soil (WAS). The total water requested for agriculture is the sum of the individual optimal water applications for the five different crops. Determination of the water applied to the soil, however, involves much more complex calculations. The reader is referred to Chapter III, where the determinants of the amount of water applied to the soil are described.

As noted earlier in discussing the effect of water on crop yields, under some circumstances the water applied to the soil may exceed the optimum application rates for the individual crops. Under these circumstances, the fraction for excess water application (AWXF) assumes a value greater than one. This variable is used in the crop building block to distribute the excess water across all crops in proportion to the optimal water application for each crop.

```
AWN.K=MAX(0,AWOOV.K-WAS.K)                                  231, A
    AWN      - SHORTFALL IN WATER AVAILABLE (KCM/YEAR)
                 <231>
    AWOOV    - WATER REGUESTED FOR OLD VALLEY LANDS <235>
    WAS      - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                 (KCM/YR) <37.1>

AWA.K=WAS.K+WNVSP.K                                         232, A
    AWA      - WATER AVAILABLE FOR AGRICULTURE <232>
    WAS      - NILE WATER APPLIED TO SURFACE IN OLD VALLEY
                 (KCM/YR) <37.1>
    WNVSP    - NEW VALLEY WATER SUPPLIED BY GROUND WATER
                 PUMPING <22>

AWO.K=ARWO.K+ANWO.K+ACWO.K+AOWO.K+AEWO.K                    233, A
    AWO      - WATER REQUESTED (KCM/YEAR) <233>
    ARWO     - OPTIMAL WATER APPLICATION FOR RICE (KCM/
                 YEAR)
    ANWO     - OPTIMAL WATER APPLICATION FOR GRAIN (KCM/
                 YEAR)
    ACWO     - OPTIMAL WATER APPLICATION FOR COTTON (KCM/
                 YEAR)
    AOWO     - OPTIMAL WATER APPLICATION FOR F&V (KCM/
                 YEAR)
    AEWO     - OPTIMAL WATER APPLICATION FOR FODDER (KCM/
                 YEAR)
```

```
AWXF.K=MAX(1,AWA.K/AWO.K)                                    234, A
     AWXF    - FRACTION FOR EXCESS WATER APPLICATON <234>
     AWA     - WATER AVAILABLE FOR AGRICULTURE <232>
     AWO     - WATER REQUESTED (KCM/YEAR) <233>

AWOOV.K=AWO.K*(1-AFFNV.K)                                    235, A
     AWOOV   - WATER REQUESTED FOR OLD VALLEY LANDS <235>
     AWO     - WATER REQUESTED (KCM/YEAR) <233>
     AFFNV   - FRACTION OF AGRICULTURAL LAND IN THE NEW
                 VALLEY <229>

AWWR.K=(ARWO.K/ARIW.K)+(ANWO.K/ANIW.K)+(ACWO.K/        236, A
  ACIW.K)+(AOWO.K/ACIW.K)+(AEWO.K/AEIW.K)
    AWWR     - WEIGHTED REQUESTS FOR AGRICULTURAL WATER
                 <236>
    ARWO     - OPTIMAL WATER APPLICATION FOR RICE (KCM/
                 YEAR)
    ARIW     - RICE PRIORITY FOR WATER
    ANWO     - OPTIMAL WATER APPLICATION FOR GRAIN (KCM/
                 YEAR)
    ANIW     - GRAIN PRIORITY FOR WATER
    ACWO     - OPTIMAL WATER APPLICATION FOR COTTON (KCM/
                 YEAR)
    ACIW     - COTTON PRIORITY FOR WATER
    AOWO     - OPTIMAL WATER APPLICATION FOR F&V (KCM/
                 YEAR)
    AOIW     - F&V PRIORITY FOR WATER
    AEWO     - OPTIMAL WATER APPLICATION FOR FODDER (KCM/
                 YEAR)
    AEIW     - FODDER PRIORITY FOR WATER
```

Soil Nutrients -- As mentioned earlier in the discussion of fertilizer effects on plant growth, the Egypt model treats explicitly the effects of nitrogen and phosphates on crop growth. These soil nutrients (AN) are derived from both organic (ANO) and inorganic (ANC) sources.

Organic nutrients (ANO) are assumed to be available from livestock manure (ANOM) and the by-products of fodder cultivation (ANOE). The organic nutrients available from manure are determined by the amount of manure production (ABU and ADU, as calculated in the livestock portion of the model) and the nutrient content of manure (ANCU, assumed to be .8% by weight).[19] The organic nutrients available from fodder cultivation are assumed, for simplicity, to be proportional to the amount of land being cultivated for fodder (AEF).

Chemical nutrient (ACN) availability is determined by domestic fertilizer production (FP) and fertilizer imports (FQ). It is assumed that the nutrient content of fertilizer in Egypt (FNC) is 15% by weight.[20] The desired application rate for chemical fertilizers (ANCD) is modeled as determined by the past application rate (ANCA) and a growth factor (ANCDG) that represents the incentives for increasing the application rate for chemical fertilizers to increase production. The model's foreign trade and industrial sectors will determine whether the desired amount of chemical fertilizer is actually available for application.

```
ANN.K=MAX(0,ANR.K-AN.K)                                    237, A
    ANN     - SHORTFALL IN NUTRIENT AVAILABILITY <237>
    ANR     - NUTRIENTS REQUESTED (TONNES/YEAR) <238>
    AN      - SOIL NUTRIENTS AVAILABLE <239>

ANR.K=ARNR.K+ANNR.K+ACNR.K+ADNR.K+AENR.K                   238, A
    ANR     - NUTRIENTS REQUESTED (TONNES/YEAR) <238>
    ARNR    - RICE NUTRIENTS REQUIRED
    ANNR    - GRAIN NUTRIENTS REQUIRED
    ACNR    - COTTON NUTRIENTS REQUIRED
    ADNR    - FRUITS AND VEGETABLES NUTRIENTS REQUIRED
    AENR    - FODDER NUTRIENTS REQUIRED
```

```
AN.K=ANO.K+ANC.K                                                    239, A
    AN      - SOIL NUTRIENTS AVAILABLE <239>
    ANO     - ORGANIC NUTRIENTS (TONNES) <240>
    ANC     - CHEMICAL NUTRIENTS AVAILABLE (TONNES/YEAR)
                <243>

ANO.K=SMOOTH(ANOM.K+ANOE.K,ANOAT)
ANOAT=1                                                             240, A
    ANO     - ORGANIC NUTRIENTS (TONNES) <240>                      240.2, C
    ANOM    - ORGANIC NUTRIENTS FROM MANURE <241>
    ANOE    - ORGANIC NUTRIENTS FROM FODDER CULTIVATION
                (TONNES/YEAR) <242>
    ANOAT   - AVERAGING TIME FOR ORGANIC NUTRIENTS
                (YEARS) <240.2>

ANOM.K=(ABU.K+ADU.K)*ANCU
ANCU=.008                                                           241, A
    ANOM    - ORGANIC NUTRIENTS FROM MANURE <241>                   241.2, C
    ABU     - MANURE PRODUCED BY FOOD LIVESTOCK <333>
    ADU     - MANURE PRODUCED BY DRAFT LIVESTOCK <315>
    ANCU    - NUTRIENT CONTENT OF MANURE (FRACTION OF
                GROSS WEIGHT) <241.2>

ANOE.K=AEF.K*ANOEN
ANOEN=.04                                                           242, A
    ANOE    - ORGANIC NUTRIENTS FROM FODDER CULTIVATION             242.2, C
                (TONNES/YEAR) <242>
    AEF     - FEDDANS ALLOCATED TO FODDER
    ANOEN   - NORMAL ORGANIC NUTRIENTS PER HECTARE
                CULTIVATED IN FODDER CROPS (TONNES/
                HECTARE) <242.2>

ANC.K=DELAY1((FP.K+FG.K)*FNC,ANCDT)
ANCDT=1                                                             243, A
    ANC     - CHEMICAL NUTRIENTS AVAILABLE (TONNES/YEAR)            243.2, C
                <243>
    FP      - FERTILIZER PRODUCTION <392>
    FG      - FERTILIZER IMPORTS (TONNES/YEAR) <399.1>
    FNC     - FRACTION OF FERTILIZER THAT IS NUTRIENT
                <393.2>
    ANCDT   - DELIVERY TIME FOR CHEMICAL NUTRIENTS
                <243.2>

ANNWR.K=(ARNR.K/ARICN.K)+(ANNR.K/ANICN.K)+(ACNR.K/                  244, A
  ACICN.K)+(AONR.K/AOICN.K)+(AENR.K/AEICN.K)
    ANNWR   - WEIGHTED REQUESTS FOR AGRICULTURAL
                NUTRIENTS <244>
    ARNR    - RICE NUTRIENTS REQUIRED
    ARICN   - RICE PRIORITY FOR CHEMICAL NUTRIENTS
    ANNR    - GRAIN NUTRIENTS REQUIRED
    ANICN   - GRAIN PRIORITY FOR CHEMICAL NUTRIENTS
    ACNR    - COTTON NUTRIENTS REQUIRED
    ACICN   - COTTON PRIORITY FOR CHEMICAL NUTRIENTS
    AONR    - FRUITS AND VEGETABLES NUTRIENTS REQUIRED
    AOICN   - F&V PRIORITY FOR CHEMICAL NUTRIENTS
    AENR    - FODDER NUTRIENTS REQUIRED
    AEICN   - FODDER PRIORITY FOR CHEMICAL NUTRIENTS
```

```
ANCD.K=AF.K*ANCA.K*(1+ANCDG.K)                               245, A
    ANCD    - REQUESTED CHEMICAL NUTRIENTS (TONNES/YEAR)
                <245>
    AF      - FEDDANS AVAILABLE FOR AGRICULTURE <209>
    ANCA    - AVERAGE APPLICATION OF CHEMICAL NUTRIENTS
                (TONNES/FEDDAN) <246.1>
    ANCDG   - DESIRED ANNUAL GROWTH IN CHEMICAL NUTRIENT
                APPLICATION <247.1>

ANCA.K=SMOOTH(ANC.K/AF.K,ANCRAT)                             246, A
ANCA=ANCAI                                                   246.1, N
ANCRAT=1                                                     246.3, C
ANCAI=.021                                                   246.5, C
    ANCA    - AVERAGE APPLICATION OF CHEMICAL NUTRIENTS
                (TONNES/FEDDAN) <246.1>
    ANC     - CHEMICAL NUTRIENTS AVAILABLE (TONNES/YEAR)
                <243>
    AF      - FEDDANS AVAILABLE FOR AGRICULTURE <209>
    ANCRAT  - TIME TO PERCEIVE CHANGES IN CHEMICAL
                NUTRIENT NEEDS (YEARS) <246.3>
    ANCAI   - INITIAL APPLICATION OF CHEMICAL NUTRIENT
                (TONNES NUTRIENT/FEDDAN) <246.5>

ANCDG.K=FIFGE(ANCDG2,ANCDG1,ANCI.K,1.0)                      247, A
ANCDG=ANCDG1                                                 247.1, N
ANCDG1=.07                                                   247.3, C
ANCDG2=-.05                                                  247.4, C
    ANCDG   - DESIRED ANNUAL GROWTH IN CHEMICAL NUTRIENT
                APPLICATION <247.1>
    ANCDG2  - CONSTANTS FOR ANNUAL GROWTH IN CHEMICAL
                NUTRIENTS <247.4>
    ANCI    - INDEX OF NUTRIENT AVAILABILITY <248>

ANCI.K=SMOOTH(AN.K/ANR.K,ANCRAT)                             248, A
    ANCI    - INDEX OF NUTRIENT AVAILABILITY <248>
    AN      - SOIL NUTRIENTS AVAILABLE <239>
    ANR     - NUTRIENTS REQUESTED (TONNES/YEAR) <238>
    ANCRAT  - TIME TO PERCEIVE CHANGES IN CHEMICAL
                NUTRIENT NEEDS (YEARS) <246.3>
```

Labor -- The adequacy of labor for agriculture is determined by the balance between the labor requirements for individual crops (ALR) and the effective agricultural labor requested is simply the sum of the individual labor requests for the five crops categories. The effective labor force available is determined by applying the cropping index (AFCI) and efficiency index (AFEI), as calculated in the equations dealing with agricultural land resources, to the "raw agricultural labor force (AL).

The cropping index acts to increase the effective labor force available by recognizing the more efficient use of labor that can occur with the year-round harvesting of crops. If the average cropping index is 1.7, the model calculates the effective labor force (expressed in terms of man-years of effort per year) as 70% larger than the agricultural labor headcount. These extra man-years of activity are available for distribution to meet the needs of the different crops. In contrast, the efficiency index acts to reduce the effective labor force available if an inefficient distribution of land between summer and winter crops exists.

The calculation of the agricultural labor force (AL) closely resembles the calculation of the crop labor force (AXL) described earlier in Section V-A. A one-year time delay (PLTT) is assumed to occur between the recognition of a need for reallocation of labor and the actual transfer of labor from other rural needs to the agricultural labor force.

```
ALN.K=MAX(0,ALR.K-AFCI.K*AFEI.K*AL.K)                       249, A
    ALN     - SHORTFALL IN AGRICULTURF LABOR <249>
    ALR     - AGRICULTURE LABCE REQUESTED <250>
    AFCI    - CROPPING INDEX <213>
    AFEI    - EFFICIENCY INDEX FOR LAND USE <214>
    AL      - MEN AVAILABLE FOR CROP (MEN/SEASON) <34>

ALR.K=ARLR.K+ANLR.K+ACLR.K+ACLR.K+AELR.K                    250, A
    ALR     - AGRICULTURE LABCE REQUESTED <250>
    ARLR    - LABOR REQUESTED FOR RICE
    ANLR    - LABOR REQUESTED FOR GRAIN
    ACLR    - LABOR REQUESTED FOR COTTON
    AOLR    - LABOR REQUESTED FOR F&V
    AELR    - LABOR REQUESTED FOR FODDER
```

```
AL.K=SMOOTH(ALI.K,PLTT)                                     251, A
     AL       - MEN AVAILABLE FOR CROP (MEN/SEASON) <34>
     ALI      - MEN INDICATED FOR CROP (MEN/SEASON) <35.1>
     PLTT     - TRANSFER TIME FOR LABOR (YEARS) <124.4>

ALI.K=SHARE(ALR.K,PRLN.K,AIL.K,PRLWR.K,AIN.K)               252, A
     ALI      - MEN INDICATED FOR CROP (MEN/SEASON) <35.1>
     SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
     ALR      - AGRICULTURE LABOR REQUESTED <253>
     PRLN     - SHORTFALL IN RURAL LABOR
     PRLWR    - WEIGHTED REQUESTS FOR URBAN LABOR <143>
     AIN      - NORMAL PRIORITY FOR AGRICULTURE <253>

AIN.K=TABHL(AINT,TIME.K,1960,2010,10)                       253, A
AINT=.1/.1/.1/.1/.1/.1                                      253.2, T
     AIN      - NORMAL PRIORITY FOR AGRICULTURE <253>
     AINT     - TABLE FOR NORMAL AGRICULTURE PRIORITY
                  <253.2>

ALWR.K=(ARLR.K/ARIL.K)+(ANLR.K/ANIL.K)+(ACLR.K/           254, A
 ACIL.K)+(AOLR.K/AOIL.K)+(AELR.K/AEIL.K)
    ALWR     - WEIGHTED REQUESTS FOR AGRICULTURAL LABOR
                 <254>
    ARLR     - LABOR REQUESTED FOR RICE
    ARIL     - RICE PRIORITY FOR LABOR
    ANLR     - LABOR REQUESTED FOR GRAIN
    ANIL     - GRAIN PRIORITY FOR LABOR
    ACLR     - LABOR REQUESTED FOR COTTON
    ACIL     - COTTON PRIORITY FOR LABOR
    AOLR     - LABOR REQUESTED FOR F&V
    AOIL     - F&V PRIORITY FOR LABOR
    AELR     - LABOR REQUESTED FOR FODDER
    AEIL     - FODDER PRIORITY FOR LABOR
```

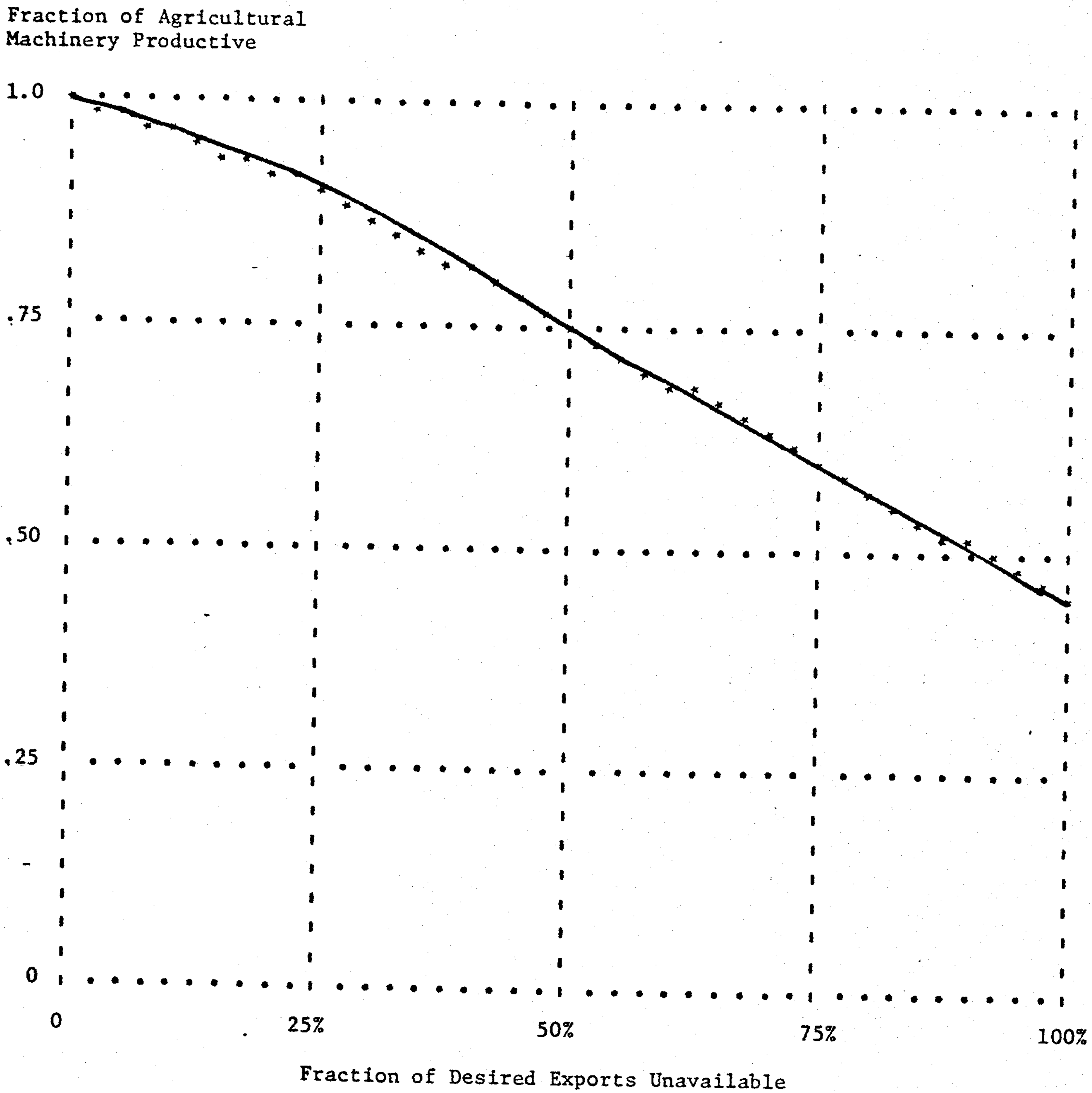
Motive Power -- The adequacy of motive power is determined by a balance between motive power requested (AMR) and the effective motive power available. Once again, the cropping (AFCI) and efficiency (AFEI) indices are used to determine how much effective motive power is obtained from the actual motive power (AM) on hand. The total motive power requested by agriculture is determined by summing the motive power requests from the individual crops.

The actual motive power available (AM) includes the contributions of both draft animals (ADL) and agricultural capital or machinery (AG). Machinery (expressed in financial terms) is assumed to be a substitute for draft animals at a fixed substitution ratio (AAGSR) of 2,000 Egyptian pounds being equivalent to one draft animal.

The actual agricultural capital investment in place is modified by two factors to determine the effective amount of capital investment available. The first is the adequacy of energy available for agriculture (AEA), which expresses the percentage of the energy requirement of the agricultural capital in place that is actually supplied. If only 80% of the necessary energy is supplied, then only 80% of the capital is assumed to be effective. The second factor (AGPF) reflects the consequences for agricultural capital of an inability on the part of the Egyptian economy to meet its import requirements.[21] As shown in Figure V-15, inability to meet import requirements has a progressive negative effect on the productivity of agricultural capital, a reflection of the importance of spare parts imports for Egyptian agriculture.

The draft livestock available (ADL) for agriculture is largely equal to the total headcount of adult draft animals (ADA). However, some of these draft animals will not be available for use in the fields because of their involvement in draft animal births (ADB). It is assumed in the model that one year of productive adult draft animal time (ADBLPT) is lost for every birth.

Figure V-15: Productivity of Agricultural Machinery



The amount of draft animals needed (ADR) is determined from the total mot e power requirement (AMR) and the agricultural machinery on hand (AG). Section V-D describes in detail the determinants of the size of draft animal herd in Egypt.

The model equations that describe the accumulation of agricultural capital goods are quite similar to the capital goods equations for the industry building block, as described in Chapter VI. Therefore, the agricultural capital goods equations are described only briefly here, and the reader is referred to Chapter VI for a more detailed explanation of the logic behind the model's treatment of capital goods accumulation.

Agricultural machinery (AG) in the model is a pool that is increased by deliveries (AGD) of capital from the domestic capital goods sector and imports (AGQ) from the foreign trade sector. The pool is diminished by the wear-out of agricultural capital (AGW), with the wear-out rate based on an assumed 20-year lifetime (AGWL). The deliveries of capital to agriculture (AGD) are determined by the competition between the agriculture sector and other sectors of the economy that also require capital goods. The model's standard resource allocation logic is used to represent this competition. An initial value of 316 million pounds is assumed for the amount of agricultural capital investment in place in 1960.[22]

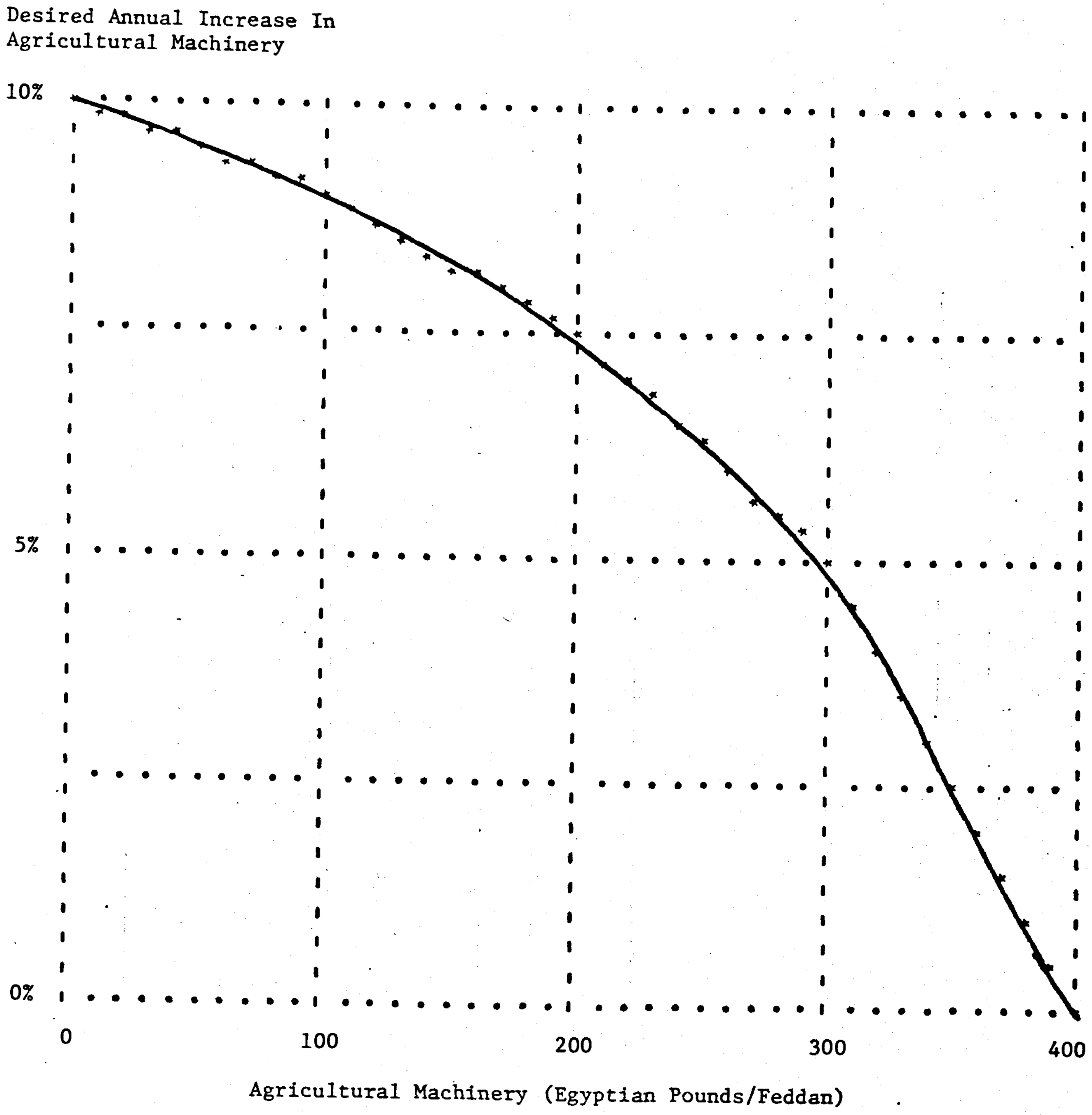
The capital requested for agriculture (AGR) is largely determined by the desired annual change in agricultural capital (AGDAC). The calculation of this desired annual change for agriculture represents a significant departure from the logic used in ordering capital for industrial sectors of the economy. and combines three separate influences. The first, the target annual change established by the government (AGGAG), is an external input to the model that sets a base 2 1/2% annual growth rate for agricultural capital. This factor could be varied over time to investigate the consequences of a greater government push for mechanization of agriculture. The second factor, the effect of labor availability on agricultural capital (AGELA), accelerates the mechanization of agriculture when a rural labor shortage exists, and slows down the mechanization when there is excess rural labor. The final effect is a balance factor (AGFBF) that prevents excessive mechanization by monitoring the ratio of agricultural capital (AG) to the agricultural land area (AF). As shown in Figure V-16, as the ratio of capital to land area increases, the desired annual change in agricultural capital is reduced.

```
AMN.K=MAX(0,AMR.K-AFCI.K*AFEI.K*AM.K)                    255, A
    AMN     - SHORTFALL IN MOTIVE POWER <255>
    AMR     - MOTIVE POWER REQUESTED <256>
    AFCI    - CROPPING INDEX <213>
    AFEI    - EFFICIENCY INDEX FOR LAND USE <214>
    AM      - MOTIVE POWER AVAILABLE <258>

AMR.K=ARMR.K+ANMR.K+ACMR.K+AOMR.K+AEMR.K                 256, A
    AMR     - MOTIVE POWER REQUESTED <256>
    ARMR    - MOTIVE POWER REQUESTED FOR RICE
    ANMR    - MOTIVE POWER REQUESTED FOR GRAIN
    ACMR    - MOTIVE POWER REQUESTED FOR COTTON
    AOMR    - MOTIVE POWER REQUESTED FOR F&V
    AEMR    - MOTIVE POWER REQUESTED FOR FODDER

AMWR.K=(ARMR.K/ARIM.K)+(ANMR.K/ANIM.K)+(ACMR.K/          257, A
  ACIM.K)+(AOMR.K/AOIM.K)+(AEMR.K/AEIM.K)
    AMWR    - WEIGHTED REQUESTS FOR AGRICULTURAL MOTIVE
                POWER <257>
    ARMR    - MOTIVE POWER REQUESTED FOR RICE
    ARIM    - RICE PRIORITY FOR MOTIVE POWER
    ANMR    - MOTIVE POWER REQUESTED FOR GRAIN
    ANIM    - GRAIN PRIORITY FOR MOTIVE POWER
    ACMR    - MOTIVE POWER REQUESTED FOR COTTON
    ACIM    - COTTON PRIORITY FOR MOTIVE POWER
    AOMR    - MOTIVE POWER REQUESTED FOR F&V
    AOIM    - F&V PRIORITY FOR MOTIVE POWER
    AEMR    - MOTIVE POWER REQUESTED FOR FODDER
    AEIM    - FODDER PRIORITY FOR MOTIVE POWER
```

Figure V-16: Use of Agricultural Machinery



```
AM.K=ADL.K+(AG.K*AEA.K*AGPF.K/AAGSR)                         258, A
AAGSR=2500                                                   258.2, C
    AM      - MOTIVE POWER AVAILABLE <258>
    ADL     - DRAFT LIVESTOCK AVAILABLE <259>
    AG      - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AEA     - ADEQUACY OF ENERGY SUPPLIED TO AGRICULTURE
                <284.1>
    AGPF    - FRACTION OF AGRICULTURE CAPITAL PRODUCTIVE
                <261>
    AAGSR   - ANIMAL/CAPITAL SUBSTITUTION RATIO (POUNDS/
                ANIMAL) <258.2>

ADL.K=ADA.K-ADB.K*ADBLPT                                     259, A
ADBLPT=1                                                     259.2, C
    ADL     - DRAFT LIVESTOCK AVAILABLE <259>
    ADA     - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
    ADB     - DRAFT LIVESTOCK BIRTHS (ANIMALS/YEAR) <308>
    ADBLPT  - PRODUCTIVE TIME LOST FOR DRAFT ANIMAL
                BIRTHS (YEARS/BIRTH) <259.2>

ADR.K=AMR.K-SMOOTH(AG.K*AGPF.K/AAGSR,ADRAT)                  260, A
ADRAT=1                                                      260.2, C
    ADR     - REQUESTED DRAFT ANIMALS <260>
    AMR     - MOTIVE POWER REQUESTED <256>
    AG      - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AGPF    - FRACTION OF AGRICULTURE CAPITAL PRODUCTIVE
                <261>
    AAGSR   - ANIMAL/CAPITAL SUBSTITUTION RATIO (POUNDS/
                ANIMAL) <258.2>
    ADRAT   - AVERAGING TIME FOR REQUESTED DRAFT ANIMALS
                (YEARS) <260.2>

AGPF.K=TABLE(AGPFT,XN.K,0,XNT.K,XNT.K/4)                     261, A
AGPFT=1/.9/.75/.6/.45                                        261.2, T
    AGPF    - FRACTION OF AGRICULTURE CAPITAL PRODUCTIVE
                <261>
    AGPFT   - TABLE FOR FRACTION OF AGRICULTURAL CAPITAL
                PRODUCTIVE <261.2>
    XN      - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                <422>
    XNT     - TOTAL FOREIGN EXCHANGE NEEDS <418>

AG.K=AG.J+(DT)(AGD.J+(AGQ.J/SGXQR.J)-AGW.J)                  262, L
AG=AGI                                                       262.1, N
AGI=316E6                                                    262.3, C
    AG      - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AGD     - DELIVERIES OF CAPITAL GOODS TO AGRICULTURE
                (POUNDS/YEAR) <264>
    AGQ     - IMPORTS OF CAPITAL GOODS FOR AGRICULTURE
                (FOREX/YEAR) <276>
    SGXQR   - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
                <349>
    AGW     - WEAROUT OF AGRICULTURE CAPITAL GOODS
                (POUNDS/YEAR) <263>
    AGI     - INITIAL AGRICULTURAL CAPITAL (POUNDS)***
                INCLUDES IRRIGATION*** <262.3>
```

```
AGW.K=AG.K/AGWL                                                   263, A
AGWL=20                                                           263.2, C
    AGW     - WEAROUT OF AGRICULTURE CAPITAL GOODS
                (POUNDS/YEAR) <263>
    AG      - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AGWL    - LIFETIME FOR AGRICULTURAL CAPITAL (YEARS)
                <263.2>

AGD.K=DELAY3P(AGC.K,POS(AGCT.K),AGUC.K)                           264, A
    AGD     - DELIVERIES OF CAPITAL GOODS TO AGRICULTURE
                (POUNDS/YEAR) <264>
    AGC     - COMMITMENTS OF CAPITAL GOODS TO AGRICULTURE
                (POUNDS/YEAR) <268.1>
    AGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <265.1>
    AGUC    - AGRICULTURAL CAFITAL UNDER CONSTRUCTON

AGCT.K=AGUC.K/AGCA.K                                              265, A
AGCT=SGCTN                                                        265.1, N
    AGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <265.1>
    AGUC    - AGRICULTURAL CAFITAL UNDER CONSTRUCTON
    AGCA    - CONSTRUCTION ACTIVITY FOR SECTOR CAPITAL
                (POUNDS/YEAR) <266>
    SGCTN   - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
                CAPITAL (YEARS) <347.5>

AGCA.K=SHARE(AGCR.K,GPN.K,AIGC.K,GPWR.K,AIN.K)                    266, A
    AGCA    - CONSTRUCTION ACTIVITY FOR SECTOR CAPITAL
                (POUNDS/YEAR) <266>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    AGCR    - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
                (POUNDS/YEAR) <267>
    GPN     - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
    GPWR    - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    AIN     - NORMAL PRIORITY FOR AGRICULTURE <253>

AGCR.K=AGUC.K/SGCTN                                               267, A
    AGCR    - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
                (POUNDS/YEAR) <267>
    AGUC    - AGRICULTURAL CAPITAL UNDER CONSTRUCTON
    SGCTN   - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
                CAPITAL (YEARS) <347.5>
```

```
AGC.K=SHARE(AGO.K,GON.K,AIGO.K,GOWR.K,AIN.K)             268, A
AGC=AGW*SGGFI                                            268.1, N
    AGC    - COMMITMENTS OF CAPITAL GOODS TO AGRICULTURE
               (POUNDS/YEAR) <268.1>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    AGO    - ORDERS PLACED FOR CAPITAL GOODS FOR
               AGRICULTURE (POUNDS/YEAR) <269>
    GON    - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR   - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    AIN    - NORMAL PRIORITY FOR AGRICULTURE <253>
    AGW    - WEAROUT OF AGRICULTURE CAPITAL GOODS
               (POUNDS/YEAR) <263>
    SGGFI  - INITIAL GROWTH FACTOR FOR INDUSTRIAL
               CAPITAL <347.7>

AGO.K=MAX(0,AGW.K+(AGR.K+AGBD.K-(AG.K+AGUC.K+            269, A
  AGQD.K))/SGOT)
    AGO    - ORDERS PLACED FOR CAPITAL GOODS FOR
               AGRICULTURE (POUNDS/YEAR) <269>
    AGW    - WEAROUT OF AGRICULTURE CAPITAL GOODS
               (POUNDS/YEAR) <263>
    AGR    - CAPITAL REQUESTED FOR AGRICULTURE (POUNDS)
               <271>
    AGBD   - DESIRED BACKLOG OF CONSTRUCTION TO REPLACE
               WEAROUT <270>
    AG     - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AGUC   - AGRICULTURAL CAPITAL UNDER CONSTRUCTON
    AGQD   - IMPORTED AGRICULTURAL CAPITAL BEING
               DELIVERED
    SGOT   - ORDERING TIME FOR INDUSTRIAL CAPITAL
               (YEARS) <347.9>

AGBD.K=AGW.K*AGCT.K                                      270, A
    AGBD   - DESIRED BACKLOG OF CONSTRUCTION TO REPLACE
               WEAROUT <270>
    AGW    - WEAROUT OF AGRICULTURE CAPITAL GOODS
               (POUNDS/YEAR) <263>
    AGCT   - CONSTRUCTION TIME FOR SECTOR CAPITAL
               (YEARS) <265.1>

AGR.K=AG.K*(1+AGDAC.K*(AGCT.K+SGOT))                     271, A
    AGR    - CAPITAL REQUESTED FOR AGRICULTURE (POUNDS)
               <271>
    AG     - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AGDAC  - DESIRED ANNUAL CHANGE FOR AGRICULTURAL
               CAPITAL <272>
    AGCT   - CONSTRUCTION TIME FOR SECTOR CAPITAL
               (YEARS) <265.1>
    SGOT   - ORDERING TIME FOR INDUSTRIAL CAPITAL
               (YEARS) <347.9>
```

```
AGDAC.K=AGGAG.K*AGELA.K*AGFBF.K                              272, A
    AGDAC  - DESIRED ANNUAL CHANGE FOR AGRICULTURAL
               CAPITAL <272>
    AGGAG  - BASE ANNUAL CHANGE ADMINISTRED BY
               GOVERNMENT <273>
    AGELA  - EFFECT OF LABOR AVAILABILITY ON
               AGRICULTURAL CAPITAL <274>
    AGFBF  - BALANCE FACTOR FOR CAPITAL/FEDDAN RATIO
               <275>

AGGAG.K=TABLE(AGGAGT,TIME.K,1960,2010,10)                    273, A
AGGAGT=.025/.025/.025/.025/.025/.025                         273.2, T
    AGGAG  - BASE ANNUAL CHANGE ADMINISTRED BY
               GOVERNMENT <273>
    AGGAGT - TABLE FOR GOVERNMENT ADMINISTERED GROWTH
               RATE FOR AGRICULTURAL CAPITAL <273.2>

AGELA.K=TABLE(AGELAT,PRLR.K/FOS(PRLF.K),.5,1.5,.25) 274, A
AGELAT=1.5/1.2/1/.8/.67                                      274.2, T
    AGELA  - EFFECT OF LABOR AVAILABILITY ON
               AGRICULTURAL CAPITAL <274>
    AGELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
               ON AGRICULTURAL CAPITAL <274.2>
    PRLR   - REQUESTED RURAL LABOR <142>
    PRLF   - RURAL LABOR FORCE

AGFBF.K=TABLE(AGFBFT,AG.K/AF.K,0,400,100)                    275, A
AGFBFT=2/1.8/1.5/1/0                                         275.2, T
    AGFBF  - BALANCE FACTOR FOR CAPITAL/FEDDAN RATIO
               <275>
    AGFBFT - TABLE FOR BALANCE FACTOR FOR CAPITAL/FEDDAN
               RATIO <275.2>
    AG     - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AF     - FEDDANS AVAILABLE FOR AGRICULTURE <209>
```

CAPITAL GOODS IMPORTS

```
AGQ.K=DELAY3P(AGQC.K,SGQDT,AGQD.K)                           276, A
    AGQ    - IMPORTS OF CAPITAL GOODS FOR AGRICULTURE
               (FOREX/YEAR) <276>
    AGQC   - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
               AGRICULTURE (FOREX/YEAR) <277.1>
    SGQDT  - DELIVERY TIME FOR IMPORTED CAPITAL (YEARS)
               <348.2>
    AGQD   - IMPORTED AGRICULTURAL CAPITAL BEING
               DELIVERED
```

```
AGQC.K=SHARE(AGQO.K,GXN.K,AIG.K,GXWR.K,AIN.K)          277, A
AGQC=AGGCI                                              277.1, N
AGGCI=0                                                 277.3, C
    AGQC    - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
                AGRICULTURE (FOREX/YEAR) <277.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    AGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR
                AGRICULTURE (FOREX/YEAR) <278>
    GXN     - SHORTFALL IN FOREIGN EXCHANGE FOR IMPORTING
                CAPITAL (FOREX/YEAR) <377>
    GXWR    - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <379>
    AIN     - NORMAL PRIORITY FOR AGRICULTURE <253>
    AGGCI   - INITIAL AGRICULTURAL CAPITAL IMPORTS
                <277.3>

AGQO.K=(AGQOS.K+AGQOT.K)*SGXQR.K*QEXA.K                 278, A
    AGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR
                AGRICULTURE (FOREX/YEAR) <278>
    AGGOS   - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
                FOR DOMESTIC SHORTFALL <279>
    AGQOT   - CAPITAL GOODS IMPORT ORDERS TO ABSORB NEW
                TECHNOLOGY <280>
    SGXQR   - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
                <349>
    QEXA    - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                REQUESTS FOR IMPORTS <486>

AGQOS.K=SMOOTH(AGQOSF*(AGO.K-AGC.K),SGQOAT)             279, A
AGQOSF=.01                                              279.2, C
    AGGOS   - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
                FOR DOMESTIC SHORTFALL <279>
    AGQOSF  - FRACTION OF DOMESTIC AGRICULTURAL CAPITAL
                SHORTFALL ORDERED FOR IMPORT <279.2>
    AGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                AGRICULTURE (POUNDS/YEAR) <269>
    AGC     - COMMITMENTS OF CAPITAL GOODS TO AGRICULTURE
                (POUNDS/YEAR) <268.1>
    SGQOAT  - TIME TO ADJUST IMPORT ORDERS TO DOMESTIC
                SHORTFALL (YEARS) <348.4>

AGQOT.K=AGW.K*TABLE(AGQOTT,TIME.K,1960,2010,10)         280, A
AGQOTT=.1/.1/.1/.1/.1/.1                                280.2, T
    AGQOT   - CAPITAL GOODS IMPORT ORDERS TO ABSORB NEW
                TECHNOLOGY <280>
    AGW     - WEAROUT OF AGRICULTURE CAPITAL GOODS
                (POUNDS/YEAR) <263>
    AGQOTT  - TABLE FOR AGRICULTURAL CAPITAL GOODS ORDERS
                TO ABSORB NEW TECHNOLOGY <280.2>
```

Transportation and Energy -- The model's treatments of transportatio and energy for agriculture are quite similar. For both production factors, an adequacy calculation is made by comparing factor availability (AT, AE) with factor requirements (ATR, AER). The total agricultural requirement for transportation is determined by summing the transportation requirements of the individual crops. The requirements for energy are determined from the total stock of capital goods in agriculture (AG) and a conversion factor (AEGRN) that represents the average per unit of capital equipment.[23] The supply of transportation (AT) and energy (AE) for agriculture is governed by the model's resource allocation logic.

```
ATA.K=AT.K/ATR.K                                      281, A
ATA=1                                                 281.1, N
    ATA    - ADEQUACY OF TRANSPORTATION SUPPLIED TO
               AGRICULTURE <281.1>
    AT     - TRANSPORTATION SUPPLIED TO AGRICULTURE
               <283>
    ATR    - TRANSPORTATION REQUIRED (TONNE-MILES/
               SEASON) <5>

ATR.K=ANTR.K+ARTR.K+ACTR.K+ACTR.K+AETR.K              282, A
    ATR    - TRANSPORTATION REQUIRED (TONNE-MILES/
               SEASON) <5>
    ANTR   - TRANSPORTATION REQUIRED FOR GRAIN
    ARTR   - TRANSPORTATION REQUIRED FOR RICE
    ACTR   - TRANSPORTATION REQUIRED FOR COTTON
    ACTR   - TRANSPORTATION REQUIRED FOR F&V
    AETR   - TRANSPORTATION REQUIRED FOR FODDER

AT.K=SHARE(ATR.K,TPN.K,AIT.K,TWR.K,AIN.K)             283, A
    AT     - TRANSPORTATION SUPPLIED TO AGRICULTURE
               <283>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    ATR    - TRANSPORTATION REQUIRED (TONNE-MILES/
               SEASON) <5>
    TPN    - SHORTFALL IN PRODUCTION OF TRANSPORTATION
    TWR    - WEIGHTED REQUESTS FOR TRANSPORTATION <402>
    AIN    - NORMAL PRIORITY FOR AGRICULTURE <253>
```

```
AEA.K=AE.K/AER.K                                          284, A
AEA=1                                                     284.1, N
    AEA     - ADEQUACY OF ENERGY SUPPLIED TO AGRICULTURE
                <284.1>
    AE      - ENERGY SUPPLIED TO AGRICULTURE (KWH/YEAR)
                <286>
    AER     - ENERGY REQUIRED FOR AGRICULTURE (KWH/YEAR)
                <285>

AER.K=AG.K*AEGRN                                          285, A
AEGRN=AEI/AGI                                             285.2, N
AEI=209E6                                                 285.4, C
    AER     - ENERGY REQUIRED FOR AGRICULTURE (KWH/YEAR)
                <285>
    AG      - AGRICULTURE CAPITAL GOODS (POUNDS) <262.1>
    AEGRN   - NORMAL ENERGY/CAPITAL RATIO FOR AGRICULTURE
                <285.2>
    AEI     - INITIAL ENERGY SUPPLIED TO AGRICULTURE
                (KWH/YEAR) <285.4>
    AGI     - INITIAL AGRICULTURAL CAPITAL (POUNDS)***
                INCLUDES IRRIGATION*** <262.3>


AE.K=SHARE(AER.K,EPN.K,AIE.K,EWR.K,AIN.K)                 286, A
    AE      - ENERGY SUPPLIED TO AGRICULTURE (KWH/YEAR)
                <286>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    AER     - ENERGY REQUIRED FOR AGRICULTURE (KWH/YEAR)
                <285>
    EPN     - SHORTFALL IN PRODUCTION OF ENERGY
    EWR     - WEIGHTED REQUESTS FOR ENERGY <385>
    AIN     - NORMAL PRIORITY FOR AGRICULTURE <253>
```

V-C. New Valley

An important Egyptian agricultural resource is the potentially arable land of the New Valley region West of the Nile River. The separation of these lands from the underground Nile water system protects them, at least initially, from the water-logging and salinity that affects much of Egypt's current agriculture. In addition, the New Valley lands are accessible to a large, new source of water -- the Nubianaquifer.

The question for reclamation of New Valley lands are similar in most respects to the equations for Nile Valley reclamation described in Section V-B. The major exception is the assumed higher cost of reclamation in the New Valley (NFGR): 600 pounds per feddan, as opposed to 400 pounds in the Nile Valley. The +50% differential reflects the costs of digging wells to being underground water to the surface and the greater infrastructure investment requried to provide access to the distant lands.

```
NF.K=NFE.K+NFID.K*NFPF                                      287, A
NFPF=.4                                                     287.2, C
    NF      - PRODUCTIVE FEDDANS IN NEW VALLEY REGIONS
                <287>
    NFE     - ESTABLISHED ARABLE NEW VALLEY FEDDANS
                <288.1>
    NFID    - ARABLE NEW VALLEY FEDDANS BEING DEVELOPED
                <290.1>
    NFPF    - PRODUCTION FACTOR FOR NEW VALLEY LAND IN
                DEVELOPMENT <287.2>

NFE.K=NFE.J+(DT)*(NFER.J)                                   288, L
NFE=0                                                       288.1, N
    NFE     - ESTABLISHED ARABLE NEW VALLEY FEDDANS
                <288.1>
    NFER    - RATE FOR ESTABLISHED ARABLE NEW VALLEY
                FEDDANS <289>

NFER.K=NFID.K/NFTP                                          289, A
NFTP=6                                                      289.2, C
    NFER    - RATE FOR ESTABLISHED ARABLE NEW VALLEY
                FEDDANS <289>
    NFID    - ARABLE NEW VALLEY FEDDANS BEING DEVELOPED
                <290.1>
    NFTP    - TIME TO DEVELOP RECLAIMED NEW VALLEY
                FEDDANS (YEARS) <289.2>
```

```
NFID.K=NFID.J+(DT)(NFRA.J-NFER.J)                      290, L
NFID=0                                                  290.1, N
    NFID   - ARABLE NEW VALLEY FEDDANS BEING DEVELOPED
               <290.1>
    NFRA   - RECLAMATION OF NEW VALLEY FEDDANS FOR
               AGRICULTURE <291>
    NFER   - RATE FOR ESTABLISHED ARABLE NEW VALLEY
               FEDDANS <289>

NFRA.K=NFGD.K/NFGR                                      291, A
NFGR=600                                                291.2, C
    NFRA   - RECLAMATION OF NEW VALLEY FEDDANS FOR
               AGRICULTURE <291>
    NFGD   - COMPLETION OF INVESTMENT FOR RECLAMATION
               <292>
    NFGR   - INVESTMENT REQUIRED FOR NEW VALLEY
               RECLAMATION (POUNDS/FEDDAN) <291.2>

NFGD.K=DELAY3P(NFGC.K,NFGRT.K,NFGIP.K)                 292, A
    NFGD   - COMPLETION OF INVESTMENT FOR RECLAMATION
               <292>
    NFGRT  - TIME FOR COMPLETION OF RECLAMATION PROJECTS
               <293.1>
    NFGIP  - NEW VALLEY LAND RECLAMATION IN PROGRESS
               (FEDDANS)

NFGRT.K=POS(NFGIP.K)/POS(NFGCA.K)                      293, A
NFGRT=NFGRTN                                            293.1, N
    NFGRT  - TIME FOR COMPLETION OF RECLAMATION PROJECTS
               <293.1>
    NFGIP  - NEW VALLEY LAND RECLAMATION IN PROGRESS
               (FEDDANS)
    NFGCA  - ACTIVITY FOR NEW VALLEY RECLAMATION <294>
    NFGRTN - TIME TP RECLAIM NEW VALLEY LAND (YEARS)
               <295.2>

NFGCA.K=SHARE(NFGCR.K,GPN.K,NFIGC.K,GPWR.K,AIN.K)      294, A
    NFGCA  - ACTIVITY FOR NEW VALLEY RECLAMATION <294>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    NFGCR  - ACTIVITY REQUESTED FOR NEW VALLEY
               RECLAMATION <295>
    GPN    - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
    GPWR   - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    AIN    - NORMAL PRIORITY FOR AGRICULTURE <253>

NFGCR.K=NFGIP.K/NFGRTN                                  295, A
NFGRTN=1                                                295.2, C
    NFGCR  - ACTIVITY REQUESTED FOR NEW VALLEY
               RECLAMATION <295>
    NFGIP  - NEW VALLEY LAND RECLAMATION IN PROGRESS
               (FEDDANS)
    NFGRTN - TIME TP RECLAIM NEW VALLEY LAND (YEARS)
               <295.2>
```

```
NFGC.K=SHARE(NFGO.K,GON.K,NFIGO.K,GOWR.K,AIN.K)         296, A
NFGC=NFGO                                                296.1, N
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    NFGO    - DESIRED NEW VALLEY RECLAMATION ACTIVITY
                INVESTMENT COMMITMENT TO NEW VALLEY
                RECLAMATION <297>
    GON     - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR    - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    AIN     - NORMAL PRIORITY FOR AGRICULTURE <253>

NFGO.K=FIFGE(NFGO1.K,NFGO2.K,AFGSW,1)                    297, A
    NFGO    - DESIRED NEW VALLEY RECLAMATION ACTIVITY
                INVESTMENT COMMITMENT TO NEW VALLEY
                RECLAMATION <297>
    NFGO1   - ORDERS FOR INVESTMENT IN NEW VALLEY
                RECLAMATION (POUNDS/YEAR) <298>
    NFGO2   - DESIRED NEW VALLEY RECLAMATION ACTIVITY
                <299>
    AFGSW   - SWITCH FOR TESTING DESIRED RECLAMATION
                ACTIVITY <225.2>

NFGO1.K=TABHL(NFGO1T,TIME.K,1980,2010,5)*1E3*NFGR        298, A
NFGO1T=0/0/0/0/0/0/0                                     298.2, T
    NFGO1   - ORDERS FOR INVESTMENT IN NEW VALLEY
                RECLAMATION (POUNDS/YEAR) <298>
    NFGO1T  - TABLE FOR INVESTMENT RECLAMATION ORDERS
                <298.2>
    NFGR    - INVESTMENT REQUIRED FOR NEW VALLEY
                RECLAMATION (POUNDS/FEDDAN) <291.2>

NFGO2.K=FIFGE(0,NFGO2C,1980,TIME.K)*1E3*NFGR             299, A
NFGO2C=30                                                299.2, C
    NFGO2   - DESIRED NEW VALLEY RECLAMATION ACTIVITY
                <299>
    NFGO2C  - CONSTANT FOR DESIRED NEW VALLEY RECLAMATION
                ACTIVITY <299.2>
    NFGR    - INVESTMENT REQUIRED FOR NEW VALLEY
                RECLAMATION (POUNDS/FEDDAN) <291.2>
```

V-D. LIVESTOCK

The Egypt model distinguishes between two different classifications of livestock. The first is draft livestock, including cattle, water buffalo, horses, donkeys, and other beasts of burden who are capable of supplying motive power to agriculture. In addition, draft livestock are also an important source of meat products. The second classification is food livestock. This category embraces goats, sheep, chickens, and any other major animal types who can supply food, but no agricultural motive power.

The model's treatment of livestock populations superficially resembles the treatment of human populations. For both draft livestock and food livestock, the model distinguishes between two different age groups -- immature or non-productive animals, and adult or productive animals. A maturation flow links the two age groups, and birth and death rates for both livestock types are calculated internally. The equations for each of the two types will be discussed in turn.

Draft Livestock -- The number of draft livestock (AD) is the sum of the number of immature draft animals (ADI) and adult draft animals (ADA). Maturation (ADM) from the immature to adult draft animal stocks is governed by an assumed five-year maturation time (ADMT). The initial, 1960 herd sizes are assumed to be 1.5 million immature draft animals (ADII) and 2.5 million adult draft animals (ADAI).[24]

Deaths of adult draft animals (ADAD) are determined by the normal productive lifetime for draft animals (ADPLN, assumed to be 7.5 years) and the effect of fodder available (ADADEE). As shown in Figure V-17, adequate or near adequate supplies of fodder (ADE) maintain the productive lifetime for draft animals near its normal value. A serious failure to meet fodder requirements (ADER), however, will have a severe effect on the lifetime of draft livestock. Immature draft livestock deaths (ADID) are also influenced by fodder availability. The lower the ratio of fodder available to fodder required, the greater is the annual death rate for immature draft animals (ADIDR).

```
   DRAFT LIVESTOCK

AD.K=ADI.K+ADA.K                                          300, A
     AD      - DRAFT LIVESTOCK (ANIMALS) <300>
     ADI     - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
     ADA     - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>

ADA.K=ADA.J+(DT)(ADM.J-ADAD.J)                            301, L
ADA=ADAI                                                  301.1, N
ADAI=2.5E6                                                301.3, C
     ADA     - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
     ADM     - DRAFT LIVESTOCK MATURATION (ANIMALS/YEAR)
                 <304>
     ADAD    - ADULT DRAFT LIVESTOCK DEATHS (ANIMALS/YEAR)
                 <302>
     ADAI    - INITIAL ADULT DRAFT ANIMALS <301.3>

ADAD.K=ADA.K/(ADPLN*ADADEE.K)                             302, A
ADPLN=7.5                                                 302.2, C
```

```
        ADAD    - ADULT DRAFT LIVESTOCK DEATHS (ANIMALS/YEAR)
                    <302>
        ADA     - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
        ADPLN   - NORMAL PRODUCTIVE LIFETIME (YEARS) FOR
                    DRAFT ANIMALS <302.2>
        ADADEE - EFFECT OF FODDER SUPPLY ON DRAFT LIVESTOCK
                    DEATHS <303>

ADADEE.K=TABLE(ADADEET,ADE.K/ADER.K,0,1,.25)                  303, A
ADADEET=0/.5/.75/.95/1                                        303.2, T
        ADADEE - EFFECT OF FODDER SUPPLY ON DRAFT LIVESTOCK
                    DEATHS <303>
        ADADEET- TABLE FOR THE EFFECT OF FODDER SUPPLY ON
                    DRAFT ANIMAL DEATHS <303.2>
        ADE     - FODDER FOR DRAFT ANIMALS (TONNES/YEAR)
                    <313>
        ADER    - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
                    YEAR) <314>

ADM.K=ADI.K/ADMT                                              304, A
ADMT=5                                                        304.2, C
        ADM     - DRAFT LIVESTOCK MATURATION (ANIMALS/YEAR)
                    <304>
        ADI     - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
        ADMT    - DRAFT LIVESTOCK MATURATION TIME (YEARS)
                    <304.2>

ADI.K=ADI.J+(DT)(ADB.J-ADM.J-ADID.J)                          305, L
ADI=ADII                                                      305.1, N
ADII=1.5E6                                                    305.3, C
        ADI     - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
        ADB     - DRAFT LIVESTOCK BIRTHS (ANIMALS/YEAR) <308>
        ADM     - DRAFT LIVESTOCK MATURATION (ANIMALS/YEAR)
                    <304>
        ADID    - IMMATURE DRAFT LIVESTOCK DEATHS <306>
        ADII    - INITIAL IMMATURE DRAFT ANIMALS <305.3>


ADID.K=ADI.K*ADIDR.K                                          306, A
        ADID    - IMMATURE DRAFT LIVESTOCK DEATHS <306>
        ADI     - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
        ADIDR   - NORMAL ANNUAL DEATH RATE FOR IMMATURE DRAFT
                    ANIMALS <307>

ADIDR.K=TABLE(ADIDRT,ADE.K/ADER.K,0,1,.25)                    307, A
ADIDRT=1/.6/.3/.15/.02                                        307.2, T
        ADIDR   - NORMAL ANNUAL DEATH RATE FOR IMMATURE DRAFT
                    ANIMALS <307>
        ADIDRT - TABLE FOR IMMATURE DRAFT ANIMAL DEATH RATE
                    <307.2>
        ADE     - FODDER FOR DRAFT ANIMALS (TONNES/YEAR)
                    <313>
        ADER    - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
                    YEAR) <314>
```

Draft livestock births (ADB) are the smaller of the maximum possible draft livestock births (ADBM) and desired draft livestock births (ADBD). The maximum possible births are determined from the total adult population (ADA) and an assumption that no more than 25% (ADBF) of this herd is capable of bearing young animals (the remaining adults being either males or females too old to reproduce). Desired draft livestock births are based on the need to replace deaths of adult draft animals (ADAD) and immature draft animals (ADID). This base rate will be adjusted, however, to reflect the effects of fodder availability (ADBDEE) and the effect of changing requirements for draft animals (ADBDRE). The effect of fodder availability on desired births is to reduce desired births below the replacement level under conditions of extreme fodder shortage. This would conserve fodder supplies for animals already alive and productive. The effect of changing draft animal requirements is to boost the desired birth rate above the replacement rate if a larger draft animal herd (ADA) is necessary to meet the requirements (ADR) determined by the motive power needs of crop agriculture.

Fodder available for draft animals (ADE) is determined by the fodder required (ADER) and by the model's resource allocation logic. The fodder requirement results from the size of the immature and adult draft animal populations, and an estimated 4.4 metric tonne annual fodder requirement per immature draft animal (ADIEN) and 8.8 metric tonne requirement per adult draft animal (ADAEN).[25]

As mentioned in Section V-B, organic materials are an important source of nutrients for Egyptian crop agriculture. An important source of these organic materials is the manure produced by draft livestock (ADU), which is calculated in the model from the size of the immature and adult draft animal herds. It is assumed that 1.5 tonne of manure per year is produced by each immature draft animal (ADIUN) and that 7.0 tonne per year is produced by each adult draft animals (ADAUN).[26] Not all of the manure produced is actually used. The model includes a variable for the fraction of the manure which is recovered; this fraction can be varied over time to investigate the consequences of changes in the way Egypt handles organic wastes. The base assumption is that 45% of the manure produced by draft livestock in Egypt is recovered, processed, and applied to the fields.[27]

```
ADB.K=MIN(ADBM.K,ADBD.K)                                         308, A
    ADB      - DRAFT LIVESTOCK BIRTHS (ANIMALS/YEAR) <308>
    MIN      - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    ADBM     - MAXIMUM POSSIBLE DRAFT LIVESTOCK BIRTHS
                 <309>
    ADBD     - DESIRED DRAFT LIVESTOCK BIRTHS <310>

ADBM.K=ADA.K*ADBF                                                309, A
ADBF=.25                                                         309.2, C
    ADBM     - MAXIMUM POSSIBLE DRAFT LIVESTOCK BIRTHS
                 <309>
    ADA      - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
    ADBF     - MAXIMUM BREEDING FRACTION FOR DRAFT ANIMAL
                 BIRTHS <309.2>

ADBD.K=(ADAD.K+ADID.K)*ADBDEE.K*ADBDRE.K                         310, A
    ADBD     - DESIRED DRAFT LIVESTOCK BIRTHS <310>
    ADAD     - ADULT DRAFT LIVESTOCK DEATHS (ANIMALS/YEAR)
                 <302>
    ADID     - IMMATURE DRAFT LIVESTOCK DEATHS <306>
    ADBDEE   - EFFECT OF FODDER AVAILABILITY ON DESIRED
                 DRAFT ANIMAL BIRTHS <311>
    ADBDRE   - EFFECT OF REQUIREMENTS ON DESIRED DRAFT
                 ANIMAL BIRTHS <312>

ADBDEE.K=TABLE(ADBDEET,ADE.K/ADER.K,0,1,.25)                     311, A
ADBDEET=0/.4/.7/.9/1                                             311.2, T
    ADBDEE   - EFFECT OF FODDER AVAILABILITY ON DESIRED
                 DRAFT ANIMAL BIRTHS <311>
    ADBDEET  - TABLE FOR THE EFFECT OF FODDER AVAILABILITY
                 ON DESIRED DRAFT ANIMAL BIRTHS <311.2>
    ADE      - FODDER FOR DRAFT ANIMALS (TONNES/YEAR)
                 <313>
    ADER     - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
                 YEAR) <314>
```

```
ADBORE.K=TABLE(ADBORET,ADR.K/ADA.K,.8,1.2,.1)       312, A
ADBORET=.5/.8/1/1.25/2                              312.2, T
    ADBORE - EFFECT OF REQUIREMENTS ON DESIRED DRAFT
               ANIMAL BIRTHS <312>
    ADBORET- TABLE FOR THE EFFECT OF REQUIREMENTS ON
               DESIRED DRAFT ANIMAL BIRTHS <312.2>
    ADR    - REQUESTED DRAFT ANIMALS <260>
    ADA    - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>

ADE.K=SHARE(ADER.K,AEPN.K,ADIE.K,AEWR.K,ADIN)       313, A
ADIN=.1                                             313.2, C
    ADE    - FODDER FOR DRAFT ANIMALS (TONNES/YEAR)
               <313>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    ADER   - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
               YEAR) <314>
    AEPN   - SHORTFALL IN PRODUCTION OF FODDER
    AEWR   - WEIGHTED REQUESTS FOR FODDER PRODUCTION
               <205>
    ADIN   - NORMAL PRIORITY FOR DRAFT ANIMALS <313.2>

ADER.K=ADI.K*ADIEN+ADA.K*ADAEN                      314, A
ADIEN=4.8                                           314.2, C
ADAEN=9.7                                           314.4, C
    ADER   - FODDER REQUESTED FOR DRAFT ANIMALS (TONNES/
               YEAR) <314>
    ADI    - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
    ADIEN  - NORMAL FODDER CONSUMPTION BY IMMATURE DRAFT
               ANIMALS (TONNES/YEAR) <314.2>
    ADA    - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
    ADAEN  - NORMAL FODDER CONSUMPTION BY MATURE DRAFT
               ANIMALS (TONNES/YEAR) <314.4>

ADU.K=(ADI.K*ADIUN+ADA.K*ADAUN)*AUFR.K              315, A
ADIUN=1.5                                           315.2, C
ADAUN=7                                             315.4, C
    ADU    - MANURE PRODUCED BY DRAFT LIVESTOCK <315>
    ADI    - IMMATURE DRAFT ANIMALS (ANIMALS) <305.1>
    ADIUN  - NORMAL MANURE PRODUCTION BY IMMATURE DRAFT
               ANIMALS (TONNES/YEAR) <315.2>
    ADA    - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
    ADAUN  - NORMAL MANURE PRODUCTION BY ADULT DRAFT
               ANIMALS (TONNES/YEAR) <315.4>
    AUFR   - MANURE FRACTION RECOVERED <316>

AUFR.K=TABLE(AUFRT,TIME.K,1960,2010,10)             316, A
AUFRT=.45/.45/.45/.45/.45/.45                       316.2, T
    AUFR   - MANURE FRACTION RECOVERED <316>
    AUFRT  - TABLE FOR MANURE FRACTION RECOVERED <316.2>
```

Food Livestock -- The food livestock herd (AB) is also divided into immature animals (ADI) and adult animals (ADA). The initial, 1960 herd size is estimated at 1,500,000 adult food livestock (ADAI) and 600,000 immature food livestock (ADII).[28] The equations describing the food livestock population are quite similar to the equations for the draft livestock population, and only the most significant differences will be noted here.

Because many of the immature draft animals are destined for slaughter, rather than a productive lifetime as adults, the maturation flow into the adult food livestock population is the maturation flow out of the immature population (ABM) reduced by the fraction of maturing animals that are slaughtered (ABSF). This slaughter fraction also figures in the calculation of desired food livestock births (ABBD), since the animals which are slaughtered (ABS) must be replaced with new births.

The total food production from livestock (ALFP) is a combination of the food production from food livestock and the food production from draft livestock. The production from food livestock includes: 1) the food produced from the slaughter of immature food livestock (ALFPM); 2) the slaughters of adult food livestock that have passed their productive breeding time (ABAD); and 3) the production from live adult animals, which primarily comprises milk (combined in ALFPA). Similarly, food production from draft animals includes the recovery of meat from slaughtered animals and milk from adult draft animals (ALFPD).

Like the crop agriculture sector of the model, the food livestock sector includes a calculation of the adequacy of meat production, as compared with meat requirements. The model calculates the desired annual change in livestock food production (ALFDAC) necessary to close any gap between supply

(ALFP) and the urban (PUMR) and rural (PRMR) meat requirements. This desired annual change in livestock food production is instrumental in determining the desired food livestock births (ABBD).

```
  FOOD LIVESTOCK

AB.K=ABI.K+ABA.K                                          317, A
     AB      - FOOD LIVESTOCK (ANIMALS) <317>
     ABI     - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
     ABA     - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>

ABA.K=ABA.J+(DT)(ABM.J*(1-ABSF.J)-ABAD.J)                 318, L
ABA=ABAI                                                  318.1, N
ABAI=1.5E6                                                318.3, C
     ABA     - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>
     ABM     - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
                 <321>
     ABSF    - SLAUGHTER FRACTION FOR IMMATURE FOOD
                 LIVESTOCK <336>
     ABAD    - ADULT FOOD LIVESTOCK DEATHS (ANIMALS/YEAR)
                 <319>
     ABAI    - INITIAL ADULT FOOD LIVESTOCK <318.3>

ABAD.K=ABA.K/(ABPLN*ABADEE.K)                             319, A
ABPLN=2.5                                                 319.2, C
     ABAD    - ADULT FOOD LIVESTOCK DEATHS (ANIMALS/YEAR)
                 <319>
     ABA     - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>
     ABPLN   - NORMAL PRODUCTIVE LIFETIME FOR FOOD
                 LIVESTOCK (YEARS) <319.2>
     ABADEE  - EFFECT OF FODDER SUPPLY ON FOOD LIVESTOCK
                 DEATHS <320>

ABADEE.K=TABLE(ABADEET,ABE.K/ABER.K,0,1,.25)              320, A
ABADEET=0/.5/.75/.95/1                                    320.2, T
     ABADEE  - EFFECT OF FODDER SUPPLY ON FOOD LIVESTOCK
                 DEATHS <320>
     ABADEET- TABLE FOR THE EFFECT OF FODDER SUPPLY ON
                 FOOD LIVESTOCK DEATHS <320.2>
     ABE     - FODDER FOR FOOD ANIMALS (TONNES/YEAR) <331>
     ABER    - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
                 YEAR) <332>

ABM.K=ABI.K/ABMT                                          321, A
ABMT=1                                                    321.2, C
     ABM     - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
                 <321>
     ABI     - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
     ABMT    - MATURATION TIME FOR FOOD LIVESTOCK (YEARS)
                 <321.2>
```

```
ABI.K=    I.J+(DT)(ABB.J-ABM.J-ABID.J)                  322, L
ABI=A                                                   322.1, N
ABII=.                                                  322.3, C
   A
   AB       - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
   AB       - FOOD LIVESTOCK BIRTHS (ANIMALS/YEAR) <325>
            - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
                 <321>
   AB       - IMMATURE FOOD LIVESTOCK DEATHS <323>
   AB       - INITIAL IMMATURE DRAFT LIVESTOCK <322.3>
ABID.K    ABI.K*ABIDR.K                                 323, A
   AB
   AB       - IMMATURE FOOD LIVESTOCK DEATHS <323>
   AB       - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
            - NORMAL DEATH RATE FOR IMMATURE FOOD
                 LIVESTOCK <324>


ABIDR.K   TABLE(ABIDRT,ABE.K/ABER.K,0,1,.25)           324, A
ABIDRT=    .6/.3/.15/.05                               324.2, T
  ABI
            - NORMAL DEATH RATE FOR IMMATURE FOOD
   ABI           LIVESTOCK <324>
         RT - TABLE FOR IMMATURE FOOD ANIMAL DEATH RATE
   ABE           <324.2>
   ABE      - FODDER FOR FOOD ANIMALS (TONNES/YEAR) <331>
            - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
                 YEAR) <332>
ABB.K=M
  -ABB    N(ABBM.K,ABBD.K)                              325, A
   MIN      - FOOD LIVESTOCK BIRTHS (ANIMALS/YEAR) <325>
   ABB      - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
            - MAXIMUM POSSIBLE FOOD LIVESTOCK BIRTHS
   ABB           <326>
            - DESIRED FOOD LIVESTOCK BIRTHS <327>
ABBM.K=
ABBF=4     A.K*ABBF                                     326, A
  - ABB.                                                326.2, C
            - MAXIMUM POSSIBLE FOOD LIVESTOCK BIRTHS
   ABA           <326>
   ABB      - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>
            - MAXIMUM BIRTHS PER ADULT FOOD ANIMAL
                 <326.2>
ABBD.K=
 - ABB     S.K*ABBDEE.K*ABBDRE.K                        327, A
   ABS      - DESIRED FOOD LIVESTOCK BIRTHS <327>
   ABB      - SLAUGHTERS FO FOOD LIVESTOCK <330>
            - EFFECT OF FODDER AVAILABILITY ON DESIRED
   ABB           FOOD LIVESTOCK BIRTHS <328>
            - EFFECT OF REQUIREMENTS ON DESIRED FOOD
                 LIVESTOCK BIRTHS <329.1>
```

```
ABBDEE.K=TABLE(ABBDEET,ABE.K/ABER.K,0,1,.25)                   328, A
ABBDEET=0/.4/.7/.9/1                                            328.2, T
    ABBDEE - EFFECT OF FODDER AVAILABILITY ON DESIRED
               FOOD LIVESTOCK BIRTHS <328>
    ABBDEET- TABLE FOR THE EFFECT OF FODDER AVAILABILITY
               ON DESIRED FOOD LIVESTOCK BIRTHS <328.2>
    ABE    - FODDER FOR FOOD ANIMALS (TONNES/YEAR) <331>
    ABER   - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
               YEAR) <332>

ABBDRE.K=TABLE(ABBDRET,ALFDAC.K,-.3,.45,.15)                   329, A
ABBDRE=1                                                        329.1, N
ABBDRET=.75/.9/1/1.1/1.4/2                                      329.3, T
    ABBDRE - EFFECT OF REQUIREMENTS ON DESIRED FOOD
               LIVESTOCK BIRTHS <329.1>
    ABBDRET- TABLE FOR THE EFFECT OF REQUIREMENTS ON
               DESIRED FOOD LIVESTOCK BIRTHS <329.3>
    ALFDAC - DESIRED ANNUAL CHANGE IN LIVESTOCK FOOD
               PRODUCTION <340>


ABS.K=ABAD.K+ABID.K+ABSF.K*ABM.K                                330, A
    ABS    - SLAUGHTERS FO FOOD LIVESTOCK <330>
    ABAD   - ADULT FOOD LIVESTOCK DEATHS (ANIMALS/YEAR)
               <319>
    ABID   - IMMATURE FOOD LIVESTOCK DEATHS <323>
    ABSF   - SLAUGHTER FRACTION FOR IMMATURE FOOD
               LIVESTOCK <336>
    ABM    - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
               <321>

ABE.K=SHARE(ABER.K,AEPN.K,ABIE.K,AEWR.K,ABIN)                   331, A
ABIN=.1                                                         331.2, C
    ABE    - FODDER FOR FOOD ANIMALS (TONNES/YEAR) <331>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    ABER   - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
               YEAR) <332>
    AEPN   - SHORTFALL IN PRODUCTION OF FODDER
    AEWR   - WEIGHTED REQUESTS FOR FODDER PRODUCTION
               <205>
    ABIN   - NORMAL PRIORITY FOR FOOD LIVESTOCK <331.2>

ABER.K=ABI.K*ABIEN+ABA.K*ABAEN                                  332, A
ABIEN=2.4                                                       332.2, C
ABAEN=6.6                                                       332.4, C
    ABER   - FODDER REQUESTED FOR FOOD ANIMALS (TONNES/
               YEAR) <332>
    ABI    - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
    ABIEN  - NORMAL FODDER CONSUMPTION BY IMMATURE FOOD
               ANIMALS (TONNES/YEAR) <332.2>
    ABA    - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>
    ABAEN  - NORMAL FODDER CONSUMPTION BY ADULT FOOD
               ANIMALS (TONNES/YEAR) <332.4>
```

```
ABU.K=(ABI.K*ABIUN+ABA.K*ABAUN)*ALFR.K                      333, A
ABIUN=.75                                                   333.2, C
ABAUN=1.5                                                   333.4, C
    ABU    - MANURE PRODUCED BY FOOD LIVESTOCK <333>
    ABI    - IMMATURE FOOD ANIMALS (ANIMALS) <322.1>
    ABIUN  - NORMAL MANURE PRODUCTION BY IMMATURE FOOD

ALFP.K=ALFPM.K+ALFPA.K+ALFPD.K                              334, A
    ALFP   - FOOD PRODUCTION FROM LIVESTOCK <334>
    ALFPM  - FOOD PRODUCTION FROM IMMATURE FOOD
               LIVESTOCK <335>
    ALFPA  - FOOD PRODUCTION FROM ADULT FOOD LIVESTOCK
               <338>
    ALFPD  - FOOD PRODUCTION FROM DRAFT LIVESTOCK <339>

ALFPM.K=ABM.K*ABSF.K*ABMFPN
ABMFPN=.060                                                 335, A
    ALFPM  - FOOD PRODUCTION FROM IMMATURE FOOD             335.2, C
               LIVESTOCK <335>
    ABM    - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
               <321>
    ABSF   - SLAUGHTER FRACTION FOR IMMATURE FOOD
               LIVESTOCK <336>
    ABMFPN - NORMAL FOOD PRODUCTION FROM SLAUGHTERED
               MATURING FOOD ANIMALS <335.2>

ABSF.K=MAX(1-(ABMD.K/ABM.K),0)
    ABSF   - SLAUGHTER FRACTION FOR IMMATURE FOOD           336, A
               LIVESTOCK <336>
    ABMD   - DESIRED MATURATION RATE FOR FOOD LIVESTOCK
               <337>
    ABM    - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
               <321>

ABMD.K=MAX(ABAD.K*ABBDEE.K*ABBDRE.K,ABM.K)                  337, A
    ABMD   - DESIRED MATURATION RATE FOR FOOD LIVESTOCK
               <337>
    ABAD   - ADULT FOOD LIVESTOCK DEATHS (ANIMALS/YEAR)
               <319>
    ABBDEE - EFFECT OF FODDER AVAILABILITY ON DESIRED
               FOOD LIVESTOCK BIRTHS <328>
    ABBDRE - EFFECT OF REQUIREMENTS ON DESIRED FOOD
               LIVESTOCK BIRTHS <329.1>
    ABM    - FOOD LIVESTOCK MATURATION (ANIMALS/YEAR)
               <321>

ALFPA.K=ABA.K*ABAFPN+ABAD.K*ABSFPN
ABAFPN=.090                                                 338, A
ABSFPN=.060                                                 338.2, C
    ALFPA  - FOOD PRODUCTION FROM ADULT FOOD LIVESTOCK      338.4, C
               <338>
    ABA    - ADULT FOOD LIVESTOCK (ANIMALS) <318.1>
    ABAFPN - NORMAL FOOD PRODUCTION FROM ADULT FOOD
               DRAFT ANIMAL (TONNES/YEAR) <338.2>
    AB D   - ADULT FOOD LIVESTOCK DEATHS (ANIMALS/YEAR)
               <319>
    ABSFPN - NORMAL FOOD PRODUCTION FROM SLAUGHTERED
               ADULT FOOD ANIMAL <338.4>
```

```
ALFPD.K=ADA.K*ADAFPN+ADAD.K*ADSFPN
ADAFPN=.060                                                  339, A
ADSFPN=.120                                                  339.2, C
    ALFPD  - FOOD PRODUCTION FROM DRAFT LIVESTOCK <339>      339.4, C
    ADA    - ADULT DRAFT LIVESTOCK (ANIMALS) <301.1>
    ADAFPN - NORMAL ANNUAL FOOD PRODUCTION FROM ADULT
               DRAFT ANIMALS <339.2>
    ADAD   - ADULT DRAFT LIVESTOCK DEATHS (ANIMALS/YEAR)
               <302>
    ADSFPN - NORMAL MEEAT RECOVERY FROM SLAUGHTERED
               DRAFT ANIMAL (TONNES/ANIMAL) <339.4>


ALFDAC.K=TABLE(ALFDACT,ALFIAC.K,-.1,.3,.1)                   340, A
ALFDACT=-.1/0/.06/.09/.1                                     340.2, T
    ALFDAC - DESIRED ANNUAL CHANGE IN LIVESTOCK FOOD
               PRODUCTION <340>
    ALFDACT- TABLE FOR THE DESIRED ANNUAL CHANGE IN MEAT
               PRODUCTION <340.2>
    ALFIAC - INDICATED ANNUAL CHANGE FOR LIVESTOCK FOOD
               PRODUCTION <341>

ALFIAC.K=SMOOTH(ALFDFC.K/ALFTA,ALFAT)+ALFGI.K                341, A
ALFTA=5                                                      341.2, C
ALFAT=1                                                      341.4, C
    ALFIAC - INDICATED ANNUAL CHANGE FOR LIVESTOCK FOOD
               PRODUCTION <341>
    ALFDFC - DESIRED FRACTIONAL CHANGE IN LIVESTOCK
               PRODUCTION <343>
    ALFTA  - ADJUSTMENT TIME FOR MEAT PRODUCTION (YEARS)
               <341.2>
    ALFAT  - AVERAGING TIME FOR MEAT PRODUCTION (YEARS)
               <341.4>
    ALFGI  - GOVERNMENT INFLUENCE ON MEAT PRODUCTION
               <342>

ALFGI.K=TABLE(ALFGIT,TIME.K,1960,2010,10)                    342, A
ALFGIT=.05/.05/.05/.05/.05/.05                               342.2, T
    ALFGI  - GOVERNMENT INFLUENCE ON MEAT PRODUCTION
               <342>
    ALFGIT - TABLE FOR GOVERNMENT INFLUENCE ON MEAT
               PRODUCTION <342.2>

ALFDFC.K=(PRMR.K+PUMR.K-ALFP.K)/ALFP.K                       343, A
    ALFDFC - DESIRED FRACTIONAL CHANGE IN LIVESTOCK
               PRODUCTION <343>
    PRMR   - REQUESTED RURAL MEAT CONSUMPTION (TONNES/
               YEAR)
    PUMR   - REQUESTED URBAN MEAT CONSUMPTION (TONNES/
               YEAR)
    ALFP   - FOOD PRODUCTION FROM LIVESTOCK <334>

AMPN.K=MAX(PRMR.K+PUMR.K-ALFP.K,0)                           344, A
    AMPN   - SHORTFALL IN MEAT PRODUCTION <344>
    PRMR   - REQUESTED RURAL MEAT CONSUMPTION (TONNES/
               YEAR)
    PUMR   - REQUESTED URBAN MEAT CONSUMPTION (TONNES/
               YEAR)
    ALFP   - FOOD PRODUCTION FROM LIVESTOCK <334>
```

```
AMPWR.K=(PUMR.K/PUIM.K)+(PRMR.K/PRIM.K)                    345, A
    AMPWR  - WEIGHTED REQUESTS FOR MEAT PRODUCTION <345>
    PUMR   - REQUESTED URBAN MEAT CONSUMPTION (TONNES/
               YEAR)
    PUIM   - URBAN PRIORITY FOR MEAT
    PRMR   - REQUESTED RURAL MEAT CONSUMPTION (TONNES/
               YEAR)
    PRIM   - RURAL PRIORITY FOR MEAT
```

VI. INDUSTRIAL ACTIVITY AND FOREIGN TRADE

Consideration of Egypt's overall economic development is a necessary part of any study of the role of water resources in that country's future. The ultimate outcome of a wide range of development strategies, and the resulting need for water of adequate quantity and quality, will depend upon trends in a number of different Egyptian industries, and decisions regarding foreign trade.

Although several categories of Egyptian industrial activity and foreign trade are represented in the simulation model, the detailed accorded to each industrial sector does not compare with the detail accorded to agricultural production. The agricultural sector has direct and close ties with the water sector that require considerable model structure for an adequate representation. In contrast, Egypt's industrial sectors do not have direct links to the water sector of the same importance. Therefore, less model detail is sufficient to determine the consequences for the water sector of various industrial trends.

Part A of this Chapter describes the model's treatment of industrial activity. Part B covers military requirements, and Part C treats foreign trade.

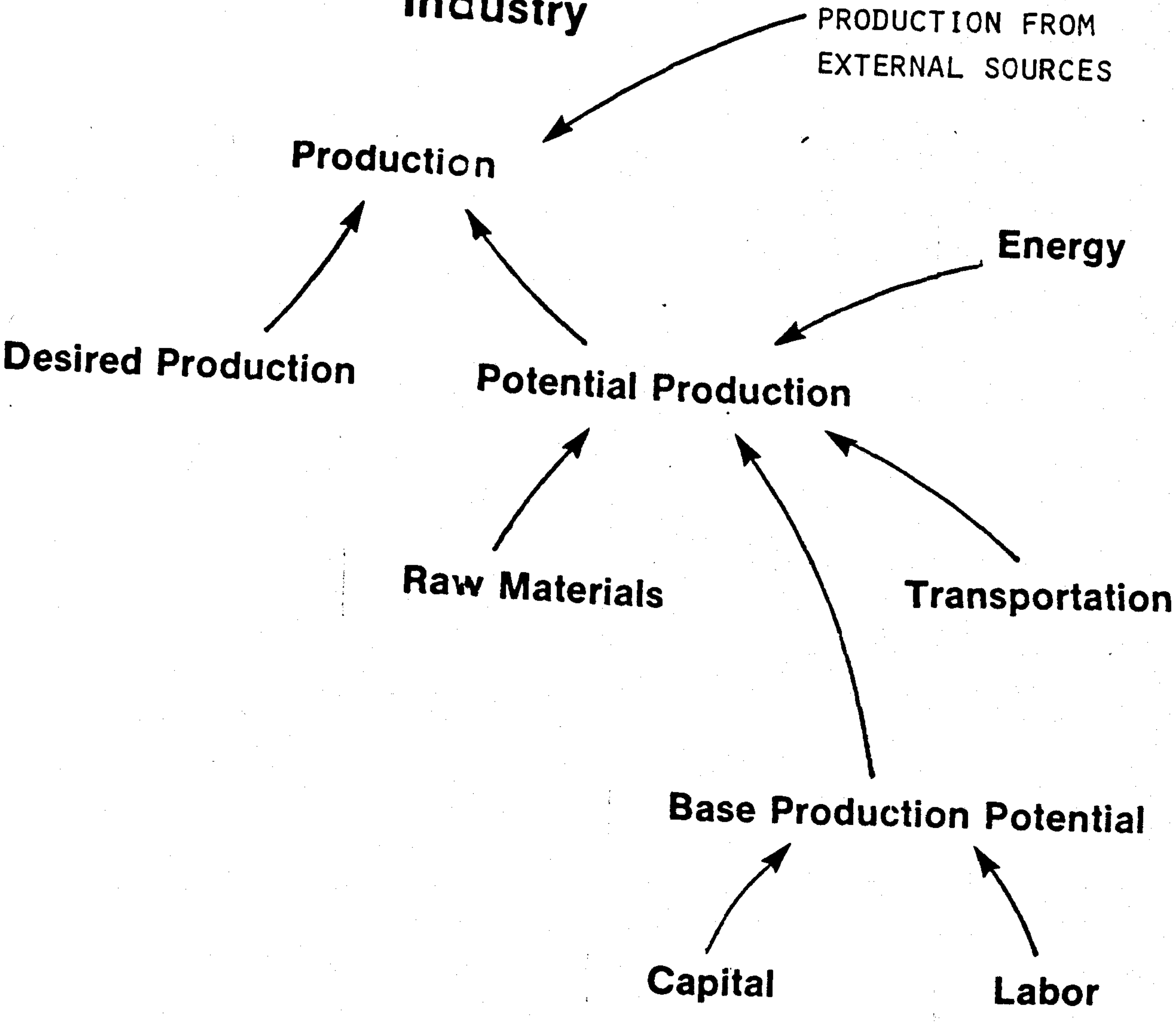
VI-A. INDUSTRIAL ACTIVITY

The most important aspects of production are quite similar for each major industrial sector of Egypt's economy. Figure VI-1 shows a basic model "building block" that is duplicated several times to represent various sectors of Egyptian industry. This building block consists of a very general causal structure for representing industrial production. Each time this generalized structure is used in the model, industry-specific parameters are introduced to, in effect, customer-tailor the building block to reflect conditions in a particular industry.

Referring to Figure VI-1, for each industry production is determined by a comparison of potential production with demand, with production being the smaller of the two quantities. Potential production itself is determined by the sector's base production capacity and the availability of other necessary production factors. The base production capacity for any sector will depend primarily on that sector's existing capital investment, with labor force adequacy being a secondary factor. Three other production factors are included--energy, transportation, and raw materials. Each industrial sector competes for all five production inputs with other industrial sectors of the economy, and with the population sector for certain items (e.g., energy) that the population consumes directly.

Not all industrial sectors require all five inputs. The transportation sector, for instance, is assumed to have no significant raw materials or transportation requirements itself (that is, relative to other sectors which consume most of these resources in the Egyptian economy). The fertilizer sector's labor requirement is small enough relative to the needs of the other sectors

Figure VI-I: Industry



of the economy that it can be ignored. In such circumstances, the model equations for non-essential inputs are de-activated, and have no influence on the sector's production.

The simulation model's explicit industrial sectors include the following: 1) capital goods, 2) consumer goods, 3) energy, 4) transportation and 5) fertilizer. The capital goods sector supplies machinery for all industrial sectors, the agricultural sector, the water sector (e.g., pumps), and for the population itself (houses, schools, etc.). The consumer goods sector competes indirectly for agricultural resources through its use of cotton as a raw material. It also defines the population's material standard of living and serves as a potential source of foreign exchange.[1] The energy sector includes the production of hydro-electric power from the Nile water, and also production from nuclear sources and fossil fuels.[2] The transportation sector provides an important production input to the other industrial sectors and to agriculture; it represents an alternative to moving goods and people via the Nile river system. The domestic fertilizer industry supplies another key production input to the agricultural sector, and is a major consumer of energy. Fertilizer will become increasingly important if other limits to agricultural production are overcome.

In the balance of this section, the specific model equations that represent industrial activity in Egypt are described. As mentioned earlier, a building block was developed that is universal enough to represent any industrial sector of the economy. The differences among producing sectors are represented in parameter values assigned to the replication of the building block for each sector.

For ease of explanation, the industrial building block is divided into four parts. These are production, labor, machinery, and desired production. Each part will be discussed in turn, followed by the pertinent equations from the model.

Production -- The output produced by any of the industrial sectors (OUTPUT) is influenced by six separate considerations: demand for the sector's output, and five production factors: capital investment, labor force, raw materials, energy, and transportation. The potential sector production from capital and labor (SPPGL) establishes a maximum production potential from sector resources. The smaller of potential production and demand (SPR) establishes a production base (SPB) that determines sector requirements for the other three inputs. The ability of the sector to acquire the required amounts of these inputs will determine how much of the production base is actually delivered.

Demand for any sector (SPR) will be determined by the requirements of other industrial sectors, the agricultural sector, or the direct requirements of the urban and rural populations. In addition, foreign trade requirements influence the requested production for Egypt's consumer goods sector.

Potential sector output (SPPGL) is modeled as proportional to the capital goods investment (SG) in place for the sector. A conversion ratio (SPGRN) specifies the normal amount of sector output per unit of capital investment, and, of course, would be different for different sectors. Output in the model is represented in physical units for fertilizer (metric tonnes), transportation (tonne-kilometers), and energy (kilowatt-hours). The units for consumer goods and capital goods are monetary, i.e., Egyptian pounds. The conversion ratios for each sector are presented below.

Normal Sector Output Per Unit of Capital[3]

	Capital Goods	Consumer Goods	Energy	Transportation	Fertilizer
Output/Unit Capital	.96	.90	32	63	.22
Output Units	pounds	pounds	kilowatt hours	tonne-kilometers	tonnes

Labor availability also influences the output per unit of capital investment, and is represented in the model as an index (SPELA) that can vary from zero to one or more. The index specifies the fraction of the output indicated from the sector capital investment that is actually available, given the current sector workforce. If labor is scarce, the index would assume a value less than one; excess labor would yield an index value greater than one, allowing a higher than normal output from the sector capital. The model's calculation of the labor availability index will be described later in this chapter.

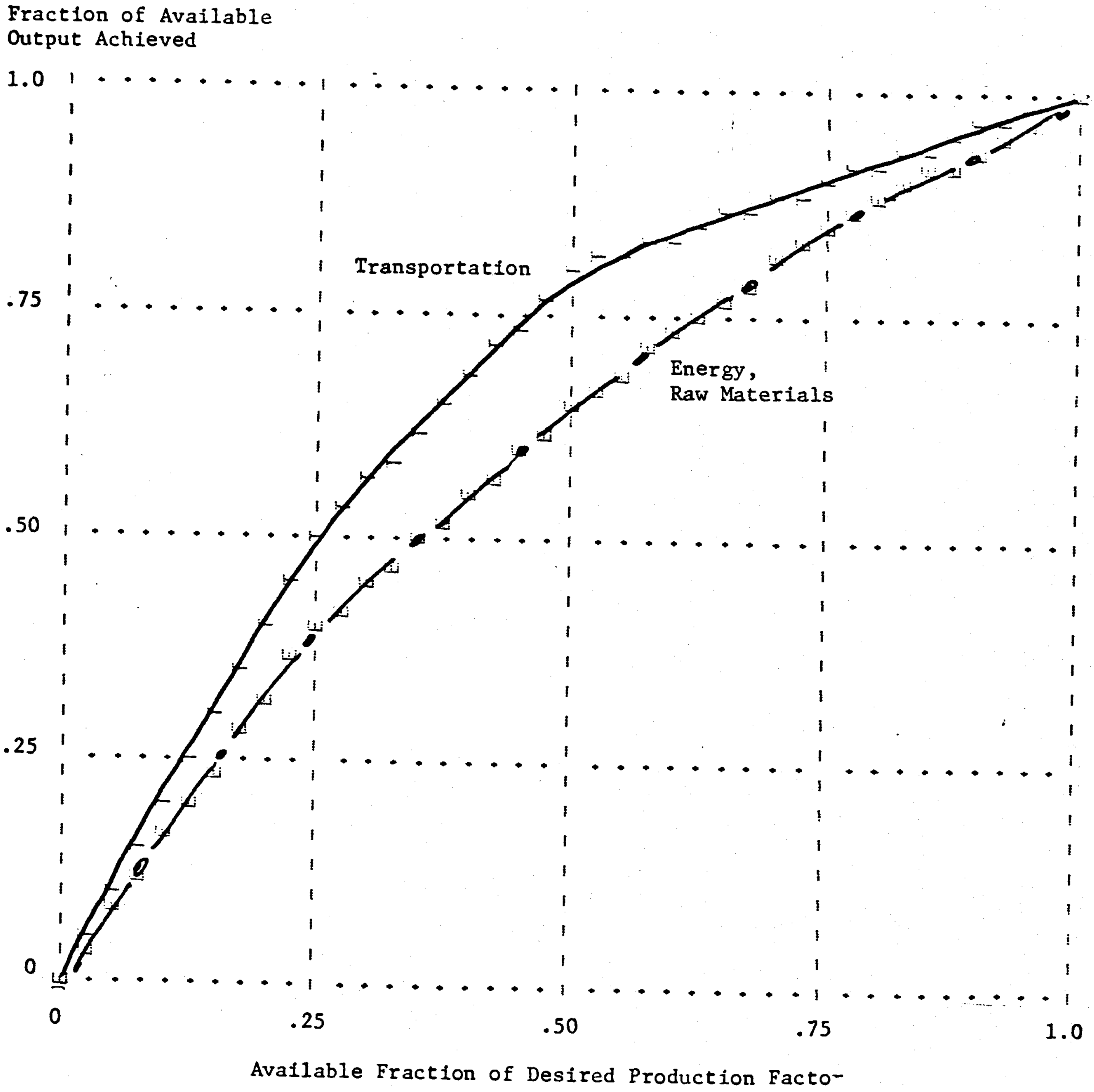
The effects of raw material, energy, and transportation availability on potential sector production are all treated similarly in the model. For each production factor, an availability index is calculated. Like the labor availability index, the other factor availability indices specify the fraction of production that is obtained, relative to the production that would be generated if the particular factor were fully available. Each index is determined from the ratio of factor available (SR for raw materials, SE for energy, ST for transportation) to factor required (SRD, SER, STR), as shown in Figure VI-2.

The availability of the individual production factors is governed by the model's resource allocation logic (see Chapter VII), and the industrial sectors must compete with each other and other sectors of the economy if a short-fall exists for a given commodity. Requirements are primarily based on the sector production base (SPB) and conversion factors specifying the amount of each remaining factor input required per unit of output, as shown below:

Production Factor Requirements

	Capital Goods	Consumer Goods	Energy	Trans.	Fertilizer
Trans/Unit Output[4] (tonne-km)	3.5	2.4	—	—	220
Energy/Unit Capital[5] (kw-hrs)	.68	.68	—	.68	7.4

Figure VI-2:
Effect of Raw Materials, Energy, and Transportation on Production



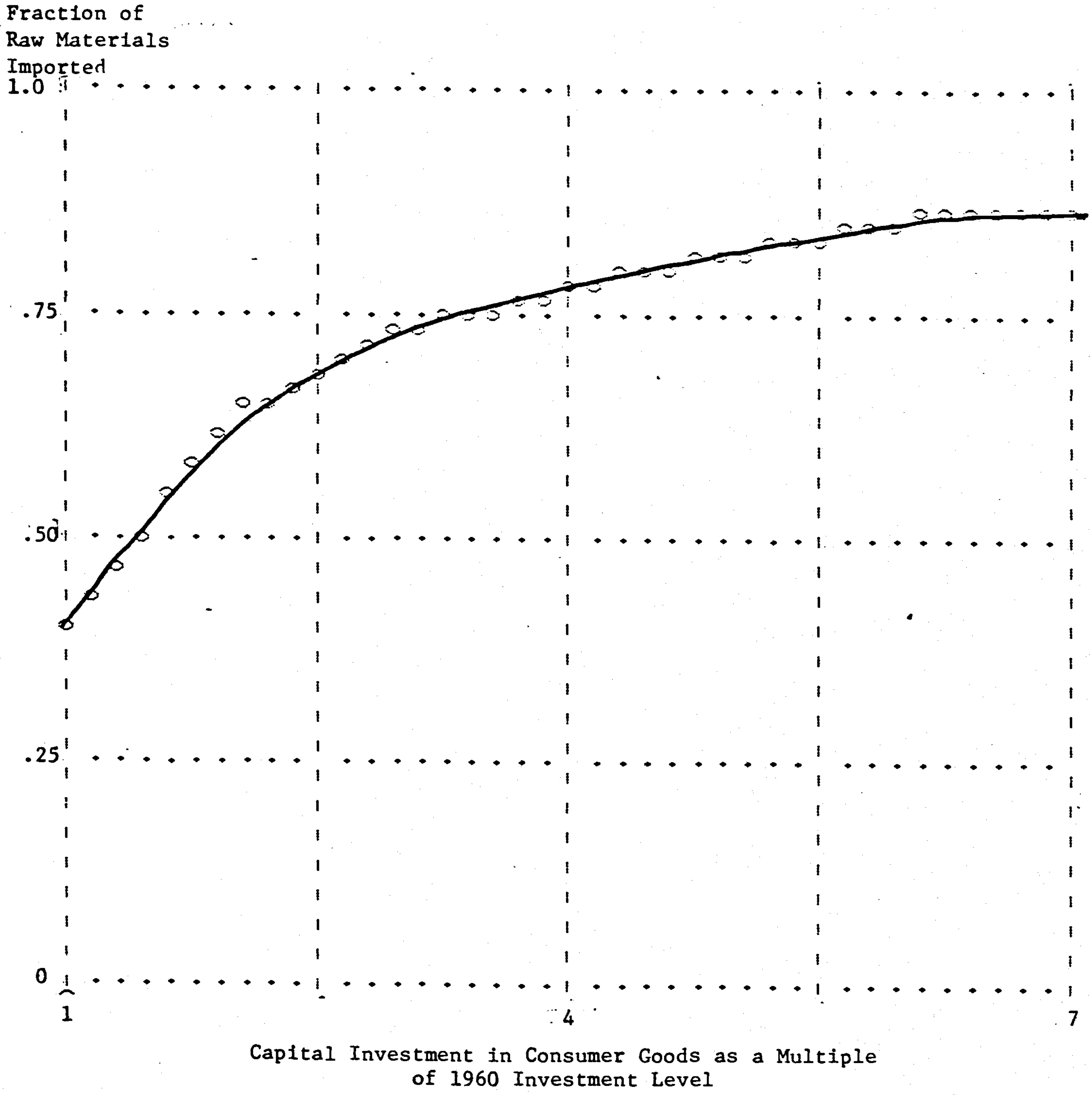
The parameter values for energy and transportation requirements per unit of output from each sector are calculated from 1960 data. Not all sectors require each production input -- it is assumed for simplicity's sake, for example, that there is no transportation required to produce transportation, and that no raw materials are required for capital goods. The only raw material specifically represented in the model is cotton and other non-food agricultural production for the manufacture of consumer goods. Furthermore, the model inporates an assumption that consumer goods output (in monetary terms) per tonne of agricultural raw material will increase with new investment in consumer goods capital, as the consumer goods industry diversifies from agriculturally based production (e.g., cotton clothing, straw baskets) to other consumer items. Non-agricultural consumer goods raw materials are assumed to be imported. This effect is shown in Figure VI-3.

```
  SECTOR PRODUCTION.

OUTPUT.K=SMOOTH(SPB.K*SPERA.K*SPEEA.K*SPETA.K,         2, A
  SPPAT)+SPES.K
    OUTPUT - SECTOR PRODUCTION (UNITS/YEAR) <2>
    SPB    - SECTOR PRODUCTION BASE (UNITS/YEAR) <3>
    SPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
               POTENTIAL SECTOR PRODUCTION <5.1>
    SPEEA  - EFFECT OF ENERGY AVAILABITY ON POTENTIAL
               SECTOR PRODUCTION <9.1>
    SPETA  - EFFECT OF TRANSPORTATION ON POTENTIAL
               SECTOR PRODUCTION <12.1>
    SPPAT  - AVERAGING TIME FOR POTENTIAL SECTOR
               PRODUCTION (YEARS) <346.2>

SPB.K=MIN(SPR.K,SPPGL.K)                                3, A
    SPB    - SECTOR PRODUCTION BASE (UNITS/YEAR) <3>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    SPR    - REQUESTED SECTOR PRODUCTION
    SPPGL  - POTENTIAL SECTOR PRODUCTION FROM CAPITAL
               GOODS AND LABOR (UNITS/YEAR) <4>
```

Figure VI-3:
Raw Materials Requirements for Consumer Goods



```
SPPGL.K=SG.K*SPGRN*SPELA.K                                   4, A
SPGRN=SPI/SGI                                                4.3, N
    SPPGL  - POTENTIAL SECTOR PRODUCTION FROM CAPITAL
               GOODS AND LABOR (UNITS/YEAR) <4>
    SG     - SECTOR CAPITAL GOODS (POUNDS) <23.1>
    SPGRN  - NORMAL OUTPUT/CAPITAL RATIO <4.3>
    SPELA  - EFFECT OF LABOR AVAILABILITY ON POTENTIAL
               SECTOR PRODUCTION <15>
    SPI    - INITIAL SECTOR PRODUCTION
    SGI    - INITIAL SECTOR CAPITAL

SPERA.K=TABLE(SPERAT,SR.K/POS(SRD.K),0,1,.25)                5, A
SPERA=1                                                      5.1, N
    SPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
               POTENTIAL SECTOR PRODUCTION <5.1>
    SR     - RAW MATERIALS AVAILABLE (UNITS/YEAR) <7>
    SRD    - RAW MATERIALS DESIRED (UNITS/YEAR) <6>

SRD.K=SPB.K/POS(SPRRN)                                       6, A
    SRD    - RAW MATERIALS DESIRED (UNITS/YEAR) <6>
    SPB    - SECTOR PRODUCTION BASE (UNITS/YEAR) <3>
    SPRRN  - NORMAL PRODUCTION/RAW MATERIAL RATIO

SR.K=DELAY1(SRI.K,SRDT)                                      7, A
    SR     - RAW MATERIALS AVAILABLE (UNITS/YEAR) <7>
    SRDT   - DELIVERY TIME FOR RAW MATERIALS (YEARS)
               <346>

SRR.K=SRD.K*(1+SPDAC.K*SRDT)                                 8, A
    SRR    - RAW MATERIALS REQUESTED (UNITS/YEAR) <8>
    SRD    - RAW MATERIALS DESIRED (UNITS/YEAR) <6>
    SPDAC  - DESIRED ANNUAL CHANGE IN SECTOR PRODUCTION
               <42>
    SRDT   - DELIVERY TIME FOR RAW MATERIALS (YEARS)
               <346>

SPEEA.K=TABLE(SPEEAT,SE.K/POS(SER.K),0,1,.25)                9, A
SPEEA=1                                                      9.1, N
    SPEEA  - EFFECT OF ENERGY AVAILABITY ON POTENTIAL
               SECTOR PRODUCTION <9.1>
    SPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON SECTOR PRODUCTION
    SE     - ENERGY AVAILABLE (KWH'S/YEAR) <11>
    SER    - ENERGY REQUESTED (KWH'S/YEAR) <10>

SER.K=SPB.K*SPERA.K*SEPRN*EDF.K                              10, A
SEPRN=SEI/SPI                                                10.2, N
    SER    - ENERGY REQUESTED (KWH'S/YEAR) <10>
    SPB    - SECTOR PRODUCTION BASE (UNITS/YEAR) <3>
    SPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
               POTENTIAL SECTOR PRODUCTION <5.1>
    SEPRN  - NORMAL ENERGY/OUTPUT RATIO <10.2>
    EDF    - ENERGY DEMAND FACTOR <391>
    SEI    - INITIAL SECTOR ENERGY USAGE
    SPI    - INITIAL SECTOR PRODUCTION
```

```
SE.K=SHARE(SER.K,EPN.K,SIE.K,EWR.K,SIN.K)                 11, A
     SE      - ENERGY AVAILABLE (KWH*S/YEAR) <11>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
     SER     - ENERGY REQUESTED (KWH*S/YEAR) <10>
     EPN     - SHORTFALL IN PRODUCTION OF ENERGY
     EWR     - WEIGHTED REQUESTS FOR ENERGY <385>
     SIN     - NORMAL SECTOR PRIORITY

SPETA.K=TABLE(SPETAT,ST.K/POS(STR.K),0,1,.25)             12, A
SPETA=1                                                   12.1, N
     SPETA   - EFFECT OF TRANSPORTATION ON POTENTIAL
                  SECTOR PRODUCTION <12.1>
     SPETAT  - TABLE FOR THE EFFECT OF TRANSPORTATION
                  AVAILABILITY ON PRODUCTION
     ST      - TRANSPORTATION AVAILABLE (TONNE-KM*S/YEAR)
                  <14>
     STR     - TRANSPORTATION REQUESTED (TONNE-KM*S/YEAR)
                  <13>

STR.K=SPB.K*SPERA.K*SPEEA.K*STPRN                         13, A
     STR     - TRANSPORTATION REQUESTED (TONNE-KM*S/YEAR)
                  <13>
     SPB     - SECTOR PRODUCTION BASE (UNITS/YEAR) <3>
     SPERA   - EFFECT OF RAW MATERIAL AVAILABILITY ON
                  POTENTIAL SECTOR PRODUCTION <5.1>
     SPEEA   - EFFECT OF ENERGY AVAILABITY ON POTENTIAL
                  SECTOR PRODUCTION <9.1>
     STPRN   - NORMAL TRANSPORTATION REQUIREMENT PER UNIT
                  OF SECTOR PRODUCTION

ST.K=SHARE(STR.K,TPN.K,SIT.K,TWR.K,SIN.K)                 14, A
     ST      - TRANSPORTATION AVAILABLE (TONNE-KM*S/YEAR)
                  <14>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
     STR     - TRANSPORTATION REQUESTED (TONNE-KM*S/YEAR)
                  <13>
     TPN     - SHORTFALL IN PRODUCTION OF TRANSPORTATION
     TWR     - WEIGHTED REQUESTS FOR TRANSPORTATION <402>
     SIN     - NORMAL SECTOR PRIORITY
```

Labor -- In the basic industrial building block used in the model, labor is an important determinant of output. As noted earlier in this chapter, an index for the effect of labor on sector production (SPELA) is calculated separately for each sector. The index is determined from the ratio of the available sector labor (SL) to the optimal amount of labor (SLD) dictated by the sector's current supply of capital goods. The marginal productivity of labor is assumed to decrease as the ratio of labor to capital increases (Figure VI-4). The optimal ratio of labor to capital (SLGRN) is taken as the 1960 ratio multiplied by a factor that decreases labor requirements as a sector's stock of capital grows over time. This factor represents the assumed increases in technology that occurs with greater capital investment, and the resulting reductions in labor required per unit of capital (or unit of output).

The amount of labor available to a sector (SL) is determined from the labor requirements of each sector (SLR) and the urban labor force available for industrial and service employment. Individual sector labor force requirements are based upon the optimal labor allocations (SLD) described above. However, the model also includes an assumption that labor requirements are increased in response to a perceived need for rapidly increasing a sector's output. That is, the greater the desired annual change in sector output (SPDAC), the greater the request for labor (Figure VI-5). This allows for immediate, although inefficient, increases in sector output that can be effected more rapidly than increases from new capital investment.

The model's labor equations also include an experience effect (SLEE) on labor productivity. This experience factor reduces the effective labor force available (stated in equivalent man-years per year) at times when a rapid increase in a sector's labor force necessitates the introduction of unskilled or inexperienced workers. It is assumed that a new worker in a sector is 35% less

Figure VI-4:
Effect of Labor Availability on Output

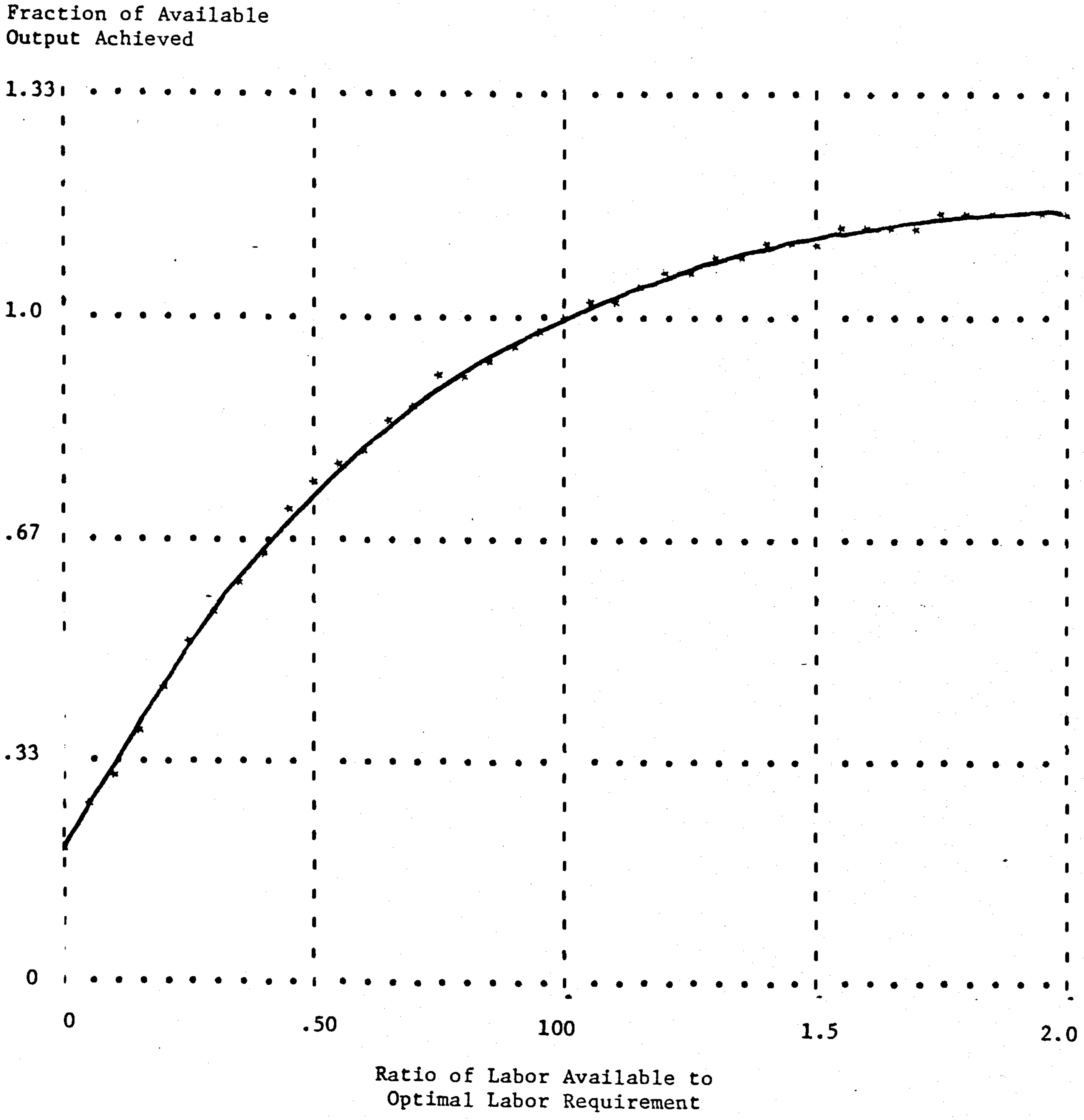
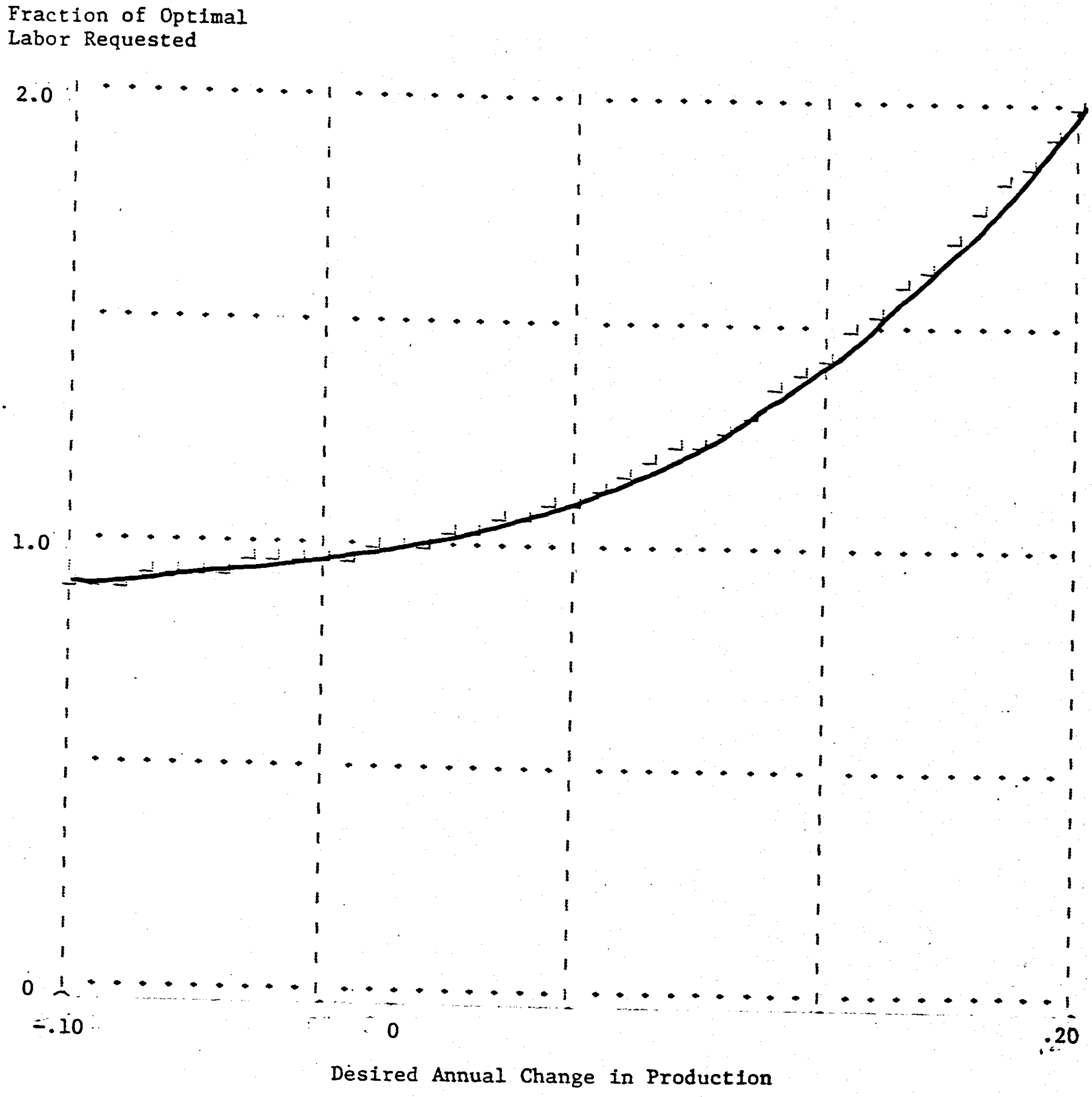


Figure VI-5
Effect of Needed Production Changes on Labor Requested



productive than a worker with five years of experience.

It appears likely that Egypt will have a steady supply of urban industrial workers for the foreseeable future. Indeed, Egypt seems much more likely to face an oversupply, rather than an undersupply, of urban labor. However, possible future scenarios may, through some direct or indirect mechanism, reduce the urban labor pool sufficiently to constrict industrial output. Therefore, the model's standard allocation logic is used to distribute urban labor among the competing needs of the industrial and service sectors. Priorities assigned to each sector determine which sectors suffer labor force reductions in the event of a general labor shortage.

Estimates of the 1960 industrial labor force are provided to the model for calculations of base labor/capital ratios. During model simulations, labor requirements and allocations are calculated internally in the manner described above.

1960 Labor Force Distributions[6]

	Capital Goods	Consumer Goods	Transportation	Urban Services
Thousand Men	315	470	220	1,170

```
SPELA.K=TABLE(SPELAT,SL.K*SLEE.K/POS(SLD.K),0,2,      15, A
  .25)
    SPELA  - EFFECT OF LABOR AVAILABILITY ON POTENTIAL
                SECTOR PRODUCTION <15>
    SPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON SECTOR PRODUCTION
    SL     - LABOR AVAILABLE (MEN) <18>
    SLEE   - EXPERIENCE EFFECT ON LABOR AVAILABLE <21>
    SLD    - LABOR DESIRED (MEN/YEAR) <16>

SLD.K=SG.K*SLCRN.K
                                                       16, A
    SLD    - LABOR DESIRED (MEN/YEAR) <16>
    SG     - SECTOR CAPITAL GOODS (POUNDS) <23.1>
    SLCRN  - NORMAL LABOR/CAPITAL RATIO <17>
```

```
SLGRN.K=(SLII/SGI)*TABHL(SLGRNT,SGI/SG.K,0,.5,.05)  17, A
    SLGRN  - NORMAL LABOR/CAPITAL RATIO <17>
    SLII   - INITIAL SECTOR LABOR FORCE
    SGI    - INITIAL SECTOR CAPITAL
    SLGRNT - TABLE FOR NORMAL CAPITAL/LABOR RATIO
               <346.4>
    SG     - SECTOR CAPITAL GOODS (POUNDS) <23.1>

SL.K=SMOOTH(SLI.K,SLTT)                             18, A
    SL     - LABOR AVAILABLE (MEN) <18>
    SLI    - LABOR INDICATED (MEN) <19.1>
    SLTT   - TIME TO TRANSFER INDUSTRIAL LABOR (YEARS)
               <346.6>

SLI.K=SHARE(SLR.K,PLN.K,SIL.K,PLWR.K,SIN.K)         19, A
SLI=SLD                                             19.1, N
    SLI    - LABOR INDICATED (MEN) <19.1>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    SLR    - LABOR REQUESTED (MEN) <20>
    PLN    - SHORTFALL IN AREA LABOR FORCE
    PLWR   - WEIGHTED REQUESTS FOR AREA LABOR
    SIN    - NORMAL SECTOR PRIORITY
    SLD    - LABOR DESIRED (MEN/YEAR) <16>

SLR.K=SLD.K*TABLE(SLRT,SPDAC.K,-.1,.2,.05)          20, A
    SLR    - LABOR REQUESTED (MEN) <20>
    SLD    - LABOR DESIRED (MEN/YEAR) <16>
    SLRT   - TABLE FOR REQUESTED SECTOR LABOR
    SPDAC  - DESIRED ANNUAL CHANGE IN SECTOR PRODUCTION
               <42>

SLEE.K=TABHL(SLEET,SLE.K/POS(SL.K),0,1,.25)         21, A
    SLEE   - EXPERIENCE EFFECT ON LABOR AVAILABLE <21>
    SLEET  - TABLE FOR THE EFFECT OF EXPERIENCE ON LABOR
               EFFECTIVENESS <346.8>
    SLE    - EXPERIENCED LABOR (MEN) <22>
    SL     - LABOR AVAILABLE (MEN) <18>

SLE.K=SMOOTH(SL.K,SLET)                             22, A
    SLE    - EXPERIENCED LABOR (MEN) <22>
    SL     - LABOR AVAILABLE (MEN) <18>
    SLET   - LABOR EXPERIENCE TIME (YEARS) <347.1>
```

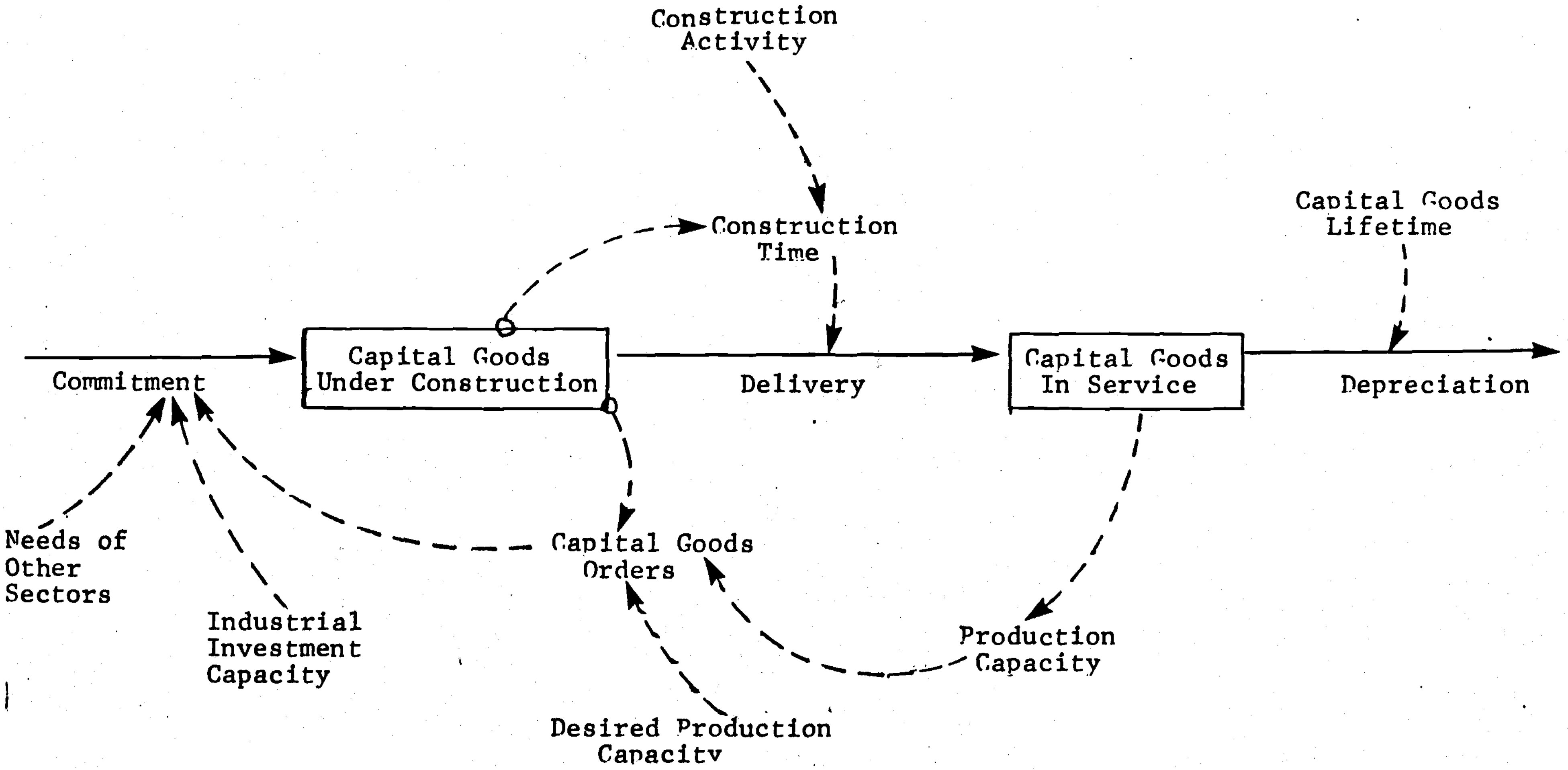
Capital Goods -- The basic determinant of industrial output in the Egypt model is the stock of capital goods (SG) in each sector. The model measures this investment in monetary units (e.g., Egyptian pounds). As shown in Figure VI-6, capital goods are obtained from both domestic production (SGD) and from imports (SGQ). Industrial capital is assumed to depreciate (SGW) over a lifetime (SGWL) of 20 years.

Figure V-6 indicates that, in the Egypt model, capital investment is represented as a two-stage process. First, sectoral orders for capital goods lead to a commitment, i.e., a decision that a certain amount of capital goods will be produced for each sector. Second, capital goods production capacity is allocated among the commitments, thereby causing some commitments to be fulfilled faster than others. We believe that this formulation realistically captures the delays, the inertia, and the flexibility to accelerate or stretch out projects that are essential parts of industrial capital creation.

Deliveries of capital goods from domestic production (SGD) depend primarily on the commitments of capital goods (SGC) made to each sector in the past. These commitments determine the amount of capital goods under construction (SGUC) within each sector. Comparison of the capital under construction with the amount of construction activity (SGCA) for each sector determines the construction time (SGCT). That is, the time interval between the commitment of capital goods and their availability to produce sector output.

Both the commitment of capital goods (SGC) and construction activity (SGCA) are governed by the model's resource allocation logic. The country's domestic capital goods capacity is determined by the size of the capital goods sector, and must be distributed over the competing needs of the water control, agricultural, population, and industrial sectors. The relative priorities of these competing sectors determine which capital needs will be best satisfied in the event that domestic supply is inadequate to meet demand. The allocation of

Figure VI-6: Capitol Goods Ordering Process



capital goods commitments is very important; the model uses these commitments to distribute capital goods production capacity among domestic needs. Each sector would then typically receive the construction activity necessary to complete current capital goods projects in the normal construction time (SGCTN). However, in the event of disruptions to capital goods construction (caused, for example, by a labor or energy shortage), the delivery times for capital goods projects would be stretched out.

Capital goods orders (SGO) are calculated to provide each sector with the capacity necessary to meet future production requirements (SPD). These requirements for sectoral production, and the normal output per unit of capital (SPGRN), together determine a desired capital goods stock (SGR) for each industrial sector. The orders placed for new capital goods commitments are determined from the difference between this desired capital stock and the amount of capital stock already on hand (SG), under construction (SGUC), and on order through imports (SGQD). In addition, orders are placed to replace depreciating capital equipment (SGW). Even if desired and actual capital are exactly equal, this replacement ordering is necessary to stay in balance.

Estimates of 1960 capital goods in place for each sector are used in the model to initialize all simulations and perform output/capital calculations. All changes to these initial capital stocks are calculated in the model.

1960 Capital Goods on Hand[7]

	Capital Goods	Consumer Goods	Transportation	Energy	Fertilizer
Million Egyptian Pounds	250	260	690	50	5

The model treats explicitly the possibility of capital goods imports (SGQ) for any of the industrial sectors. Imports follow from commitments (SGQC) of foreign exchange to meet all or part of the import needs for each sector, after an assumed two year delay (SGQDT). Commitments for capital goods imports are the result of an allocation of the economy's foreign exchange resources; the industrial sectors must compete with requirements for food imports and for the use of foreign exchange to pay outstanding debts.

The individual sector orders for capital goods imports (SGQO) are based on two components. Some import orders (SGQOS) represent attempts to compensate for any shortfall between total capital goods orders (SGO) and commitments from domestic capacity (SGC). Other orders (SGQOT) are placed to acquire new technology from other industrial countries. This second category of orders are represented as proportional to the new capital acquisition necessary to replace depreciated equipment (SGW). Because capital goods are measured in Egyptian pounds, an inflation factor (SGQXR) is used to represent any change in the relative values of Egyptian and foreign currencies. In addition, capital goods orders are also regulated by foreign exchange availability (QEXA), so that orders are reduced whenever a precarious foreign exchange condition exists.

```
   CAPITAL GOODS

SG.K=SG.J+(DT)(SGD.J+(SGQ.J/SGXQR.J)-SGW.J)         23, L
SG=SGI                                              23.1, N
    SG      - SECTOR CAPITAL GOODS (POUNDS) <23.1>
    SGD     - DELIVERIES OF CAPITAL GOODS TO SECTOR
                (POUNDS/YEAR) <25>
    SGQ     - IMPORTS OF CAPITAL GOODS FOR SECTOR (FOREX/
                YEAR) <35>
    SGXQR   - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
                <349>
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SGI     - INITIAL SECTOR CAPITAL

SGW.K=SG.K/SGWL                                     24, A
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SG      - SECTOR CAPITAL GOODS (POUNDS) <23.1>
    SGWL    - LIFETIME OF INDUSTRIAL CAPITAL (YEARS)
                <347.3>
```

```
SGD.K=DELAY3P(SGC.K,POS(SGCT.K),SGUC.K)                      25, A
    SGD     - DELIVERIES OF CAPITAL GOODS TO SECTOR
                (POUNDS/YEAR) <25>
    SGC     - COMMITMENTS OF CAPITAL GOODS TO SECTOR
                (POUNDS/YEAR) <29.1>
    SGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <26.1>
    SGUC    - INDUSTRIAL CAPITAL UNDER CONSTRUCTION


SGCT.K=SGUC.K/SGCA.K                                         26, A
SGCT=SGCTN                                                   26.1, N
    SGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <26.1>
    SGUC    - INDUSTRIAL CAPITAL UNDER CONSTRUCTION
    SGCA    - CONSTRUCTION ACTIVITY FOR SECTOR CAPITAL
                (POUNDS/YEAR) <27>
    SGCTN   - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
                CAPITAL (YEARS) <347.5>

SGCA.K=SHARE(SGCR.K,GPN.K,SIGC.K,GPWR.K,SIN.K)               27, A
    SGCA    - CONSTRUCTION ACTIVITY FOR SECTOR CAPITAL
                (POUNDS/YEAR) <27>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    SGCR    - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
                (POUNDS/YEAR) <28>
    GPN     - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
    GPWR    - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    SIN     - NORMAL SECTOR PRIORITY

SGCR.K=SGUC.K/SGCTN                                          28, A
    SGCR    - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
                (POUNDS/YEAR) <28>
    SGUC    - INDUSTRIAL CAPITAL UNDER CONSTRUCTION
    SGCTN   - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
                CAPITAL (YEARS) <347.5>

SGC.K=SHARE(SGO.K,GON.K,SIGO.K,GOWR.K,SIN.K)                 29, A
SGC=SGW*SGGFI                                                29.1, N
    SGC     - COMMITMENTS OF CAPITAL GOODS TO SECTOR
                (POUNDS/YEAR) <29.1>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    SGO     - ORDERS PLACED FOR CAPITAL GOODS FOR SECTOR
                (POUNDS/YEAR) <30>
    GON     - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOWR    - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    SIN     - NORMAL SECTOR PRIORITY
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SGGFI   - INITIAL GROWTH FACTOR FOR INDUSTRIAL
                CAPITAL <347.7>
```

```
SGO.K=MAX(0,SGW.K+(SGR.K+SGBD.K-(SG.K+SGUC.K+               30, A
  SGQD.K))/SGOT)*SGOES.K*SGOET.K
    SGO     - ORDERS PLACED FOR CAPITAL GOODS FOR SECTOR
                (POUNDS/YEAR) <30>
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SGR     - DESIRED CAPITAL GOODS FOR SECTOR (POUNDS)
                <32>
    SGBD    - DESIRED BACKLOG OF CONSTRUCTION TO REPLACE
                WEAROUT <31>
    SG      - SECTOR CAPITAL GOODS (POUNDS) <23.1>
    SGUC    - INDUSTRIAL CAPITAL UNDER CONSTRUCTION
    SGQD    - IMPORTED INDUSTRIAL CAPITAL BEING DELIVERED
    SGOT    - ORDERING TIME FOR INDUSTRIAL CAPITAL
                (YEARS) <347.9>
    SGOES   - EFFECT OF SHORTAGES ON ORDERS FOR CAPITAL
                <33>
    SGOET   - EFFECT OF CAPITAL CONSTRUCTION TIME ON
                ORDERS FOR CAPITAL <34>

SGBD.K=SGW.K*SGCT.K                                          31, A
    SGBD    - DESIRED BACKLOG OF CONSTRUCTION TO REPLACE
                WEAROUT <31>
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <26.1>

SGR.K=MAX(0,SPD.K/SPGRN)                                     32, A
    SGR     - DESIRED CAPITAL GOODS FOR SECTOR (POUNDS)
                <32>
    SPD     - DESIRED SECTOR PRODUCTION AT END OF
                ORDERING AND CONSTRUCTION HORIZON FOR
                CAPITAL GOODS <41>
    SPGRN   - NORMAL OUTPUT/CAPITAL RATIO <4.3>

SGOES.K=TABHL(SGOEST,SPERA.K*SPEEA.K*SPETA.K,0,1,            33, A
  .25)
    SGOES   - EFFECT OF SHORTAGES ON ORDERS FOR CAPITAL
                <33>
    SGOEST  - TABLE FOR THE EFFECT OF SHORTAGES ON
                CAPITAL ORDERS <349.4>
    SPERA   - EFFECT OF RAW MATERIAL AVAILABILITY ON
                POTENTIAL SECTOR PRODUCTION <5.1>
    SPEEA   - EFFECT OF ENERGY AVAILABITY ON POTENTIAL
                SECTOR PRODUCTION <9.1>
    SPETA   - EFFECT OF TRANSPORTATION ON POTENTIAL
                SECTOR PRODUCTION <12.1>
```

```
SGOET.K=TABHL(SGOETT,GCT.K/SGCTN,1,2,.25)                  34, A
    SGOET  - EFFECT OF CAPITAL CONSTRUCTION TIME ON
               ORDERS FOR CAPITAL <34>
    SGOETT - TABLE FOR THE EFFECT OF  CONSTRUCTION TIME
               ON ORDERS FOR CAPITAL <349.6>
    GCT    - AVERAGE CONSTRUCTION TIME FOR CAPITAL GOODS
               <382>
    SGCTN  - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
               CAPITAL (YEARS) <347.5>

   CAPITAL GOODS IMPORTS

SGQ.K=DELAY3P(SGQC.K,SGQDT,SGQD.K)                          35, A
    SGQ    - IMPORTS OF CAPITAL GOODS FOR SECTOR (FOREX/
               YEAR) <35>
    SGQC   - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
               SECTOR (FOREX/YEAR) <36.1>
    SGQDT  - DELIVERY TIME FOR IMPORTED CAPITAL (YEARS)
               <348.2>
    SGQD   - IMPORTED INDUSTRIAL CAPITAL BEING DELIVERED

SGQC.K=SHARE(SGQO.K,GXN.K,SIG.K,GXWR.K,SIN.K)             36, A
SGQC=SGQCI                                                  36.1, N
    SGQC   - COMMITMENTS TO IMPORT CAPITAL GOODS FOR
               SECTOR (FOREX/YEAR) <36.1>
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    SGQO   - ORDERS TO IMPORT CAPITAL GOODS FOR SECTOR
               (FOREX/YEAR) <37>
    GXN    - SHORTFALL IN FOREIGN EXCHANGE FOR IMPORTING
               CAPITAL (FOREX/YEAR) <377>
    GXWR   - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <379>
    SIN    - NORMAL SECTOR PRIORITY
    SGQCI  - INITIAL CAPITAL GOODS IMPORTS

SGQO.K=(SGQOS.K+SGQOT.K)*SGXQR.K*QEXA.K                     37, A
    SGQO   - ORDERS TO IMPORT CAPITAL GOODS FOR SECTOR
               (FOREX/YEAR) <37>
    SGQOS  - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
               FOR DOMESTIC SHORTFALL <38>
    SGQOT  - CAPITAL GOODS IMPORT ORDERS TO ABSORB NEW
               TECHNOLOGY <39>
    SGXQR  - FOREIGN EXCHANGE RATIO FOR IMPORTED CAPITAL
               <349>
    QEXA   - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
               REQUESTS FOR IMPORTS <486>
```

```
SGQOS.K=SMOOTH(SGQOSF.K*MAX((SGO.K/FOS(SGOET.K))-     38, A
  SGC.K,0),SGQOAT)
    SGQOS   - CAPITAL GOODS IMPORT ORDERS TO COMPENSATE
                FOR DOMESTIC SHORTFALL <38>
    SGQOSF  - FRACTION OF CAPITAL GOODS SHORTFALL ORDERED
                FOR IMPORT
    SGO     - ORDERS PLACED FOR CAPITAL GOODS FOR SECTOR
                (POUNDS/YEAR) <30>
    SGOET   - EFFECT OF CAPITAL CONSTRUCTION TIME ON
                ORDERS FOR CAPITAL <34>
    SGC     - COMMITMENTS OF CAPITAL GOODS TO SECTOR
                (POUNDS/YEAR) <29.1>
    SGQOAT  - TIME TO ADJUST IMPORT ORDERS TO DOMESTIC
                SHORTFALL (YEARS) <348.4>

SGQOT.K=SGW.K*TABLE(SGQOTT,TIME.K,1960,2010,10)       39, A
    SGQOT   - CAPITAL GOODS IMPORT ORDERS TO ABSORB NEW
                TECHNOLOGY <39>
    SGW     - WEAROUT OF SECTOR CAPITAL GOODS (POUNDS/
                YEAR) <24>
    SGQOTT  - TABLE FOR ORDERS FOR CAPITAL GOODS FOR
                IMPORT
```

Desired Production -- Each industrial sector calculates a desired future output, to plan the proper growth in production capacity. Any discrepancies (SPN) between current sector output (OUTPUT) and anticipated production requirements (SPRG) are translated into a desired annual change in sector production (SPDAC). This desired annual change is used to guide sector requests for labor and capital.

The basis for calculating the desired annual change in output is the ratio of the necessary fractional change in sector output (SPDFC) to the number of years over which discrepancies between current output and estimated demand are to be corrected (SPTA, assumed to be a planning horizon of five years). In addition, the model provides for government-generated growth targets (SPGI) as additional inputs to the calculation of industrial growth rates. These government objectives are external inputs which can be varied to investigate different official development strategies.

```
  DESIRED PRODUCTION

SPN.K=MAX(0,SPR.K-OUTPUT.K)                                40, A
    SPN     - SECTOR PRODUCTION SHORTFALL (UNITS/YEAR)
                <40>
    SPR     - REQUESTED SECTOR PRODUCTION
    OUTPUT  - SECTOR PRODUCTION (UNITS/YEAR) <2>

SPD.K=SMOOTH(OUTPUT.K,SPAT)*(1+SPDAC.K*(SGCT.K+            41, A
  SGOT))-SPES.K
    SPD     - DESIRED SECTOR PRODUCTION AT END OF
                ORDERING AND CONSTRUCTION HORIZON FOR
                CAPITAL GOODS <41>
    OUTPUT  - SECTOR PRODUCTION (UNITS/YEAR) <2>
    SPAT    - TIME TO PERCEIVE CHANGES IN SECTOR
                PRODUCTION (YEARS) <348.6>
    SPDAC   - DESIRED ANNUAL CHANGE IN SECTOR PRODUCTION
                <42>
    SGCT    - CONSTRUCTION TIME FOR SECTOR CAPITAL
                (YEARS) <26.1>
    SGOT    - ORDERING TIME FOR INDUSTRIAL CAPITAL
                (YEARS) <347.9>

SPDAC.K=TABHL(SPDACT,SPIAC.K,-.2,.2,.05)                   42, A
    SPDAC   - DESIRED ANNUAL CHANGE IN SECTOR PRODUCTION
                <42>
    SPDACT  - TABLE FOR DESIRED ANNUAL CHANGE IN SECTOR
                PRODUCTION
    SPIAC   - INDICATED ANNUAL CHANGE FOR SECTOR
                PRODUCTION <43>
```

```
SPIAC.K=SMOOTH(SPDFC.K/SPTA,SPAT)+SPGI.K                    43, A
    SPIAC  - INDICATED ANNUAL CHANGE FOR SECTOR
               PRODUCTION <43>
    SPDFC  - DESIRED FRACTIONAL CHANGE IN SECTOR
               PRODUCTION <44>
    SPTA   - TIME TO ADJUST SECTOR PRODUCTION (YEARS)
               <348.8>
    SPAT   - TIME TO PERCEIVE CHANGES IN SECTOR
               PRODUCTION (YEARS) <348.6>
    SPGI   - GOVERNMENT INFLUENCE ON DESIRED GROWTH RATE
               <45>

SPDFC.K=(SPRG.K-SPESA.K-(OUTPUT.K-SPES.K))/                 44, A
  (OUTPUT.K-SPES.K)
    SPDFC  - DESIRED FRACTIONAL CHANGE IN SECTOR
               PRODUCTION <44>
    SPRG   - REQUESTED SECTOR PRODUCTION USED TO
               DETERMINE NEEDED GROWTH
    OUTPUT - SECTOR PRODUCTION (UNITS/YEAR) <2>

SPGI.K=TABLE(SPGIT,TIME.K,1960,2010,10)                     45, A
    SPGI   - GOVERNMENT INFLUENCE ON DESIRED GROWTH RATE
               <45>
    SPGIT  - TABLE FOR GOVERNMENT INFLUENCE ON SECTOR
               PRODUCTION

SIN.K=TABLE(SINT,TIME.K,1960,2010,10)                       46, A
    SIN    - NORMAL SECTOR PRIORITY

MEND
```

The remaining equations implement the industrial building block for each of the five sectors. They contain the parameters that are common to all sectors, as well as the parameters that distinguish one sector from another. They are listed for reference.

```
   CONSTANTS FOR ALL USES OF INDUSTRIAL OUTPUT MACRO
SRDT=.5                                                  346, C
SPPAT=.5                                                 346.2, C
SLGRNT=0/.2/.3/.4/.5/.62/.74/.84/.92/.97/1               346.4, T
SLTT=1                                                   346.6, C
SLEET=.65/.75/.85/.93/1                                  346.8, T
SLET=5                                                   347.1, C
SGWL=20                                                  347.3, C
SGCTN=2                                                  347.5, C
SGGFI=2.25                                               347.7, C
SGOT=2                                                   347.9, C
SGQDT=2                                                  348.2, C
SGQOAT=1                                                 348.4, C
SPAT=1                                                   348.6, C
SPTA=5                                                   348.8, C
    SRDT   - DELIVERY TIME FOR RAW MATERIALS (YEARS)
               <346>
    SPPAT  - AVERAGING TIME FOR POTENTIAL SECTOR
               PRODUCTION (YEARS) <346.2>
    SLGRNT - TABLE FOR NORMAL CAPITAL/LABOR RATIO
               <346.4>
    SLTT   - TIME TO TRANSFER INDUSTRIAL LABOR (YEARS)
               <346.6>
    SLEET  - TABLE FOR THE EFFECT OF EXPERIENCE ON LABOR
               EFFECTIVENESS <346.8>
    SLET   - LABOR EXPERIENCE TIME (YEARS) <347.1>
    SGWL   - LIFETIME OF INDUSTRIAL CAPITAL (YEARS)
               <347.3>
    SGCTN  - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
               CAPITAL (YEARS) <347.5>
    SGGFI  - INITIAL GROWTH FACTOR FOR INDUSTRIAL
               CAPITAL <347.7>
    SGOT   - ORDERING TIME FOR INDUSTRIAL CAPITAL
               (YEARS) <347.9>
    SGQDT  - DELIVERY TIME FOR IMPORTED CAPITAL (YEARS)
               <348.2>
    SGQOAT - TIME TO ADJUST IMPORT ORDERS TO DOMESTIC
               SHORTFALL (YEARS) <348.4>
    SPAT   - TIME TO PERCEIVE CHANGES IN SECTOR
               PRODUCTION (YEARS) <348.6>
    SPTA   - TIME TO ADJUST SECTOR PRODUCTION (YEARS)
               <348.8>
```

CONSUMER GOODS PRODUCTION

```
UP.K=OUTPUT(UPR,UPI,UPELAT,ULII,UPERAT,UPRRN.K,          351, A
  UINT,UIN,UPEEAT,UEI,UPETAT,UTPRN,ULRT,UGI,UGQOTT,
  UGQOSF,UPDACT,UPRG,PULN,PULWR.K,UGQCI,UPGIT,
  UPPGL,UPELA,UPERA,URR,URI.K,UPEEA,UER,UE,UPETA,
  UTR,UT,UL,ULR,UG,UGR,UGQ,UGQO,UGCR,UGO,UGC,UIE,
  UIT,UIL,UIGC,UIGO,UIO,UPN,UPDAC,0,0)
.UP=UPI                                                   351.9, N
UPI=250E6                                                 352.2, C
     UP     - CONSUMER GOODS PRODUCTION <351>
     OUTPUT - SECTOR PRODUCTION (UNITS/YEAR) <2>
     UPR    - REQUESTED CONSUMER GOODS PRODUCTION <353>
     UPI    - INITIAL CONSUMER GOODS PRODUCTION <352.2>
     UPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON CONSUMER GOODS PRODUCTION <354.2>
     ULII   - INITIAL CONSUMER GOODS LABOR (MEN) <354.5>
     UPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
                AVAILABILITY ON CONSUMER GOODS PRODUCTION
                <354.7>
     UPRRN  - OUTPUT/RAW MATERIAL RATIO FOR CONSUMER
                GOODS <360.2>
     UINT   - NORMAL PRIORITY FOR CONSUMER GOODS <360.4>
     UPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
                ON CONSUMER GOODS PRODUCTION <360.6>
     UEI    - INITIAL ENERGY CONSUMPTION FOR CONSUMER
                GOODS (KWH) <360.9>
     UPETAT - TABLE FOR THE EFFECT OF TRANSPORTATION
                AVAILABILITY ON CONSUMER GOODS PRODUCTION
                <361.2>
     UTPRN  - NORMAL TRANSPORTATION/OUTPUT RATIO (TONNE-
                KM/POUND) <361.5>
     ULRT   - TABLE FOR REQUESTED CONSUMER GOODS LABOR
                <361.7>
     UGI    - INITIAL CAPITAL FOR CONSUMER GOODS <361.9>
     UGQOTT - CAPITAL IMPORT ORDERS FOR CONSUMER GOODS TO
                ABSORB NEW TECHNOLOGY <362.2>
     UGQOSF - FRACTION OF DOMESTIC CONSUMER GOODS CAPITAL
                SHORTFALL ORDERED FOR IMPORT <363>
     UPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
                CONSUMER GOODS PRODUCTION <363.3>
     UPRG   - CONSUMER GOODS PRODUCTION REQUEST USED FOR
                GROWTH CALCULATIONS <364>
     PULN   - SHORTFALL IN URBAN LABOR
     PULWR  - WEIGHTED REQUESTS FOR URBAN LABOR <133>
     UGQCI  - INITIAL CONSUMER GOODS CAPITAL ON ORDER FOR
                IMPORT (FOREX/YEAR) <364.2>
     UPGIT  - GOVERNMENT INFLUENCE ON CONSUMER GOODS
                GROWTH RATE <364.4>
     UPPGL  - POTENTIAL PRODUCTION OF CONSUMER GOODS FROM
                CAPITAL AND LABOR
     UPELA  - EFFECT OF LABOR AVAILABILITY ON CONSUMER
                GOODS PRODUCTION
     UPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
                CONSUMER GOODS PRODUCTION
     URR    - RAW MATERIALS REQUESTED FOR CONSUMER GOODS
                PRODUCTION
```

```
    URI     - INDICATED RAW MATERIALS FOR CONSUMER GOODS
                (POUNDS) <355>
    UPEEA   - EFFECT OF ENERGY AVAILABILITY ON CONSUMER
                GOODS PRODUCTION
    UER     - ENERGY REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    UE      - ENERGY ALLOCATED FOR CONSUMER GOODS
                PRODUCTION
    UPETA   - EFFECT OF TRANSPORTATION AVAILABILITY ON
                CONSUMER GOODS PRODUCTION
    UTR     - TRANSPORTATION REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    UT      - TRANSPORTATION ALLOCATED FOR CONSUMER GOODS
                PRODUCTION
    UL      - LABOR ALLOCATED FOR CONSUMER GOODS
                PRODUCTION
    ULR     - LABOR REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    UG      - CAPITAL GOODS IN PLACE FOR CONSUMER GOODS
                PRODUCTION
    UGR     - CAPITAL GOODS REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    UGQ     - CAPITAL GOODS IMPORTS FOR CONSUMER GOODS
                PRODUCTION
    UGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                CONSUMER GOODS PRODUCTION
    UGCR    - REQUESTED CONSTRUCTION ACTIVITY FOR
                CONSUMER GOODS CAPITAL GOODS
    UGO     - CONSUMER GOODS ORDERS FOR CAPITAL GOODS
    UGC     - COMMITMENT OF CAPITAL GOODS TO CONSUMER
                GOODS PRODUCTION
    UIE     - CONSUMER GOODS PRIORITY FOR ENERGY
    UIT     - CONSUMER GOODS PRIORITY FOR TRANSPORTATION
    UIL     - CONSUMER GOODS PRIORITY FOR LABOR
    UIGC    - CONSUMER GOODS PRIORITY FOR CONSTRUCTION
                ACTIVITY
    UIGO    - CONSUMER GOODS PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    UIQ     - CONSUMER GOODS PRIORITY FOR CAPITAL GOODS
                IMPORTS
    UPN     - SHORTFALL IN PRODUCTION OF CONSUMER GOODS
    UPDAC   - DESIRED ANNUAL CHANGE IN CONSUMER GOODS
                PRODUCTION

UPR.K=PUUR.K+PRUR.K+CUR.K                                  353, A
    UPR     - REQUESTED CONSUMER GOODS PRODUCTION <353>
    PUUR    - CONSUMER GOODS REQUESTED FOR URBAN
                POPULATION (POUNDS/YEAR)
    PRUR    - CONSUMER GOODS REQUESTED FOR RURAL
                POPULATION (POUNDS/YEAR)
    CUR     - REQUESTED DELIVERIES OF CONSUMER GOODS FOR
                EXPORT <455>
```

```
UWR.K=(PUUR.K/PUIU.K)+(PRUR.K/PRIU.K)+(CUR.K/CIU.K) 354, A
UPELAT=.2/.5/.75/.9/1/1.07/1.12/1.15/1.15             354.2, T
ULII=470E3                                            354.5, C
UPERAT=0/.4/.65/.85/1                                 354.7, T
    UWR     - WEIGHTED REQUESTS FOR CONSUMER GOODS <354>
    PUUR    - CONSUMER GOODS REQUESTED FOR URBAN
                POPULATION (POUNDS/YEAR)
    PUIU    - URBAN PRIORITY FOR CONSUMER GOODS
    PRUR    - CONSUMER GOODS REQUESTED FOR RURAL
                POPULATION (POUNDS/YEAR)
    PRIU    - RURAL PRIORITY FOR CONSUMER GOODS
    CUR     - REQUESTED DELIVERIES OF CONSUMER GOODS FOR
                EXPORT <455>
    UPELAT  - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON CONSUMER GOODS PRODUCTION <354.2>
    ULII    - INITIAL CONSUMER GOODS LABOR (MEN) <354.5>
    UPERAT  - TABLE FOR THE EFFECT OF RAW MATERIALS
                AVAILABILITY ON CONSUMER GOODS PRODUCTION
                <354.7>

URI.K=UACI.K+UQMI.K                                   355, A
    URI     - INDICATED RAW MATERIALS FOR CONSUMER GOODS
                (POUNDS) <355>
    UACI    - INDICATED AGRICULTURAL RAW MATERIALS FOR
                CONSUMER GOODS <359>
    UQMI    - INDICATED IMPORTED RAW MATERIALS FOR
                CONSUMER GOODS (POUNDS) <356>

UQMI.K=SHARE(UQMR.K,QMN.K,UIQM.K,QMWR.K,UIN.K)        356, A
    UQMI    - INDICATED IMPORTED RAW MATERIALS FOR
                CONSUMER GOODS (POUNDS) <356>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    UQMR    - REQUESTED IMPORTED RAW MATERIALS FOR
                CONSUMER GOODS (POUNDS) <357>
    QMN     - SHORTFALL IN MISCELLANEOUS IMPORTS <483>
    QMWR    - WEIGHTED REQUESTS FOR MISCELLANEOUS IMPORTS
                <484>

UQMR.K=URR.K*URQF.K                                   357, A
    UQMR    - REQUESTED IMPORTED RAW MATERIALS FOR
                CONSUMER GOODS (POUNDS) <357>
    URR     - RAW MATERIALS REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    URQF    - FRACTION OF CONSUMER GOODS RAW MATERIALS
                FROM IMPORTS <358>

URQF.K=TABLE(URQFT,UGI/UG.K,0,1,.25)                  358, A
URQFT=1/.77/.64/.51/.4                                358.2, T
    URQF    - FRACTION OF CONSUMER GOODS RAW MATERIALS
                FROM IMPORTS <358>
    URQFT   - TABLE FOR FRACTION OF CONSUMER GOODS RAW
                MATERIALS FROM IMPORTS <358.2>
    UGI     - INITIAL CAPITAL FOR CONSUMER GOODS <361.9>
    UG      - CAPITAL GOODS IN PLACE FOR CONSUMER GOODS
                PRODUCTION
```

```
UACI.K=SHARE(UACR.K,ACPN.K,UIAC.K,ACWR.K,UIN.K)*        359, A
  UPACR
UPACR=250
     UACI    - INDICATED AGRICULTURAL RAW MATERIALS FOR  359.2, C
                 CONSUMER GOODS <359>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     UACR    - REQUESTED AGRICULTURAL RAW MATERIALS FOR
                 CONSUMER GOODS <360>
     ACPN    - SHORTFALL IN PRODUCTION OF COTTON
     ACWR    - WEIGHTED REQUESTS FOR COTTON PRODUCTION
                 <189>
     UPACR   - CONSUMER GOODS RAW MATERIAL VALUE OF COTTON
                 (POUNDS/TONNE) <359.2>

UACR.K=URR.K*(1-URQF.K)/UPACR
UPRRN=2.75                                              360, A
UINT=.1/.1/.1/.1/.1/.1                                  360.2, C
UPEEAT=0/.4/.65/.85/1                                   360.4, T
UEI=176E6                                               360.6, T
UPETAT=0/.5/.8/.9/1                                     360.9, C
UTPRN=2.4                                               361.2, T
ULRT=.9/.95/1/1.1/1.3/1.6/2                             361.5, C
UGI=260E6                                               361.7, T
UGQOTT=.1/.1/.1/.1/.1/.1                                361.9, C
    UACR    - REQUESTED AGRICULTURAL RAW MATERIALS FOR  362.2, T
                CONSUMER GOODS <360>
    URR     - RAW_MATERIALS REQUESTED FOR CONSUMER GOODS
                PRODUCTION
    URQF    - FRACTION OF CONSUMER GOODS RAW MATERIALS
                FROM IMPORTS <358>
    UPACR   - CONSUMER GOODS RAW MATERIAL VALUE OF COTTON
                (POUNDS/TONNE) <359.2>
    UPRRN   - OUTPUT/RAW MATERIAL RATIO FOR CONSUMER
                GOODS <360.2>
    UINT    - NORMAL PRIORITY FOR CONSUMER GOODS <360.4>
    UPEEAT  - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
                ON CONSUMER GOODS PRODUCTION <360.6>
    UEI     - INITIAL ENERGY CONSUMPTION FOR CONSUMER
                GOODS (KWH) <360.9>
    UPETAT  - TABLE FOR THE EFFECT OF TRANSPORTATION
                AVAILABILITY ON CONSUMER GOODS PRODUCTION
                <361.2>
    UTPRN   - NORMAL TRANSPORTATION/OUTPUT RATIO (TONNE-
                KM/POUND) <361.5>
    ULRT    - TABLE FOR REQUESTED CONSUMER GOODS LABOR
                <361.7>
    UGI     - INITIAL CAPITAL FOR CONSUMER GOODS <361.9>
    UGQOTT  - CAPITAL IMPORT ORDERS FOR CONSUMER GOODS TO
                ABSORB NEW TECHNOLOGY <362.2>

  OSF.K=.75
UPDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1            363, A
    UGQOSF  - FRACTION OF DOMESTIC CONSUMER GOODS CAPITAL   363.3, T
                SHORTFALL ORDERED FOR IMPORT <363>
    UPDACT  - TABLE FOR THE DESIRED ANNUAL CHANGE IN
                CONSUMER GOODS PRODUCTION <363.3>
```

```
UPRG.K=UPR.K                                              364, A
UGQCI=0                                                   364.2, C
UPGIT=.05/.05/.05/.05/.05/.05                             364.4, T
    UPRG    - CONSUMER GOODS PRODUCTION REQUEST USED FOR
                GROWTH CALCULATIONS <364>
    UPR     - REQUESTED CONSUMER GOODS PRODUCTION <353>
    UGQCI   - INITIAL CONSUMER GOODS CAPITAL ON ORDER FOR
                IMPORT (FOREX/YEAR) <364.2>
    UPGIT   - GOVERNMENT INFLUENCE ON CONSUMER GOODS
                GROWTH RATE <364.4>
```

CAPITAL GOODS PRODUCTION

```
GP.K=OUTPUT(GPR,GPI,GPELAT,GLII,GPERAT,GPRRN,GINT,   365, A
  GIN,GPEEAT,GEI,GPETAT,GTPRN,GLRT,GGI,GGQOTT,
  GGGOSF,GPDACT,GPRG,PULN,PULWR.K,GGCCI,GPGIT,
  GPPGL,GPELA,GPERA,GOMR.K,GOMI.K,GPEEA,GER,GE,
  GPETA,GTR,GT,GL,GLR,GG,GGR,GGQ,CGGO,GGCR,GCO,GGC,
  GIE,GIT,GIL,GIGC,GIGC,GIQ,GPN,GPDAC,0,0)
    GP      - CAPITAL GOODS PRODUCTION <365>
    OUTPUT  - SECTOR PRODUCTION (UNITS/YEAR) <2>
    GPR     - REQUESTED CAPITAL GOODS PRODUCTION <366>
    GPI     - INITIAL PRODUCTION OF CAPITAL GOODS
                (POUNDS) <367.4>
    GPELAT  - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON CAPITAL GOODS PRODUCTION <367.6>
    GLII    - INITIAL CAPITAL GOODS LABOR (MEN) <367.9>
    GPERAT  - TABLE FOR THE EFFECT OF RAW MATERIALS
                AVAILABILITY ON CAPITAL GOODS PRODUCTION
                <368.2>
    GPRRN   - OUTPUT/RAW MATERIAL RATIO FOR CAPITAL GOODS
                <369.3>
    GINT    - NORMAL PRIORITY FOR CAPITAL GOODS <369.5>
    GPEEAT  - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
                ON CAPITAL GOODS PRODUCTION <369.7>
    GEI     - INITIAL ENERGY CONSUMPTION FOR CAPITAL
                GOODS (KWH) <370.1>
    GPETAT  - TABLE FOR THE EFFECT OF TRANSPORTATION
                AVAILABILITY ON CAPITAL GOODS PRODUCTION
                <370.3>
    GTPRN   - NORMAL TRANSPORTATION/OUTPUT RATIO FOR
                CAPITAL GOODS (KM'S) <370.6>
    GLRT    - TABLE FOR REQUESTED CAPITAL GOODS LABOR
                <370.9>
    GGI     - INITIAL CAPITAL FOR CAPITAL GOODS <371.2>
    GGQOTT  - CAPITAL IMPORT ORDERS FOR CAPITAL GOODS TO
                ABSORB NEW TECHNOLOGY <371.4>
    GGGOSF  - FRACTION OF DOMESTIC CAPITAL GOODS CAPITAL
                SHORTFALL ORDERED FOR IMPORT <372>
```

GPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN CAPITAL GOODS PRODUCTION <372.3>
GPRG - CAPITAL GOODS PRODUCTION REQUEST USED FOR GROWTH CALCULATIONS <373>
PULN - SHORTFALL IN URBAN LABOR
PULWR - WEIGHTED REQUESTS FOR URBAN LABOR <133>
GGQCI - INITIAL CAPITAL GOODS CAPITAL ON ORDER FOR IMPORT (FOREX/YEAR) <376.2>
GPGIT - GOVERNMENT INFLUENCE ON CAPITAL GOODS GROWTH RATE <376.4>
GPPGL - POTENTIAL PRODUCTION OF CAPITAL GOODS FROM CAPITAL AND LABOR
GPELA - EFFECT OF LABOR AVAILABILITY ON CAPITAL GOODS PRODUCTION
GPERA - EFFECT OF RAW MATERIAL AVAILABILITY ON CAPITAL GOODS PRODUCTION
GQMR - MISCELLANEOUS IMPORT REQUIREMENTS FOR CAPITAL GOODS PRODUCTION
GQMI - INDICATED IMPORTED RAW MATERIALS FOR

GPEEA - EFFECT OF ENERGY AVAILABILITY ON CAPITAL GOODS PRODUCTION
GER - ENERGY REQUESTED FOR CAPITAL GOODS PRODUCTION
GE - ENERGY ALLOCATED FOR CAPITAL GOODS PRODUCTION
GPETA - EFFECT OF TRANSPORTATION AVAILABILITY ON CAPITAL GOODS PRODUCTION
GTR - TRANSPORTATION REQUESTED FOR CAPITAL GOODS PRODUCTION
GT - TRANSPORTATION ALLOCATED FOR CAPITAL GOODS PRODUCTION
GL - LABOR ALLOCATED FOR CAPITAL GOODS PRODUCTION
GLR - LABOR REQUESTED FOR CAPITAL GOODS PRODUCTION
GG - CAPITAL GOODS IN PLACE FOR CAPITAL GOODS PRODUCTION
GGR - CAPITAL GOODS REQUESTED FOR CAPITAL GOODS PRODUCTION
GGQ - CAPITAL GOODS IMPORTS FOR CAPITAL GOODS PRODUCTION
GGQO - CAPITAL GOODS ORDERED FOR IMPORT FOR CAPITAL GOODS PRODUCTION
GGCR - REQUESTED CONSTRUCTION ACTIVITY FOR CAPITAL GOODS CAPITAL GOODS
GGO - CAPITAL GOODS ORDERS FOR CAPITAL GOODS
GGC - COMMITMENT OF CAPITAL GOODS TO CAPITAL GOODS PRODUCTION
GIE - CAPITAL GOODS PRIORITY FOR ENERGY
GIT - CAPITAL GOODS PRIORITY FOR TRANSPORTATION
GIL - CAPITAL GOODS PRIORITY FOR LABOR

```
     GIGC     - CAPITAL GOODS PRIORITY FOR CONSTRUCTION
                   ACTIVITY
     GIGO     - CAPITAL GOODS PRIORITY FOR CAPITAL GOODS
                   COMMITMENTS
     GIQ      - CAPITAL GOODS PRIORITY FOR CAPITAL GOODS
                   IMPORTS
     GPN      - SHORTFALL IN PRODUCTION OF CAPITAL GOODS
     GPDAC    - DESIRED ANNUAL CHANGE IN CAPITAL GOODS
                   PRODUCTION


GPR.K=PUGCR.K+PRGCR.K+UGCR.K+TGCR.K+GGCR.K+FGCR.K+     366, A
  EGCR.K+WGCR.K+AGCR.K+AFGCR.K+NFGCR.K
    GPR      - REQUESTED CAPITAL GOODS PRODUCTION <366>
    PUGCR    - CONSTRUCTION REQUESTED FOR URBAN HOUSEHOLD
                  AND SERVICE CAPITAL
    PRGCR    - CONSTRUCTION REQUESTED FOR RURAL HOUSEHOLD
                  AND SERVICE CAPITAL
    UGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                  CONSUMER GOODS CAPITAL GOODS
    TGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                  TRANSPORTATION CAPITAL GOODS
    GGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR CAPITAL
                  GOODS CAPITAL GOODS
    FGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                  FERTILIZER CAPITAL GOODS
    EGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR ENERGY
                  CAPITAL GOODS
    WGCR     - CONSTRUCTION REQUESTED FOR DRAINAGE CAPITAL
                  (POUNDS/YEAR) <83>
    AGCR     - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
                  (POUNDS/YEAR) <267>
    AFGCR    - ACTIVITY REQUESTED FOR LAND RECLAMATION
                  <223>
    NFGCR    - ACTIVITY REQUESTED FOR NEW VALLEY
                  RECLAMATION <295>


GPWR.K=(PUGCR.K/PUIGC.K)+(PRGCR.K/PRIGC.K)+(UGCR.K/   367, A
  UIGC.K)+(TGCR.K/TIGC.K)+(GGCR.K/GIGC.K)+(FGCR.K/
  FIGC.K)+(EGCR.K/EIGC.K)+(WGCR.K/WIGC.K)+(AGCR.K/
  AIGC.K)+(AFGCR.K/AFIGC.K)+(NFGCR.K/NFIGC.K)
GPI=225E6                                              367.4, C
GPELAT=.2/.5/.75/.9/1/1.07/1.12/1.15/1.15             367.6, T
GLII=315E3                                             367.9, C
GPERAT=0/.4/.65/.85/1                                  368.2, T
    GPWR     - WEIGHTED REQUESTS FOR CAPITAL GOODS <367>
    PUGCR    - CONSTRUCTION REQUESTED FOR URBAN HOUSEHOLD
                  AND SERVICE CAPITAL
    PUIGC    - URBAN PRIORITY FOR CAPITAL GOODS
                  CONSTRUCTION
    PRGCR    - CONSTRUCTION REQUESTED FOR RURAL HOUSEHOLD
                  AND SERVICE CAPITAL
    PRIGC    - RURAL PRIORITY FOR CAPITAL GOODS
                  CONSTRUCTION
    UGCR     - REQUESTED CONSTRUCTION ACTIVITY FOR
                  CONSUMER GOODS CAPITAL GOODS
```

```
UIGC    - CONSUMER GOODS PRIORITY FOR CONSTRUCTION
             ACTIVITY
 TGCR   - REQUESTED CONSTRUCTION ACTIVITY FOR
             TRANSPORTATION CAPITAL GOODS
 TIGC   - TRANSPORTATION PRIORITY FOR CONSTRUCTION
             ACTIVITY
 GGCR   - REQUESTED CONSTRUCTION ACTIVITY FOR CAPITAL
             GOODS CAPITAL GOODS
 GIGC   - CAPITAL GOODS PRIORITY FOR CONSTRUCTION
             ACTIVITY
 FGCR   - REQUESTED CONSTRUCTION ACTIVITY FOR
             FERTILIZER CAPITAL GOODS
 FIGC   - FERTILIZER PRIORITY FOR CONSTRUCTION
             ACTIVITY
 EGCR   - REQUESTED CONSTRUCTION ACTIVITY FOR ENERGY
             CAPITAL GOODS
 EIGC   - ENERGY PRIORITY FOR CONSTRUCTION ACTIVITY
 WGCR   - CONSTRUCTION REQUESTED FOR DRAINAGE CAPITAL
             (POUNDS/YEAR) <83>
 AGCR   - CONSTRUCTION REQUESTED FOR SECTOR CAPITAL
             (POUNDS/YEAR) <267>
 AFGCR  - ACTIVITY REQUESTED FOR LAND RECLAMATION
             <223>
 NFGCR  - ACTIVITY REQUESTED FOR NEW VALLEY
             RECLAMATION <295>
 GPI    - INITIAL PRODUCTION OF CAPITAL GOODS
             (POUNDS) <367.4>
 GPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
             ON CAPITAL GOODS PRODUCTION <367.6>
 GLII   - INITIAL CAPITAL GOODS LABOR (MEN) <367.9>
 GPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
             AVAILABILITY ON CAPITAL GOODS PRODUCTION
             <368.2>


GQMI.K=SHARE(GQMR.K,GMN.K,GIGM.K,GMWR.K,GIN.K)          369, A
GPRRN=2                                                  369.3, C
GINT=.2/.2/.2/.2/.2/.2                                   369.5, T
GPEEAT=0/.4/.65/.85/1                                    369.7, T
GEI=169E6                                                370.1, C
GPETAT=0/.5/.8/.9/1                                      370.3, T
GTPRN=3.5                                                370.6, C
GLRT=.9/.95/1/1.1/1.3/1.6/2                              370.9, T
GGI=250E6                                                371.2, C
GGQOTT=.1/.1/.1/.1/.1/.1                                 371.4, T
    GGMI    - INDICATED IMPORTED RAW MATERIALS FOR
                 CAPITAL GOODS PRODUCTION (POUNDS/YEAR)
                 <369>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    GQMR    - MISCELLANEOUS IMPORT REQUIREMENTS FOR
                 CAPITAL GOODS PRODUCTION
    GMN     - SHORTFALL IN MISCELLANEOUS IMPORTS <483>
    GMWR    - WEIGHTED REQUESTS FOR MISCELLANEOUS IMPORTS
                 <484>
```

```
    GPRRN  - OUTPUT/RAW MATERIAL RATIO FOR CAPITAL GOODS
               <369.3>
    GINT   - NORMAL PRIORITY FOR CAPITAL GOODS <369.5>
    GPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON CAPITAL GOODS PRODUCTION <369.7>
    GEI    - INITIAL ENERGY CONSUMPTION FOR CAPITAL
               GOODS (KWH) <370.1>
    GPETAT - TABLE FOR THE EFFECT OF TRANSPORTATION
               AVAILABILITY ON CAPITAL GOODS PRODUCTION
               <370.3>
    GTPRN  - NORMAL TRANSPORTATION/OUTPUT RATIO FOR
               CAPITAL GOODS (KM'S) <370.6>
    GLRT   - TABLE FOR REQUESTED CAPITAL GOODS LABOR
               <370.9>
    GGI    - INITIAL CAPITAL FOR CAPITAL GOODS <371.2>
    GGQOTT - CAPITAL IMPORT ORDERS FOR CAPITAL GOODS TO
               ABSORB NEW TECHNOLOGY <371.4>

GGQOSF.K=.75                                             372, A
GPDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1             372.3, T
    GGQOSF - FRACTION OF DOMESTIC CAPITAL GOODS CAPITAL
               SHORTFALL ORDERED FOR IMPORT <372>
    GPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
               CAPITAL GOODS PRODUCTION <372.3>

GPRG.K=MAX(GOR.K,GPR.K)                                  373, A
    GPRG   - CAPITAL GOODS PRODUCTION REQUEST USED FOR
               GROWTH CALCULATIONS <373>
    GOR    - ORDERS FOR CAPITAL GOODS <374>
    GPR    - REQUESTED CAPITAL GOODS PRODUCTION <366>


GOR.K=PUGO.K+PRGO.K+UGO.K+TGO.K+GGO.K+FGO.K+EGO.K+   374, A
  WGO.K+AGO.K+AFGO.K+NFGO.K
    GOR    - ORDERS FOR CAPITAL GOODS <374>
    PUGO   - URBAN ORDERS FOR HOUSEHOLD AND SERVICE
               CAPITAL
    PRGO   - RURAL ORDERS FOR HOUSEHOLD AND SERVICE
               CAPITAL
    UGO    - CONSUMER GOODS ORDERS FOR CAPITAL GOODS
    TGO    - TRANSPORTATION ORDERS FOR CAPITAL GOODS
    GGO    - CAPITAL GOODS ORDERS FOR CAPITAL GOODS
    FGO    - FERTILIZER ORDERS FOR CAPITAL GOODS
    EGO    - ENERGY ORDERS FOR CAPITAL GOODS
    WGO    - ORDERS PLACED FOR CAPITAL GOODS FOR
               DRAINAGE (POUNDS/YEAR) <85>
    AGO    - ORDERS PLACED FOR CAPITAL GOODS FOR
               AGRICULTURE (POUNDS/YEAR) <269>
    AFGO   - DESIRED RECLAMATION ACTIVITY <225>
    NFGO   - DESIRED NEW VALLEY RECLAMATION ACTIVITY
               INVESTMENT COMMITMENT TO NEW VALLEY
               RECLAMATION <297>
```

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GOWR.K=(PUGO.K/PUIGO.K)+(PRGO.K/PRIGO.K)+(UGO.K/        375, A
  UIGO.K)+(TGO.K/TIGO.K)+(GGO.K/GIGO.K)+(FGO.K/
  FIGO.K)+(EGO.K/EIGO.K)+(WGO.K/WIGO.K)+(AGO.K/
  AIGO.K)+(AFGO.K/AFIGO.K)+(NFGO.K/NFIGO.K)
    GOWR    - WEIGHTED ORDERS FOR CAPITAL GOODS <375>
    PUGO    - URBAN ORDERS FOR HOUSEHOLD AND SERVICE
                CAPITAL
    PUIGO   - URBAN PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    PRGO    - RURAL ORDERS FOR HOUSEHOLD AND SERVICE
                CAPITAL
    PRIGO   - RURAL PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    UGO     - CONSUMER GOODS ORDERS FOR CAPITAL GOODS
    UIGO    - CONSUMER GOODS PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    TGO     - TRANSPORTATION ORDERS FOR CAPITAL GOODS
    TIGO    - TRANSPORTATION PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    GGO     - CAPITAL GOODS ORDERS FOR CAPITAL GOODS
    GIGO    - CAPITAL GOODS PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    FGO     - FERTILIZER ORDERS FOR CAPITAL GOODS
    FIGO    - FERTILIZER PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    EGO     - ENERGY ORDERS FOR CAPITAL GOODS
    EIGO    - ENERGY PRIORITY FOR CAPITAL GOODS
                COMMITMENTS
    WGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                DRAINAGE (POUNDS/YEAR) <85>
    AGO     - ORDERS PLACED FOR CAPITAL GOODS FOR
                AGRICULTURE (POUNDS/YEAR) <269>
    AFGO    - DESIRED RECLAMATION ACTIVITY <225>
    NFGO    - DESIRED NEW VALLEY RECLAMATION ACTIVITY
                INVESTMENT COMMITMENT TO NEW VALLEY
                RECLAMATION <297>


GON.K=MAX(GOR.K-GPPGL.K,0)                                376, A
GGGCI=0                                                   376.2, C
GPGIT=.05/.05/.05/.05/.05/.05                             376.4, T
GPDAC=GPDACI                                              376.6, N
GPDACI=.1                                                 376.7, C
    GON     - SHORTFALL IN ORDERS FOR CAPITAL GOODS <376>
    GOR     - ORDERS FOR CAPITAL GOODS <374>
    GPPGL   - POTENTIAL PRODUCTION OF CAPITAL GOODS FROM
                CAPITAL AND LABOR
    GGGCI   - INITIAL CAPITAL GOODS CAPITAL ON ORDER FOR
                IMPORT (FOREX/YEAR) <376.2>
    GPGIT   - GOVERNMENT INFLUENCE ON CAPITAL GOODS
                GROWTH RATE <376.4>
    GPDAC   - DESIRED ANNUAL CHANGE IN CAPITAL GOODS
                PRODUCTION
    GPDACI  - INITIAL DESIRED ANNUAL GROWTH RATE FOR
                CAPITAL PRODUCTION <376.7>
```

```
GXN.K=MAX(0,GQRT.K-GGXV.K-XLDN.K)                       377, A
     GXN     - SHORTFALL IN FOREIGN EXCHANGE FOR IMPORTING
                 CAPITAL (FOREX/YEAR) <377>
     GQRT    - TOTAL REQUESTS FOR CAPITAL IMPORTS (FOREX/
                 YEAR) <378>
     GGXV    - POUNDS VALUE OF CAPITAL GOODS IMPORTS <471>
     XLDN    - NEW LONG TERM DEBT (POUNDS/YEAR) <439.1>

GQRT.K=UGGO.K+TGGO.K+GGGO.K+FGGO.K+EGGO.K+WGGO.K+       378, A
  AGGO.K
     GQRT    - TOTAL REQUESTS FOR CAPITAL IMPORTS (FOREX/
                 YEAR) <378>
     UGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                 CONSUMER GOODS PRODUCTION
     TGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                 TRANSPORTATION PRODUCTION
     GGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                 CAPITAL GOODS PRODUCTION
     FGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                 FERTILIZER PRODUCTION
     EGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR ENERGY
                 PRODUCTION
     WGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR DRAINAGE
                 (FOREX/YEAR) <90>
     AGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR
                 AGRICULTURE (FOREX/YEAR) <278>

GXWR.K=(UGGO.K/UIQ.K)+(TGGO.K/TIQ.K)+(GGGO.K/GIQ.K) 379, A
  +(FGGO.K/FIQ.K)+(EGGO.K/EIQ.K)+(WGGO.K/WIQ.K)+
  (AGGO.K/AIQ.K)
    GXWR    - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <379>
    UGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                CONSUMER GOODS PRODUCTION
    UIQ     - CONSUMER GOODS PRIORITY FOR CAPITAL GOODS
                IMPORTS
    TGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                TRANSPORTATION PRODUCTION
    TIQ     - TRANSPORTATION PRIORITY FOR CAPITAL GOODS
                IMPORTS
    GGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                CAPITAL GOODS PRODUCTION
    GIQ     - CAPITAL GOODS PRIORITY FOR CAPITAL GOODS
                IMPORTS
    FGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                FERTILIZER PRODUCTION
    FIQ     - FERTILIZER PRIORITY FOR CAPITAL GOODS
                IMPORTS
    EGGO    - CAPITAL GOODS ORDERED FOR IMPORT FOR ENERGY
                PRODUCTION
    EIQ     - ENERGY PRIORITY FOR CAPITAL GOODS IMPORTS
    WGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <90>
    AGGO    - ORDERS TO IMPORT CAPITAL GOODS FOR
                AGRICULTURE (FOREX/YEAR) <278>
```

```
GIXN.K=GXWRP.K/GQRT.K                                     380. A
    GIXN    - NORMAL PRIORITY OF CAPITAL GOODS FOR
                FOREIGN EXCHANGE <380>
    GXWRP   - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <381>
    GQRT    - TOTAL REQUESTS FOR CAPITAL IMPORTS (FOREX/
                YEAR) <378>


GXWRP.K=(UGQO.K*UIQ.K)+(TGQO.K*TIQ.K)+(GGQO.K*            381. A
  GIQ.K)+(FGQO.K*FIQ.K)+(EGQO.K*EIQ.K)+(WGQO.K*
  WIQ.K)+(AGQO.K*AIQ.K)
    GXWRP   - WEIGHTED REQUESTS FOR CAPITAL IMPORTS <381>
    UGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                CONSUMER GOODS PRODUCTION
    UIQ     - CONSUMER GOODS PRIORITY FOR CAPITAL GOODS
                IMPORTS
    TGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                TRANSPORTATION PRODUCTION
    TIQ     - TRANSPORTATION PRIORITY FOR CAPITAL GOODS
                IMPORTS
    GGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                CAPITAL GOODS PRODUCTION
    GIQ     - CAPITAL GOODS PRIORITY FOR CAPITAL GOODS
                IMPORTS
    FGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR
                FERTILIZER PRODUCTION
    FIQ     - FERTILIZER PRIORITY FOR CAPITAL GOODS
                IMPORTS
    EGQO    - CAPITAL GOODS ORDERED FOR IMPORT FOR ENERGY
                PRODUCTION
    EIQ     - ENERGY PRIORITY FOR CAPITAL GOODS IMPORTS
    WGQO    - ORDERS TO IMPORT CAPITAL GOODS FOR DRAINAGE
                (FOREX/YEAR) <90>
    AGQO    - ORDERS TO IMPORT CAPITAL GOODS FOR
                AGRICULTURE (FOREX/YEAR) <278>

GCT.K=SGCTN/POS(GP.K/GPR.K)                               382. A
    GCT     - AVERAGE CONSTRUCTION TIME FOR CAPITAL GOODS
                <382>
    SGCTN   - NORMAL CONSTRUCTION TIME FOR INDUSTRIAL
                CAPITAL (YEARS) <347.5>
    GP      - CAPITAL GOODS PRODUCTION <365>
    GPR     - REQUESTED CAPITAL GOODS PRODUCTION <366>
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```
ENERGY PRODUCTION

EP.K=OUTPUT(EPR,EPI,EPELAT,ELII,EPERAT,EPRRN,EINT,   383, A
  EIN,EPEEAT,EEI,EPETAT,0,ELRT,EGI,EGQOTT,EGQOSF,
  EPDACT,EPRG,PULN,PULWR.K,EGQCI,EPGIT,EPPGL,EPELA,
  EPERA,ERR,0,EPEEA,EER,EE,EPETA,ETR,ET,EL,ELR,EG,
  EGR,EGQ,EGQO,EGCR,EGO,EGC,EIE,EIT,EIL,EIGC,EIGO,
  EIG,EPN,EPDAC,WHEO.K,WHEA.K)
    EP     - ENERGY PRODUCTION <383>
    OUTPUT - SECTOR PRODUCTION (UNITS/YEAR) <2>
    EPR    - REQUESTED ENERGY PRODUCTION <384>
    EPI    - INITIAL PRODUCTION OF ENERGY (KWH'S)
               <385.4>
    EPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
               ON ENERGY PRODUCTION <385.6>
    ELII   - INITIAL ENERGY LABOR (MEN) <385.9>
    EPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
               AVAILABILITY ON ENERGY PRODUCTION <386.2>
    EPRRN  - OUTPUT/RAW MATERIAL RATIO FOR ENERGY
               (POUNDS/TONNE) <386.5>
    EINT   - NORMAL PRIORITY FOR ENERGY <386.7>
    EPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON ENERGY PRODUCTION <386.9>
    EEI    - INITIAL ENERGY CONSUMPTION FOR ENERGY (KWH)
               <387.3>
    EPETAT - TABLE FOR THE EFFECT OF TRANSPORTATION
               AVAILABILITY ON ENERGY PRODUCTION <387.5>
    ELRT   - TABLE FOR REQUESTED ENERGY LABOR <387.8>
    EGI    - INITIAL CAPITAL FOR ENERGY <388.1>
    EGQOTT - CAPITAL IMPORT ORDERS FOR ENERGY TO ABSORB
               NEW TECHNOLOGY <388.3>
    EGQOSF - FRACTION OF DOMESTIC ENERGY CAPITAL
               SHORTFALL ORDERED FOR IMPORT <389>
    EPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
               ENERGY PRODUCTION <389.3>
    EPRG   - ENERGY PRODUCTION REQUEST USED FOR GROWTH
               CALCULATIONS <390>
    PULN   - SHORTFALL IN URBAN LABOR
    PULWR  - WEIGHTED REQUESTS FOR URBAN LABOR <133>
    EGQCI  - INITIAL ENERGY CAPITAL ON ORDER FOR IMPORT
               (FOREX/YEAR) <390.2>
    EPGIT  - GOVERNMENT INFLUENCE ON ENERGY GROWTH RATE
               <390.4>
    EPPGL  - POTENTIAL PRODUCTION OF ENERGY FROM CAPITAL
               AND LABOR
    EPELA  - EFFECT OF LABOR AVAILABILITY ON ENERGY
               PRODUCTION
    EPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
               ENERGY PRODUCTION
    ERR    - RAW MATERIALS REQUESTED FOR ENERGY
               PRODUCTION
    EPEEA  - EFFECT OF ENERGY AVAILABILITY ON ENERGY
               PRODUCTION
    EER    - ENERGY REQUESTED FOR ENERGY PRODUCTION
    EE     - ENERGY ALLOCATED FOR ENERGY PRODUCTION
    EPETA  - EFFECT OF TRANSPORTATION AVAILABILITY ON
               ENERGY PRODUCTION
```

ETR - TRANSPORTATION REQUESTED FOR ENERGY PRODUCTION
ET - TRANSPORTATION ALLOCATED FOR ENERGY PRODUCTION
EL - LABOR ALLOCATED FOR ENERGY PRODUCTION
ELR - LABOR REQUESTED FOR ENERGY PRODUCTION
EG - CAPITAL GOODS IN PLACE FOR ENERGY PRODUCTION
EGR - CAPITAL GOODS REQUESTED FOR ENERGY PRODUCTION
EGQ - CAPITAL GOODS IMPORTS FOR ENERGY PRODUCTION
EGQO - CAPITAL GOODS ORDERED FOR IMPORT FOR ENERGY PRODUCTION
EGCR - REQUESTED CONSTRUCTION ACTIVITY FOR ENERGY CAPITAL GOODS
EGO - ENERGY ORDERS FOR CAPITAL GOODS
EGC - COMMITMENT OF CAPITAL GOODS TO ENERGY PRODUCTION
EIE - ENERGY PRIORITY FOR ENERGY
EIT - ENERGY PRIORITY FOR TRANSPORTATION
EIL - ENERGY PRIORITY FOR LABOR
EIGC - ENERGY PRIORITY FOR CONSTRUCTION ACTIVITY
EIGO - ENERGY PRIORITY FOR CAPITAL GOODS COMMITMENTS
EIQ - ENERGY PRIORITY FOR CAPITAL GOODS IMPORTS
EPN - SHORTFALL IN PRODUCTION OF ENERGY
EPDAC - DESIRED ANNUAL CHANGE IN ENERGY PRODUCTION
WHEO - HYDROELECTRIC ENERGY OUTPUT (KWH/YR) <52.1>
WHEA - HYDROELECTRIC ENERGY AVAILABLE <53.1>

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PR.K=PUER.K+PRER.K+GER.K+UER.K+TER.K+FER.K+AER.K+   384, A
 WDER.K
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EPR - REQUESTED ENERGY PRODUCTION <384>
PUER - URBAN ENERGY CONSUMPTION REQUESTED (KWH/YEAR)
PRER - RURAL ENERGY CONSUMPTION REQUESTED (KWH/YEAR)
GER - ENERGY REQUESTED FOR CAPITAL GOODS PRODUCTION
UER - ENERGY REQUESTED FOR CONSUMER GOODS PRODUCTION
TER - ENERGY REQUESTED FOR TRANSPORTATION PRODUCTION
FER - ENERGY REQUESTED FOR FERTILIZER PRODUCTION
AER - ENERGY REQUIRED FOR AGRICULTURE (KWH/YEAR) <285>
WDER - WATER-DRAINAGE ENERGY REQUIREMENTS (KWH/HA-YR) <72>

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EWR.K=(PUER.K/PUIE.K)+(PRER.K/PRIE.K)+(GER.K/GIE.K) 385, A
  +(UER.K/UIE.K)+(TER.K/TIE.K)+(FER.K/FIE.K)+
  (AER.K/AIE.K)+(WDER.K/WDIE.K)
EPI=1600E6                                          385.4, C
EPELAT=1/1/1/1/1/1/1/1/1                            385.6, T
ELII=0                                              385.9, C
EPERAT=1/1/1/1/1                                    386.2, T
EPRRN=2500                                          386.5, C
EINT=.1/.1/.1/.1/.1/.1                              386.7, T
EPEEAT=1/1/1/1/1                                    386.9, T
EEI=0                                               387.3, C
EPETAT=1/1/1/1/1                                    387.5, T
ELRT=1/1/1/1/1/1/1                                  387.8, T
EGI=50E6                                            388.1, C
EGGOTT=.1/.1/.1/.1/.1/.1                            388.3, T
    EWR    - WEIGHTED REQUESTS FOR ENERGY <385>
    PUER   - URBAN ENERGY CONSUMPTION REQUESTED (KWH/
               YEAR)
    PUIE   - URBAN PRIORITY FOR ENERGY
    PRER   - RURAL ENERGY CONSUMPTION REQUESTED (KWH/
               YEAR)
    PRIE   - RURAL PRIORITY FOR ENERGY
    GER    - ENERGY REQUESTED FOR CAPITAL GOODS
               PRODUCTION
    GIE    - CAPITAL GOODS PRIORITY FOR ENERGY
    UER    - ENERGY REQUESTED FOR CONSUMER GOODS
               PRODUCTION
    UIE    - CONSUMER GOODS PRIORITY FOR ENERGY
    TER    - ENERGY REQUESTED FOR TRANSPORTATION
               PRODUCTION
    TIE    - TRANSPORTATION PRIORITY FOR ENERGY
    FER    - ENERGY REQUESTED FOR FERTILIZER PRODUCTION
    FIE    - FERTILIZER PRIORITY FOR ENERGY
    AER    - ENERGY REQUIRED FOR AGRICULTURE (KWH/YEAR)
               <285>
    WDER   - WATER-DRAINAGE ENERGY REQUIREMENTS (KWH/HA-
               YR) <72>
    EPI    - INITIAL PRODUCTION OF ENERGY (KWH'S)
               <385.4>
    EPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
               ON ENERGY PRODUCTION <385.6>
    ELII   - INITIAL ENERGY LABOR (MEN) <385.9>
    EPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
               AVAILABILITY ON ENERGY PRODUCTION <386.2>
    EPRRN  - OUTPUT/RAW MATERIAL RATIO FOR ENERGY
               (POUNDS/TONNE) <386.5>
    EINT   - NORMAL PRIORITY FOR ENERGY <386.7>
    EPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON ENERGY PRODUCTION <386.9>
    EEI    - INITIAL ENERGY CONSUMPTION FOR ENERGY (KWH)
               <387.3>
    EPETAT - TABLE FOR THE EFFECT OF TRANSPORTATION
               AVAILABILITY ON ENERGY PRODUCTION <387.5>
    ELRT   - TABLE FOR REQUESTED ENERGY LABOR <387.8>
    EGI    - INITIAL CAPITAL FOR ENERGY <388.1>
    EGGOTT - CAPITAL IMPORT ORDERS FOR ENERGY TO ABSORB
               NEW TECHNOLOGY <398.3>
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EGQOSF.K=.75                                                389, A
EPDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1                389.3, T
    EGQOSF - FRACTION OF DOMESTIC ENERGY CAPITAL
               SHORTFALL ORDERED FOR IMPORT <389>
    EPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
               ENERGY PRODUCTION <389.3>

EPRG.K=EPR.K                                                390, A
EGQCI=0                                                     390.2, C
EPGIT=.05/.05/.05/.05/.05/.05                               390.4, T
    EPRG   - ENERGY PRODUCTION REQUEST USED FOR GROWTH
               CALCULATIONS <390>
    EPR    - REQUESTED ENERGY PRODUCTION <384>
    EGQCI  - INITIAL ENERGY CAPITAL ON ORDER FOR IMPORT
               (FOREX/YEAR) <390.2>
    EPGIT  - GOVERNMENT INFLUENCE ON ENERGY GROWTH RATE
               <390.4>

EDF.K=TABHL(EDFT,TIME.K,1960,2010,10)                       391, A
EDFT=1/1/1/1/1/1                                            391.2, T
    EDF    - ENERGY DEMAND FACTOR <391>
    EDFT   - TABLE FOR ENERGY DEMAND FACTOR <391.2>


   FERTILIZER PRODUCTION

FP.K=OUTPUT(FPR,FPI,FPELAT,FLII,FPERAT,FPRRN,FINT,          392, A
  FIN,FPEEAT,FEI,FPETAT,FTPRN,FLRT,FGI,FGQOTT,
  FGQOSF,FPDACT,FPRG,PULN,PULWR.K,FGQCI,FPGIT,
  FPPGL,FPELA,FPERA,FRR,0,FPEEA,FER,FE,FPETA,FTR,
  FT,FL,FLR,FG,FGR,FGQ,FGQO,FGCR,FGD,FGC,FIE,FIT,
  FIL,FIGC,FIGO,FIQ,FPN,FPDAC,0,0)
     FP     - FERTILIZER PRODUCTION <392>
     OUTPUT - SECTOR PRODUCTION (UNITS/YEAR) <2>
     FPR    - REQUESTED FERTILIZER PRODUCTION <393>
     FPI    - INITIAL PRODUCTION OF FERTILIZER (TONNES)
                <393.4>
     FPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON FERTILIZER PRODUCTION <393.6>
     FLII   - INITIAL FERTILIZER LABOR (MEN) <393.9>
     FPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
                AVAILABILITY ON FERTILIZER PRODUCTION
                <394.2>
     FPRRN  - OUTPUT/RAW MATERIAL RATIO FOR FERTILIZER
                (TONNES/TONNE) <394.5>
     FINT   - NORMAL PRIORITY FOR FERTILIZER <394.7>
     FPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
                ON FERTILIZER PRODUCTION <394.9>
     FEI    - INITIAL ENERGY CONSUMPTION FOR FERTILIZER
                (KWH) <395.3>
     FPETAT - TABLE FOR THE EFFECT OF TRASNPORTATION
                AVAILABILITY ON FERTILIZER PRODUCTION
                <395.5>
     FTPRN  - NORMAL TRANSPORTATION/OUTPUT RATIO FOR
                FERTILIZER (KM'S) <395.8>
     FLRT   - TABLE FOR REQUESTED FERTILIZER LABOR
                <396.1>
     FGI    - INITIAL CAPITAL FOR FERTILIZER <396.3>
     FGQOTT - CAPITAL IMPORT ORDERS FOR FERTILIZER TO
                ABSORB NEW TECHNOLOGY <396.5>
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    FGQOSF - FRACTION OF DOMESTIC FERTILIZER CAPITAL
                SHORTFALL ORDERED FOR IMPORT <397>
    FPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
                FERTILIZER PRODUCTION <397.3>
    FPRG   - FERTILIZER PRODUCTION REQUEST USED FOR
                GROWTH CALCULATIONS <398>
    PULN   - SHORTFALL IN URBAN LABOR
    PULWR  - WEIGHTED REQUESTS FOR URBAN LABOR <133>
    FGQCI  - INITIAL FERTILIZER CAPITAL ON ORDER FOR
                IMPORT (FOREX/YEAR) <398.2>
    FPGIT  - GOVERNMENT INFLUENCE ON FERTILIZER GROWTH
                RATE <398.4>
    FPPGL  - POTENTIAL PRODUCTION OF FERTILIZER FROM
                CAPITAL AND LABOR
    FPELA  - EFFECT OF LABOR AVAILABILITY ON FERTILIZER
                PRODUCTION
    FPERA  - EFFECT OF RAW MATERIAL AVAILABILITY ON
                FERTILIZER PRODUCTION
    FRR    - RAW MATERIALS REQUESTED FOR FERTILIZER
                PRODUCTION
    FPEEA  - EFFECT OF ENERGY AVAILABILITY ON FERTILIZER
                PRODUCTION


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  FER    - ENERGY REQUESTED FOR FERTILIZER PRODUCTION
  FE     - ENERGY ALLOCATED FOR FERTILIZER PRODUCTION
  FPETA  - EFFECT OF TRANSPORTATION AVAILABILITY ON
              FERTILIZER PRODUCTION
  FTR    - TRANSPORTATION REQUESTED FOR FERTILIZER
              PRODUCTION
  FT     - TRANSPORTATION ALLOCATED FOR FERTILIZER
              PRODUCTION
  FL     - LABOR ALLOCATED FOR FERTILIZER PRODUCTION
  FLR    - LABOR REQUESTED FOR FERTILIZER PRODUCTION
  FG     - CAPITAL GOODS IN PLACE FOR FERTILIZER
              PRODUCTION
  FGR    - CAPITAL GOODS REQUESTED FOR FERTILIZER
              PRODUCTION
  FGQ    - CAPITAL GOODS IMPORTS FOR FERTILIZER
              PRODUCTION
  FGQO   - CAPITAL GOODS ORDERED FOR IMPORT FOR
              FERTILIZER PRODUCTION
  FGCR   - REQUESTED CONSTRUCTION ACTIVITY FOR
              FERTILIZER CAPITAL GOODS
  FGO    - FERTILIZER ORDERS FOR CAPITAL GOODS
  FGC    - COMMITMENT OF CAPITAL GOODS TO FERTILIZER
              PRODUCTION
  FIE    - FERTILIZER PRIORITY FOR ENERGY
  FIT    - FERTILIZER PRIORITY FOR TRANSPORTATION
  FIL    - FERTILIZER PRIORITY FOR LABOR
  FIGC   - FERTILIZER PRIORITY FOR CONSTRUCTION
              ACTIVITY
  FIGO   - FERTILIZER PRIORITY FOR CAPITAL GOODS
              COMMITMENTS
  FIQ    - FERTILIZER PRIORITY FOR CAPITAL GOODS
              IMPORTS
  FPN    - SHORTFALL IN PRODUCTION OF FERTILIZER
  FPDAC  - DESIRED ANNUAL CHANGE IN FERTILIZER
              PRODUCTION
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FPR.K=ANCD.K/FNC                                           393, A
FNC=.15                                                    393.2, C
FPI=1.09E6                                                 393.4, C
FPELAT=1/1/1/1/1/1/1/1/1                                   393.6, T
FLII=0                                                     393.9, C
FPERAT=1/1/1/1/1                                           394.2, T
FPRRN=1E12                                                 394.5, C
FINT=.1/.1/.1/.1/.1/.1                                     394.7, T
FPEEAT=0/.4/.65/.85/1                                      394.9, T
FEI=37E6                                                   395.3, C
FPETAT=0/.5/.8/.9/1                                        395.5, T
FTPRN=220                                                  395.8, C
FLRT=1/1/1/1/1/1/1                                         396.1, T
FGI=5E6                                                    396.3, C
FGQOTT=.1/.1/.1/.1/.1/.1                                   396.5, T
    FPR    - REQUESTED FERTILIZER PRODUCTION <393>
    ANCD   - REGUESTED CHEMICAL NUTRIENTS (TONNES/YEAR)
               <245>
    FNC    - FRACTION OF FERTILIZER THAT IS NUTRIENT
             . <393.2>
    FPI    - INITIAL PRODUCTION OF FERTILIZER (TONNES)
               <393.4>
    FPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
               ON FERTILIZER PRODUCTION <393.6>
    FLII   - INITIAL FERTILIZER LABOR (MEN) <393.9>
    FPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
               AVAILABILITY ON FERTILIZER PRODUCTION
               <394.2>
    FPRRN  - OUTPUT/RAW MATERIAL RATIO FOR FERTILIZER
               (TONNES/TONNE) <394.5>
    FINT   - NORMAL PRIORITY FOR FERTILIZER <394.7>
    FPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON FERTILIZER PRODUCTION <394.9>
    FEI    - INITIAL ENERGY CONSUMPTION FOR FERTILIZER
               (KWH) <395.3>
    FPETAT - TABLE FOR THE EFFECT OF TRASNPORTATION
               AVAILABILITY ON FERTILIZER PRODUCTION
               <395.5>
    FTPRN  - NORMAL TRANSPORTATION/OUTPUT RATIO FOR
               FERTILIZER (KM'S) <395.8>
    FLRT   - TABLE FOR REGUESTED FERTILIZER LABOR
               <396.1>
    FGI    - INITIAL CAPITAL FOR FERTILIZER <396.3>
    FGQOTT - CAPITAL IMPORT ORDERS FOR FERTILIZER TO
               ABSORB NEW TECHNOLOGY <396.5>

FGQOSF.K=.75                                               397, A
FPDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1               397.3, T
    FGQOSF - FRACTION OF DOMESTIC FERTILIZER CAPITAL
               SHORTFALL ORDERED FOR IMPORT <397>
    FPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
               FERTILIZER PRODUCTION <397.3>
```

```
FPRG.K=FPR.K
FGQCI=0                                                   398, A
FPGIT=.05/.05/.05/.05/.05/.05                             398.2, C
    FPRG   - FERTILIZER PRODUCTION REQUEST USED FOR      398.4, T
               GROWTH CALCULATIONS <398>
    FPR    - REQUESTED FERTILIZER PRODUCTION <393>
    FGQCI  - INITIAL FERTILIZER CAPITAL ON ORDER FOR
               IMPORT (FOREX/YEAR) <398.2>
    FPGIT  - GOVERNMENT INFLUENCE ON FERTILIZER GROWTH
               RATE <398.4>

FQ.K=QFXV.K/FPRICE.K
FQ=FQI                                                    399, A
FQI=100E3                                                 399.1, N
    FQ     - FERTILIZER IMPORTS (TONNES/YEAR) <399.1>     399.3, C
    QFXV   - POUNDS VALUE OF FERTILIZER IMPORTS <472>
    FPRICE - PRICE OF CHEMICAL FERTILIZER <485>
    FQI    - INITIAL FERTILIZER IMPORTS (TONNES/YEAR)
               <399.3>
```

TRANSPORTATION PRODUCTION

```
TP.K=OUTPUT(TPR,TPI,TPELAT,TLII,TPERAT,TPRRN,TINT,   400, A
  TIN,TPEEAT,TEI,TPETAT,0,TLRT,TGI,TGQOTT,TGQOSF,
  ,PDACT,TPRG,PULN,PULWR.K,TGQCI,TPGIT,TPPGL,TPELA,
  TPERA,TRR,0,TPEEA,TER,TE,TPETA,TTR,TT,TL,TLR,TG,
  TGR,TGD,TGQC,TGCR,TGO,TGC,TIE,TIT,TIL,TIGC,TIGO,
  TIQ,TPN,TPDAC,0,0)
    TP      - TRANSPORTATION PRODUCTION <400>
    OUTPUT  - SECTOR PRODUCTION (UNITS/YEAR) <2>
    TPR     - REQUESTED TRANSPORTATION PRODUCTION <401>
    TPI     - INITIAL PRODUCTION OF TRANSPORTATION
                (TONNE-KM'S) <402.2>
    TPELAT  - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
                ON TRANSPORTATION PRODUCTION <402.4>
    TLII    - INITIAL TRANSPORTATION LABOR (MEN) <402.7>
    TPERAT  - TABLE FOR THE EFFECT OF RAW MATERIALS
                AVAILABILITY ON TRANSPORTATION PRODUCTION
                <402.9>
    TPRRN   - OUTPUT/RAW MATERIAL RATIO FOR
                TRANSPORTATION (POUNDS/TONNE) <403.3>
    TINT    - NORMAL PRIORITY FOR TRANSPORTATION <403.5>
    TPEEAT  - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
                ON TRANSPORTATION PRODUCTION <403.7>
    TEI     - INITIAL ENERGY CONSUMPTION FOR
                TRANSPORTATION (KWH) <404.1>
    TPETAT  - TABLE FOR THE EFFECT OF TRANSPORTATION
                AVAILABILITY ON TRANSPORTATION PRODUCTION
                <404.3>
    TLRT    - TABLE FOR REQUESTED TRANSPORTATION LABOR
                <404.6>
    TGI     - INITIAL CAPITAL FOR TRANSPORTATION <404.8>
    TGQOTT  - CAPITAL IMPORT ORDERS FOR TRANSPORTATION TO
                ABSORB NEW TECHNOLOGY <405.1>
    TGQOSF  - FRACTION OF DOMESTIC TRANSPORTATION CAPITAL
                SHORTFALL <406>
    TPDACT  - TABLE FOR THE DESIRED ANNUAL CHANGE IN
                TRANSPORTATION PRODUCTION <406.2>
    TPRG    - TRANSPORTATION PRODUCTION REQUEST USED FOR
                GROWTH CALCULATIONS <407>
    PULN    - SHORTFALL IN URBAN LABOR
    PULWR   - WEIGHTED REQUESTS FOR URBAN LABOR <133>
    TGQCI   - INITIAL TRANSPORTATION CAPITAL ON ORDER FOR
                IMPORT (FOREX/YEAR) <407.2>
    TPGIT   - GOVERNMENT INFLUENCE ON TRANSPORTATION
                GROWTH RATE <407.4>
    TPPGL   - POTENTIAL PRODUCTION OF TRANSPORTATION FROM
                CAPITAL AND LABOR
    TPELA   - EFFECT OF LABOR AVAILABILITY ON
                TRANSPORTATION PRODUCTION
    TPERA   - EFFECT OF RAW MATERIAL AVAILABILITY ON
                TRANSPORTATION PRODUCTION
    TRR     - RAW MATERIALS REQUESTED FOR TRANSPORTATION
                PRODUCTION
    TPEEA   - EFFECT OF ENERGY AVAILABILITY ON
                TRANSPORTATION PRODUCTION
    TER     - ENERGY REQUESTED FOR TRANSPORTATION
                PRODUCTION
```

TE - ENERGY ALLOCATED FOR TRANSPORTATION PRODUCTION

TPETA - EFFECT OF TRANSPORTATION AVAILABILITY ON TRANSPORTATION PRODUCTION

TTR - TRANSPORTATION REQUESTED FOR TRANSPORTATION PRODUCTION

TT - TRANSPORTATION ALLOCATED FOR TRANSPORTATION PRODUCTION

TL - LABOR ALLOCATED FOR TRANSPORTATION PRODUCTION

TLR - LABOR REQUESTED FOR TRANSPORTATION PRODUCTION

TG - CAPITAL GOODS IN PLACE FOR TRANSPORTATION PRODUCTION

TGR - CAPITAL GOODS REQUESTED FOR TRANSPORTATION PRODUCTION

TGQ - CAPITAL GOODS IMPORTS FOR TRANSPORTATION PRODUCTION

TGQO - CAPITAL GOODS ORDERED FOR IMPORT FOR TRANSPORTATION PRODUCTION

TGCR - REQUESTED CONSTRUCTION ACTIVITY FOR TRANSPORTATION CAPITAL GOODS

TGO - TRANSPORTATION ORDERS FOR CAPITAL GOODS

TGC - COMMITMENT OF CAPITAL GOODS TO TRANSPORTATION PRODUCTION

TIE - TRANSPORTATION PRIORITY FOR ENERGY

TIT - TRANSPORTATION PRIORITY FOR TRANSPORTATION

TIL - TRANSPORTATION PRIORITY FOR LABOR

TIGC - TRANSPORTATION PRIORITY FOR CONSTRUCTION ACTIVITY

TIGO - TRANSPORTATION PRIORITY FOR CAPITAL GOODS COMMITMENTS

TIQ - TRANSPORTATION PRIORITY FOR CAPITAL GOODS IMPORTS

TPN - SHORTFALL IN PRODUCTION OF TRANSPORTATION

TPDAC - DESIRED ANNUAL CHANGE IN TRANSPORTATION PRODUCTION

```
TPR.K=SMOOTH(ATR.K+GTR.K+UTR.K+FTR.K,TPRAT)          401, A
TPRAT=.5                                             401.2, C
```

TPR - REQUESTED TRANSPORTATION PRODUCTION <401>

ATR - TRANSPORTATION REQUIRED (TONNE-MILES/ SEASON) <5>

GTR - TRANSPORTATION REQUESTED FOR CAPITAL GOODS PRODUCTION

UTR - TRANSPORTATION REQUESTED FOR CONSUMER GOODS PRODUCTION

FTR - TRANSPORTATION REQUESTED FOR FERTILIZER PRODUCTION

TPRAT - TIME TO AVERAGE TRANSPORTATION REQUESTS <401.2>

```
TWR.K=(ATR.K/AIT.K)+(GTR.K/GIT.K)+(UTR.K/UIT.K)+       402, A
  (FTR.K/FIT.K)
TPI=2.18E9                                             402.2, C
TPELAT=.2/.5/.75/.9/1/1.07/1.12/1.14/1.15              402.4, T
TLII=220E3                                             402.7, C
TPERAT=1/1/1/1/1                                       402.9, T
TPRRN=1E12                                             403.3, C
TINT=.1/.1/.1/.1/.1/.1                                 403.5, T
TPEEAT=0/.4/.65/.85/1                                  403.7, T
TEI=467E6                                              404.1, C
TPETAT=1/1/1/1/1                                       404.3, T
TLRT=.9/.95/1/1.1/1.3/1.6/2                            404.6, T
TGI=690E6                                              404.8, C
TGQOTT=.1/.1/.1/.1/.1/.1                               405.1, T
    TWR    - WEIGHTED REQUESTS FOR TRANSPORTATION <402>
    ATR    - TRANSPORTATION REQUIRED (TONNE-MILES/
               SEASON) <5>
    GTR    - TRANSPORTATION REQUESTED FOR CAPITAL GOODS
               PRODUCTION
    GIT    - CAPITAL GOODS PRIORITY FOR TRANSPORTATION
    UTR    - TRANSPORTATION REQUESTED FOR CONSUMER GOODS
               PRODUCTION
    UIT    - CONSUMER GOODS PRIORITY FOR TRANSPORTATION
    FTR    - TRANSPORTATION REQUESTED FOR FERTILIZER
               PRODUCTION
    FIT    - FERTILIZER PRIORITY FOR TRANSPORTATION
    TPI    - INITIAL PRODUCTION OF TRANSPORTATION
               (TONNE-KM'S) <402.2>
    TPELAT - TABLE FOR THE EFFECT OF LABOR AVAILABILITY
               ON TRANSPORTATION PRODUCTION <402.4>
    TLII   - INITIAL TRANSPORTATION LABOR (MEN) <402.7>
    TPERAT - TABLE FOR THE EFFECT OF RAW MATERIALS
               AVAILABILITY ON TRANSPORTATION PRODUCTION
               <402.9>
    TPRRN  - OUTPUT/RAW MATERIAL RATIO FOR
               TRANSPORTATION (POUNDS/TONNE) <403.3>
    TINT   - NORMAL PRIORITY FOR TRANSPORTATION <403.5>
    TPEEAT - TABLE FOR THE EFFECT OF ENERGY AVAILABILITY
               ON TRANSPORTATION PRODUCTION <403.7>
    TEI    - INITIAL ENERGY CONSUMPTION FOR
               TRANSPORTATION (KWH) <404.1>
    TPETAT - TABLE FOR THE EFFECT OF TRANSPORTATION
               AVAILABILITY ON TRANSPORTATION PRODUCTION
               <404.3>
    TLRT   - TABLE FOR REQUESTED TRANSPORTATION LABOR
               <404.6>
    TGI    - INITIAL CAPITAL FOR TRANSPORTATION <404.8>
    TGQOTT - CAPITAL IMPORT ORDERS FOR TRANSPORTATION TO
               ABSORB NEW TECHNOLOGY <405.1>

TGQOSF.K=.75                                           406, A
TPDACT=-.1/-.075/-.05/-.025/0/.04/.07/.09/.1           406.2, T
    TGGOSF - FRACTION OF DOMESTIC TRANSPORTATION CAPITAL
               SHORTFALL <406>
    TPDACT - TABLE FOR THE DESIRED ANNUAL CHANGE IN
               TRANSPORTATION PRODUCTION <406.2>
```

```
TPRG.K=TPR.K                                                407, A
TGQCI=0                                                     407.2, C
TPGIT=.05/.05/.05/.05/.05/.05                               407.4, T
     TPRG    - TRANSPORTATION PRODUCTION REQUEST USED FOR
                  GROWTH CALCULATIONS <407>
     TPR     - REQUESTED TRANSPORTATION PRODUCTION <401>
     TGQCI   - INITIAL TRANSPORTATION CAPITAL ON ORDER FOR
                  IMPORT (FOREX/YEAR) <407.2>
     TPGIT   - GOVERNMENT INFLUENCE ON TRANSPORTATION
                  GROWTH RATE <407.4>
```

VI-B. MILITARY

The discussion of national resource allocation in Chapter II noted the possibility for diverting economic resources for military use. The simulation model treats this possibility explicitly with equations to represent the key requirements for the armed forces: labor and imported hardware. Imports (MGQ) are an external input to the model that can be varied to approximate the economic impact of differing military strategy. The greater the military requirements, the less the foreign exchange available to meet economic needs. Military labor requirements (MLR) are also an external input that competes with the industrial and service requirements for the total urban labor force available.

```
MGQ.K=TABHL(MGQT,TIME.K,1960,2010,10)*1E6                     408, A
MGQT=100/100/100/100/100/100                                   408.2, T
    MGQ     - DESIRED MILITARY CAPITAL GOODS IMPORTS (NET
                AFTER ARAB AID) <408>
    MGQT    - TABLE FOR DESIRED MILITARY CAPITAL GOODS
                IMPORTS (MILLION POUNDS) <408.2>

ML.K=SMOOTH(MLI.K,SLTT)                                        409, A
    ML      - MILITARY LABOR <409>
    MLI     - MILITARY LABOR INDICATED <410>
    SLTT    - TIME TO TRANSFER INDUSTRIAL LABOR (YEARS)
                <346.6>

MLI.K=SHARE(MLR.K,PULN.K,MIL.K,PULWR.K,MIN)                    410, A
MIN=.8                                                         410.2, C
    MLI     - MILITARY LABOR INDICATED <410>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    MLR     - MILITARY LABOR REQUESTED <411>
    PULN    - SHORTFALL IN URBAN LABOR
    PULWR   - WEIGHTED REQUESTS FOR URBAN LABOR <133>
    MIN     - NORMAL PRIORITY OF MILITARY SECTOR <410.2>

MLR.K=TABHL(MLRT,TIME.K,1960,2010,10)*1E3                      411, A
MLRT=200/250/300/350/400/450                                   411.2, T
    MLR     - MILITARY LABOR REQUESTED <411>
    MLRT    - TABLE FOR MILITARY LABOR REQUESTED
                (THOUSAND MEN)ORDERED FOR IMPORT <411.2>
```

VI-C. FOREIGN TRADE

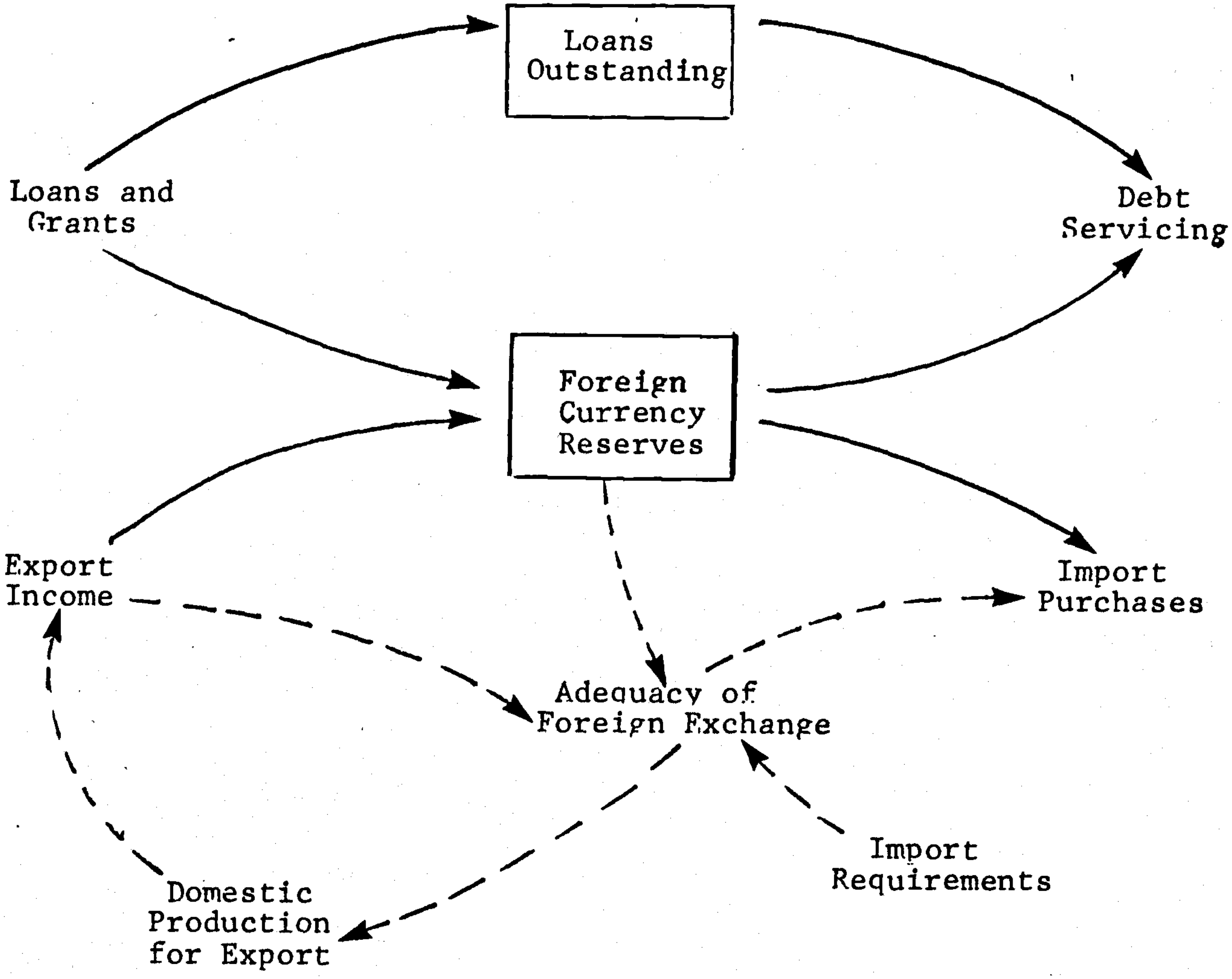
Like industrial activity, foreign trade is modeled in considerably less detail than agricultural production. Egypt's foreign trade is an important supplementary source of food for domestic consumption and capital goods to advance industrialization. At present, Egypt's exports are primarily agricultural,[8] but plans exist to turn Egypt into a major source of industrial goods.[9]

The model's foreign trade sector is, for the most part, an accounting device to monitor the country's exports, imports, aid and grants, and resulting foreign trade balance. In addition, the foreign trade sector monitors the availability of hard currency; this influences resource allocation decisions throughout the economy. The remainder of this section discusses foreign exchange reserves, debts, imports, and exports.

Foreign Exchange Reserves -- As shown in Figure VI-7, the heart of Egypt's foreign trade system is the maintenance of hard-currency reserves. These funds are necessary to purchase imports and pay back past debts; they are made available from imports, grants, and the assumption of new debts. The availability of foreign exchange determines which of the country's import needs and development objectives can be met.

Foreign exchange reserves (XR) in the model are a stock that is increased by export income (CI) and new short and long-term debt (XSDN, XLDN) and is decreased by imports (QT), interest payments (XTIP), and the retirement of short and long-term debt (XSDR, XLDR). Egypt's foreign exchange adequacy (XAX) is determined by the ratio of foreign exchange available from exports (CIAV) and excess reserves (XAR) to the economy's total foreign exchange requirements (XNT). The closer this ratio is to 1.0, the better able are the Egyptians to meet all their import requirements.

Figure VI-7:
Foreign Trade



Excess reserves are defined in the model to be any extra funds beyond the amount necessary to serve as a cushion for trade (XRD). Typically, this cushion would equal the monetary value of six months worth of average imports (QTA). Total foreign exchange requirements are the sum of funds needed for imports (QTR) and debt service (XNDS), and funds needed to restore reserves (XRR) to their desired level in the event of a declining foreign exchange position. The model attaches a high priority to servicing debt and restoring foreign currency reserves.

```
   FOREIGN EXCHANGE SECTOR

XR.K=XR.J+(DT)(CI.J+XSDN.J-QT.J-XTIP.J-XLDR.J-        412, L
  XSDR.J)
XR=XRZ                                                412.2, N
XRZ=100E6                                             412.4, C
    XR      - FOREIGN EXCHANGE RESERVES <412.2>
    CI      - EXPORT INCOME <443>
    XSDN    - NEW SHORT TERM DEBT (POUNDS/YEAR) <431.1>
    QT      - POUNDS VALUE OF TOTAL IMPORTS (EXCLUDING
                IMPORTS FINANCED WITH LONG TERM DEBT OR
                GRANTS) <470>
    XTIP    - TOTAL INTEREST PAYMENTS <432>
    XLDR    - RETIREMENT OF LONG TERM DEBT
    XSDR    - RETIREMENT OF SHORT TERM DEBT
    XRZ     - INITIAL FOREIGN EXCHANGE RESERVES (POUNDS)
                <412.4>

   ADEQUACY OF FOREIGN EXCHANGE

XAX.K=(CIAV.K+XAR.K)/XNT.K                            413, A
XAX=XAXI                                              413.1, N
XAXI=1                                                413.4, C
    XAX     - ADEQUACY OF AVAILABLE FOREIGN EXCHANGE
                (DOES NOT INCLUDE POTENTIAL BORROWING)
                <413.1>
    CIAV    - AVERAGE EXPORT INCOME <414>
    XAR     - FOREIGN EXCHANGE AVAILABLE FROM RESERVES
                <415.1>
    XNT     - TOTAL FOREIGN EXCHANGE NEEDS <418>
    XAXI    - INITIAL FOREIGN EXCHANGE ADEQUACY <413.4>

CIAV.K=SMOOTH(CI.K,CIT)                               414, A
CIT=1                                                 414.2, C
    CIAV    - AVERAGE EXPORT INCOME <414>
    CI      - EXPORT INCOME <443>
    CIT     - TIME TO AVERAGE EXPORTS (YEARS) <414.2>
```

```
XAR.K=MAX((XR.K-XRD.K)/XROT,0)                                415, A
XAR=0                                                          415.1, N
XROT=5                                                         415.3, C
    XAR      - FOREIGN EXCHANGE AVAILABLE FROM RESERVES
                 <415.1>
    XR       - FOREIGN EXCHANGE RESERVES <412.2>
    XRD      - DESIRED FOREIGN EXCHANGE RESERVES <416>
    XROT     - FOREIGN RESERVES DEPLETION TIME (YEARS)
                 <415.3>

XRD.K=XNC*(QTA.K+XNDS.K)                                       416, A
XNC=.4                                                         416.2, C
    XRD      - DESIRED FOREIGN EXCHANGE RESERVES <416>
    XNC      - NORMAL FOREIGN EXCHANGE COVERAGE (YEARS)
                 <416.2>
    QTA      - AVERAGE IMPORTS, <417.1>
    XNDS     - FOREIGN EXCHANGE NEEDED FOR DEBT SERVICE
                 (POUNDS/YEAR) <419>

QTA.K=SMOOTH(QT.K,1)                                           417, A
QTA=225E6                                                      417.1, N
    QTA      - AVERAGE IMPORTS, <417.1>
    QT       - POUNDS VALUE OF TOTAL IMPORTS (EXCLUDING
                 IMPORTS FINANCED WITH LONG TERM DEBT OR
                 GRANTS) <470>

XNT.K=QTR.K+XNDS.K+XRRR.K                                      418, A
    XNT      - TOTAL FOREIGN EXCHANGE NEEDS <418>
    QTR      - TOTAL REQUESTS FOR IMPORTS (POUNDS/YEAR)
                 <479>
    XNDS     - FOREIGN EXCHANGE NEEDED FOR DEBT SERVICE
                 (POUNDS/YEAR) <419>
    XRRR     - REQUESTED FOREIGN EXCHANGE TO REPLENISH
                 RESERVES <421>

XNDS.K=XSDRR.K+XSDIPN.K+XLDRR.K+XLDIPN.K                       419, A
    XNDS     - FOREIGN EXCHANGE NEEDED FOR DEBT SERVICE
                 (POUNDS/YEAR) <419>
    XSDRR    - REQUESTED RETIREMENT OF SHORT TERM DEBT
    XSDIPN   - INTEREST PAYMENTS NECESSARY FOR SHORT TERM
                 DEBT
    XLDRR    - REQUESTED RETIREMENT OF LONG TERM DEBT
    XLDIPN   - INTEREST PAYMENTS NECESSARY FOR LONG TERM
                 DEBT

XRR.K=SHARE(XRRR.K,XN.K,IRX.K,XWR.K,XRIN)                      420, A
XRIN=.5                                                        420.2, C
    XRR      - FOREIGN EXCHANGE USED TO REPLENISH RESERVES
                 <420>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    XRRR     - REQUESTED FOREIGN EXCHANGE TO REPLENISH
                 RESERVES <421>
    XN       - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                 <422>
```

```
    XWR     - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                <423>
    XRIN    - NORMAL PRIORITY OF RESERVES FOR FOREIGN
                EXCHANGE <420.2>

XRRR.K=MAX(XRD.K-XR.K,0)/XRRRT                        421, A
XRRRT=1                                               421.2, C
    XRRR    - REQUESTED FOREIGN EXCHANGE TO REPLENISH
                RESERVES <421>
    XRD     - DESIRED FOREIGN EXCHANGE RESERVES <416>
    XR      - FOREIGN EXCHANGE RESERVES <412.2>
    XRRRT   - TIME TO CORRECT DEFICIENCY IN FOREIGN
                RESERVES <421.2>

   FOREIGN EXCHANGE ALLOCATION

XN.K=MAX(XNT.K-CIAV.K-XAR.K-XSDN.K,0)                 422, A
    XN      - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                <422>
    XNT     - TOTAL FOREIGN EXCHANGE NEEDS <418>
    CIAV    - AVERAGE EXPORT INCOME <414>
    XAR     - FOREIGN EXCHANGE AVAILABLE FROM RESERVES
                <415.1>
    XSDN    - NEW SHORT TERM DEBT (POUNDS/YEAR) <431.1>

XWR.K=(XSDRR.K/XSDIR.K)+(XLDRR.K/XLDIR.K)+(QGR.K/     423, A
  IGX.K)+(QFR.K/IFX.K)+(QMR.K/QMIX.K)+(QANR.K/
  ANIX.K)+(XRRR.K/XRIN)
    XWR     - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                <423>
    XSDRR   - REQUESTED RETIREMENT OF SHORT TERM DEBT
    XSDIR   - PRIORITY OF SHORT TERM DEBT RETIREMENT FOR
                FOREIGN EXCHANGE
    XLDRR   - REQUESTED RETIREMENT OF LONG TERM DEBT
    XLDIR   - PRIORITY OF LONG TERM DEBT RETIREMENT FOR
                FOREIGN EXCHANGE
    QGR     - REQUESTED CAPITAL GOODS IMPORTS <480>
    QFR     - REQUESTED FERTILIZER IMPORTS <481>
    QMR     - REQUESTED MISCELLANEOUS IMPORTS <482>
    QANR    - REQUESTED GRAIN IMPORTS (FOREX/YEAR) <477>
    XRRR    - REQUESTED FOREIGN EXCHANGE TO REPLENISH
                RESERVES <421>
    XRIN    - NORMAL PRIORITY OF RESERVES FOR FOREIGN
                EXCHANGE <420.2>
```

Debt -- Many developing countries have relied upon foreign borrowing to compensate for an internal inability to fund imports and development projects. Egypt is no exception, and the country has accumulated an enormous debt burden that is traceable in part to the country's extensive food imports and the military buildup since the 1967 war with Isreal.[10] The model includes the equation structure necessary to represent the accumulation of debt in Egypt when the country's balance of payments deteriorates, or when hard currency requirements suddenly grow.

The basic model structure for borrowing is a "building block" to monitor the debt outstanding at any point in time and calculate service requirements. The building block is used in the model twice, to represent short-term and long-term debt. The amount of debt outstanding (DEBT) is increased by the assumption of new debt (ND) and decreased by debt retirement (RD). The desired debt retirement (RRD) is determined by the debt lifetime (LIFTIME) -- four years for short term debt, and 25 years for long term debt. The average interest rate (AIR) for the total amount of debt outstanding can change over time if the interest rate for retired debt (RIR) differs from the current interest rate (CIR) for new debt. The primary differences in the model's treatment of short-term and long-term debt lie in the mechanism for accumulating new debt and in the calculation of an interest rate.

Most short-term debt is advanced to a developing country by the suppliers of its imports, who offer credit terms to secure business. Therefore, new short-term debt available (XSDA) is assumed to be proportional to the total amount of desired imports. The proportionality constant (QFSD) for this relationship can be varied over time from its base value of .25, to represent the consequences of a change in Egypt's import mix that increases or decreases the availability of short term debt. The country's desired new short-term debt

(XSDD) is based on the shortfall (XN) between foreign exchange availability and foreign exchange requirements. High interest rates are assumed to reduce the desired short term debt (XEISDN). Also, an effect of political factors on short-term debt (XEPSDN) is included to represent changes in Egypt's willingness to accumulate new debt. The new short-term debt (XSDN) assumed by Egypt is the smaller of (a) the debt available and (b) the debt desired, plus additional borrowing (i.e., the capitalization of interest) if the country fails to meet its interest payment requirements.

The assumption of new long-term debt in the model is tied specifically to the capital investment projects most likely to be financed by outside industry or aid. The basis for new long-term debt (XLDN) is any gap between desired capital goods imports (GQRT) and the capital imports that can be financed through normal trade (QGXV). High interest rates are assumed to decrease the desired amount of long-term debt, limiting debt financing to the most essential projects (XEILDN). In addition, an effect of political factors on long-term debt (XEIPLDN) is included, to allow investigation of the consequences of internally versus externally financed development strategies.

The interest rate for long term debt (XLDCI) is assumed to depend on Egypt's ability to meet its currently outstanding debt.[11] The model calculates a coverage ratio (XDCR) that compares exchange requirements to service current debt (XNDS) with the exchange generated by exports (CIAV). The greater the coverage ratio, the more vulnerable are Egypt's debt service payments, and the more likely are foreign creditors to raise the interest rate they require for long-term investments (see Figure VI-8). The interest rate Egypt must pay for short-term debt (XSDCI) is assumed to be determined by the long-term interest rate (Figure VI-9).

Figure VI-8:
Long-Term Interest Rate

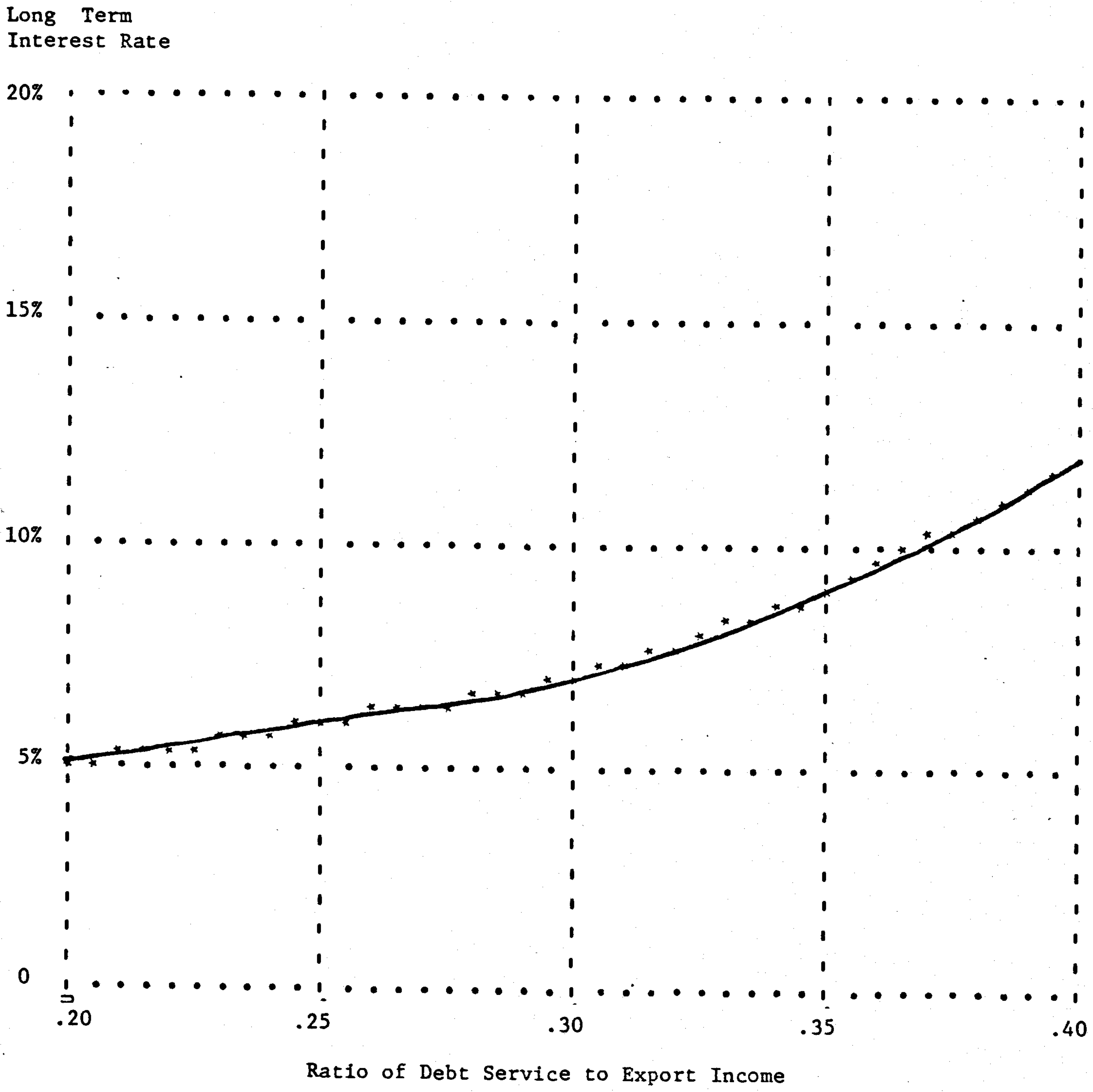
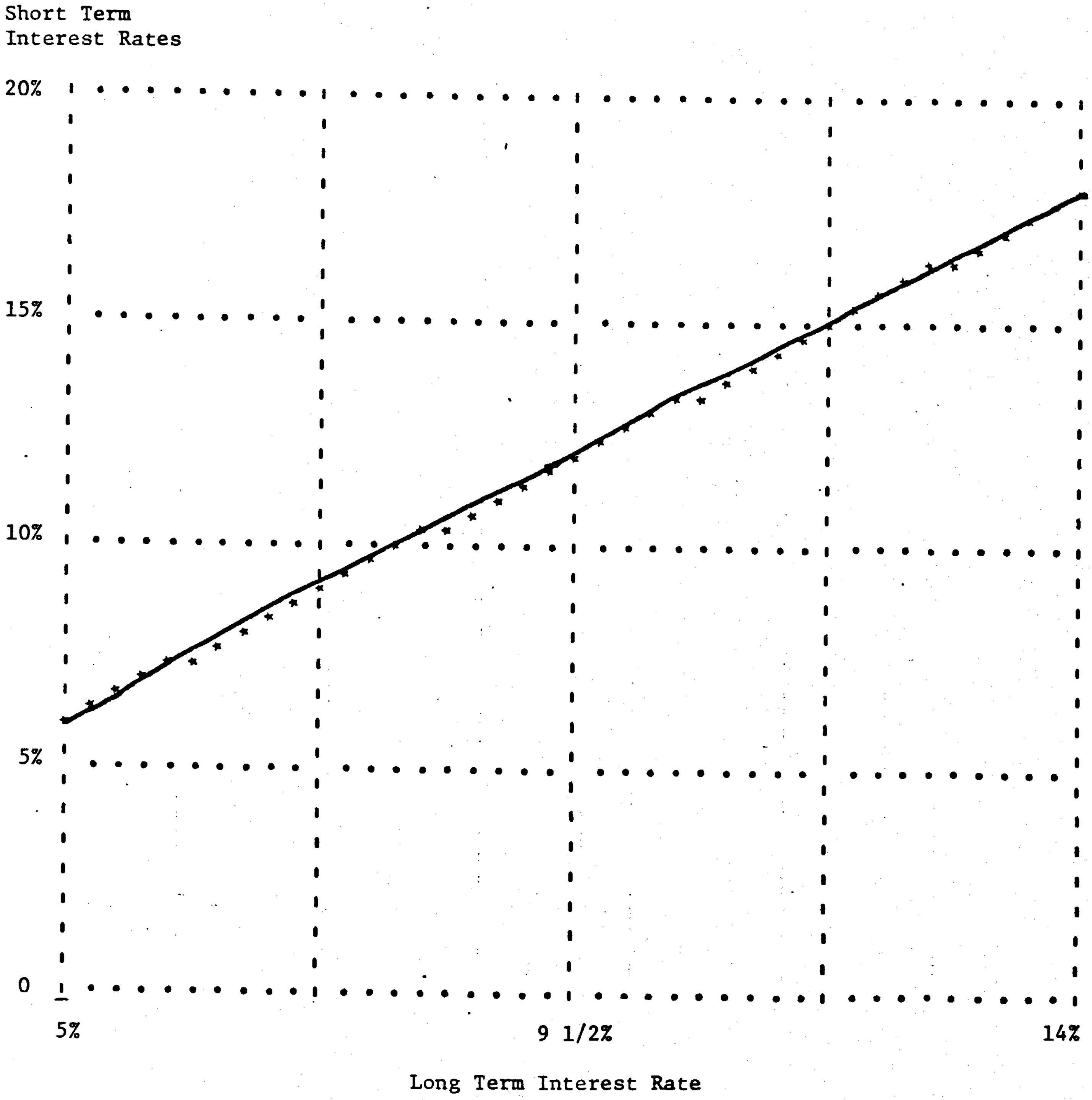


Figure VI-9:
Short-Term Interest Rate



```
   DEBT BUILDING BLOCK

MACRO     DEBT(ND,RRD,RD,IDX,XDIN,LIFTIME,CIR,IPN,        .1
  DEBTZ,AIRZ)
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                 BUILDING BLOCK <1.1>
    RRD     - REQUESTED RETIREMENT OF DEBT <3>
    RD      - RETIREMENT OF DEBT (POUNDS/YEAR) <2>
    IDX     - PRIORITY OF DEBT REDUCTION FOR FOREIGN
                 EXCHANGE
    IPN     - INTEREST PAYMENT NECESSARY TO MEET CURRENT
                 OBLIGATIONS <7>

INTRN     AIR,CAIR,RIR                                     .2
    AIR     - AVERAGE INTEREST RATE FOR SURRENT DEBT
                 <4.1>
    CAIR    - CHANGE IN AVERAGE INTEREST RATE <5>
    RIR     - RETIREMENT INTEREST RATE <6>

DEBT.K=DEBT.J+(DT)(ND.J-RD.J)                              1, L
DEBT=DEBTZ                                                 1.1, N
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                 BUILDING BLOCK <1.1>
    RD      - RETIREMENT OF DEBT (POUNDS/YEAR) <2>

RD.K=SHARE(RRD.K,XN.K,IDX.K,XWR.K,XDIN)                    2, A
    RD      - RETIREMENT OF DEBT (POUNDS/YEAR) <2>
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
    RRD     - REQUESTED RETIREMENT OF DEBT <3>
    XN      - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                 <422>
    IDX     - PRIORITY OF DEBT REDUCTION FOR FOREIGN
                 EXCHANGE
    XWR     - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                 <423>

RRD.K=DEBT.K/LIFTIME                                       3, A
    RRD     - REQUESTED RETIREMENT OF DEBT <3>
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                 BUILDING BLOCK <1.1>

AIR.K=AIR.J+(DT)(CAIR.J)                                   4, L
AIR=AIRZ                                                   4.1, N
    AIR     - AVERAGE INTEREST RATE FOR SURRENT DEBT
                 <4.1>
    CAIR    - CHANGE IN AVERAGE INTEREST RATE <5>
```

```
CAIR.K=(ND.K/POS(ND.K+DEBT.K))*(CIR.K-AIR.K)+(RD.K/ 5, A
  POS(DEBT.K-RD.K))*(RIR.K-AIR.K)
    CAIR    - CHANGE IN AVERAGE INTEREST RATE <5>
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                BUILDING BLOCK <1.1>
    AIR     - AVERAGE INTEREST RATE FOR SURRENT DEBT
                <4.1>
    RD      - RETIREMENT OF DEBT (POUNDS/YEAR) <2>
    RIR     - RETIREMENT INTEREST RATE <6>

RIR.K=DLINF3(CIR.K,LIFTIME)
    RIR     - RETIREMENT INTEREST RATE <6>             6, A

IPN.K=DEBT.K*AIR.K
    IPN     - INTEREST PAYMENT NECESSARY TO MEET CURRENT  7, A
                OBLIGATIONS <7>
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                BUILDING BLOCK <1.1>
    AIR     - AVERAGE INTEREST RATE FOR SURRENT DEBT
                <4.1>

XLDN.K=MAX(0,XLDRT.K*XEILDN.K*XEPLDN.K)                439, A
XLDN=0                                                 439.1, N
    XLDN    - NEW LONG TERM DEBT (POUNDS/YEAR) <439.1>
    XLDRT   - TOTAL REQUESTS FOR CAPITAL DELIVERIES
                FINANCED WITH LONG TERM DEBT <442>
```

3

```
    XEILDN  - EFFECT OF INTEREST RATES ON NEW LONG TERM
                DEBT <440>
    XEPLDN  - EFFECT OF POLITICAL FACTORS ON NEW LONG
                TERM DEBT <441>

XEILDN.K=TABHL(XEILDNT,XLDCI.K,.05,.12,.01)            440, A
XEILDNT=1/1/.95/.75/.5/.25/.1/0                        440.2, T
    XEILDN  - EFFECT OF INTEREST RATES ON NEW LONG TERM
                DEBT <440>
    XEILDNT- TABLE FOR THE EFFECT OF INTEREST RATES ON
                NEW LONG TERM DEBT <440.2>
    XLDCI   - CURRENT INTEREST RATE FOR LONG TERM DEBT
                <434>

XEPLDN.K=TABHL(XEPLDNT,TIME.K,1960,2010,10)            441, A
XEPLDNT=.5/.5/.5/.5/.5/.5                              441.2, T
    XEPLDN  - EFFECT OF POLITICAL FACTORS ON NEW LONG
                TERM DEBT <441>
    XEPLDNT- TABLE FOR THE EFFECT OF POLITICAL FACTORS
                ON NEW LONG TERM DEBT <441.2>

XLDRT.K=SMOOTH(GGRT.K-QGXV.K,XTGRFLD)                  442, A
XTGRFLD=1                                              442.3, C
    XLDRT   - TOTAL REQUESTS FOR CAPITAL DELIVERIES
                FINANCED WITH LONG TERM DEBT <442>
    GGRT    - TOTAL REQUESTS FOR CAPITAL IMPORTS (FOREX/
                YEAR) <378>
    QGXV    - POUNDS VALUE OF CAPITAL GOODS IMPORTS <471>
    XTGRFLD- AVERAGING TIME FOR CAPITAL REQUESTS
                FINANCED WITH LONG TERM DEBT <442.3>
```

```
   SHORT TERM DEBT

XSD.K=DEBT(XSDN.K,XSDRR.K,XSDR.K,XSDIR.K,XSDIRN,      424, A
  XSDL,XSDCI.K,XSDIPN.K,0,0)
XSDIRN=.8                                             424.3, C
XSDL=4                                                424.6, C
    XSD     - SHORT TERM DEBT <424>
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                BUILDING BLOCK <1.1>
    XSDN    - NEW SHORT TERM DEBT (POUNDS/YEAR) <431.1>
    XSDRR   - REQUESTED RETIREMENT OF SHORT TERM DEBT
    XSDR    - RETIREMENT OF SHORT TERM DEBT
    XSDIR   - PRIORITY OF SHORT TERM DEBT RETIREMENT FOR
                FOREIGN EXCHANGE
    XSDIRN  - NORMAL PRIORITY OF SHORT TERM DEBT
                RETIREMENT FOR FOREIGN EXCHANGE <424.3>
    XSDL    - LIFETIME FOR SHORT TERM DEBT (YEARS)
                <424.6>
    XSDCI   - CURRENT INTEREST RATE FOR SHORT TERM DEBT
                <428>
    XSDIPN  - INTEREST PAYMENTS NECESSARY FOR SHORT TERM
                DEBT

XSDD.K=SMOOTH(XN.K,XNAT)*XEISDN.K*XEPSDN.K            425, A
XNAT=.5                                               425.2, C
    XSDD    - DESIRED NEW SHORT TERM DEBT (POUNDS) <425>
    XN      - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                <422>
    XNAT    - TIME TO AVERAGE FOREIGN EXCHANGE SHORTFALL
                (YEARS) <425.2>
    XEISDN  - EFFECT OF INTEREST RATES ON NEW SHORT TERM
                DEBT <426>
    XEPSDN  - EFFECT OF POLITICAL FACTORS ON NEW SHORT
                TERM DEBT <427>

XEISDN.K=TABLE(XEISDNT,XSDCI.K,.05,.2,.05)            426, A
XEISDNT=1/.5/.1/0                                     426.2, T
    XEISDN  - EFFECT OF INTEREST RATES ON NEW SHORT TERM
                DEBT <426>
    XEISDNT- TABLE FOR THE EFFECT OF INTEREST RATES ON
                NEW SHORT TERM DEBT <426.2>
    XSDCI   - CURRENT INTEREST RATE FOR SHORT TERM DEBT
                <428>

XEPSDN.K=TABLE(XEPSDNT,TIME.K,1960,2010,5)            427, A
XEPSDNT=1/1/1/1/1/1/1/1/1/1/1                         427.2, T
    XEPSDN  - EFFECT OF POLITICAL FACTORS ON NEW SHORT
                TERM DEBT <427>
    XEPSDNT- TABLE FOR THE EFFECT OF POLITICAL FACTOR ON
                SHORT TERM DEBT <427.2>
```

```
XSDCI.K=TABLE(XSDCIT,XLDCI.K,.05,.14,.03)                     428, A
XSDCIT=.06/.10/.14/.18                                         428.2, T
    XSDCI  - CURRENT INTEREST RATE FOR SHORT TERM DEBT
               <428>
    XSDCIT - TABLE FOR CURRENT INTEREST RATE FOR SHORT
               TERM DEBT <428.2>
    XLDCI  - CURRENT INTEREST RATE FOR LONG TERM DEBT
               <434>

XSDA.K=SMOOTH(QTR.K*QFSD.K,1)                                  429, A
    XSDA   - NEW SHORT TERM DEBT AVAILABLE (POUNDS)
               <429>
    QTR    - TOTAL REQUESTS FOR IMPORTS (POUNDS/YEAR)
               <479>
    QFSD   - IMPORT FRACTION FOR SHORT TERM DEBT <430>

QFSD.K=TABLE(QFSDT,TIME.K,1960,2010,10)                        430, A
QFSDT=.25/.25/.25/.25/.25/.25                                  430.2, T
    QFSD   - IMPORT FRACTION FOR SHORT TERM DEBT <430>
    QFSDT  - TABLE FOR IMPORT FRACTION FOR SHORT TERM
               DEBT <430.2>

XSDN.K=MIN(XSDA.K,XSDD.K)+(XSDIPN.K+XLDIPN.K-                 431, A
  XTIP.K)
XSDN=0                                                         431.1, N
    XSDN   - NEW SHORT TERM DEBT (POUNDS/YEAR) <431.1>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    XSDA   - NEW SHORT TERM DEBT AVAILABLE (POUNDS)
               <429>
    XSDD   - DESIRED NEW SHORT TERM DEBT (POUNDS) <425>
    XSDIPN - INTEREST PAYMENTS NECESSARY FOR SHORT TERM
               DEBT
    XLDIPN - INTEREST PAYMENTS NECESSARY FOR LONG TERM
               DEBT
    XTIP   - TOTAL INTEREST PAYMENTS <432>

XTIP.K=MIN(XSDIPN.K+XLDIPN.K,CIAV.K+XAR.K)                    432, A
    XTIP   - TOTAL INTEREST PAYMENTS <432>
    MIN    - NORMAL PRIORITY OF MILITARY SECTOR <410.2>
    XSDIPN - INTEREST PAYMENTS NECESSARY FOR SHORT TERM
               DEBT
    XLDIPN - INTEREST PAYMENTS NECESSARY FOR LONG TERM
               DEBT
    CIAV   - AVERAGE EXPORT INCOME <414>
    XAR    - FOREIGN EXCHANGE AVAILABLE FROM RESERVES
               <415.1>
```

```
 LONG TERM DEBT

XLD.K=DEPT(XLDN.K,XLDRR.K,XLDR.K,XLDIR.K,XLDIRN,      433, A
  XLDL,XLDCI.K,XLDIPN.K,0,0)
XLDIRN=.8                                             433.3, C
XLDL=25                                               433.6, C
    XLD     - LONG TERM DEBT <433>
    DEBT    - DEBT OUTSTANDING, AS MONITORED BY DEBT
                BUILDING BLOCK <1.1>
    XLDN    - NEW LONG TERM DEBT (POUNDS/YEAR) <439.1>
    XLDRR   - REQUESTED RETIREMENT OF LONG TERM DEBT
    XLDR    - RETIREMENT OF LONG TERM DEBT
    XLDIR   - PRIORITY OF LONG TERM DEBT RETIREMENT FOR
                FOREIGN EXCHANGE
    XLDIRN  - NORMAL PRIORITY OF LONG TERM DEBT
                RETIREMENT FOR FOREIGN EXCHANGE <433.3>
    XLDL    - LIFETIME FOR LONG TERM DEBT (YEARS) <433.6>
    XLDCI   - CURRENT INTEREST RATE FOR LONG TERM DEBT
                <434>
    XLDIPN  - INTEREST PAYMENTS NECESSARY FOR LONG TERM
                DEBT

XLDCI.K=XLDCIC.K*XLDCIE.K                             434, A
    XLDCI   - CURRENT INTEREST RATE FOR LONG TERM DEBT
                <434>
    XLDCIC  - CURRENT INTEREST RATE FOR LONG TERM DEBT
                INDICATED BY INTEREST COVERAGE <435>
    XLDCIE  - EXTERNAL EFFECTS ON INTEREST RATE FOR LONG
                TERM DEBT <438>

XLDCIC.K=TABHL(XLDCICT,XDCRA.K,.2,.4,.05)             435, A
XLDCICT=.05/.06/.07/.09/.12                           435.3, T
    XLDCIC  - CURRENT INTEREST RATE FOR LONG TERM DEBT
                INDICATED BY INTEREST COVERAGE <435>
    XLDCICT- TABLE FOR CURRENT INTEREST RATE FOR LONG
                TERM DEBT <435.3>
    XDCRA   - AVERAGE DEBT COVERAGE RATIO <436>

XDCRA.K=SMOOTH(XDCR.K,XDCRAAT)                        436, A
XDCRAAT=3                                             436.2, C
    XDCRA   - AVERAGE DEBT COVERAGE RATIO <436>
    XDCR    - DEBT COVERAGE RATIO <437>
    XDCRAAT- COVERAGE RATIO AVERAGING TIME (YEARS)
                <436.2>

XDCR.K=XNDS.K/CIAV.K                                  437, A
    XDCR    - DEBT COVERAGE RATIO <437>
    XNDS    - FOREIGN EXCHANGE NEEDED FOR DEBT SERVICE
                (POUNDS/YEAR) <419>
    CIAV    - AVERAGE EXPORT INCOME <414>

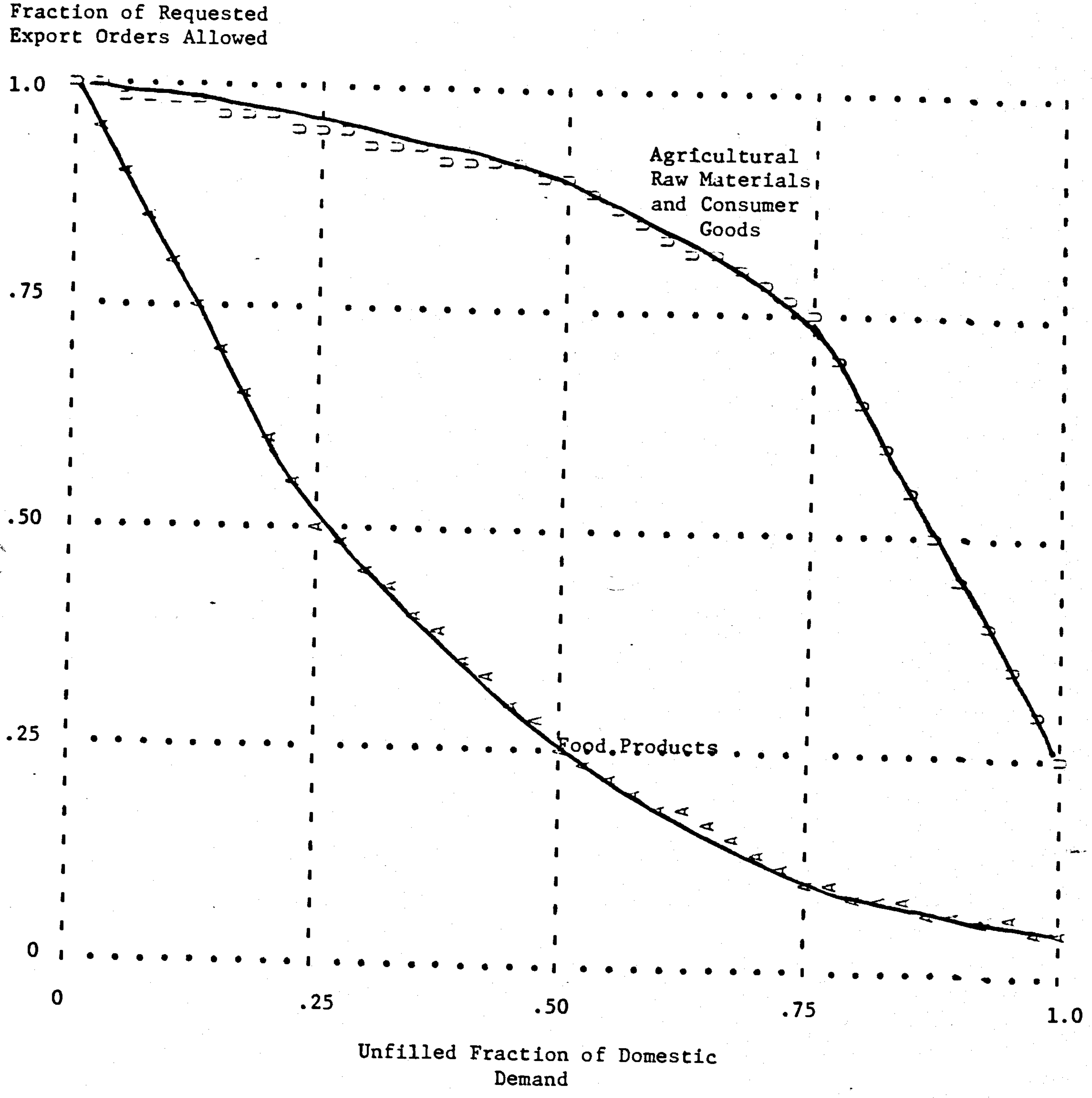
XLDCIE.K=TABHL(XLDCIET,TIME.K,1960,2010,10)           438, A
XLDCIET=1/1/1/1/1/1                                   438.2, T
    XLDCIE  - EXTERNAL EFFECTS ON INTEREST RATE FOR LONG
                TERM DEBT <438>
    XLDCIET- TABLE FOR EXTERNAL EFFECTS ON INTEREST RATE
                FOR LONG TERM DEBT <438.2>
```

Exports -- The foreign trade sector of the model includes a building block of equations to represent, in general form, the factors that stimulate exports from Egypt's economy. This building block is reproduced four times for each of the important, or potentially important, Egyptian export goods that are treated explicitly in the model -- consumer goods (CU), cotton (CAC), fruits and vegetables (CAO), and rice (CAR)[12]. Oil exports, the foreign exchange earnings from the Suez Canal and services, and other sources are currently lumped together in a miscellaneous category (CMXV). This variable can be changed to represent the consequences of different long-term trends for these earnings.

Development of export trade in any product is often a lengthy process of the cultivation of potential markets and the development of the ability to service them. New export business may be largely determined by past export business, since the contacts and goodwill guild up from satisfactory relationships can form the base for new dealings. For this reason, in the Egypt model orders for export delivery (EXPORT) are based upon recent export business (CAV). The amount of the exportable product actually made available to meet these orders will depend upon the competition between export and internal requirements. We have assumed that export orders have a higher priority (CIN) than does internal consumption.

A number of factors are assumed to be capable of increasing or decreasing export orders. First, exports may be limited by internal shortages (CLIS). The model assumes that export orders will be reduced if internal shortages are so large that domestic needs are hopelessly underfilled (Figure VI-10). A second influence is the effect of foreign exchange shortages (CEXA); this effect boosts export orders if foreign exchange is inadequate to meet perceived needs. The

Figure VI-10: Effect of Internal Shortages on Exports



foreign exchange effect can be adjusted to represent different trade strategies. That is, higher values of CEXA for an individual product represent a greater reliance on growth in that item's exports to meet foreign exchange needs.

A third influence on export orders are external factors (CEEF), primarily changing market conditions that can increase or decrease the demand for Egypt's exportable output. These factors are external inputs to the model that vary over time for each product. The final influence on export orders is another external input, the effect on exports of political factors (CEPF), that can be varied over time to represent the consequences of a government policy to push or discourage exports.

```
CI.K=CUXV.K+CAXV.K+CMXV.K                                 443, A
    CI      - EXPORT INCOME <443>
    CUXV    - POUNDS VALUE OF CONSUMER GOODS EXPORTS
                <444>
    CAXV    - POUNDS VALUE OF AGRICULTURAL EXPORTS <446>
    CMXV    - POUNDS VALUE OF MISCELLANEOUS EXPORTS <450>

CUXV.K=CU.K*UPRICE.K                                      444, A
    CUXV    - POUNDS VALUE OF CONSUMER GOODS EXPORTS
                <444>
    CU      - CONSUMER GOODS EXPORTS
    UPRICE  - PRICE FOR CONSUMER GOODS (POUNDS/UNIT)
                <445>

UPRICE.K=TABHL(UPRICET,TIME.K,1960,2010,10)               445, A
UPRICET=1/1/1/1/1/1                                       445.2, T
    UPRICE  - PRICE FOR CONSUMER GOODS (POUNDS/UNIT)
                <445>
    UPRICET- TABLE FOR PRICE FOR CONSUMER GOODS (POUNDS/
                UNIT) <445.2>

CAXV.K=CAR.K*XARP.K+CAO.K*XAOP.K+CAC.K*XACP.K             446, A
    CAXV    - POUNDS VALUE OF AGRICULTURAL EXPORTS <446>
    CAR     - RICE EXPORTS
    XARP    - PRICE FOR EXPORTED RICE (POUNDS/TONNE)
                <447>
    CAO     - FRUITS AND VEGETABLES EXPORTS
    XAOP    - PRICE FOR EXPORTED F&V (POUNDS/TONNE) <449>
    CAC     - COTTON EXPORTS
    XACP    - PRICE FOR EXPORTED COTTON (POUNDS/TONNE)
                <448>
```

```
XARP.K=TABHL(XARPT,TIME.K,1970,1975,5)                           447, A
  RPT=50/90                                                      447.2, T
    XARP    - PRICE FOR EXPORTED RICE (POUNDS/TONNE)
                <447>
    XARPT   - TABLE FOR PRICE FOR EXPORTED RICE <447.2>

XACP.K=TABHL(XACPT,TIME.K,1970,1975,5)                           448, A
XACPT=530/750                                                    448.2, T
    XACP    - PRICE FOR EXPORTED COTTON (POUNDS/TONNE)
                <448>
    XACPT   - TABLE FOR PRICE FOR EXPORTED COTTON <448.2>

XAOP.K=30                                                        449, A
    XAOP    - PRICE FOR EXPORTED F&V (POUNDS/TONNE) <449>

CMXV.K=TABLE(CMXVT,TIME.K,1960,2010,10)*1E6                      450, A
CMXVT=0/70/140/200/280/390                                       450.2, T
    CMXV    - POUNDS VALUE OF MISCELLANEOUS EXPORTS <450>
    CMXVT   - TABLE FOR MISCELLANEOUS EXPORTS (MILLION
                POUNDS/YEAR) <450.2>

CIN.K=TABHL(CINT,TIME.K,1960,2010,10)                            451, A
CINT=.2/.2/.2/.2/.2/.2                                           451.3, T
    CIN     - NORMAL PRIORITY OF EXPORT SECTOR FOR
                PRODUCTION FROM OTHER SECTORS OF THE
                ECONOMY <451>
    CINT    - TABLE FOR THE NORMAL PRIORITY OF EXPORT
                REQUESTS <451.3>

   EXPORT MACRO

MACRO     EXPORT(EXPOI,C,SFALL,SDR,CLIST,CEXAT,                  .1
  CEEFT,CLIS,CEXA,SCI)
    EXPORT - ORDERS FOR EXPORT <1.1>
    CLIS    - LIMIT ON EXPORTS DUE TO INTERNAL SHORTAGE
                <3>
    CEXA    - EFFECT ON EXPORTS OF FOREIGN EXCHANGE
                ADEQUACY <5>

INTRN     CAV,SC,CEEF                                            .3
    CAV     - AVERAGE EXPORTS <2>
    SC      - SUPPLY CONDITION FOR SECTOR OUTPUT <4.1>
    CEEF    - EFFECT ON EXPORTS OF EXTERNAL FACTORS <6>

EXPORT.K=CAV.K*CLIS.K*CEXA.K*CEPF.K*CEEF.K                       1, A
EXPORT=EXPOI                                                     1.1, N
    EXPORT - ORDERS FOR EXPORT <1.1>
    CAV     - AVERAGE EXPORTS <2>
    CLIS    - LIMIT ON EXPORTS DUE TO INTERNAL SHORTAGE
                <3>
    CEXA    - EFFECT ON EXPORTS OF FOREIGN EXCHANGE
                ADEQUACY <5>
    CEPF    - EFFECT ON EXPORTS OF POLITICAL FACTORS
                <453>
    CEEF    - EFFECT ON EXPORTS OF EXTERNAL FACTORS <6>
```

```
CAV.K=SMOOTH(C.K,CAVAT)                                  2, A
     CAV     - AVERAGE EXPORTS <2>
     CAVAT   - AVERAGING TIME FOR AVERAGING EXPORTS <452>

CLIS.K=TABHL(CLIST,SC.K,0,1,.25)                         3, A
     CLIS    - LIMIT ON EXPORTS DUE TO INTERNAL SHORTAGE
                 <3>
     SC      - SUPPLY CONDITION FOR SECTOR OUTPUT <4.1>

SC.K=SMOOTH((SFALL.K-C.K)/SDR.K,CSCAT)                   4, A
SC=SCI                                                   4.1, N
     SC      - SUPPLY CONDITION FOR SECTOR OUTPUT <4.1>
     CSCAT   - AVERAGING TIME FOR EXPORT SUPPLY CONDITION
                 <452.2>

CEXA.K=TABHL(CEXAT,XAXS.K,0,1,.2)                        5, A
     CEXA    - EFFECT ON EXPORTS OF FOREIGN EXCHANGE
                 ADEQUACY <5>
     XAXS    - AVERAGE FOREIGN EXCHANGE ADEQUACY <487>

CEEF.K=TABLE(CEEFT,TIME.K,1960,2010,10)                  6, A
     CEEF    - EFFECT ON EXPORTS OF EXTERNAL FACTORS <6>

MEND

CAVAT=2 YEARS                                            452, C
CSCAT=1                                                  452.2, C
     CAVAT   - AVERAGING TIME FOR AVERAGING EXPORTS <452>
     CSCAT   - AVERAGING TIME FOR EXPORT SUPPLY CONDITION
                 <452.2>

CEPF.K=TABHL(CEPFT,TIME.K,1960,2010,10)                  453, A
CEPFT=1/1/1/1/1/1                                        453.2, T
     CEPF    - EFFECT ON EXPORTS OF POLITICAL FACTORS
                 <453>
     CEPFT   - TABLE FOR THE EFFECT ON EXPORTS OF
                 POLITICAL FACTORS <453.2>

  CONSUMER GOODS EXPORTS

CU.K=SHARE(CUR.K,UPN.K,CIU.K,UWR.K,CIN.K)                454, A
     CU      - CONSUMER GOODS EXPORTS
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     CUR     - REQUESTED DELIVERIES OF CONSUMER GOODS FOR
                 EXPORT <455>
     UPN     - SHORTFALL IN PRODUCTION OF CONSUMER GOODS
     UWR     - WEIGHTED REQUESTS FOR CONSUMER GOODS <354>
     CIN     - NORMAL PRIORITY OF EXPORT SECTOR FOR
                 PRODUCTION FROM OTHER SECTORS OF THE
                 ECONOMY <451>
```

```
CUR.K=CUB.K/PUTN                                        455, A
    CUR      - REQUESTED DELIVERIES OF CONSUMER GOODS FOR
                 EXPORT <455>
    CUB      - BACKLOG OF ORDERS FOR CONSUMER GOODS
                 EXPORTS <456.1>
    PUTN     - ORDERING TIME FOR CONSUMERGOODS (YEARS)
                 <122.9>

CUB.K=CUB.J+(DT)(CUO.J-CU.J)                            456, L
CUB=CUO*PUTN                                            456.1, N
    CUB      - BACKLOG OF ORDERS FOR CONSUMER GOODS
                 EXPORTS <456.1>
    CUO      - ORDER RATE FOR EXPORTS OF CONSUMER GOODS
                 <457>
    CU       - CONSUMER GOODS EXPORTS
    PUTN     - ORDERING TIME FOR CONSUMERGOODS (YEARS)
                 <122.9>


CUO.K=EXPORT(CUOI,CU.K,UPN.K,UPR.K,CULIST,CUEXAT,       457, A
  CUEEFT,CULIS.K,CUEXA.K,CUSCI)*CUDLM.K
CUSCI=.75                                               457.3, C
CUOI=60E6                                               457.5, C
CULIST=1/.95/.9/.75/.25                                 457.7, T
CUEXAT=1.25/1.24/1.21/1.17/1.12/1                       458.1, T
CUEEFT=1.1/1.1/1.1/1.1/1.1/1.1                          458.4, T
    CUO      - ORDER RATE FOR EXPORTS OF CONSUMER GOODS
                 <457>
    EXPORT   - ORDERS FOR EXPORT <1.1>
    CUOI     - INITIAL CONSUMER GOODS EXPORT ORDERS
                 <457.5>
    CU       - CONSUMER GOODS EXPORTS
    UPN      - SHORTFALL IN PRODUCTION OF CONSUMER GOODS
    UPR      - REQUESTED CONSUMER GOODS PRODUCTION <353>
    CULIST   - TABLE FOR THE EFFECT OF INTERNAL SHORTAGES
                 ON CONSUMER GOODS EXPORTS <457.7>
    CUEXAT   - TABLE FOR THE EFFECT OF FOREIGN EXCHANGE
                 ADEQUACY ON CONSUMER GOODS EXPORTS
                 <458.1>
    CUEEFT   - TABLE FOR THE EFFECT OF EXTERNAL FACTORS ON
                 CONSUMER GOODS EXPORTS <458.4>
    CULIS    - EFFECT OF INTERNAL SHORTAGES ON CONSUMER
                 GOODS EXPORTS
    CUEXA    - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                 CONSUMER GOODS EXPORTS
    CUSCI    - INITIAL SUPPLY CONDITION FOR CONSUMER GOODS
                 EXPORTS <457.3>
    CUDLM    - MULTIPLIER FOR THE EFFECT OF DELIVERY DELAY
                 ON EXPORT ORDERS FOR CONSUMER GOODS
                 <459.1>
```

```
CUDLM.K=TABLE(CUDLMT,CUDLP.K,0,4,1)                        459, A
CUDLM=1                                                     459.1, N
CUDLMT=1/1/.8/.25/0                                         459.4, T
    CUDLM   - MULTIPLIER FOR THE EFFECT OF DELIVERY DELAY
                ON EXPORT ORDERS FOR CONSUMER GOODS
                <459.1>
    CUDLMT  - TABLE FOR THE EFFECT OF DELIVERY DELAY ON
                EXPORT ORDERS FOR CONSUMER GOODS <459.4>
    CUDLP   - PERCEIVED DELIVERY DELAY FOR CONSUMERS
                GOODS FOR EXPORT <460>

CUDLP.K=SMOOTH(CUB.K/POS(CU.K),1)                           460, A
    CUDLP   - PERCEIVED DELIVERY DELAY FOR CONSUMERS
                GOODS FOR EXPORT <460>
    CUB     - BACKLOG OF ORDERS FOR CONSUMER GOODS
                EXPORTS <456.1>
    CU      - CONSUMER GOODS EXPORTS
```

RICE EXPORTS

```
CAR.K=SHARE(CARR.K,ARPN.K,CIAR.K,ARWR.K,CIN.K)              461, A
    CAR     - RICE EXPORTS
    SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
    CARR    - REQUESTED RICE EXPORTS <462>
    ARPN    - SHORTFALL IN PRODUCTION OF RICE
    ARWR    - WEIGHTED REQUESTS FOR RICE PRODUCTION <181>
    CIN     - NORMAL PRIORITY OF EXPORT SECTOR FOR
                PRODUCTION FROM OTHER SECTORS OF THE
                ECONOMY <451>

CARR.K=EXPORT(CARRI,CAR.K,ARPN.K,ARPR.K,CARLIST,
  CAREXAT,CAREEFT,CARLIS.K,CAREXA.K,CARSCI)                 462, A
CARSCI=.75                                                  462.3, C
CARRI=395E3                                                 462.5, C
CARLIST=1/.5/.25/.10/.05                                    462.7, T
CAREXAT=1.12/1.12/1.1/1.08/1.06/1                           462.9, T
CAREEFT=1.05/1.05/1.05/1.05/1.05/1.05                       463.3, T
    CARR    - REQUESTED RICE EXPORTS <462>
    EXPORT  - ORDERS FOR EXPORT <1.1>
    CARRI   - INITIAL RICE EXPORT ORDERS <462.5>
    CAR     - RICE EXPORTS
    ARPN    - SHORTFALL IN PRODUCTION OF RICE
    ARPR    - REQUESTED RICE PRODUCTION <180>
    CARLIST- TABLE FOR THE EFFECT OF INTERNAL SHORTAGES
                ON RICE EXPORTS <462.7>
    CAREXAT- TABLE FOR THE EFFECT OF FOREIGN EXCHANGE
                ADEQUACY ON RICE EXPORTS <462.9>
    CAREEFT- TABLE FOR THE EFFECT OF EXTERNAL FACTORS
                RICE EXPORTS <463.3>
    CARLIS - EFFECT OF INTERNAL SHORTAGES ON RICE
                EXPORTS
    CAREXA - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON RICE
                EXPORTS
    CARSCI - INITIAL SUPPLY CONDITION FOR RICE EXPORTS
                <462.3>
```

```
   F&V EXPORTS

CAO.K=SHARE(CAOR.K,AOPN.K,CIAO.K,AOWR.K,CIN.K)          464, A
     CAO     - FRUITS AND VEGETABLES EXPORTS
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     CAOR    - REQUESTED F&V EXPORTS <465>
     AOPN    - SHORTFALL IN PRODUCTION OF F&V
     AOWR    - WEIGHTED REQUESTS FOR F&V PRODUCTION <197>
     CIN     - NORMAL PRIORITY OF EXPORT SECTOR FOR
                 PRODUCTION FROM OTHER SECTORS OF THE
                 ECONOMY <451>


CAOR.K=EXPORT(CAORI,CAO.K,AOPN.K,AOPR.K,CAOLIST,        465, A
  CAOEXAT,CAOEEFT,CAOLIS.K,CAOEXA.K,CAOSCI)
CAOSCI=.75                                               465.3, C
CAORI=4.73E6                                             465.5, C
CAOLIST=1/.5/.25/.10/.05                                 465.7, T
CAOEXAT=1.12/1.12/1.1/1.08/1.06/1                        465.9, T
CAOEEFT=1.05/1.05/1.05/1.05/1.05/1.05                    466.3, T
     CAOR    - REQUESTED F&V EXPORTS <465>
     EXPORT  - ORDERS FOR EXPORT <1.1>
     CAORI   - INITIAL F&V EXPORT ORDERS <465.5>
     CAO     - FRUITS AND VEGETABLES EXPORTS
     AOPN    - SHORTFALL IN PRODUCTION OF F&V
     AOPR    - REQUESTED F&V PRODUCTION <196>
     CAOLIST- TABLE FOR THE EFFECT OF INTERNAL SHORTAGES
                ON F&V EXPORTS <465.7>
     CAOEXAT- TABLE FOR THE EFFECT OF FOREIGN EXCHANGE
                ADEQUACY ON F&V EXPORTS <465.9>
     CAOEEFT- TABLE FOR THE EFFECT OF EXTERNAL FACTORS F&
                V EXPORTS <466.3>
     CAOLIS  - EFFECT OF INTERNAL SHORTAGES ON FRUITS AND
                VEG. EXPORTS
     CAOEXA  - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                FRUITS AND VEG. EXPORTS
     CAOSCI  - INITIAL SUPPLY CONDITION FOR F&V EXPORTS
                <465.3>

   COTTON EXPORTS

CAC.K=SHARE(CACR.K,ACPN.K,CIAC.K,ACWR.K,CIN.K)          467, A
     CAC     - COTTON EXPORTS
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                ALLOCATION MACRO <1>
     CACR    - REQUESTED COTTON EXPORTS <468>
     ACPN    - SHORTFALL IN PRODUCTION OF COTTON
     ACWR    - WEIGHTED REQUESTS FOR COTTON PRODUCTION
                <189>
     CIN     - NORMAL PRIORITY OF EXPORT SECTOR FOR
                PRODUCTION FROM OTHER SECTORS OF THE
                ECONOMY <451>
```

```
CACR.K=EXPORT(CACRI,CAC.K,ACPN.K,ACPR.K,CACLIST,          468, A
  CACEXAT,CACEEFT,CACLIS.K,CACEXA.K,CACSCI)
CACSCI=.75                                                468.3, C
CACRI=280E3                                               468.5, C
CACLIST=1/.5/.25/.10/.05                                  468.7, T
CACEXAT=1.12/1.12/1.1/1.08/1.06/1                         468.9, T
CACEEFT=1.05/1.05/1.05/1.05/1.05/1.05                     469.3, T
    CACR    - REQUESTED COTTON EXPORTS <468>
    EXPORT  - ORDERS FOR EXPORT <1.1>
    CACRI   - INITIAL COTTON EXPORT ORDERS <468.5>
    CAC     - COTTON EXPORTS
    ACPN    - SHORTFALL IN PRODUCTION OF COTTON
    ACPR    - REQUESTED COTTON PRODUCTION <188>
    CACLIST- TABLE FOR THE EFFECT OF INTERNAL SHORTAGES
               ON COTTON  EXPORTS <468.7>
    CACEXAT- TABLE FOR THE EFFECT OF FOREIGN EXCHANGE
               ADEQUACY ON COTTON EXPORTS <468.9>

    CACEEFT- TABLE FOR THE EFFECT OF EXTERNAL FACTORS
               COTTON EXPORTS <469.3>
    CACLIS - EFFECT OF INTERNAL SHORTAGES ON COTTON
               EXPORTS
    CACEXA - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
               COTTON EXPORTS
    CACSCI - INITIAL SUPPLY CONDITION FOR COTTON CROP
               EXPORTS <468.3>
```

Imports -- Imports in the Egypt model result from the distribution of available foreign exchange over the import requirements for various traded goods. Imports of fertilizer (QFXV), capital goods (QGXV), grains (QANV), and military items (MGZ) are represented explicitly in the model.[13] Remaining imports are grouped in a miscellaneous category (QMXV) that is assumed to be proportional to the economy's total industrial activity, as measured by capital goods production (GP) and consumer goods production (UP).[14]

The import requirements for grains and fertilizer (expressed in tonnes) are determined elsewhere in the model, as are the capital goods requirements (measured in Egyptian pounds). The import needs which are originally expressed in tonnes are converted to foreign exchange requirements based on the world market prices for each type of goods. These prices are external inputs to the model that may be varied over time to investigate their impact on Egypt's balance of trade.

Egypt's import requirements are influenced by two additional factors. First, a foreign exchange shortage (XAXS) is assumed to reduce the economy's demand for imported goods (ZEXA), leading to a better balance between the supply of, and demand for, foreign currency. Second, a government policy effect on imports (QEGP) is included in the model. This effect allows the model to be used to investigate the consequences of a policy of restricting importing orders to an amount below what is necessary to meet all internal needs. The government policy effect is an external input that can vary over time.

```
IMPORTS

QT.K=QGXV.K+QANXV.K+QFXV.K+QMXV.K+MGQ.K                      470, A
    QT       - POUNDS VALUE OF TOTAL IMPORTS (EXCLUDING
                  IMPORTS FINANCED WITH LONG TERM DEBT OR
                  GRANTS) <470>
    QGXV     - POUNDS VALUE OF CAPITAL GOODS IMPORTS <471>
    QANXV    - POUNDS VALUE OF AGRICULTURE IMPORTS <475>
    QFXV     - POUNDS VALUE OF FERTILIZER IMPORTS <472>
    QMXV     - POUNDS VALUE OF MISCELLANEOUS IMPORTS <473>
    MGQ      - DESIRED MILITARY CAPITAL GOODS IMPORTS (NET
                  AFTER ARAB AID) <408>

QGXV.K=SHARE(QGR.K,XN.K,IGX.K,XWR.K,GIXN.K)                  471, A
    QGXV     - POUNDS VALUE OF CAPITAL GOODS IMPORTS <471>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
    QGR      - REQUESTED CAPITAL GOODS IMPORTS <480>
    XN       - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                  <422>
    XWR      - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                  <423>
    GIXN     - NORMAL PRIORITY OF CAPITAL GOODS FOR
                  FOREIGN EXCHANGE <380>

QFXV.K=SHARE(QFR.K,XN.K,IFX.K,XWR.K,FIN.K)                   472, A
    QFXV     - POUNDS VALUE OF FERTILIZER IMPORTS <472>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
    QFR      - REQUESTED FERTILIZER IMPORTS <481>
    XN       - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                  <422>
    XWR      - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                  <423>

QMXV.K=SHARE(QMR.K,XN.K,QMIX.K,XWR.K,QMIXN.K)                473, A
    QMXV     - POUNDS VALUE OF MISCELLANEOUS IMPORTS <473>
    SHARE    - ALLOCATION TO SECTOR DETERMINED BY
                  ALLOCATION MACRO <1>
    QMR      - REQUESTED MISCELLANEOUS IMPORTS <482>
    XN       - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                  <422>
    XWR      - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                  <423>
    QMIXN    - NORMAL PRIORITY FOR MISCELLANEOUS IMPORTS
                  <474>

QMIXN.K=(GQMR.K*GIN.K+UQMR.K*UIN.K)/(GQMR.K+UQMR.K) 474, A
    QMIXN    - NORMAL PRIORITY FOR MISCELLANEOUS IMPORTS
                  <474>
    GQMR     - MISCELLANEOUS IMPORT REQUIREMENTS FOR
                  CAPITAL GOODS PRODUCTION
    UQMR     - REQUESTED IMPORTED RAW MATERIALS FOR
                  CONSUMER GOODS (POUNDS) <357>
```

```
 QANXV.K=SHARE(QANR.K,XN.K,ANIX.K,XWR.K,ANIXN.K)       475, A
     QANXV   - POUNDS VALUE OF AGRICULTURE IMPORTS <475>
     SHARE   - ALLOCATION TO SECTOR DETERMINED BY
                 ALLOCATION MACRO <1>
     QANR    - REQUESTED GRAIN IMPORTS (FOREX/YEAR) <477>
     XN      - FOREIGN EXCHANGE SHORTFALL (POUNDS/YEAR)
                 <422>
     XWR     - WEIGHTED REQUESTS FOR FOREIGN EXCHANGE
                 <423>
     ANIXN   - NORMAL PRIORITY FOR GRAIN IMPORTS <476>

 ANIXN.K=TABHL(PUINNT,TIME.K,1960,2010,10)             476, A
     ANIXN   - NORMAL PRIORITY FOR GRAIN IMPORTS <476>
     PUINNT  - NORMAL PRIORITY FOR THE URBAN POPULATION
                 <129.1>

 QANR.K=ANQR.K*XANP.K                                   477, A
     QANR    - REQUESTED GRAIN IMPORTS (FOREX/YEAR) <477>
     ANQR    - REQUESTED GRAIN IMPORTS (TONNES/YEAR) <173>
     XANP    - PRICE FOR IMPORTED GRAIN (POUNDS/TONNE)
                 <478>

XANP.K=TABHL(XANPT,TIME.K,1970,1975,5)                 478, A
XANPT=20/60                                            478.2, T
    XANP    - PRICE FOR IMPORTED GRAIN (POUNDS/TONNE)
                <478>
    XANPT   - TABLE FOR PRICE FOR IMPORTED GRAIN (MOSTLY
                WHEAT) <478.2>

QTR.K=QANR.K+QGR.K+QFR.K+QMR.K+MGQ.K                   479, A
    QTR     - TOTAL REQUESTS FOR IMPORTS (POUNDS/YEAR)
                <479>
    QANR    - REQUESTED GRAIN IMPORTS (FOREX/YEAR) <477>
    QGR     - REQUESTED CAPITAL GOODS IMPORTS <480>
    QFR     - REQUESTED FERTILIZER IMPORTS <481>
    QMR     - REQUESTED MISCELLANEOUS IMPORTS <482>
    MGQ     - DESIRED MILITARY CAPITAL GOODS IMPORTS (NET
                AFTER ARAB AID) <408>

QGR.K=GQRT.K*QEGP.K                                    480, A
    QGR     - REQUESTED CAPITAL GOODS IMPORTS <480>
    GQRT    - TOTAL REQUESTS FOR CAPITAL IMPORTS (FOREX/
                YEAR) <378>
    QEGP    - EFFECT OF GOVERNMENT POLICY ON REQUESTS FOR
                IMPORTS <488>

QFR.K=(FPR.K-FP.K)*FPRICE.K*QEGP.K                     481, A
    QFR     - REQUESTED FERTILIZER IMPORTS <481>
    FPR     - REQUESTED FERTILIZER PRODUCTION <393>
    FP      - FERTILIZER PRODUCTION <392>
    FPRICE  - PRICE OF CHEMICAL FERTILIZER <485>
    QEGP    - EFFECT OF GOVERNMENT POLICY ON REQUESTS FOR
                IMPORTS <488>
```

```
 QMR.K=(GQMR.K+UQMR.K)*QEXA.K*QEGP.K                          482, A
     QMR     - REQUESTED MISCELLANEOUS IMPORTS <482>
     GQMR    - MISCELLANEOUS IMPORT REQUIREMENTS FOR
                  CAPITAL GOODS PRODUCTION
     UQMR    - REQUESTED IMPORTED RAW MATERIALS FOR
                  CONSUMER GOODS (POUNDS) <357>
     QEXA    - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                  REQUESTS FOR IMPORTS <486>
     QEGP    - EFFECT OF GOVERNMENT POLICY ON REQUESTS FOR
                  IMPORTS <488>

 QMN.K=QMR.K-QMXV.K                                           483, A
     QMN     - SHORTFALL IN MISCELLANEOUS IMPORTS <483>
     QMR     - REQUESTED MISCELLANEOUS IMPORTS <482>
     QMXV    - POUNDS VALUE OF MISCELLANEOUS IMPORTS <473>

 QMWR.K=(GQMR.K/GIQM.K)+(UQMR.K/UIQM.K)                       484, A
     QMWR    - WEIGHTED REQUESTS FOR MISCELLANEOUS IMPORTS
                  <484>
     GQMR    - MISCELLANEOUS IMPORT REQUIREMENTS FOR
                  CAPITAL GOODS PRODUCTION
     UQMR    - REQUESTED IMPORTED RAW MATERIALS FOR
                  CONSUMER GOODS (POUNDS) <357>

FPRICE.K=TABLE(FPRICET,TIME.K,1960,2010,10)                   485, A
FPRICET=70/70/70/70/70/70                                     485.2, T
    FPRICE - PRICE OF CHEMICAL FERTILIZER <485>
    FPRICET- TABLE FOR CHEMICAL FERTILIZER PRICE <485.2>

   IMPORT INFLUENCES

QEXA.K=TABHL(QEXAT,XAXS.K,0,1,.2)                             486, A
QEXAT=.1/.31/.5/.75/.95/1                                     486.2, T
    QEXA     - EFFECT OF FOREIGN EXCHANGE ADEQUACY ON
                  REQUESTS FOR IMPORTS <486>
    QEXAT    - TABLE FOR THE EFFECT OF FOREIGN EXCHANGE
                  ADEQUACY ON REQUESTS FOR IMPORTS <486.2>
    XAXS     - AVERAGE FOREIGN EXCHANGE ADEQUACY <487>

XAXS.K=SMOOTH(XAX.K,XAXAT)                                    487, A
XAXAT=1                                                       487.2, C
    XAXS     - AVERAGE FOREIGN EXCHANGE ADEQUACY <487>
    XAX      - ADEQUACY OF AVAILABLE FOREIGN EXCHANGE
                  (DOES NOT INCLUDE POTENTIAL BORROWING)
                  <413.1>
    XAXAT    - AVERAGING TIME FOR AVERAGE FOREIGN EXCHANGE
                  ADEQUACY (YEARS) <487.2>
```

```
QEGP.K=TABLE(QEGPT,TIME.K,1960,2010,5)                            488, A
QEGPT=1/1/1/1/1/1/1/1/1/1/1                                       488.2, T
    QEGP    - EFFECT OF GOVERNMENT POLICY ON REQUESTS FOR
                 IMPORTS <488>
    QEGPT   - TABLE FOR THE EFFECT OF GOVERNMENT POLICY
                 ON REQUESTS FOR IMPORTS <488.2>

   TEMPORARY EQUATIONS TO BE REPLACED BY OTHER MODEL SECTORS

MACRO    LINEX(A,B)                                                .1

LINEX.K=A.K+((B.K-A.K)*(TIME.K-1960)/15)                          1, A

MEND

VLR.K=LINEX(880E3,1290E3)                                         489, A

VIL.K=.1                                                          490, A
```

VII. RESOURCE ALLOCATION

Chapter II, the overview to this report, focussed on the importance of resource allocation decisions to the future of Egypt's economic development. Four of the most important resource allocation decisions, and their implications, were discussed in some detail. Besides these overall resource allocation decisions, however, there are numerous other decision points throughout Egypt's economy where scarce resources are allocated among competing demands.

The policies that determine the allocation of scarce resources at these decision points may be formal or informal, explicit or implicit. Formal and explicit policies may result from meetings between the heads of various national ministries who agree on the division of various resources and are in a position to see that those decisions are implemented. Informal and implicit policies result from the much less structured interaction that occurs between buyers and sellers on the free or black markets, or the decisions farmers make about where to plant their crops, and how carefully to water and fertilize each of their different plots.

Resource allocation in Egypt appears to be a mix of the two processes sketched out above. Most agricultural[1] and industrial production and investment is nominally, at least, directed from the central government in Cairo. In fact, however, the government bureaucracy appears to be incapable of enforcing strict adherance to the centrally-determined policies. Instead, the resource allocation decisions actually implemented at the local level respond at least in part to a host of other signals, including black market prices, perceived production shortfalls, and the like.

Because the allocation of scarce resources is a pervasive element of the Egyptian economy, the model includes a generalized allocation process. This "module" is used many times, in all sectors of the model. The allocation process compares the supply of a particular good or resource with the various demands for it to determine the allocation (SHARE) to each sector. If the supply exceeds the demand, then no trade-offs are necessary and all competing requests can be met. If, as is more common, demand exceeds supply, then a shortfall (SF) exists (i.e., the excess of demand over supply) and something must be done. Not everyone can get what he wants. In the model, the reconciliation of supply and demands is accomplished by distributing the shortfall among competing requests. High priority sectors absorb very little of the shortfall, since their needs are paramount and must be met if possible. Low priority requests, on the other hand, absorb much more of the shortfall, and therefore receive a smaller percentage of their demands.

To distribute a shortfall, the allocation process weighs both the requests (REQ) and the priorities (PRIOR) of each sector. The priorities are indices that can vary from zero to one, with values close to one signifying a high priority, and values close to zero signifying a low priority. When a sector's request is divided by its priority, the resulting quotient is used as an indication of how much of any shortfall that sector should absorb. Low-priority sectors, with priority indices below .1, will have a very large request/priority quotient, signifying that a large amount of the shortfall should be allocated there. High-priority sectors, with priority indices ranging from .3 to 1, will have a much smaller request/priority quotient; an indication that a lesser fraction of any shortfall should be allocated to those sectors. These weighted requests for foreign exchange are summed to a total (WREQ) that the model's allocation process compares with the overall shortfall to determine how much of the shortfall each sector will absorb.

```
SHARE.K=REQ.K-SF.K*(REQ.K/PRIOR.K)/POS(WREQ.K)          1, A
    SHARE  - ALLOCATION TO SECTOR DETERMINED BY
               ALLOCATION MACRO <1>
    REQ    - SECTOR REQUEST
    SF     - SHORTFALL BETWEEN TOTAL REQUESTS AND
               AVAILABILITY
    PRIOR  - SECTOR PRIORITY <2.1>
    WREQ   - WEIGHTED SECTOR REQUESTS

PRIOR.K=MIN(1,MAX(PRN,1.25*SMOOTH(SF.K/POS(WREQ.K),  2, A
  DT)))
PRIOR=PRN                                               2.1, N
    PRIOR  - SECTOR PRIORITY <2.1>
    PRN    - NORMAL SECTOR PRIORITY
    SF     - SHORTFALL BETWEEN TOTAL REQUESTS AND
               AVAILABILITY
    WREQ   - WEIGHTED SECTOR REQUESTS
```

VIII. NOTES ON PARAMETERS

The detailed Appendix A description of the simulation model identified numerous parameters representing model assumptions about future Egyptian government policy, or physical and social processes. This Section collects more than 100 of those assumptions in a single list to assist the use of the simulation model for policy analysis. The list provides the "base simulation" values for each of the parameters (for an explanation of the "base simulation", see Chapter III of the final report), and an explanation of the implications of variations in each one. By varying individual parameters, or groups of parameters, from their base simulation values, the model user can use the simulation model to determine the consequences of alternative policy or process assumptions.

The organization of this sector matches the organization of the Appendix A model description. The parameters are presented in sets that correspond to the water, population, agriculture, and industry and foreign trade sectors of the model. As a result, the user of this list should be able to match the parameters to the portions of the model structure they belong to, and thereby conduct precise simulation experiments to test different theories about Egyptian development.

Although the entire range of model parameters is presented here, the reader is reminded that the focus of the modeling project has been the role of water resources in Egypt's future. The modeling detail tends to decrease for the sectors more removed from direct interactions with the water resources sector. Therefore, model projections for these sectors must, of necessity, be less precise than projections for sectors dealing more directly with water management issues. The results of simulation experiments with the industrial and foreign trade sectors must be taken as qualitative indications of future trends, rather than exacting numerical forecasts. The proviso is also true, to a lesser extent, for the agriculture and population sectors.

Water Management Parameters -- The most important water management parameters deal with factors affecting the supply of water to Egypt, its management on route to the farmland, and the construction of drainage facilities. WASB, measured in thousands of cubic meters per year, is added to the assumed annual Nile flow of 84 billion cubic meters per year, and can assume positive values to test the implications of extra water becoming available (from construction of a swamp bypass) or negative values to represent less water availability (if, for example, more water is required for Sudanese agriculture). WSCLFT, WECLFT, and WFSALRT are all indices representing the fraction of water lost from the irrigation system from evaporation, seepage, or surface runoff, respectively. Reductions in any of the parameter values would connote improvements in irrigation water management. WAFSLNT represents the annual fraction of seepage loss for Lake Nasser.

Two parameters from the drainage portion of the model are important for policy analysis. WFDATC2 is the annual target for installation of drainage facilities (in feddans drained) after the time specified by WFDTT, and would be varied to represent more or less aggressive drainage programs. WFDPT expresses the cost per feddan for drainage facilities as a function of the fraction of land area already drained. Higher values for the later entries in the table would signify an increasing cost for drainage as the program is extended to more marginal land.

The final parameters from the water sector influence the rate of capital formation. WINT is the normal priority for the water sector for capital investment, and for the base simulation has a constant value of .1. The consequences of a higher or lower priority for capital investment in the water sector would be determined by varying the 1980 and 1990 values in the middle of the table. WGQFST determines the reliance on imported water control construction to compensate for any domestic inability to meet desired irrigation targets.

```
C WASB=0
T WELCFT=.1/.1/.1/.1/.1/.1
T WSLCFT=.1/.1/.1/.1/.1/.1
T WFSALRT=.15/.15/.15/.15/.15/.15
T WAFSLNT=.05/.05/.04/.03/.03/.03
C WFDTT=1980
C WFDATC2=250E3
T WFDPT=250/250/250/250/250/250
T WINT=.1/.1/.1/.1/.1/.1
T WGQOSFT=.25/.25/.25/.25/.25/.25/.25/.25/.25
```

Demographic parameters -- The demographic parameters for policy testing the Egypt model can be divided among three general categories. The first category includes the parameters that help determine the overall fertility of Egypt's population, and the possible influence of different government progams. The second set of parameters are economic, and specify the requirements of the population sectors for output from the capital goods, consumer goods, and service sectors of the economy, as well as the supply of labor available from the population. The third set of demographic parameters specifies food requirements for the population.

There are three different types of parameters affecting the Egypt's model calculation of rural and urban birth rates. PFCMBT specifies the fraction of the rural and urban populations targeted for government programs encouraging the use of modern birth control devices. The latter values of the table could be increased or decreased from their base simulation values of 50% to project the consequences of more or less aggressive government birth control programs.

PUMAT and PRMAT specify the average urban and rural marriage ages. The tables could be varied in the same manner as the birth control table to determine the efficacy of attempts to reduce population growth by raising average marriage ages. The final two parameters, PUDFSNT and PRDFSNT, represent the effect of assumed social and cultural values on water and rural desired family size. Reduction or increases in the latter values of these tables would represent social disincentives or incentives toward having more children.

```
T PFCMBT=.5/.5/.5/.5/.5/.5
T PUMAT=20/20/20/20/20/20
T PRMAT=18/18/18/18/18/18
T PUDFSNT=.9/.9/.7/.7/.7/.7/.7/.7/.7/.7/.7
T PRDFSNT=1/1/.8/.8/.8/.8/.8/.8/.8/.8/.8
```

The economic requirements parameters include capital goods, consumer goods, and service requirements, as well as the priorities that determine the allocation of scarce economic production among the urban and rural populations. PUGRT and PRGRT specify fractional changes in per capita goods requirements (in real terms, without any inflationary effect) for the urban and rural populations. The latter values of the table would be varied to project the consequences of differing requirements for household, service, and government capital later in the time period of the simulation. PUUOT and PRUOT specify per capita consumer goods requirements, measured in units of Egyptian pounds consumed per year. The higher urban value acknowledges the higher money incomes available to urban residents. PUGSCDT and PRGSCDT specify service labor requirements in terms of service personnel (doctors, educators, etc.) per person. Service requirements are also assumed to be higher in urban than in rural areas. PUINNT and PRINNT specify the urban and rural priorities for economic and agricultural goods. The urban priority is set higher in the simulation model, reflecting the favorable treatment generally accorded to urban areas at the expense of rural areas.

```
T PUGRT=1/1/1/1/1/1
T PRGRT=1/1/1/1/1/1
T PUUOT=15/15/15/15/15/15
T PRUOT=9/9/9/9/9/9
T PUGSCDT=.12/.12/.15/.15/.15/.15
T PRGSCDT=.06/.06/.09/.09/.09/.09
T PUINNT=.2/.2/.2/.2/.2/.2
T PRINNT=.1/.1/.1/.1/.1/.1
```

The next half dozen parameters in the demographic sector specify the labor force participation rates for the urban and rural populations. The rates are highest for the 15 to 44 year olds (PUXET, PRXET) and the 45-64 year olds (PUYET, PRYET). Small labor force participation for the 0-15 year olds is assumed to represent limited economic roles for children (PUQET, PRQET). PLSPT specifies productivity of service labor in both urban and rural areas, and the latter values from the table could be increased to test the implications of productivity improvements.

```
T PUQET=.05/.05/.05/.05/.05/.05
T PUXET=.54/.54/.54/.54/.54/.54
T PUYET=.5/.5/.5/.5/.5/.5
T PRQET=.1/.1/.1/.1/.1/.1
T PRXET=.5/.5/.5/.5/.5/.5
T PRYET=.45/.45/.45/.45/.45/.45
T PLSPT=1/1/1/1/1/1
```

The final major set of demographic parameters deals with food consumption requirements. PURCCT and PRRCCT specify the desired daily calorie consumption for adults in the urban and rural areas; the latter values from the table can be varied to test the consequences of changes in overall food consumption preferences. The next six parameters specify desired daily consumption, in kilograms per person, for meats (MRCT suffix), fruits and vegetables (ORCT), and rice (RRCT). As explained in Appendix A, desired consumption of grains other than rice is assumed to be determined by the difference between desired overall calorie consumption and the calories available from consuming the other three foodstuffs. The different parameter values for urban and rural populations reflect the reliance on other grains as a staple for rural diets, and the greater role of meats, fruits and vegetables, and rice in urban areas.

Two other parameters in the demographic sector fall in a miscellaneous category. PRFSPDT specifies the fraction of the rural population suffering from persistent diseases (such as schistosomiasis). Latter values of the table could be varied to represent government programs designed to eliminate this disease. PXRUMXT is a parameter for the effect of the government programs and other external factors in the extent of rural urban migration. Latter values on the table could be decreased, for example, to test the consequences of government attempts to reduce migration into the cities.

```
T PURCCT=3000/3000/3000/3000/3000/3000
T PRRCCT=2700/2700/2700/2700/2700/2700
T PUMRCT=.075/.075/.075/.075/.075/.075
T PUORCT=1.75/1.75/1.75/1.75/1.75/1.75
T PURRCT=.300/.300/.300/.300/.300/.300
T PRMRCT=.015/.015/.015/.015/.015/.015
T PRORCT=.58/.58/.58/.58/.58/.58
T PRRRCT=.060/.060/.060/.060/.060/.060
T PRFSPDT=.6/.6/.6/.6/.6/.6
T PXRUMXT=1/1/1/1/1/1
```

Agricultural Parameters -- The bulk of the model parameters for agriculture deal with specific factors that distinguish cultivation of the five different crop categories. These include the priorities individual crops enjoy for the assignment of resources, the potential yield available from seed strains, the effect of disease and storage losses on production, and the government influences on annual production growth rates. A final collection of agricultural parameters deals largely with the resources available for overall agricultural production.

The crop priority tables (INT suffix) determine the allocation of scarce resources among the individual crops. Priorities for any one crop, or several crops in combination, could be increased or decreased to determine the implications of changes in the relative important assigned by policy makers, or the operation of controlled and black markets, on individual crops. The reference yield tables (YRT suffix) would be varied to test the consequences of the introduction of new seed types for any of the five crops categories.

```
T ANINT=.03/.06/.06/.06/.06/.06
T ARINT=.12/.09/.09/.09/.09/.09
T ACINT=.06/.068/.068/.068/.068/.068
T AOINT=.16/.16/.16/.16/.16/.16
T AEINT=.1/.1/.1/.1/.1/.1
T ANYRT=1.8/1.8/2.15/2.15/2.15/2.15
T ARYRT=2.7/2.7/2.7/2.7/2.7/2.7
T ACYRT=.38,.38,.38,.38,.38,.38
T AOYRT=20/20/20/20/20/20
T AEYRT=18/18/18/18/18/18
```

The disease effect tables (DET suffix) and the storage effect tables (SET) both specify the fraction of the harvest or production ramaining after losses for either factor. Storage effect parameters might be increased, for example, to test the gains available from improvement in warehousing and marketing practices. The disease effect parameters might be decreased to test the vulnerability of the Egyptian economy to pests or diseases that might hit one or more of the major crop categories. The final group of parameters (GIT suffix) specifies government pressured for production of each crop, in the form of incremental annual growth rates. The major motivation for production increases in the Egypt model is discrepancies between desired and actual production; however, the government influence parameters can be used to test the impact of government policies that offer extra incentives or disincentives for production.

```
T ANYDET=.9/.9/.9/.9/.9/.9
T ARYDET=.9/.9/.9/.9/.9/.9
T ACYDET=.9/.9/.9/.9/.9/.9
T AOYDET=.9/.9/.9/.9/.9/.9
T AEYDET=.9/.9/.9/.9/.9/.9
T ANSET=.9/.9/.9/.9/.9/.9
T ARSET=.9/.9/.9/.9/.9/.9
T ACSET=1/1/1/1/1/1
T AOSET=.7/.7/.7/.7/.7/.7
T AESET=.9/.9/.9/.9/.9/.9
T ANPGIT=.05/.05/.05/.05/.05/.05
T ARPGIT=.05/.1/.1/.05/.05/.05
T ACPGIT=.05/.05/.05/.05/.05/.05
T AOPGIT=.05/.05/.05/.05/.05/.05
T AEPGIT=.05/.05/.05/.05/.05/.05
```

The final set of parameters for agriculture deals with resources for agriculture as a whole, rather than for individual crops. AINT specifies the normal priority of the agriculture sector, and determines the allocation to agriculture of labor, capital goods, and other production inputs. AGGAGT is the base annual growth rate for mechanization of agriculture. The latter values of the table would be increased to investigate the consequences of a greater government push for mechanization. AGQOTT also deals with mechanization, and specifies the fraction of depreciating agricultural machinery that is replaced by new capital equipment imported from abroad to achieve a transfer of technology to Egyptian agriculture. AFG01T and NFG01T specify annual targets (in thousand feddans) for land reclamation activity in the Old Valley and New Valley, respectively. Non-zero values would be substituted for the latter entrys in the New Valley table to investigate the possibilities for major Egyptian development projects in the Western desert lands. The final parameter (ALFGIT), is the government influence on meat production. Like the influence parameters on crop production discussed above, the meat influence parameter would be increased to represent higher government targets for meat production.

```
T AINT=.1/.1/.1/.1/.1/.1
T AGGAGT=.025/.025/.025/.025/.025/.025
T AGQOTT=.1/.1/.1/.1/.1/.1
T AFGO1T=30/30/30/30/30/30
T NFGO1T=0/0/0/0/0/0/0
T ALFGIT=.05/.05/.05/.05/.05/.05
```

Industry and Foreign Trade -- The final set of parameters reviewed here deals with influences on industrial development and foreign trade. They are included to round out the possibilities for policy experimentation with the Egypt simulation model although, in most cases, they have an only indirect relationship to developments in the more important water, agricultural, and population sectors of the model.

The industrial parameters include the normal priorities for each sector, and desired plant and equipment purchases overseas. Like the normal priorities for other sectors of the model, the normal priorities for industry determine the allocation of resources among the five industrial groups. They can be varied to represent government emphasis on one industry or another, or assumptions about varying future profitabilities for each industry. Government growth influences (PGIT suffix) played exactly the same role as the government influence parameters identified for agriculture. They can be increased or decreased for individual industries, or combinations of industries, to investigate differing industrial development strategies. The capital import parameters (GQOTT suffix) determine the fraction of depreciating plant and machinery that is replaced by overseas orders to acquire new technology. The final industrial parameter is an energy demand factor (EDFT) which increases energy requirements for all industrial and population users. The latter values of the table could be increased to represent assumed increases in energy consumption for personal use or industrial production.

Two parameters in the model deal specifically with military requirements for economic goods. MLRT specifies the desired number of men in the armed forces, in thousands, and can be increased to determine the consequences of a drain on the labor force to meet military needs. MGQT specifies the annual foreign exchange requirements (millions of Egyptian pounds) required to purchase arms from overseas. Increases in the parameter could be used to test the consequences of draining off available foreign exchange for a use with no productive economic value.

```
T UINT=.1/.1/.1/.1/.1/.1
T GINT=.2/.2/.2/.2/.2/.2
T EINT=.1/.1/.1/.1/.1/.1
T FINT=.1/.1/.1/.1/.1/.1
T TINT=.1/.1/.1/.1/.1/.1
T UFGIT=.05/.05/.05/.05/.05/.05
T GFGIT=.05/.05/.05/.05/.05/.05
T EFGIT=.05/.05/.05/.05/.05/.05
T TFGIT=.05/.05/.05/.05/.05/.05
T FFGIT=.05/.05/.05/.05/.05/.05
T UGQOTT=.1/.1/.1/.1/.1/.1
T GGQOTT=.1/.1/.1/.1/.1/.1
T EGQOTT=.1/.1/.1/.1/.1/.1
T FGQOTT=.1/.1/.1/.1/.1/.1
T TGQOTT=.1/.1/.1/.1/.1/.1
T EDFT=1/1/1/1/1/1
T MGQT=100/100/100/100/100/100
T MLRT=200/250/300/350/400/450
```

The foreign trade parameters fall into three general categories -- influences on debt, influences on exports, and influences on world market prices. XLDCIET identifies any future trends in interest rates for long term or short term debt, and could be increased or decreased to investigate the consequences of more or less expensive borrowing. XEPLDNT and XEPSDNT represent the effect of political considerations on new long term and short term debt, respectively. They identify the fraction of necessary new debt that political or other policy interests will allow to occur.

The first of the export parameters, CINT, specifies the normal priority for export needs in the competition with domestic requirements for the country's agricultural and consumer goods production. CEPFT is a parameter for the effect of political factors on exports: increases or decreases in this parameter would correspond to greater or lesser attempts by the government to market Egyptian goods overseas. CMXVT specifies the miscellaneous foreign exchange earnings (in million of pounds) available from sources not represented in the model, such as oil exports, tourism, and Suez Canal fees. The final export parameters (EEFT suffix) specify the assumed growth for external markets in consumer goods (CU prefix), rice (CAR), fruits and vegetables (CAO), and cotton (CAC). The increases or decreases in the latter values for these parameters could be used to test the consequences of greater or lesser growth of world markets for Egyptian produce, and the consequent greater or lesser opportunities for export.

```
T XLDCIET=1/1/1/1/1/1
T XEPLDNT=.5/.5/.5/.5/.5/.5
T XEPSDNT=1/1/1/1/1/1/1/1/1/1/1
T CINT=.2/.2/.2/.2/.2/.2
T CMXVT=0/70/140/200/280/390
T CEPFT=1/1/1/1/1/1
T CUEEFT=1.1/1.1/1.1/1.1/1.1/1.1
T CAREEFT=1.05/1.05/1.05/1.05/1.05/1.05
T CAOEEFT=1.05/1.05/1.05/1.05/1.05/1.05
T CACEEFT=1.05/1.05/1.05/1.05/1.05/1.05
```

The final parameters specify the prices on the world market or rice (XARPT), other grains (XANPT), cotton (XACPT), fruits and vegetables (XAOPT), fertilizer (FPRICET), consumer goods (UPRICET). They can be varied to determine the implications of future increases or decreases in the relative prices for the goods Egypt trades on the world market. SGXQRT fulfills a similar role for plant and equipment purchases, and increases or decreases in the latter values of this parameter would signify increases or decreases in the relative world market prices for capital goods. QEGPT represents the effect of the governemnt policy on orders for imports, and would assume values less than one to represent a government policy of reducing, or eliminating, import orders to meet internal needs. The values for the parameter specify the fraction of necessary imports to meet economic needs that will be allowed by the government.

```
T XANPT=20/60
T XARPT=50/90
T XACPT=530/750
T FPRICET=70/70/70/70/70/70
T UPRICET=1/1/1/1/1/1
T QEGPT=1/1/1/1/1/1/1/1/1/1
T SGXQRT=1/1/1/1/1/1
```

FOOTNOTES

I. Introduction

1. Area Handbook for Egypt, (hereafter referred to as AHE), page 66.

2. AHE, page 65.

3. AHE, Pages 1, 66, 13.

4. John Waterbury, "Aish: Egypt's Growing Food Crisis", page 6.

5. For an example of the inconsistencies in official data, see John Waterbury, "Aish", page 3.

6. The basic references for System Dynamics are Jay W. Forrester's Industrial Dynamics and Alexander L. Pugh's DYNAMO User's Manual.

7. Saad Gaadalla, "Population Problems and Family Planning Programs in Egypt", page 2.

II. Overview

1. A major question surrounding plans for massive Egyptian exports of manufactured goods is whether markets will be available. See John Waterbury, "LRPing in the Arab World", page 11.

2. For a description of Egyptian foreign aid requirements and the likelihood of Arab countries meeting those needs, see Business Week, October 25, 1976, page 49.

3. John Waterbury, "Aish...", page 8.

4. Business Week, February 16, 1974, page 70, describes Egypt's efforts to attract foreign investment.

5. John Waterbury, "Chickens and Eggs: Egypt's Population Problems Revisited", (Hereafter referred to as "C&E"), page 1.

III. Water

1. Abu Al-Izz, M.S., Landforms of Egypt. American University in Cairo Press, Cairo, 1971, p. 87.

2. Ibid, p. 118.

3. Ibid.

FOOTNOTES

(cont.)

III. Water (Cont.)

4. Shata, A. and I.E. Fayuomy, "Remarks on the Hydrogeology of the Nile Delta, UAR", Symposium on the Hydrology of Deltas, p. 385.

5. Mikhail, Farid N., "Status of Water Resources in Egypt", p. 3-18.

6. Ezzat, M.A., "New Valley Project Ground Water Condition."

7. Most texts use the simpler term "ground water". We use "phreatic" to emphasize that standing water on the surface, as in water-logged land, is included.

8. In addition to salt, water may carry silt. Before the High Dam, the Nile carried considerable quantities of silt onto the land. Based on sensitivity experiments, this feature of Egypt's water system has been omitted from the model. See Waterbury, "Nile Stops....", page 10. See also the computer experiments on silting in the technical appendix of this report.

9. Historical values for 1960-1964 are based on Spofford, Walter O., "Notes on Available Theoretical Hydroelectric Power, Aswan High Dam", Values for 1964-1971 are from "Water Resources of the World - Selected Statistics".

10. Seepage estimates vary widely. The five percent estimate is a compromise among estimates ranging from 1.5% per year to 9% per year, reported by Yusuf Shibl, The Aswan High Dam, pp. 59-73.

11. Shibl, op. cit., p. 50.

12. Shibl, op. cit., p. 61.

13. Shibl, op. cit., p. 47.

14. Constraints, p. 58.

15. Ibid.

16. Estimated from John Waterbury, "The Nile Stops at Aswan, Part III: Comestic Hydropolitics", p. 24-25.

17. Shibl, op. cit., p. 54-55 reports that each turbine produces 180,000 kilowatts, while consuming 346 cubic meters of water per second. In one hour, therefore, a turbine will produce 180,000 kilowatt-hours, while consuming 1,246 thousand cubic meters, for a ratio of 144 KWH/KCM.

18. See Note 7 above.

19. The values for the porosity and areas of the phreatic zones of the Nile Valley and Delta are taken from the following sources:

    Abu-Al-Izz, M.S., Land Forms of Egypt, p. 87.

FOOTNOTES

(cont.)

III. Water (continued)

Shata, A. and I.E. Fayuomy, "Remarks on the Hydrogeology of the Nile Delta, UAR", Symposium on the Hydrology of Deltas, p. 385.

Mikail, Farid N., "Status of Water Resources in Egypt", Water for the Human Environment, p. 3-18.

Ezzat, M.A., "New Valley Project Ground Water Condition."

20. Assuming an average drainage-time depth of one to two meters.

21. A. Aboukhalod, "Research on Crop Water Use, Salt Affected Soils and Drainage in the Arab Republic of Egypt," FAO, p. 81.

22. U.S. Dept. of Agriculture, Saline and Alkali Soils, Agriculture Handbook No. 60, p. 8.

IV. Population

[1] The urban population is generally favored by the government, which is largely drawn from the urban elite. See John Waterbury, "Aish", page 8. Also, the urban population is better able to afford expensive food imports, see Area Handbook for Egypt, page 98.

[2] Syn Crisis, page 20.

[3] See Rural Employment Problems ..., page 28.

[4] Rural Employment Problems..., page 26-27.

[5] Meadows, et al., page 170.

[6] U. S. Census Estimates.

[7] Maximum fertility rates (annual live births per 100,000 women) in the United States have been estimated at .55, .52, and .28 respectively for 15-24, 25-34, and 35-44 year olds (Christopher Tietze, et al). We have reduced these rates by 20% for the model to reflect the differences in pre-natal care and child delivery rate between the United States and Egypt.

[8] International Bank for Reconstruction and Development, "The National Family Planning Program...", page 10, 14-15, discusses marriage ages and practices for rural and urban areas. See also Rural Employment Problems, page 25.

[9] See Waterbury, "Chickens and Eggs", page 7, for a discussion of this issue.

FOOTNOTES

(cont.)

IV. Population (cont.)

[10] See John Waterbury, "Chicken & Egg...", page 9. Also, International Bank for Reconstruction and Development, "The National Family Planning Program of the Arab Republic of Egypt," pages 10-14.

[11] Attempts to open up alternatives for women as an aid to family planning are discussed in Congressional testimony by Wiley Mosley in "World Hunger, Health, and Refugee Problems, Part VI", page 80.

[12] The empirical evidence for the relationship between child survival and desired births is discussed at length by Donella H. Meadons in *Dynamics of Growth in a Finite World*, Dennis L. Meadows, *et al*, Wright-Allen Press, 1974, pages, 107-109. The existence of this factor in Egypt is discussed in International Bank for Reconstruction and Development, op. cit., page 11.

[13] International Bank for Reconstruction and Development, op. cit., page 12, discusses traditional birth control methods.

[14] The relative effectiveness of the two different birth control methods can be illustrated by considering the case of an individual woman. Assume a newly married woman of 20 would like to have three births between the ages of 20 and 35, and attempts to limit her births with traditional methods that average 50% effectiveness. This woman is attempting an average annual birth rate of .2 (three births over 15 years). The maximum possible birth rate over the same time is .44, so her actual birth rate, mid-way between the two, would be .32 births per year. This birth rate would produce roughly five births--two extra children--over the 15 year time span. If this newly married 20-year old woman instead elected to use modern birth control methods, with a 90% effectiveness, the chances of having only three children would be greatly increased. Only one woman in four would have an extra child during the 15 years with modern methods.

[15] Waterbury, John, "Chickens and Eggs...", pages 2-4.

[16] The bureaucratic and supply problems with delivering contraceptives to villages are described in *The New York Times*, April 26, 1977, page 7. The need for health services personnel to promote modern family planning is further increased by the preference of most rural women to have their children at home. "Report and Recommendation of the President...," page 3.

[17] Estimated from the life expectancy data presented for Arabic and developed countries in Meadows, *et*, *al*., pages 178-183.

[18] Assessments of needs for individual nutrients vary, and distinctions must be drawn between the requirements for developing countries and the norms that have become typical for developed countries. The model uses requirements determined by a 1974 FAO/WHO study, as reported in Srimshaw and Young.

FOOTNOTES

(cont.)

IV. Population (continued)

[19] For obvious reasons, it is difficult to conduct controlled experiments on the impact of malnutrition on life expectancy. "Many of the links between diet, performance potential, and economic returns are poorly understood and may remain so, given the complexities of human development and behavior. Little is known, for example, about the relative damage caused by different degrees of malnutrition at different ages and of varying durations" (Berg, page 26).

[20] Syn Crisis, page 24.

[21] Ibid.

[22] Cereals (including rice) supply about 70% of calorie consumption; fruits and vegetables (including sugar) supply 13%; meat and milk supply 13% -- "World Bank, "Egyptian Agriculture...", page 14.

[23] Estimates from "A.R.E. Economic Indicators 1961-1971", page 32.

[24] See Footnote #1, above.

[25] Estimated from 1960 service employment (Federation of Egyptian Industries, Table 13).

[26] Waterbury, John, "Chickens and Eggs...," pages 7-10.

[27] Estimated from Federation of Egyptian Industries, pages 11, 20.

[28] Estimated from the 1960 values for energy usage and household capital goods. See Footnote #5 under Industry and Foreign Trade.

[29] See Rural Employment Problems..., page 28. Also, people in rural areas tend to begin work at an earlier age and retire later (Nagi, "Internal Migration...," page 278.

[30] It has been estimated that 1,800 calories/day diet reduces muscle strength by 30% and precision of movement by 15% (Alan D. Berg, page 13). Examples of reduced productivity from inadequate nutrition are described by Miriam E. Lowenberg, et al, pages 166-167.

[31] As demonstrated by the civil disorder in Egypt when the government attempted to raise the price for food.

[32] M. Faroq, page 177, summarizes estimates of lost productivity from bilharzia (schistosomiasis). See also Syn Crisis, page 29.

FOOTNOTES

(cont.)

IV. Population (continued)

[33] Area Handbook for Egypt, page 75; Mostafa H. Nagi, pages 263, 268.

[34] Mostafa, Nagi, op. cit., page 269.

[35] Rural Employment Problems..., pages 28-29.

[36] Mostafa Nagi, op. cit., pages 275-276.

V. Agriculture

[1] John Waterbury, "Aish...", pages 7, 9.

[2] There are some doubts about how much the soil is replenished by Egyptian practices for forage cultivation, as described in Major Constraints, page 5.

[3] Storage losses for fruits and vegetables may range up to 40% (Major Constraints, page 18). Storage losses for grains may reach 7% (Waterbury, "Aish...", page 7).

[4] Area Handbook for Egypt, page 285.

[5] See Footnote #4 under Industry and Foreign Trade.

[6] IBRD, "The Egyptian Economy...", page 48 discusses some of the delays involved in land transfers among crops.

[7] World Bank, Table 6.

[8] Major Constraints, page 53, suggests divisible target yields for 1985. We have adjusted these targets upward to reflect possible increases through the end of the century, and further modified the reference yields through simulation experiments.

[9] Maas and Hoffman provide estimates of the salt tolerances of crops.

[10] Shibl, Yusuf, page 44.

[11] World Bank, "Egyptian Agriculture...".

[12] Abdallah Hassan, page 54, Potassium fertilizer has had a negligible role in chemical fertilization in the past (World Bank, Table 13).

FOOTNOTES

(cont.)

V. Agriculture (continued)

[13] Major Constraints, page 99.

[14] For discussion of the inter-relationships among production input, see "Aish", page 4; Robert Mabro, page 13; and Hansen and Nashashivi, op. cit., page 150.

[15] Labor requirements for agriculture are discussed in Rural Employment Problems...", pages 55-56 and 100.

[16] Waterbury, "Aish...", page 5, discusses the losses of agricultural land to the forces of urbanization. Egypt's arable land may have remained constant over the last 10 years, or suffered a slight net loss.

[17] Waterbury, "Aish...", page 4.

[18] Major Constraints, page 97.

[19] Dawson estimates the nitrogen content of manure in China as .5% (page 138). We have used the same number for Egypt, and increased it to .8% to include phosphates.

[20] World Bank, Table 13.

[21] Waterbury discusses the importance of imported parts and equipment in "Public versus Private", page 19. See also Major Constraints, pages 154-156.

[22] Estimated from Federation of Egyptian Industries, Table 11.

[23] See Footnote #5 under Industry and Foreign Trade.

[24] World Bank, Table 5.

[25] Major Constraints, page 54, estimates a 15 tonne optimal roughage requirement. Not all of this, however, may have to come from fodder crops (page 116).

[26] Dawson provides estimates for Chinese livestock on page 139. We have adjusted these numbers for use with Egypt.

[27] Gabriel Saab describes the widespread practices for manure collection and application in Egypt (page 101). In mainland China, where manure use is extensive, 60% of the manure production is recovered (Dawson, page 138). We assume a lesser fraction for Egypt.

[28] See Footnote #24.

FOOTNOTES

(cont.)

VI. Industry and Foreign Trade

[1] Waterbury, "LRPing...", pages 9-11.

[2] Egypt is beginning development of local power generating stations to supplement the electricity available from the Aswan hydro-electric grid.

[3] Estimated from production and investment figures from Federation of Egyptian Industries, Section II, page 11.

[4] Transportation requirements were estimated from material in "Egyptian National Transportation Study -- Interim Report".

[5] The energy requirements per unit of capital were calculated by distributing an estimated 1960 power generation of 1,600 million kilowatt hours over the total capital goods stock in place.

[6] Federation of Egyptian Industries, Section II, page 13.

[7] Ibid., pages 11, 20, were used to estimate the amount of capital goods in place in 1960.

[8] World Bank, page 15.

[9] Waterbury discusses long-range export plans extensively in "LRPing in in the Arab World".

[10] Business Week, December 31, 1975, page 17.

[11] Kindleberger, page 385.

[12] Agricultural products and consumer goods made up more than 90% of the value of Egyptian exports in 1974 (International Monetary Fund, page 97).

[13] These categories made up more than 85% of the 1974 value of Egyptian exports (International Monetary Fund, page 98).

[14] Waterbury provides potential estimates for Suez Canal earnings (600-1,000 million LE in 1980), tourism (250 million LE) and oil exports (2,500 million LE) that assume completion of major development projects. These estimates will be used for alternative scenarios. See "The Opening, Part II...", pages 10, 11.

FOOTNOTES

(cont.)

VII. Resource Allocation

[1] The central government attempts to play a leading role in agricultural resource allocation. John Waterbury describes the role of the government in introducing agricultural innovations in "Aish...", page 4. The rural cooperatives play a major role in implementing government agricultural policy (Robert Mabro, pages 74-75). See also Major Constraints, pages 14, 141, and Area Handbook for Egypt, page 282.

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