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# A Model To Develop Egyptian Agriculture To Solve The Problem Of Unemployment And Low Per Capita Income In Egyptian Agriculture

I.M.I.Arman

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I. M. I. Arman**

## I: Introduction

This paper describes research into an optimization model for Egyptian agriculture using computerised linear programming techniques which could greatly increase labour absorption, whilst requiring very little capital, and could increase aggregate farming profitability.

The background to this research is the failure of Egypt's development policies to solve the increasing problem of surplus labour and disguised unemployment in agriculture. It should be stressed here that from the appraisal of the development strategy and theory on which it is based on, it can be said here that the failure of the applied strategy and policies, is due to the fact that many of the assumptions and arguments for the applied strategy and policy of encouraging industrilization are not applicable to Egypt, where the country has remained relatively poor and has been and still is unable to provide the enormous amount of capital investment required to accelerate the rate of development of the industrial sector in order to solve the problems of agricultural labour and disguised unemployment in agriculture[1]. In the light of this capital constraint and the

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** Dr. Arman is the Senior Economic, Planning& Manpower Consultant to the Ministry of Manpower And Vocational Training, Cairo-Egypt.

1. The applied development strategy and policies were presented and discussed and appraised in Chapter 2,3 and 4 of an un published Ph.D. thesis presented by Dr. Arman in 1976 to Wales University; also in a paper published in 1981 by the same author.

the failure of the adopted strategy to fulfil its objectives, Egypt has to continue to rely on agriculture as the mainstay of her economy and solution to the growing employment problems are increasingly being sought in agriculture. Policies for agriculture are being sought that will increase its income and employment in the sector and provide greater investable surplus for it. The development of agriculture along with labour intensive strategy was found to be a more appropriate method of stimulating economic progress. It is this new approach that has made the objective of this research to seek to identify a planning model for Egyptian agriculture, which can contribute towards finding a strategy to meet these objectives. The model is an optimization model which intends to contribute towards identifying a cropping pattern that will be both practicable and will increase both labour absorption and farm income beyond their existing level.

The following parts of this paper are concerned with outlining the optimization model, discussing the data used for the matrix as are the various constraint and assumptions used during the running of the model until finally a successful solution was acheived.

## II: Methodology

Linear programming. The optimization model concerned can be described as a mathematical tool which can be used to describe and analyse the existing relationships between the available resources and enterprises on the farm, regardless of whether such relationships are explicitly or implicitly involved in the formulation of the programme. It can also be used to express and transform these relationships into quantitative terms and to indicate the optimal use of the available resources, as well as to identify a cropping pattern that will be both practicable and will increase both labour absorption and farm incomes beyond their existing levels.

The suggested model is based on the assumption that in any optimization problem there are constraints which limit the solution. These constraints, or limits, reflect the minimum and maximum requirements that can be met. The suggested model applies the linear programming methodology of computation. The methodology is entirely a mathematical technique which determines the optimal solution of a problem. The economic content of the linear programming methodology is entirely nil. The methodology is based on the assumption that all the relationships between the variables involved are of a linear type[1] and that the linear function of the problem is minimized or maximized subject to a system of linear non-negative inequalities. The general format of the model is to find values for the variable Z = ( j = 1, ..., n ) that maximize:

$$Y = y_1 Z_1 + y_2 Z_2 + \ldots\ldots y_n Z_n \qquad (1)$$

Subject to:

$$a_{i1} Z_1 + a_{i2} Z_{i2} + \ldots\ldots + a_{in} Z_n \leqslant K \qquad i = 1, \ldots, m \qquad (2)$$

and $$Z_j \geqslant 0 \qquad j = 1, \ldots, n \qquad (3)$$

Where the parameters $y_i$ , $a_{ij}$ and $K_i$ may be positive, negative or zero.

The standard format given by equation (1) to (3) is quite general, and if a linear function to be minimised the problem may be written in the standard format by maximizing the negative values. If a constraint is of the linear form $\geqslant$ , the inequality may be reversed to conform to ( $\leqslant$ ) by multiplying through by -1. If the ( i th.) constraint is a strict equality, it may be represented by two weak inequalities $<$ and $>$ . The second inequality may then be reversed by multiplying through by -1.

To prepare algebraic solution for a linear programming

1. Baumol (1965), pp.70-75, 270-271; Henderson and Quandt (1971) pp.334-335; Barnard and Nix (1973), pp.281-371; also Dorfman et al. (1958), pp. 1- 34.

problem by making use of a computer will require two basic sets of inputs. The first concerns the problem itself and is contained in a matrix or a two-way table[1]. The second set concerns the programme and consists of instructions about the manipulations to be performed on the matrix. The validity of the solution obtained by making use of a computer depends not so much on the computer as on the accuracy of the data on which computation is based as well as on the skill and understanding with which relationships between the variables are translated into the matrix form.

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## III: The Mathematical Formulation Of The Optimization Model For Egyptian Agriculture

The model concerned employs linear programming techniques to determine:

(i) which of the 75 crops, cultivated under the present pattern of production in Egypt, to choose to satisfy the given objectives;

(ii) the required area of each of the chosen crops to cultivate to fulfil the given objectives.

It should be noted that the model was built to investigate the possibilities of identifying a solution to the growing employment problems in agriculture. The general format of the

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1. The size of the matrix is specified as m x n where m is the number of rows and n is the number of columns.

model can be summarised in the following way:-

Let $b_{ikj}$ be the level of ith activity in land type k in month j;

$P_{ik}$ be the level of profit per feddan (the unit of production) of activity i in land k, where profit is equal to the gross income of one feddan of activity i in land type 1 minus the cost of cultivation of one feddan with activity i in land type k;

$lab_{ikj}$ be the level of requirement of labour input to cultivate, service and harvest one feddan of activity i in land type k in month j;

$wat_{ikj}$ be the level of requirements of water to irrigate one feddan of activity i in land k in month j;

$X_{ikj}$ be the permitted land requirement of activity i in land type k for month j;

$L_{kj}$ be the land constraint of type k in month j; land should be used to cultivate the most profitable crop for the farmers, as well as absorb additional labour;

$I_j$ be water constraints in month j; which should not be exceeded;

$D_i$ be the binding on activity i; which can satisfy the given objectives such as sustaining the level of acreage cultivation with cash and foreign exchange crops;

$M_j$ be labour constraints in month j; which shoul be exhausted to solve the problem of unemployment partially in Egyptian agriculture.

Then, the objective function is

$$\text{Max} \sum_{i=1}^{75} \sum_{k=1}^{4} P_k X_{ik}$$

Subject to:

1. Land constraint of the form

$$\sum_{i=1}^{75} \sum_{j=1}^{12} \sum_{k=1}^{4} b_{ikj} \; X_{ikj} \leqslant L_{kj}$$

2. Labour constraint of the form

$$\sum_{i=1}^{75} \sum_{j=1}^{12} \sum_{k=1}^{4} lab_{ikj} \; X_{ikj} \leqslant M_j$$

3. Water constraint of the form

$$\sum_{i=1}^{75} \sum_{j=1}^{12} \sum_{k=1}^{4} wat_{ikj} \; X_{ikj} \leqslant I_j$$

4. Boundaries constraint of the form

$$\sum_{i=1}^{75} \sum_{k=1}^{4} b_{ik} \; X_{ik} \leqslant R_i$$

Where:

($i = W_w + S_s + N_n + V_v + H_h$ = 1, 2, 3, ......, 75),

($W_w$ = winter crops = 1, 2, 3, ...., 10),

($S_s$ = summer crops = 1, 2, 3, ..., 7),

($N_n$ = Nile crops = 1, 2, 3),

($H_h$ = horticulture crops = 1, 2, 3, 4),

($V_v$ = vegetable crops = 1, 2, 3, .....),

(k = 1, 2, 3, 4),

(j = 1, 2, 3, 4, ....., 12), and

(b is parameter).

The relationships between resources and activities in Egyptian agriculture were coded into a form suitable for processing by linear programming. The matrix shown in Diagram 1 illustrates the general layout of the translated relationship between resources and activities. The activities head the matrix since the first entry is their contribution to the objective function, the latter constitutes the first row, the level of resources and constraints appear in the first column of figures, while the input requirements and output contribution of the activities appear in the body of the matrix. The size of the matrix is specified as 148 rows, which represnt the different constraints (i.e. land, water, labour, profitability of each crop per unit), x 174 columns, which represnt the different crops which could be cultivated on the different grades of the agricultural land. It is not necessary to write the disposal activities as these are formed automatically in the computer from instructions given in the programme. The matrix is interpreted vertically. Reading down a column shows the amalgam of resources and constraints required by a particular activity together with any output from it; while reading across a row shows the demand and supply situations in respect of given resource or constraint. The function introduced here is linear because, irrespective of the actual level of chosen activity which may range from all activity A and no activity B to all activity B and no activity A, their net profit and their unit requirement of input resources (i.e. labour, land, water and other fixed resources) are assumed to remain unchanged.

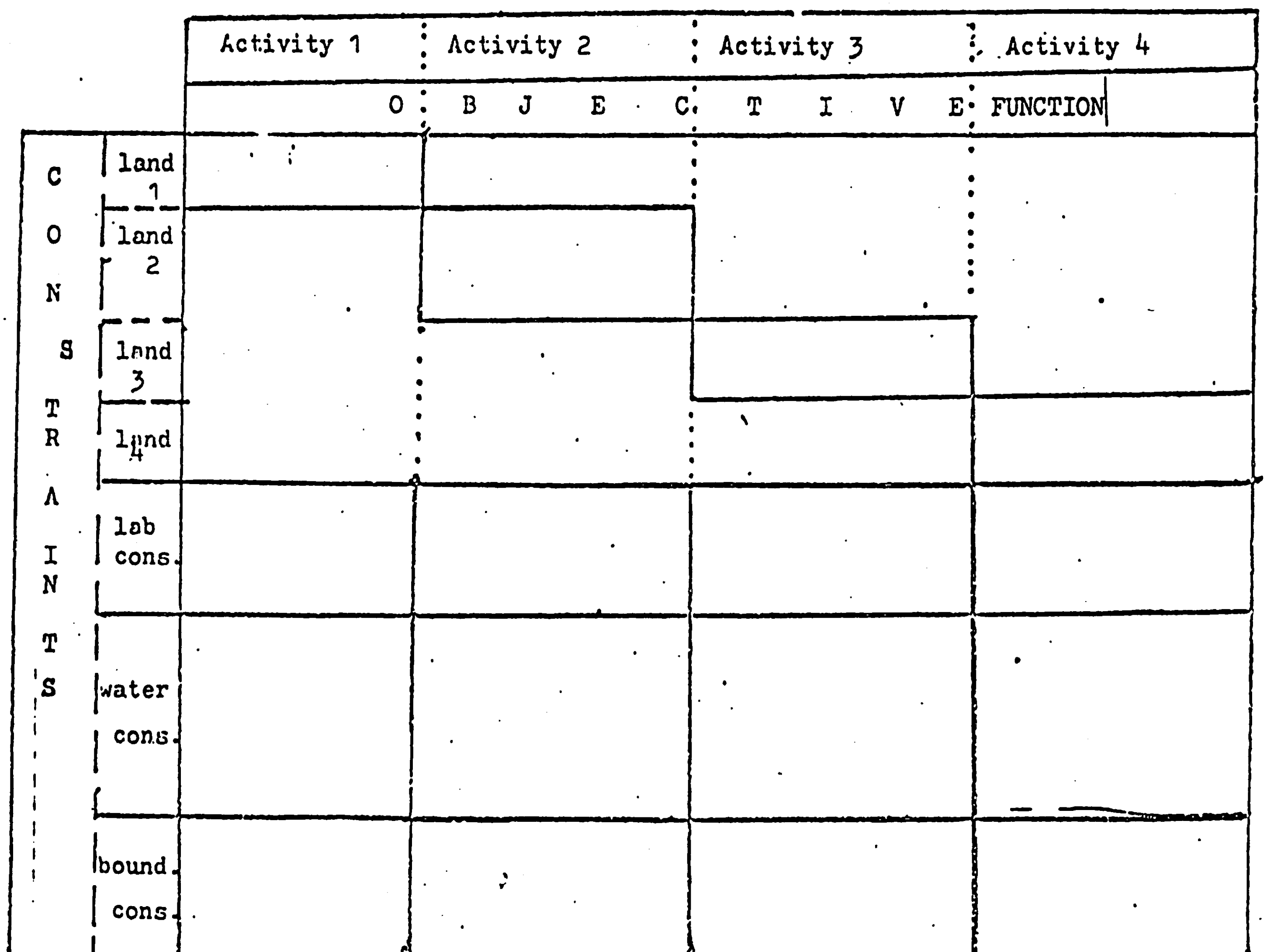
The validity and viability of the model will be discussed in the following part of this paper.

## IV: The Validity And Viability of The Optimization Model for Egyptian Agriculture

Appraisal of method[1]. The choice of the linear programming methodology for constituting and analysing all the existing

1. The evaluation is based on Baumol (1965), pp.70-75, 270- 71; Henderson and Quandt (1971), pp324- 35; Barnard and Nix (1973), pp. 281- 371; also Dorfman *et al.*(1958), pp. 1-39.

DIAGRAM 1 : LAYOUT OF THE SUGGESTED PROGRAMME FOR DEVELOPING THE EGYPTIAN AGRICULTURE



relationships between the available resources and enterprises on Egyptian farms to specify the optimal solution for the employment problems of Egypt does not mean that the chosen method is necessarily the best one which could be used for national economic planning purposes. The method was chosen because it was a convenient method which could fit in with the availability of both the data and computational facilities. For this research it could provide acceptable results regarding the'real farm' situation. Other method such as dynamic linear programming or input/output analysis could have served the purpose of this study if the required information and computational facilities had been available. However, Linear programming may be appraised under two headings. The first concerns its conceptual characteristics as an optimization techniques. The second concerns its practicality as a practical planning tool; in short, its operational feasibility.

1) The conceptual characteristics[1]. The conceptual characteristics of linear programming may be appraised in the following four points.

(a) The first main advantage of linear programming compared with other optimization techniques such as integer programming and Mont Carlo method is that complex situations can be studied in a more comprehensive and realistic manner because computations are carried out by the computer and not by the planners. For example, a problem may be studied in greater depth, as when in planning a livestock farm a whole range of potential feedstuffs is included instead of the simplifying assumption being made of a set pattern of feeding which may be unavoidable with budgeting and programme planning. Or again, a far greater range of plans may be encompassed by changing the assumption in respect of resource availability, prices and input/output coefficients, because of the ease with which fresh data can be in-

1. This point is based on: Barnard and Nix (1974); Carlsson and Lundgren (1969); Dorfman et al. (1958); also Luftsgrand and Heady (1959).

corporated and new solutions obtained. In this way, the farmer can gain a general picture of the lines along which the farms might develop instead of just a single solution based on present resources and practices. On the other hand, other techniques such as Integer programming or the Monte Carlo method can be very costly; nor they do provide a greater range of plans, because of the limitations on their use[1].

(b) The second main advantage of linear programming compared with other methods of optimization is that linear programming gives a greater degree of objectivity than other techniques because, in the process of collecting and analysing data for the construction of the matrix, issuses such as the welfare economics of the farm, decision-making from the programming standpoint, etc., which might be glossed over in other methods of planning, have to be faced. For example, the need to specify labour availability and requirements on arable farms means that this aspect is more likely to be critically reviewed than would otherwise be the case. Or again, the task assembling planning data can be a salutary excrcise for the farmer, because it shows him just how much he does and does not know of the many resources-enterprises relationships on his farm which may be vital to successful business management. On the other hand, other techniques such as Integer programming do not provide this great degree of objectivity and in most cases do not give an optimal solution for the given problem[2].

(c) The third main advantage of linear programming is that it directly produces an optimal solution for any problem wheras other planning techniques are unlikely to do so or likely to do so only in a simpler case[3].

1. For further detail, see Barnard and Nix (1974); also Baumol (1965).

2. For further details on Integer programming and the point raised, see Barnard and Nix (1974); also Baumol (1965).

3. Barnard and Nix (1974); Baumol (1965); also Carlsson and Lundgren (1969).

(d) The fourth main advantage is that linear programming is relatively cheaper to run and does not require a complicated system or language like systems dynamics[1]. Similarly linear programming does not require as much data as the Monte Carlo method or systems dynamics. All information and data required to build a linear programming matrix are available for Egypt.

2) The practical characteristics[2]. Criticism has been levvelled against the practical characteristics of linear programming as an optimization technique. The first point of criticism is that the benifits of producing a unique optimal solution by linear programming are overstated. This is because:

(a) The optimal solution produced is optimal only in terms of the efficiency with which that matrix has been constructed and the accuracy of the data.

(b) Solutions produced do not represent the 'real farm' situation, therefore these solutions should be interpreted too literally, but rather should be used as a signpost to potential development. In practice it would be exceptional for a first solution to be adopted in its entirety.

(c) There are likely to be other solutions that may differ quite fundamentally from optimal solutions, but which have almost as high a total revenue and which may be more acceptable to the farmer, perhaps because they involve less change or are considered less risky. Consequently, the danger that the optimal solution may blind the planner to other potential avenues of development is there.

(d) Optimal solutions may not be optimal in terms of profit because it is net revenue that is being maximized. This may result in an activity entering the solution at a level that of specialized machinary.

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1. Coyle (1974).

2. The argument here is based on Dorfman et al. (1958); Loftsgrand and Heady (1959); Barnard and Nix (1974); also Henderson and Quandt (1971).

These criticisms can be disputed. Solutions produced by linear programming continue to be optimal as long as the prices of the input variables are unchanged. Similarly, they are optimal in the sense that they dig deeper than other methods to find the solution which makes the best use of the scarce input resources as well as the input variables that are found in excess. Also they are optimal in the sense that they include the'real farm' situation in building the matrix, when all information involved is real and obtained from the producing units. For example, solutions may suggest that some of the resources in excess supply may be discarded or intensified to make the best profit out of tham.

The second main criticism of linear programming is that it is not a practical optimization tool where it calls for a large volume of very precise data which is unlikely to be available, for example, for Egyptian farms. Similarly, since it is a computer technique that requires a specialized knowledge of matrix building and access to a computer laboratory with trained staff, it is not likely to be a practicable technique for Egyptian farms.

This criticism can also be disputed. Linear programming compare with other optimization techniques such as the Monte Carlo method or Systems dynamics, does not require as much detailed information and data. In addition, in areas where there is a reasonable homogeneity of at least some of the major resources, particular natural factors such as soil types, topography and climate( as is the case in Egypt), linear programming can be used to obtain solutions for a 'representative Model' farm situation in order to guide planning on individual farms. In such cases, the necessary information and advisory services on farming and resources utilization could be collected and undertaken by governmental agencies. In this way the difficulties relating to collection of data, access to a computer and cost of operation could be overcome.

The third criticism of linear programming is that it it fails to take account of uncertainty. Linear programming models assume single values for net revenues, constraints and resource requirements as though perfect knowledge existed. In fact, the real farm situation is an uncertain world, especially when it comes to making plans for some time in the future. This uncertainty affects farmers' decisions.

This point is not relevent to Egypt. In the real farm situation in Egypt uncertainty can only affect farmers' decisions to a limited extent because agricultural activities on Egyptian farms are of a short-term nature lasting from three to six months. Consequently, farmers are unlikely to need to adjust their production pattern during the production period.

The fourth criticism is that linear programming can not be used to provide a solution for a dynamic problem. In general, linear programming provides a solution for a given production period, usually a year. But moving from the existing plan to the recommended plan may require adjustment and this may take several years by which time the optimal solution may have changed.

The answer to this point is that in practice agricultural plans (except for horticulture and livestock) are usually for a maximum one year in Egypt and adjustment is likely to be possible in a short space of time.

despite the possible shortcomings, linear programming was applied in this study as a planning tool to constitute and analyse the different available resources in Egyptian agriculture. It should be stressed once more that the use of this technique in this study does not imply that this method is the best which could be used for national development planning; but it was chosen because the information made available to the researcher was suitable only for this technique.

Appraisal of data used for matrix. The information collected on the main types of agricultural resources and the refinements and modifications to it which were necessary for use in the linear programming will be discussed here under five major heading land resources and constraints; water resources and constraints; labour resources and constraints; crop profitability; and crop constraints.

1. Land resources and constraints: Agricultural land in Egypt is a complex resource. In those parts of the country where cultivated land exists, individual units vary in their capacity for particular uses on account of location, soil type and fertility and man-made attributes such as drainage and field size. To obtain relevant information for the linear programming, it was necessary to know:

(i) what different grades of agricultural land it is relevant to recognize;

(ii) the extent of each grade of usable land;

(iii) what activities can be carried out on land of each recognized grade.

Information covering the above-mentioned points was collected from two different sources: the Central Agancy For Public Mobilization and Statistics(CAPM&S)[1] and the Department of Agricultural Economics, Ministry of Agriculture and Land Reclamation[2].

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1. The Central Agency for Public Mobilization and Statistic was authorized by the Central Statistics Committe in 1960 to act as the main source of information in Egypt and to to be responsible for the collection of data from various sources available in Egypt, to refine, process and publish these data regularly, to ensure that users can obtain as accurate information as possible. El-Shafei (1961) pp.3-4 also CAPM&S (1960-1972).
2. The Department of Agricultural Economics, Ministry of Agriculture and Land Reclamation acts as the main source of information and data on agriculture, in the different regions and units of production. The data and information collected by the department are regularly refined. Ministry of Agriculture (1973).

The data furnished by both CAPM&S and DAE,MALR was sufficient to meet the needs of the exercise. It should be noted that the area of Egyptian agriculture was and still is the subject of discussion. Examination of the furnished information has shown that there is a difference between the total area of the different grades of usable land and area cultivated. The reason for this difference is that the data collected on the extent of usable agricultural land and its grades are based on the 1963 land classification methodology which was put into practice from 1963. Man-made attributes, such as Aswan Dam and the improvement in both drainage and irrigation, have changed the physical characteristics of the different classified land groups and their extent. These changes have made the 1963 land classification out of date. Therefore, reservations had to be expressed about data and information collected from CAPM&S and DAE,MALR on the extent of the usable agricultural land and its different grades.

It is these reservation about the collecteddata on agricultural land in Egypt that have made it necessary to answer the question "How relevant is the data furnished to the farming situation? and how accuratelly can they represent a real farming situation in 1985 and 2000?" The answer to these questions is that we had to choose the most representative figures for the real farm situation. It was found that data published in 1972 on land classification by Habashi was more relevant[1]. In addition, we had to include the data published

1. In 1972, a Ph.D. thesis from Ain Shams University has presented a modified land classification for the usable agricultural land in the different parts of Egypt. The motive of the thesis concerned was to study the allocated resources in ARE. The data used in the modified land classification was obtained from the Ministry of Agriculture. The difference between the 1963 land classification and the one presented by Habashi, is that habashi has included in his classification the area of land reclaimed after 1963. Habashi(1972).

by the Ministry of Agriculture and Land Reclamation on area reclaimed[1] for making the exercise represent a real farm situation.

However, modification of the data selected for use in the linear programming matrix was necessary for the purpose of this exercise. Information on usable land and the extend of each recognized grade has to be introduced in the matrix on a monthly basis to over come the problem of overlaping of crops, which can affect the results obtained.

2. <u>Water resources and constraints</u>: Water constraints are largely concerned with irrigation requirements on the cultivated land over the 12 months of the year on those parts of the country where cultivated land exists water levels fluctuate over the year. To obtain relevant information for the linear programmingmatrix, it was necessary to know:

(i) the wa ter flow in the different parts of the country over the twelve month of the year;

(ii) the quantity required to irrigate one feddan of land of each crop cultivated during the period of its staying in the land.

Information covering these above two points were collected from the different sources: CAPM&S, the Ministry of Agriculture and the Ministry of Irrigation. Though useful the published data does not give full information on either the quantity of water needed every month for irrigating the crops during the period of their stay in the land; nor the efficiency of irrigation and evaporation loss for each recognized grade of land, which is needed to calculate the adequacy of water for agricultural use in the year 1985 and 2000. The Ministry of Irrigation and DAE,MALR were able to assist in completing

1. Report published by the Ministry in 1973 on land reclamation programmes and usable agricultural land and the prospectus of reclamation in Egypt. Ministry of Agriculture and Reclamation ( 1973 ).

the data collected from CAPM&S.

Analysis of the information collected on water resources has shown that the agricultural land in Egypt i.e. the valley, the Delta and the scattered land, is cultivated by making use of a number of different irrigation schemes. Egypt can not rely on rain to cultivate and irrigate her land. The insufficient level of rain fall makes her rely completely on the River Nile which is regulated to a constant level by making use of the various dams and barrages to regulate the discharge of water. Since this study is concerned with a future use of the available resources,and it is necessary to answer the question" How relevant the information collected on water resources and water use to the farming situation in 1985? and how accurately can they satisfy the irrigation needs for a real farm situation in 1985 and 2000?"

To answer these questions has required a study of water flow over the different months of the plant year, water use for irrigation, water discharge to sea, and efficiency of irrigation for Egyptian land[1]. Examination of the available data has shown that water for agricultural purposes does not act as binding constraint other things remaining equal. It was found that Egypt uses between 50 and 60 percent of her water resources for irrigation. The other 40 to 50 percent is discharged to the sea. It should be stressed here that water will not act as a constraint on expanding the area cultivated in the year 1985 and 2000. The data had to be slightly modified to fit the requirment of the linear programming matrix constraint. The data were presented in the matrix in a monthly form.

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1. Efficiency of irrigation was calculated on the basis of the equation $C= 1.8\ Mx\ T\ (D + 18)^3$, where C is crop requirement of water, M is the Blany-Giddle factor of crop consumption of water, T is number of hours of sunshine per month/year; D is average temperature. For further details see Al Samni (1963),pp.20-22; also Kamal and Hashem (1967).

3. Labour resources and constraint: Labour is a complex resource in that it influences enterprises both through its availability and through its quality. In those parts of Egypt where cultivated land exists individual farms vary in their capacity to provide labour for particular uses on account of its quality, its availability, the size of producing units and the activities already carriedout, and the age of labour force. To formulate the labour constraints in the linear programming matrix it was necessary to obtain relevant information on:

(i) total available labour force;

(ii)urban and rural supply of labour;

(iii) the different sex and age groups of labour;

(iv) the rate of growth of both the supply of labour and employment;

(v) the contribution of the different age groups of labour to the economy.

As much information as possible covering the above points was collected from CAPM&S which is the only source of information on the demographic structure. Though useful this published data does not give full information on any of the information or any of the manpowerquestions. The data published was either out of date or inadequate. More detailed information could not be obtained from either CAPM&S or any other government departments in Egypt. It was necessary therefore, to adapt the CAPM&S demographic data to estimate the 1985 and 2000 demographic and manpower data situation in Egypt. As well make use of a research covering this topic i.e. research on Egyptian labour force and its implications to national development policies, which was carried out at the University of Wales-U.K.[1] One question had to be answered to satisfy the objectives of the exercise "How relevant and accurate is the current information on the agricultural labour force to be used to project the situation in 1985 and 2000?" To answer this question, the

1. Arman, I. A Ph.D. thesis submitted to University of Wales U.K. in 1976.

available data were tested and refined. Labour force estimates were converted into man-working days[1]. It should be noted here that the adjustments to the data have enabled the study to measure and compare the different age groups and the different sex in the labour force. The converted data of labour force were presented in the linear programming matrix in the form of monthly man-working days.

4. Crop profitability constraint: Capital can be devided into fixed capital and liquid capital. Fixed capital is that one which is already comitted in material forms such as land, buildings, machinary, fences, and roads. Liquid capital is that one which is not committed such as cash in the bank or in hand. Both types of capital act as a constraint when farmers consider their returns(i.e. their profit) before committing their capital. It this reason that has made us introduce crop profitability as a constraint in the linear programming matrix to guarantee farmers positive returns if this plan is put into practice. There are two reasons behind using crop profitability in the exercise and not cost of production or the monetary values of different yields. The first is that cost of production and yield vary more greatly than profitability from one village to another, as well as from one region to another. This variation in cost and yield is mainly a result of the different grades of agricultural land[2]. Secondly, crop profitability is the indicator Egyptian farmers actually use when deciding their farming system or changing from one crop to another. To obtain relevant information on crop profitability for formulating profitability constraints in the linear programming matrix, it was necessary to know:

(i) cost of production per feddan of each crop for the different grades of agricultural land;

(ii) the yield per feddan of each crop for the different grades

1. For the population projection and the conversion of man working days; see Arman, I. (1976).
2. Land grades were discussed earlier in this part under the heading" Land resources and constraints".

of agricultural land;

(iii) the farm gate price per unit of land of each crop.

It is necessary to give the reasons behind using the farm gate price in calculating crop profitability. Farm gate prices have a considerable influence on farmers' decisions on what to grow the next year and the area to be cultivated. For example, if farm gate prices drop from the expected level, the area cultivated with onions the next year will decrease. on the other hand, if farm gate price of peanuts increases beyond its expected level, the next year the area of peanuts will increase. It is this reason that made us to use farm gate prices, to provide farmers with a positive incentives if our plan is put to practice. In addition, using farm gate prices provides the government with positive incentives to adopt our plan. In Egypt, wholesale markets are run by government bodies i.e. by public sector. If government decides to put our plan into practice, the difference between the wholesale market prices and farm gate prices can be considered a profit for the govenment.

Information on the above three points was obtained from DAE,MALR. Though useful, the furnished data were inadequate to calculate the profit constraints. The basic question to be answered was " How far do the figures accurately represnt the cost and profit of production of each region in Egypt?" Cost of production vary from one farm to another. The type of land, the level of technology and the size of farm, cause these variation. This obviouslly affect the level of profit of producingunit. Some times there may exist five levels of profit for one crop. The question was posed to DAE,MALR, but the department could not give a viable answer to this question. It is therefore it was thought that the answer to such question is to use the weighted average of the existing profitability levels for the different crops could serve the purpose of this study, if minor adjustments were made to them. For example, market size and possibility of absorbing the produced quantity and using two uper and lower level of profitability per unit of land were taken into consideration, as well as the competition between the different crops for land and the opportunity cost of replacing one crop by another. Also, a sensitivity analysis test was carried out to examine the extent to which the adjusted figures could represent a future situation in 1985 and 2000. It was found that the expected changes are very limited and changes up to 25 percent up or down would not bring levels of profitability outside the lower or upper limit of the profitability margin we are using in the linear programming matrix. This gave us confident in our assumptions in formulating the crop profitability constraints.

5. Cropping constraints: Cropping constraints are very important in influencing the pattern of production as well as the choice of the crop rotation. It is necessary at this stage to give a clear idea of how land use influences the cropping pattern. Farms in Egypt are smale. Up to 1952, the size of farms varried between less than one feddan and over two hundered feddans. Since the land reform laws the average size of farms has varied between less than one feddan and 5 feddans[1]. These farms are intensively cultivated. Some farmers plant three crops in one year; others plant their farms with two crops in one year. But three cropping is the rule. Indeed, some farmers plant their winter crops in the cotton fields before the Nile crops are harvested, thus bringing the winter crops to maturity three to four weeks earlier, to be able to plant cotton in due time. Farming techniques vary from one farm to another, but most are highly labour intensive. It should be noted here that crop production in Egypt differs from one soil type to another, and from season to another. Also, it should be stressed here that because some crops represnt not only export assets to the country, but also the back bone of the farmers cash assets; It was very important to introduce cropping constraints in the linear programming matrix to give our model the practicability shape.

The Validity of the optimization model. It should be stressed that the model was constructed to take into account

1. Arman, I. (1966); (1969) and(1976).

the special characteristics of Egyptian agriculture and that the validity and viability of the data used in the matrix were checked and tested wherever possible. The tests of the model showed that it was able to replicate the production patterns of 1960, 1966, 1970 and 1975. The reason behind the choice of those years was:

(i) it was thought to replicate an existing situation by binding the programme to a set of specific fixed reources, which could not be exceeded, would be a suitable starting point for planning the future of Egyptian agriculture;

(ii) replicating an existing situation would give confidence in the validity of the model and programme and the reliability of the information used;

(iii) the four years were chosen by the Department of Planning and Economics in Egypt as base for the national development plans;

(iv) the profitability norms used in the matrix were based on the values of those years.

The results obtained from replicating the different existing pattern of 1960, 1966 and 1970 are given in table 1 and digrams 2 to 4. Examination of the computed values and the data collected from CAPM&S and the Department of Agricultural Economics on the existing pattern of 1960, 1966 and 1970 shows that, despite the fact that there is a slight difference between the computed values of total area cultivated and the figures published by DAE,MALR ( because the model excludes certain crops) ( Table 1), the computed values match the area actually cultivated of the crops used in the model in 1960, 1966 and 1970.

Having appraised the validity and viability of the model, the information and data used in building the linear programming matrix; we will now move to discuss the various assumptions used during the running of the model until finally a successful solution was acheived. This has been been done in two stages: The first stage was the labour maximization stage. The second stage was the farm profitability optimization.

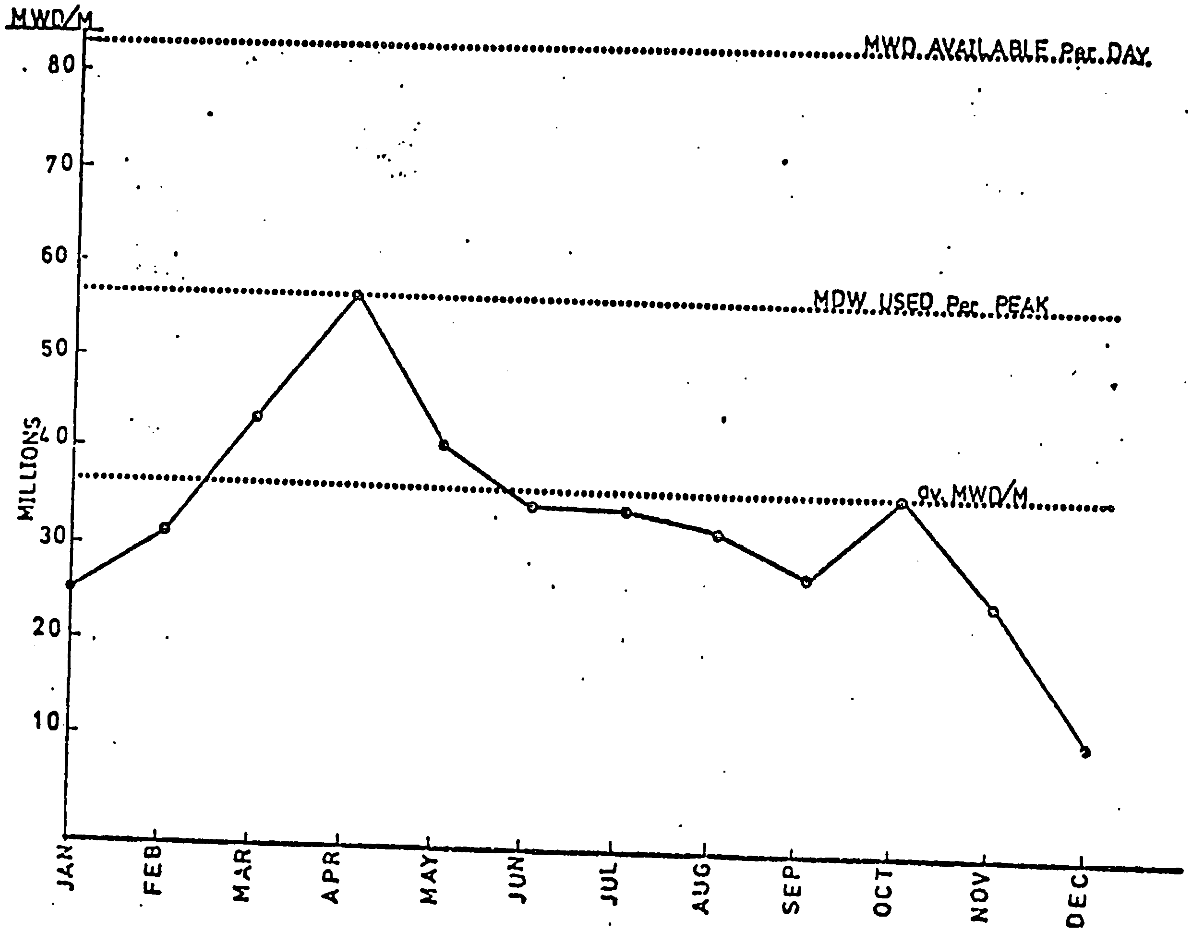
TABLE I.

COMPARISON BETWEEN THE ACREAGE OF THE MAIN CROPS REPLICATED BY THE PROGRAM FOR EXISTING PRODUCTION PATTERNS IN 1960, 1966 AND 1970 AND THE COLLECTED FIGURES FROM THE MINISTRY OF AGRICULTURE

| Crops | 1960 | | 1966 | | 1970 | |
|---|---|---|---|---|---|---|
| | Area cultivated | Replicated | Area cultivated | Replicated | Area cultivated | Replicated |
| Wheat | 1.460 | 1.459 | 1.4 | 1.399 | 1.402 | 1.401 |
| Beans | .370 | 0.369 | .4 | 0.4 | 0.420 | 0.420 |
| Onions | .005 | 0.005 | 0.05 | 0.049 | 0.05 | 0.05 |
| Clover | 2.41 | 2.409 | 2.7 | 2.699 | 2.70 | 2.699 |
| Cotton | 1.870 | 1.869 | 1.620 | 1.629 | 1.630 | 1.629 |
| Rice | 0.07 | 0.069 | 1.070 | 1.069 | 1.140 | 1.139 |
| Millet | 0.039 | 0.039 | 0.048 | 0.04 | 0.046 | 0.045 |
| Sesame | 0.004 | 0.003 | 0.004 | 0.004 | 0.004 | 0.003 |
| Oranges | 0.090 | 0.090 | 0.110 | 0.110 | 0.113 | 0.113 |
| Mangoes | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| Bananas | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 |
| Figs | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |

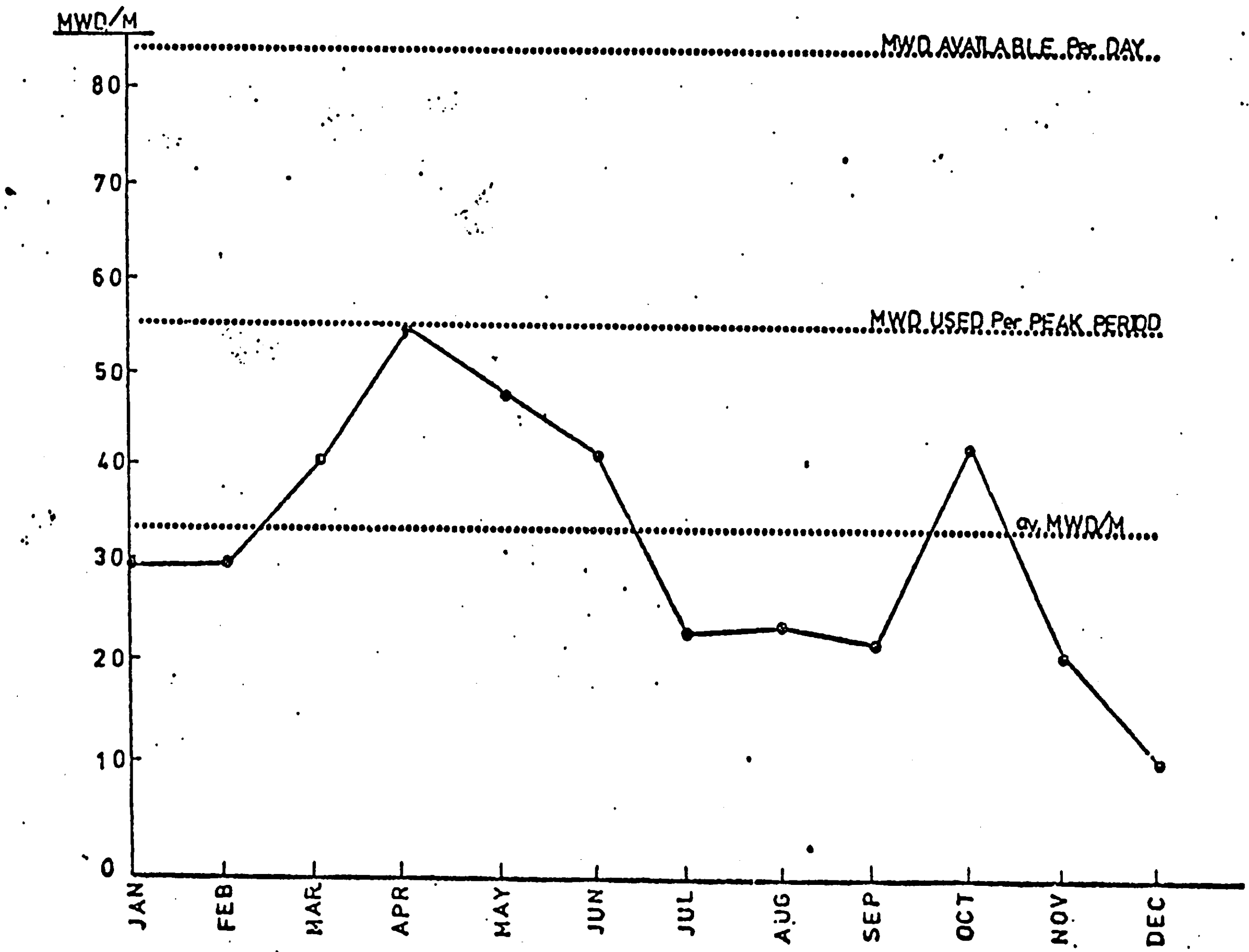
Source: Computer program set to replicate the existing production pattern in 1960, 1966 and 1970 and data collected from Ministry of Agriculture (1963).

DIAGRAM 2 : MAN WORKING DAYS (MWD) EMPLOYED BY THE PROGRAMME TO SIMULATE THE EXISTING CROPPING PATTERN IN 1960



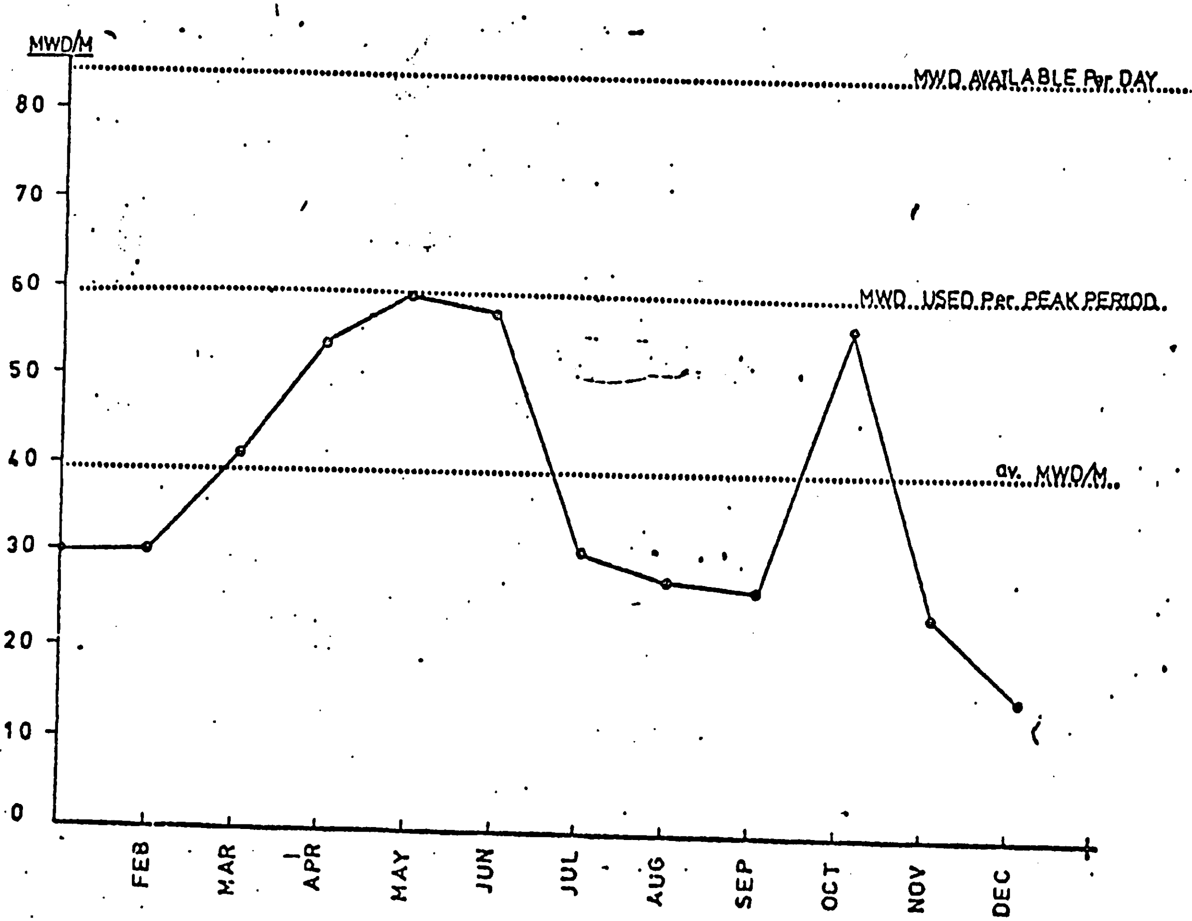

SOURCE : Computer Results Obtained from the Programme LINPROG/7.5.1974/RHS1

DIAGRAM 3: MAN WORKING DAYS (MWD) EMPLOYED BY THE PROGRAMME TO SIMULATE THE EXISTING CROPPING PATTERN IN 1966.




SOURCE : Computor Results Obtained From The Programme LINPROG 2/11.6.1974/RHS1

DIAGRAM 4 MAN WORKING DAYS (MWD) EMPLOYED BY THE PROGRAMME TO SIMULATE THE EXISTING CROPPING PATTERN IN 1970




SOURCE : Computer Results Obtained From The Programme LINPROG 2/ 20.6.1974/RHS1

## V : The Procedure Of The Linear Programmin Exercise

This exercise can be considered a pioneer investigation into the agricultural labour force, its problems, and its impact on national development in Egypt. This is because most of the previous labour utilization studies have focussed their attention on optimizing the allocation of scarce resources and none has given attention to the importance of the abundant resources and their impact on the country's development policies. Even those who have considered the agricultural labour force have treated the subject in a purely descriptive manaer or concentrated on estimating unemployment in agriculture in one province or region. None of them has attempted to carry on beyond this point. For example, the research conducted by the National Planning Institute in Cairo with the co-operation of ILO was limited to studying the rural employment problems. The research related to the nine of the 24 provinces and was devoted only to estimating unemployment and disguised unemployment in those provinces, and did not go beyond that. Similarly the research conducted by the Ministry of Manpower with the cooperation of ILO " Strategy Mission" was limited to portrait the previous data which either was out of date or un-reliable and did not go beyond that despite it was expected that it would present a practicable and concrete strategy, where it ended only by recomendations which could be characterised by superficiality and their impracticality. Similarly, research was carried out for the same purpose in Alexandria University, and was mainly concerned with one provence, and treated the subject descriptively[1].

In this part we are goining to discuss the given assumptions used during the running of the programme. The presentation will be under two headings:

1. The first stage: The labour Maximization;
2. The second stage: The Farm Profitability Maximization.

### V. 1. The First Stage: Labour Maximization

The objective at this stage was to identify a cropping

1. NPI and ILO (1965); Ministry of Manpower and ILO (1980); El Zalaki et al.(1957); Salem (1971); also Sherbini et al.(1974)

pattern which could maxi,ize the use of the available agricultural labour force, subject to the following constraints:

(i) to optimize the utilization of both agricultiral land and water resources available for irrigation;

(ii) to optimize the use of labour inputs; in addition labour inputs should be greater than that in every month of the year that was used by the old croping pattern in 1970;

(iii) the level of profit of the chosen crops should be equal or near to the level of profit in 1970; and

(iv) no inequality boundries should be imposed on the acreage of the identified crops.

The reason behind the objective of this stage was the existance of heavy seasonal peaks of employment. It was thought that increasing employment opportunities over the year in agriculture would help in increasing the number of manworking days of agricultural workers. This increase in employment opportunities over the year would also reduce the heavy demand for seasonal agricultural credit, which is sometimes used for other than the intended purpose. Evidence of this was provided in an M.Sc thesis on the key role of agricultural credits in the Egyptian agricultural economy[1]. The credit could then be invested in the overall development of the agricultural sector to provide additional employment in the sector.

The mathematical formulation of the objectives made for the first stage can be written as follows:

$$\text{Max} \sum_{i=1}^{75} \sum_{k=1}^{4} M_{ik} \; X_{ik}$$

Subject to:

(a) Land constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ijk} \, X_{ijk} \leqslant L_{kj}$$

(for all j)

1. Arman, I. (1966).

(b) Labour constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} lab_{ijk} X_{ijk} > M_j$$

(for all j)

(c) Water constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} wat_{ijk} X_{ijk} \leqslant I_j$$

(d) Crop profitability constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} Rev_{ik} X_{ik} \leqslant Rev_{1970}$$

(e) Crop boundaries constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ik} X_{ik} \geqslant \text{Zero}$$

Where: $M_{ik}$ is the level of M.W.D. used by crop i on land k;
$X_{ik}$ is the area of crop i in land k;
$L_{kj}$ is land constraint of type k in month j;
$I_j$ is water constraint in month j;
$A_{ijk}$ is the level of crop i in land k in month j;
$lab_{ijk}$ is the level of MWD used by crop i in land k in month j;
$Rev_{ik}$ is the level of profit of crop i in land k;
$Rev_{1970}$ is the level of aggregated profit of 1970; and
$wat_{ijk}$ is the level of water used to irrigate crop i in month j in land k.

The optimization model was run in the computer with the given constraints. A summary of the first computed solution is shown in table 1 to 4 and Diagram 5 . To satisfy the objectives certain adjustments in the existing production paterns would have to be made. These changes are mainly in the acreage of fourteen out of the 75 crops cultivated ( Table 2 ). These adjustments

TABLE 2

THE SELECTED CROPS AND THEIR AREA IN SOLUTION NUMBER 1 IN THE FIRST STAGE COMPARED TO 1970

Thousand feddans

| Crop | Area | | Crop | Area | |
|---|---|---|---|---|---|
| | in 1970 | Program | | in 1970 | Program |
| Fenugreek | 0.066 | 565.9 | Tomato | 0.073 | 1395 |
| Onion | 0.05 | 565.9 | Aubergine | 0.014 | 722.3 |
| Cotton | 1.8 | 643.1 | Green Peas | 0.003 | 822 |
| Rice | 1.140 | 1067 | Mangoes | 0.025 | 164.8 |
| Sugar Cane | 0.186 | 874 | Banana | 0.009 | 1595 |
| Marrow | 0.014 | 99.7 | Sesame | 0.035 | 3907 |
| Total Area | 10.550 | 8908 | Aggregate Profit | 515.2 | 467.00 |

Source: Results obtained from computer output program LNP2/RH52/20.6.74.

TABLE 3

SUMMARY OF COMPUTER OUTPUT FOR THE FIRST SOLUTION IN THE FIRST STAGE OF THE EXERCISE

million

| Resources | Available | Used | Slack | %* |
|---|---|---|---|---|
| MWD/year | 493.9 | 675.3 | +181.4 | 136.7 |
| MWD/month | 41.1 | 56.2 | + 15.1 | 136.7 |
| Water/year (cu.metre) | 52091 | 43068 | -9023 | 82.7 |
| Water/mth. (cu.metre) | 4340 | 3582 | - 758 | 82.7 |
| Area (feddans) | 6.400 | 8.909 | - | 139 |
| Aggregate profit | E£515.2 | E£467.0 | E£48.2 | 92.4 |
| Average Profit/fed E£ | E£80.5 | E£ 73.0 | E£ 7.5 | 92.4 |

Source: Computer output, program LNP2/RHS2/20.6.74

*percentage represents the ratio between the used resources and the available.

## TABLE 4

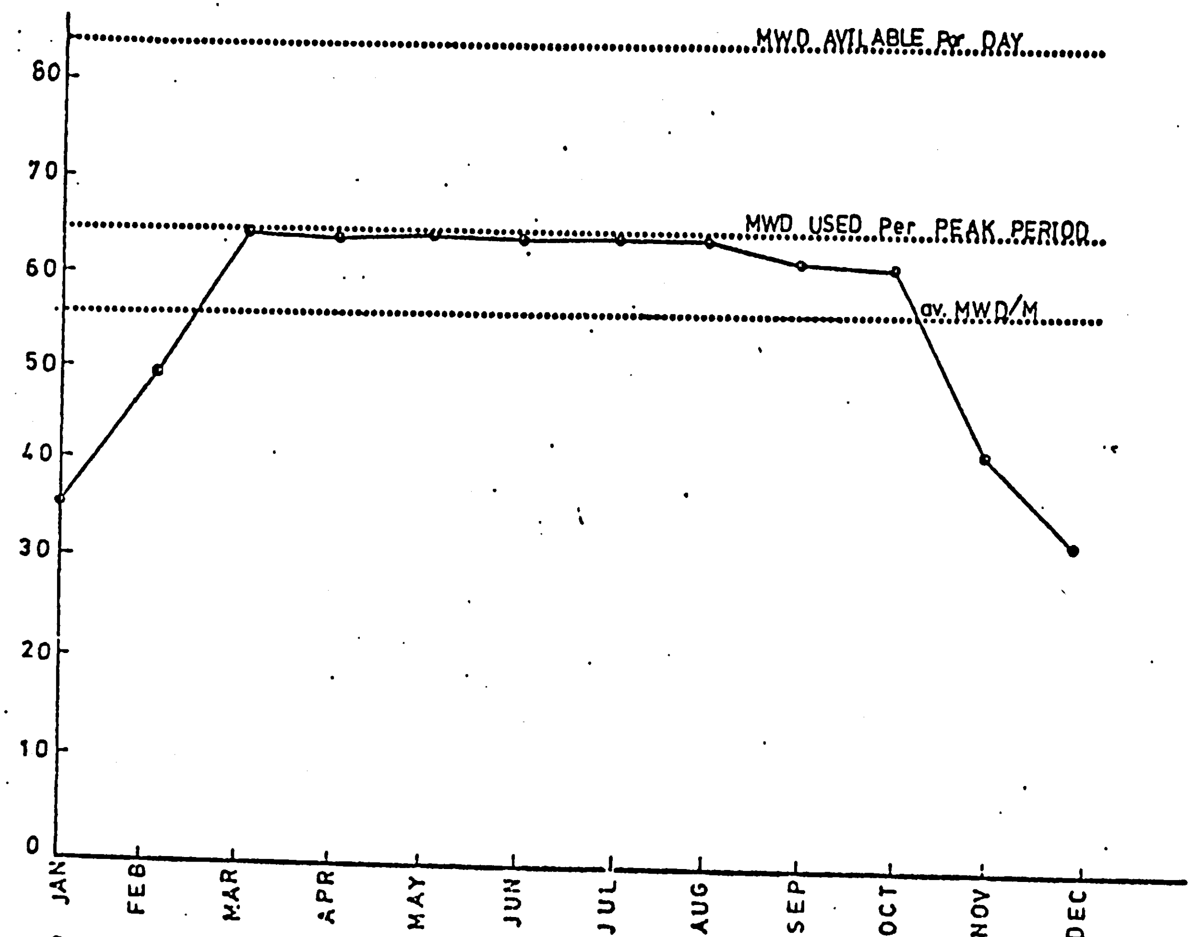
**SUMMARY OF COMPUTER OUTPUT FOR THE NUMBER OF MAN-WORKING DAYS AND WATER USED BY THE PROGRAM IN THE FIRST RUN OF THE FIRST STAGE OF THE LINEAR PROGRAMMING EXERCISE.**

| | Man-working days | | | Water resources cu.m. | | |
|---|---|---|---|---|---|---|
| | Avail. | Used | %* | Avail. | Used | %* |
| January | 31.9 | 36.2 | 113.4 | 3060 | 1901 | 62 |
| February | 32.4 | 50.0 | 154.3 | 3985 | 2200 | 55 |
| March | 43.6 | 64.7 | 148.4 | 4090 | 2835 | 69 |
| April | 58.17 | 64.7 | 111.2 | 3920 | 3807 | 97 |
| May | 64.7 | 64.7 | 100 | 5425 | 5492 | 101.2 |
| June | 63.3 | 64.7 | 102.2 | 6710 | 4653 | 69 |
| July | 37.9 | 64.7 | 170.7 | 6065 | 6166 | 102 |
| August | 33.3 | 64.7 | 194.2 | 4199 | 4217 | 100.4 |
| September | 28.36 | 62.6 | 220.7 | 3805 | 3899 | 102.5 |
| October | 58.5 | 61.6 | 105.2 | 3805 | 2774 | 74 |
| November | 26.1 | 42.1 | 161.3 | 3640 | 2735 | 75 |
| December | 14.5 | 34.0 | 234.4 | 3387 | 2445 | 72 |
| Total | 493.9 | 67.57 | 66.5 | 52091 | 43068 | 82.7 |
| Average/month | 41.1 | 56.28 | 66.5 | 4340 | 3589 | 82.7 |

* Percentage of the used is related to the amount introduced in the right-hand side i.e. the available.

Source: Computer program output LNP2/RHS2/20.6.74.

DIAGRAM 5 : MAN WORKING DAYS ( MWD ) EMPLOYED BY THE PROGRAMME TO SIMULATE THE FIRST SOLUTION IN THE LABOUR MAXIMISATION STAGE




Source : Computer results obtained from the programme LINPROG 2/20.6.74/RHS 1&2

could lead to considerable increase in the number of man-working days over the year, raising the level of employment from an average of 41.1 million man-working days per month to 56.28 million man-working days per month i.e. an increase of 36.7 percent over 1970.

However, this solution had to be rejected. The reasons were:

(a) This solution did not satisfy the other objective. It could not increase or maintain the level of profitability of the producing units. Table 2 to 4 and Diagram 5 show that the profitability dropped by an average of 8 per cent of the level of 1970. This drop can be explained as follows: The adjustments would lead to a decrease in the level of certain activities, which are important sources of income to the producer and to foreign trade. For example, the programme decreased the level of cotton cultivation from 1.8 million feddans to 0.6 million feddans. This could cause a drop of 55 percent in the profit level compared with 1970. Similarly, a drop of 55 per cent in the foreign revenue could occur as a result of the drop in cotton exports. The programme has also eliminated certain activities, which are important sources of export revenue. For example, the programme eliminated citrus production, which brings in an export revenue of an average of a million Egyptian pounds per year. Excluding this activity causes a drop of 1 per cent in aggregate profitability.

(b) This solution also had to be rejected because of the development costs which would arise from it:-

(i) It would require adjustments to the irrigation system to increase water flow in the peak periods, to meet the irrigation requirments of the selected activities. These adjustments would not only require time, but would also be very costly. Water constraints in the months of May, July, August and September would have to be exceeded to sustain the level of water flow to provide the required amount of water during those four months. This would require the building of more barrages or artesian irrigation systems, which would take at least ten years to complete.

(ii) The selected activities are mainly crops which would requir changes in both the marketing and pricing system. The quantities produced at the suggested levels of the selected activities exceed the demand for the commodities. Examination of the family budget tables[1] shows that the demand for mangoes, beans, aubergines and green peppers is inelastic, beccause to average consumers in Egypt such commodities are luxuries which they cannot afford to buy every day or even twice a week[2]. So to expand the production of such commodities would necessitate relying on other markets than the internal markets to take up the excess. But to what extent can other markets absorb this excess? To answer this question, the international demand for such commodities had to be examined. This showed that, despite the fact that Egypt can be considered a competitive producer and exporter, to market the excess would require marketing expertise, capital investment, and time.

(iii) The solution eliminated certain essential food commodities for the average family and their livestock, such as wheat, maiz, millet, and clover. And it did not compensate for this loss by increasing the total profitbility of the selected activities sufficiently to pay for replacements for those commodities. On the contrary, the aggregate profitability droped from the previous level by 10 per cent.

These implications led to the re-running of the programme after imposing limits on the acreages of the crops identified in the rejected solution. The objectives for the re-run were to identify a cropping pattern which could maximize the use of the available agricultural labour force subject to the following constraints:

(i) optimize the utilization of both agricultural land and water resources available for irrigation;

(ii) optimize the use of labour inputs; in addition labour inputs should be equal or less than the amount of MWD equivalent to the effective supply of agricultural workers available in every month of the year as estimated for 1975;

(iii) the level of profit of chosen crops should be equal or

1. CAPM&S (1962).

2. Family Budget (1971).

greater than in 1970; and

(iv) the acreage of the identified crops in the previous run should provide a yield equal to the expected consumption in 1975.

The mathematical interpretation of the assumptions we were making for the re-run of our ecercise became as follows:

$$\text{Max} \sum_{i=1}^{75} \sum_{k=1}^{4} M_{ik} \quad X_{ik}$$

subject to:

(a) Land constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ijk} \quad X_{ijk} \leqslant L_{kj}$$

( for all j)

(b) Labour constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} lab_{ijk} \quad X_{ijk} \leqslant M_{j}$$

( for all j)

(c) Water constraints:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} wat_{ijk} \, X_{ijk} \leqslant I_{j}$$

(for all j)

(d) Crop profitability:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} Rev_{ik} \quad X_{ik} \geqslant Rev_{1970}$$

(e)

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ik} \quad X_{ik} \lesseqgtr N_{i\ 1975}$$

where: $N_{i\ 1975}$ is the level of crop i which can provide a yield of crop i not in excess of expected consumption in 1975.

The model was run in the computer with these constraints, but no feasible solution was reached. Analysis of the computer output showed that the programme was unable to identify a practicable cropping pattern because of the incompatibility of the objectives. It was found that when the assumptions of increasing the profit level of the chosen crops were relaxed to the level of profit of chosen crops should be equal to/or less than the existing level, the programme began to provide a solution which satisfied only one of the objectives, the labour absorption, but did not optimize labour utilization. Table 5 shows the two solutions which were unable to satisfy the objectives of the first stage.

### V.2. The Second Stage: Crop Profitability Maximization

The objective for the second stage was to seek to identify a cropping pattern which could optimize profitability of the crops chosen, subject to the following constraints:

(i) to optimize the utilization of both agricultural land and water resources available for irrigation; in addition the area cultivated and water used should be equal to/ or less than that available;

(ii) the amount of labour input to be used should be equal to/ or less than the number of man-working days equivalent of the effective supply of labour in 1975 (to begin with);

(iii) no crop inequality[1] boundaries should limit the acreage of the chosen crops.

The mathematical interpretation of the assumptions we were making for this stage can be written as follows:

$$\text{Max profit} \sum_{i=1}^{75} \sum_{k=1}^{4} Rev_{ik} \quad X_{ik}$$

subject to:

(a) Land constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ijk} \quad X_{ijk} \leq L_{kj}$$

(for all j)

1. "Crop inequality" arises when production is in excess of consumption.

TABLE 5

THE MAXIMIZATION OF LABOUR STAGE: PER MILLION

| Item \ Objective | First solution 412.7 m.w.d. | Second solution 476.6 m.w.d. |
|---|---|---|
| Labour constraints (m.w.d) | | |
| Lab 1 | 26.2 | 31.9 |
| Lab 2 | 32.44 | 32.4 |
| Lab 3 | 43.68 | 43.6 |
| Lab 4 | 58.17 | 55.5 |
| Lab 5 | 42.80 | 61.1 |
| Lab 6 | 35.84 | 59.1 |
| Lab 7 | 35.61 | 32.4 |
| Lab 8 | 33.35 | 29.6 |
| Lab 9 | 28.3 | 28.3 |
| Lab 10 | 37.6 | 58.5 |
| Lab 11 | 26.12 | 26.1 |
| Lab 12 | 11.32 | 14.5 |
| Profit Constraint (E£) | 456.3 | 415.1 |
| Land Constraint (12 month) (feddans) | 6.400 | 6.400 |
| Land grade 1 | 0.325 | 0.325 |
| Land grade 2 | 2.356 | 2.356 |
| Land grade 3 | 2.397 | 2.397 |
| Land grade 4 | 1.3206 | 1.320 |
| Slack | | |
| Land grade 1 | - | - |
| Land grade 2 | - | - |
| Land grade 3 | - | - |
| Land grade 4 | - | - |
| Crops (feddans) | | |
| Wheat | - | - |
| Beans | - | 0.197 |
| Barley | - | - |
| Fenugreek | 0.565 | - |
| Lentils | - | - |
| Linen | - | - |
| Onion | 0.565 | 0.891 |
| Chickpeas | - | - |
| Clover | - | - |
| Cotton | 0.643 | 1.97 |
| Rice | 0.677 | 1.417 |
| Millet | - | 0.848 |
| Maize | - | - |
| Sugar Cane | 0.874 | - |
| Sesame | 0.390 | - |

| Objective / Item | 412.7 | 476.6 |
|---|---|---|
| Peanuts | 0.565 | - |
| Nile Rice | 0.390 | - |
| Nile Millets | - | - |
| Nile Maize | - | - |
| Garlic | - | - |
| Green peas | - | - |
| Dry peas | - | - |
| Beans | - | - |
| Spinach | - | 0.039 |
| Radish | - | - |
| Lettuce | - | 0.051 |
| Carrots | - | - |
| Parsley | - | - |
| Egyptian Rocket | - | 0.213 |
| Tomato | 1.395 | - |
| Marrow | 0.099 | 0.297 |
| Turnip | - | - |
| Cabbage | 0.722 | - |
| Cauliflower | - | - |
| Tomato (S) | - | - |
| Potato | - | - |
| Marrow (S) | - | |
| Harricot | - | |
| Dry Harricot | - | |
| Kidney Bean (S) | - | |
| Dry kidney bean (S) | - | |
| Beans | - | |
| Green pepper (S) | 0.822 | 0.009 |
| Carrots | - | - |
| Okra | - | 0.730 |
| Jew Melons | - | - |
| Taro | - | - |
| Aubergine | - | - |
| Sweet Potato | - | - |
| Cucumber (S) | - | 0.961 |
| Radish (S) | - | - |
| Egyptian Rocket | - | - |
| Water Melon | - | - |
| Leeks | - | - |
| Tomato (N) | - | - |
| Potato (N) | - | - |
| Marrow (N) | - | - |
| Harricot (N) | - | - |
| Cabbage (N) | - | - |
| Cauliflower (N) | - | 0.351 |
| Green Pepper (N) | - | 0.465 |
| Artichoke (N) | - | - |
| Strawberry (N) | - | - |
| Radish (N) | - | - |
| Parsley (N) | - | - |

Table 5 (Cont'd) 

| Item \ Objective | 412.7 | 476.6 |
|---|---|---|
| Egyptian Rocket | - | - |
| Kidney Beans (N) | - | - |
| Dry kidney beans | - | - |
| Leeks | - | - |
| Cucumber | - | - |
| Orange | - | - |
| Mango | 0.164 | - |
| Banana | 1.595 | - |
| Figs | - | - |
| Total Area (feddans) | 8.789 | 8.447 |

(S) = Summer crop

(N) = Nile crop

Source: Computer output of Prog. LNP2, RHS1, 7.5.1974 and LNP2, RHS1, 20.6.1974.

(b) Labour constraints:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} lab_{ijk} \; X_{ijk} \leqslant M_j$$

(for all j)

(c) Water constraints:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} wat_{ijk} \; X_{ijk} \leqslant I_j$$

(for all j)

(d) Crop inequality constraints:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} X_{ik} \geqslant 0$$

(for all i and all k)

where: $Rev_{ik}$ is the level of profit of crop i in land k;

$X_{ik}$ is the area of crop i in land k;

$A_{ijk}$ is the per unit of land requirement of crop i in land k in month j;

$lab_{ijk}$ is the number of man-working days used by crop i in month j in land k;

$L_{kj}$ is the land constraint of type k in month j;

$M_j$ is the number of man-working days constraint which equals the number of M effective supply of agricultural workers in month j; and

$I_j$ is the water constraint in month j.

The reasons for fixing the objectives at this stage in this way were:

(i) It was found that having as the objective of the first stage the maximization of the number of man-working days employed in agriculture hindered the discovery of a cropping pattern that would be practicable and at the same time increase profitability levels. Therefore it was necessary to tackle the problem in a different way.

(ii) It was seen from the first stage that setting labour constraints to be equal to/ or greater than the levels in 1970 also hindered the solution as a result of the seasonality of Egyptian agriculture. This also led to the reformulation of the labour constraint.

Having fixed the objectives for the second stage, computation proceeded. A summary of the solution is shown in Tables 6 to 8 and Diagram 6. These show that the programme suggested that Egypt should specialize only in producing cotton, rice, bananas, figs and fenugreek. The area of each selected crop is shown in Table 6. The computer output showed that:

(a) The suggested solution could maintain the level of profitability of 1970 by selecting more profitable cropping patterns than the ones developed in the first stage. In adition, it could help increase the agricultural contribution to foreign trade.

(b) It could provide employment of an average of 56.9 million man-working days over the whole year. In other words, it could raise the level of employment by 43.14 per cent of its 1970 level.

(c) Apart from January, November and December, the cropping pattern could help to solve the problem of seasonality of agricultural employment.

However, such specialization cannot be recommended becauce:

(1) The uncertainty of the international demand for such crops would affect their sales volume and could cause severe marketing problems. This uncertainty could therefore affect Egyptian foreign exchange receipts which are needed to pay for food imports. For example, Egypt represnts only 5.4 per cent of total cotton trade. She can control neither the international market nor the price of cotton as a result of the dominance of other producing countries such as the United States, Peru and Sudan. Moreover, as a result of the competition of artificial fibers in textile industry, the internatinal demand for cottom dropped from 69 percent of the total demand for wool and fibers in 1955 to 57 percent in 1970. On the other hand, the demand for artificial fibers increased from 2.1

TABLE 6

THE SELECTED CROPS AND THEIR AREA IN THE SOLUTION IN THE FIRST RUN OF THE SECOND STAGE COMPARED WITH THE AREA OF THESE CROPS IN 1970.

thousand feddans

| | Area in 1970 | Area selected by the programme |
|---|---|---|
| Fenugreek | 0.066 | 129 |
| Cotton | 1.630 | 3016 |
| Rice | 1.140 | 129 |
| Banana | 0.009 | 2682 |
| Figs | 0.008 | 53.5 |
| Total area | 10.550 | 6010 |
| Aggregate profit (E£) | E£515.2 | E£594.450 |

Source: Results obtained from computer output LNP1/. RHS3/7.5.75

TABLE 7

SUMMARY OF COMPUTER OUTPUT FOR THE FIRST SOLUTION IN THE SECOND STAGE

million

| Resource | Available | Used | Slack | % |
|---|---|---|---|---|
| MWD/year | 1,015.4 | 683.2 | 332.2 | 67.3 |
| MWD/month | 84.7 | 59.9 | 27.8 | 67.3 |
| Water/year (cu.m.) | 52,091 | 16,899 | 35,192 | 32.4 |
| Water/month (cu.m) | 4,340 | 1,408 | 2,932 | 32.4 |
| Area (feddans) | 6.400 | 6.01 | .390 | |
| Aggregate profit (E£) | - | E£594.4 | - | - |
| Average profit/fed (E£) | - | E£92.8 | - | - |

Source: Computer output program LNP7/RHS3/7.5.74.

TABLE 8

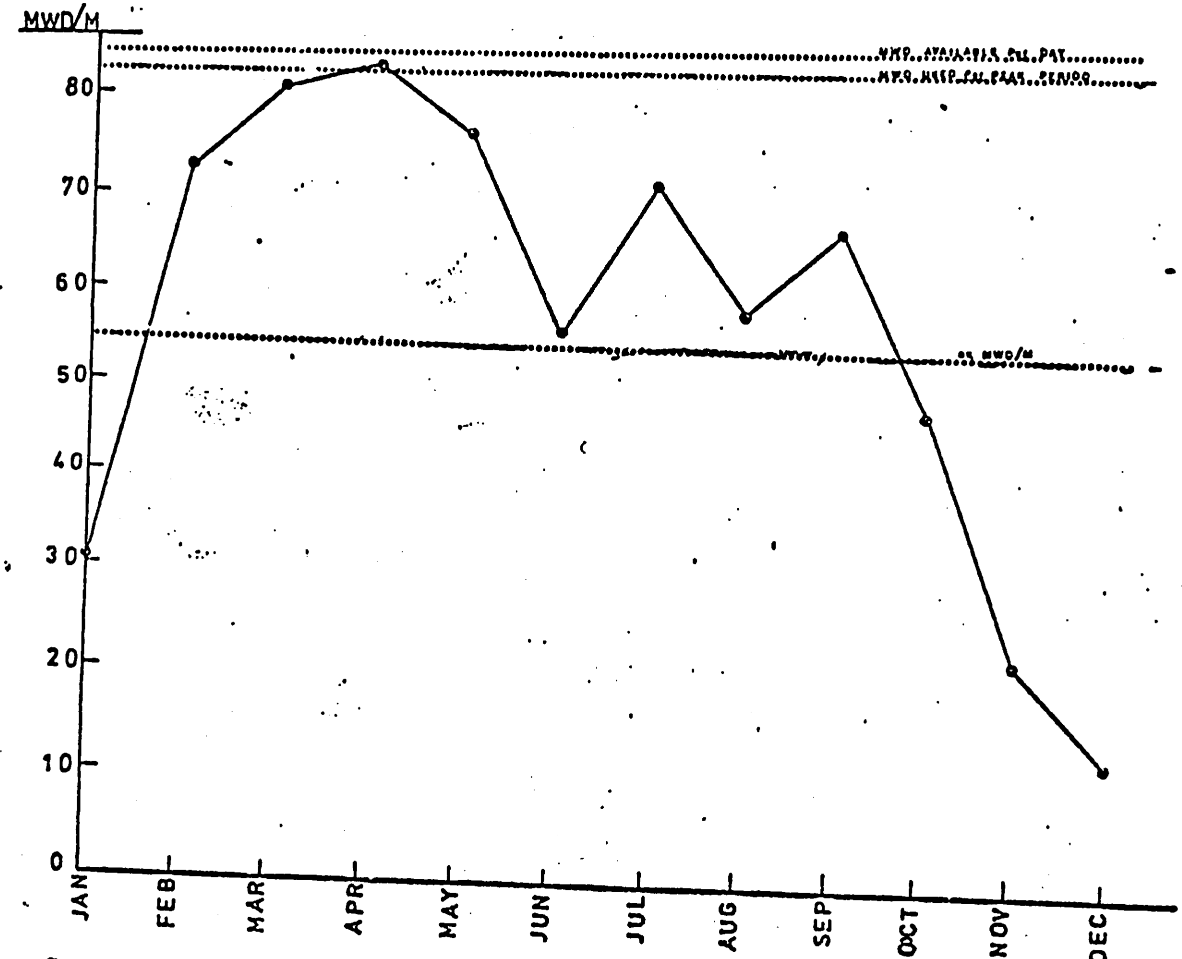
SUMMARY OF COMPUTER OUTPUT FOR THE NUMBER OF MAN-WORKING DAYS AND WATER USED BY THE PROGRAM IN THE FIRST RUN OF THE SECOND STAGE.

million

| | Man-working days | | | Water resources | | |
|---|---|---|---|---|---|---|
| | Avail | Used | % | Avail | Used | % |
| January | 84.7 | 29.212 | 34 | 3060 | 58 | 2 |
| February | 84.7 | 73.04 | 86 | 3985 | 457 | 12 |
| March | 84.7 | 82.86 | 97.8 | 4090 | 2475 | 605 |
| April | 84.7 | 84.77 | 100 | 3920 | 3486 | 89 |
| May | 84.7 | 77.48 | 91.5 | 5425 | 3531 | 65 |
| June | 84.7 | 56.11 | 66 | 6710 | 2123 | 32 |
| July | 84.7 | 72.72 | 85.8 | 6065 | 2957 | 49 |
| August | 84.7 | 58.64 | 69.2 | 4199 | 1255 | 30 |
| September | 84.7 | 67.02 | 79 | 3805 | 198 | 5 |
| October | 84.7 | 48.49 | 57.1 | 3805 | 196 | 5 |
| November | 84.7 | 16.88 | 20 | 3640 | 123 | 3 |
| December | 84.7 | 12.19 | 14 | 3387 | 41 | 1 |
| Total | 1015.4 | 683.24 | 67.3 | 52091 | 16899 | 32.4 |
| Average/ month | 84.7 | 56.9 | 67.3 | 4.340 | 1408.2 | 32.4 |

Source: Computer program output LNP7/RHS3/7.5.74.

DIAGRAM 6 : MAN WORKING DAYS ( MWD ) EMPLOYED BY THE PROGRAMME TO SIMULATE THE FIRST SOLUTION IN THE PROFIT MAXIMISATION STAGE




Source : Computer results obtained from the programme LINPROG 7/ 7.5.74/RHS 3 per cent in 1975 to 15 per cent in 1970. Consequently an increase in the cotton acreage can not be recommended.

(2) Specialisation would also endanger the aggregate profitability of the farming industry and this ground would also be imprudent and impractical.

Therefore although this solution satisfied the objectives of this stage, it had to be rejected. Compromise between the objectives again became necessary, and crop inequality constraint were again introduced. The new objective for the second stage became to identify a cropping pattern that could maximize the profit from the crops chosen subject to the following constraints:

(i) optimize the utilization of both agricultural land and water resources available for irrigation; in addition, the area cultivated and water used should be equal to/ or less than that available;

(ii) the amount of labour input to be used should be equal to/ or less than the number of man-working days equivalent of the effective supply of labour in 1975;

(iii) crop inequality boundaries should limit the acreage of the chosen crops to meet:

(a) the needs for food commodities such as maize and rice;

(b) the volume of foreign exchange needed to pay the country's total imports.

The mathematical formula for the assumption we were making can be written as follows:

$$\text{Max } P: \sum_{i=1}^{75} \sum_{k=1}^{4} Rev_{ik} \quad X_{ik}$$

subject to:

(a) <u>Land constraints</u>:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ijk} \quad X_{ijk} \leq L_{kj}$$

(for all j)

(b) <u>Labour constraints</u>:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} lab_{ijk} \quad X_{ijk} \leq [illegible]_{j}$$

(for all j)

(c) Water constraints:

$$\sum_{i=1}^{75} \quad \sum_{k=1}^{4} \quad wat_{ijk} X_{ijk} \leqslant I_j$$

(for all j)

(d) Crops inequalities boundaries constraint:

$$\sum_{i=1}^{75} \quad \sum_{k=1}^{4} \quad A_{ik} \; X_{ik} \lesseqgtr D_{ik}$$

where: $D_{ik}$ is the binding acreage on crop i in land k, which can satisfy the objectives of volume of foreign exchange and food requirements.

The search for the optimal practical cropping pattern was resumed. Some solutions were rejected either because of their impracticality or because they failed to satisfy the objectives; others were retained on one side. Inequality boundaries on the acreage of crops chosen in earlier solutions were added which it was hoped might lead to the optimal solution. Examples of the solutions obtained during this search are given in Tables 9 and 10. After numerous runs of programme it was noticed that the additional inequality boundaries led to continous decrease in both the profit and the number of man-working days employed by the new cropping patterns.

## VI: The Proposed Cropping Pattern For Egypt To Solve The Problems Of Unemployment And Low Per Capita Income

The profit maximization stage came to an end when a solution was selected from those retained earlier with the original crop inequality constraint, which was thought to satisfy the objectives and could assist in solving the surplus labour problem. This section describes the cropping pattern so discovered.

The chosen cropping pattern suggests that Egypt should specialize in cultivating only nine crops out of the existing 75 crops: cotton, millet, rice, clover, potatoes, onions, sesame, bananas and marrows. If price levels are maintained the aggregate

TABLE 9

SUMMARY OF COMPUTER OUTPUT FOR THE PROFIT MAXIMISATION STAGE

Unit $10^6$

| Resources | Prog LNP7/RHS/22.5.75 | | | | Prog LNP7/RHS/14.6.74 | | | | Prog LNP7/RHS2/24.7.74 | | | | Prog LNP7/RHS2/6.8.74 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avail | Used | Slack | %* | Avail | Used | Slack | %* | Avail | Used | Slack | %* | Avail | Used | Slack | %* |
| MWD/year | 1015.4 | 614.5 | 400.9 | 60.5 | 1015.4 | 584.7 | 420.7 | 57.5 | 1015.4 | 539.6 | 475.8 | 53.1 | 1015.4 | 617.2 | 398.2 | 60.7 |
| MWD/month | 84.7 | 51.25 | 33.45 | 60.5 | 84.7 | 48.7 | 36.0 | 57.5 | 84.7 | 44.9 | 39.8 | 53.1 | 84.7 | 51.4 | 33.3 | 60.7 |
| Water/year | 52091 | 26027 | 26064 | 50.08 | 52091 | 24963 | 27128 | 47.9 | 52091 | 24290 | 28801 | 46.6 | 52091 | 30012 | 22079 | 57.6 |
| Water/mth. | 4340 | 2168 | 2172 | 50.0 | 4340 | 2080 | 2260 | 47.9 | 4340 | 8024 | 2316 | 46.6 | 4340 | 2501 | 1839 | 57.6 |
| Area | 6.400 | 9.509 | - | 148 | 6.400 | 9.184 | - | 142 | 6.400 | 8.509 | - | 132 | 6.400 | 8.921 | - | 139 |
| Aggregate profit | - | E£708.1 | - | - | - | E£671.3 | - | - | | E£617.6 | | | | E£598.4 | | |
| Average profit/fed | - | E£110.6 | - | - | - | E£104.8 | - | - | | E£96.4 | | | | E£93.4 | | |

* Percentage represents the ratio between used and available resources.

Source: Computer output program LNP7/RHS/22.5.74, LNP7/RHS3/14.6.74, LNP7/RHS2/24.7.74 and LNP7/RHS2/6.8.74.

Table 9 (Cont'd)

Unit $10^6$

| Resource | Prog LNP7/RHS2/8.8.74 | | | | Prog LNP7/RHS1/14.6.74 | | | |
|---|---|---|---|---|---|---|---|---|
| | Avail | Used | Slack | %* | Avail | Used | Slack | %* |
| MWD/year | 1015.4 | 578.6 | 436.8 | 56.9 | 1015.4 | 443.1 | 572.3 | 43.6 |
| MWD/month | 84.7 | 47.2 | 37.5 | 56.9 | 84.7 | 36.9 | 47.8 | 43.6 |
| Water/Year | 52091 | 21608 | 30482 | 41.5 | 52091 | 13942 | 38149 | 26.8 |
| Water/Month | 4340 | 1800.7 | 2539.3 | 41.5 | 4340 | 1151.8 | 3178.2 | 26.8 |
| Area | 6.40 | 8.787 | - | 135 | 6.40 | 9.135 | - | |
| Aggregate profit | | E£547.8 | | | | E£541.8 | | |
| Average profit/fed | | E£85.3 | | | | | | |

* percentage represents the ratio between the used resources and the available

Source: Computer output, program LNP7/RHS/8.8.74 and Prog LNP7/RHS1/14.6.74

TABLE 10

THE MAXIMIZATION OF PROFIT STAGE

million

| Item \ Programme | LNP7/RHS2/8.8 | LNP7/RHS1/14.6 | LNP7/RHS/22.5.75 |
|---|---|---|---|
| Objective: Rev. | E£. 547.8 | E£ 541.8 | E£ 708.1 |
| Labour constraint (m.w.d.) | | | |
| Lab 1 | 39.9 | 31.9 | 36.9 |
| Lab 2 | 34.2 | 32.4 | 61.7 |
| Lab 3 | 46.1 | 43.6 | 67.0 |
| Lab 4 | 64.1 | 59.1 | 70.2 |
| Lab 5 | 44.9 | 57.1 | 65.5 |
| Lab 6 | 53.2 | 40.8 | 24.8 |
| Lab 7 | 70.6 | 37.3 | 51.6 |
| Lab 8 | 54.2 | 37.3 | 54.1 |
| Lab 9 | 44.7 | 27.2 | 67.7 |
| Lab 10 | 40.7 | 45.2 | 77.0 |
| Lab 11 | 53.2 | 25.1 | 37.5 |
| Lab 12 | 32.5 | 5.7 | 0 |
| Aggregate labour | 578.6 | 443.1 | 614.5 |
| Land constraint (feddans) | | | |
| Land 1 | 0.325 | 0.325 | 0.325 |
| Land 2 | 2.356 | 2.356 | 2.356 |
| Land 3 | 2.397 | 2.397 | 2.397 |
| Land 4 | 1.320 | 1.320 | 1.320 |
| Slack | | | |
| Land 1 | - | - | - |
| Land 2 | - | - | - |
| Land 3 | - | - | - |
| Land 4 | - | - | - |
| Slack labour (M.W.D.) | | | |
| Lab 1 | 44.1 | 52.1 | 47.1 |
| Lab 2 | 49.2 | 51.6 | 22.3 |
| Lab 3 | 37.9 | 40.4 | 17.0 |
| Lab 4 | 19.8 | 24.9 | 13.8 |
| Lab 5 | 39.1 | 26.9 | 18.5 |
| Lab 6 | 30.8 | 43.2 | 59.2 |
| Lab 7 | 13.4 | 46.7 | 32.4 |
| Lab 8 | 29.8 | 46.7 | 29.9 |
| Lab 9 | 39.3 | 56.8 | 16.3 |
| Lab 10 | 43.7 | 38.8 | 7.0 |
| Lab 11 | 39.8 | 58.9 | 46.5 |
| Lab 12 | 51.5 | 78.3 | 84.0 |
| Water/year (cu.m.) | 21,608 | 13.942 | 26,027 |
| Water slack (cu.m.) | 30,482 | 38,149 | 26,064 |

Table 10 (Cont'd)

MILLION

| Item \ Programme | LNP7/RHS2/8.8 | LNP7/RHS1/14.6 | LNP7/RHS/22.5.75 |
|---|---|---|---|
| **Crops (feddans)** | | | |
| Wheat | - | | - |
| Beans | - | | - |
| Barley | - | | - |
| Fenugreek | 0.066 | 0.565 | - |
| Lentils | - | | - |
| Linen | - | | - |
| Onion | 0.750 | 0.565 | - |
| Lupin | - | | - |
| Chickpeas | - | | - |
| Clover | 0.888 | | - |
| Cotton | 1.799 | 0.643 | 4.145 |
| Rice | - | 0.677 | - |
| Millet | 0.888 | | - |
| Maize | - | | - |
| Sugar cane | - | 0.874 | - |
| Sesame | 0.075 | 0.390 | - |
| Peanut | - | 0.565 | - |
| Nile Rice | 0.095 | 0.390 | - |
| Nile Maize | - | - | - |
| Garlic | - | - | - |
| Green peas | - | - | - |
| Dry green peas | - | - | - |
| Beans | - | - | - |
| Spinach | - | - | - |
| Radish | - | - | - |
| Lettuce | - | - | - |
| Carrots | 0.015 | - | - |
| Parsley | - | - | - |
| Egyptian rocket | - | - | - |
| Tomato | 1.272 | - | 2.682 |
| Marrow | 1.132 | 0.099 | - |
| Turnip | - | - | - |
| Cabbage | - | - | - |
| Cauliflower | - | - | - |
| Tomato (S) | - | 1.395 | 2.682 |
| Potato | 0.069 | - | - |
| Marrow | - | - | - |
| Harricot | - | - | - |
| Dry Haricot | - | - | - |
| Kidney Beans (S) | - | - | - |
| Dry kidney beans (S) | - | - | - |
| Beans | - | - | - |
| Green peppers (S) | - | - | - |
| Carrot | - | - | - |

(Cont'd)

Table 10 (Cont'd)

million

| Item \ Programme | LNP7/RHS2/8.8 | LNP7/RHS1/14.6 | LNP7/RHS/22.5.75 |
|---|---|---|---|
| Okra | 0.013 | - | - |
| Jew Melon | - | - | - |
| Taro | 0.050 | - | - |
| Aubergine | 1 | 0.722 | - |
| Sweet potato | - | - | - |
| Cucumber | - | - | - |
| Radish | - | - | - |
| Egyptian Rocket | - | - | - |
| Water melon | 0.142 | - | - |
| Leeks | - | - | - |
| Tomato (N) | 1.322 | - | - |
| Potato (N) | - | - | - |
| Marrow (N) | 0.020 | - | - |
| Haricot (N) | - | - | - |
| Cabbage (N) | - | - | - |
| Cauliflower (N) | - | - | - |
| Green pepper (N) | - | 0.822 | - |
| Artichoke (N) | - | - | - |
| Strawberry (N) | - | - | - |
| Radish (N) | - | - | - |
| Parsley (N) | - | - | - |
| Egyptian rocket (N) | - | - | - |
| Kidney beans (N) | - | - | - |
| Dry kidney beans (N) | - | - | - |
| Leeks (N) | - | - | - |
| Cucumber (N) | - | - | - |
| Orange | - | - | - |
| Mango | - | 0.164 | - |
| Banana | 0.002 | 1.595 | - |
| Figs | - | - | - |
| Total acreage (feddans) | 8.787 | 9.465 | 9.509 |

(S) = Summer crop (N) = Nile crop

Source: Computer programme LNP7/RHS2/8.8.74; LNP7/RHS1/14.6.74; and LNP7/RHS/22.5.75.

farm profit from these nine crops could amount to E£ 614.5 million. In addition, this cropping pattern could employ 708.13 million man-working days per year, that is a level of employment of the equivelent of 59 man-working days per month over the year.

A summary of the computer output for the cropping pattern is given in Table 11 to 13 and Diagram 7. The mathematical formulation of the objectives set for the run that developed the chosen cropping pattern can be written as follows:

$$\text{Max profit} \sum_{i=1}^{75} \sum_{k=1}^{4} Rev_{ik}\, X_{ik}$$

(a) Land Constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} A_{ijk}\, X_{ijk} \leq L_{kj}$$

(for all j)

(b) Labour constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} lab_{ijk}\, X_{ijk} \leq M_j$$

(for all j)

(c) Water constraint:

$$\sum_{i=1}^{75} \sum_{k=1}^{4} wat_{ijk}\, X_{ijk} \leq I_j$$

(for all j)

(d) Crop constraint:

$X_{10} \geq E$

$X_{11} = N$

$X_{12} \geq F$

$X_{14} + X_{13} \geq D$

$X_{18} \geq Y$

$X_{20} + X_{19} \geq Q$

where: $Rev_{ik}$ is the level of profitability of crop i in land k;
$X_{ik}$ is the area of crop i in land k;

TABLE 11

THE SELECTED CROPS AND THEIR AREA IN THE CHOSEN CROPPING PATTERN COMPARED TO 1970

million feddans

| Crop | Area in 1970 | Area selected by the computer |
|---|---|---|
| Cotton | 1.630 | 1.800 |
| Millet | 0.064 | 0.659 |
| Rice | 1.140 | 0.639 |
| Clover | 2.70 | 0.639 |
| Onion | 0.05 | 0.639 |
| Sesame | 0.004 | 0.639 |
| Potato | 0.015 | 0.020 |
| Marrow | 0.014 | 0.019 |
| Banana | 0.009 | 2.572 |
| Total area | 10.550 | 7.608 |
| Aggregate profit (E£) | E£515 | E£614.5 |

Source: Results obtained from computer program LNP7/RHS1/6.8.74

TABLE 12

SUMMARY OF COMPUTER OUTPUT FOR THE PROGRAM FOR DEVELOPING EGYPTIAN AGRICULTURE

Million

| Resource | Available | Used | Slack | % |
|---|---|---|---|---|
| MWD/year | 1017.32 | 708.13 | 309.1 | 69.6 |
| MWD/month | 84.7 | 59.0 | 25.7 | 69.6 |
| Water/year | 52091 | 23101 | 29990 | 44.3 |
| Water/month | 4340 | 1925 | 2415 | 44.3 |
| Land 1/year | 3.911 | 3.911 | - | 100 |
| Land 2/year | 28.273 | 28.243 | .04 | 99.8 |
| Land 3/year | 28.767 | 25.981 | 2.876 | 90.0 |
| Land 4/year | 15.847 | 13.207 | 2.64 | 83.3 |
| Total land/ year | 76.800 | 71.244 | 5.556 | 92.7 |
| Area (feddans) | 6.400 | 7.608 | - | 118.8 |
| Aggregate profit | | E£614.5 | | |
| Average profit/fed (E£) | | E£96.01 | | |

Source: Results obtained from computer program output LNP7/RHS1/6.8.74.

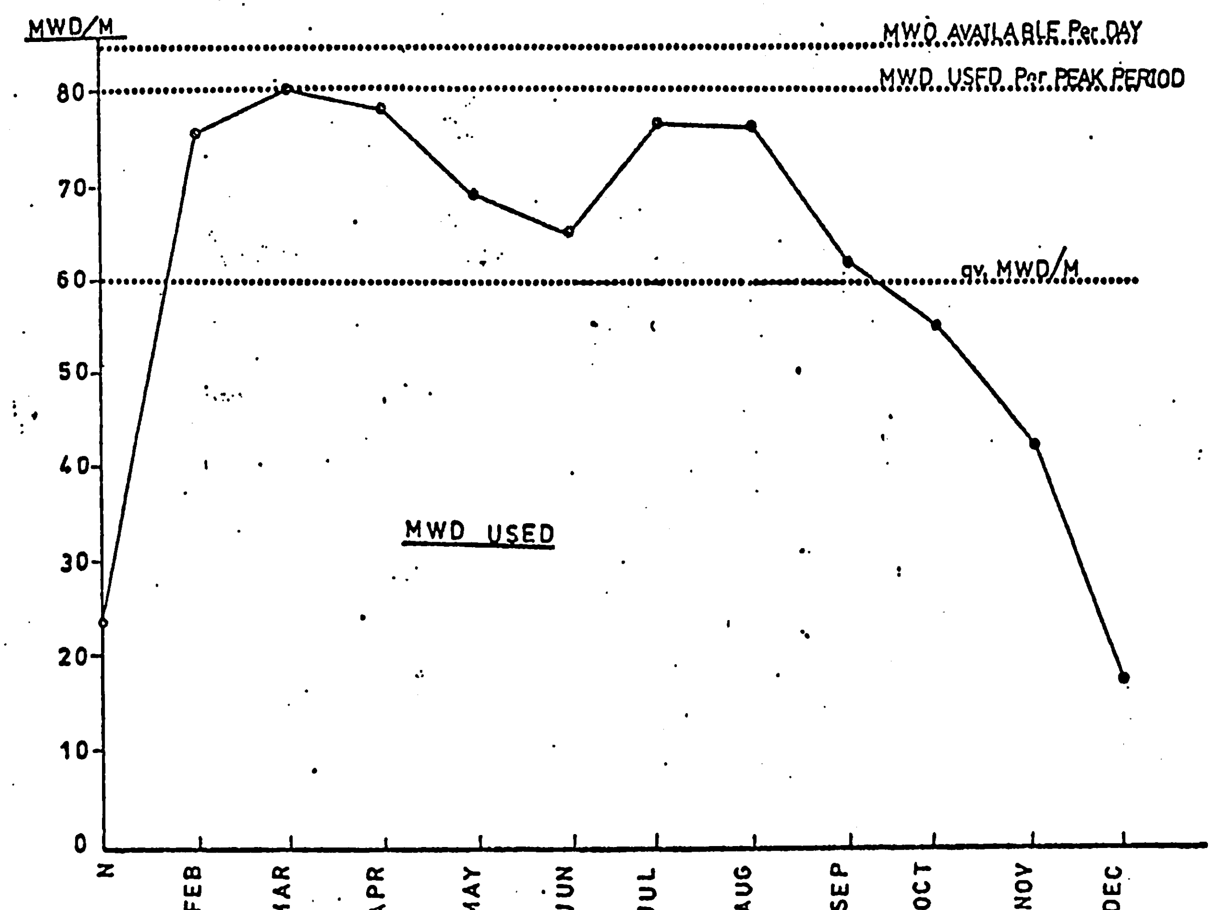
## TABLE 13

**SUMMARY OF COMPUTER OUTPUT FOR THE NUMBER OF MAN-WORKING DAYS, WATER, AND LAND USED BY THE CHOSEN CROPPING PATTERN TO DEVELOP EGYPTIAN AGRICULTURE**

| | Man-working days | | | Water resource | | | Land 1 | | Land 2 | | Land 3 | | Land 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avail | Used | % | Avail | Used | % | Used | Slack | Used | Slack | Used | Slack | Used | Slack |
| January | 84.3 | 25.6 | 30 | 3060 | 214 | 7 | 1.326 | - | 2.356 | - | 2.397 | - | 1.820 | - |
| February | 84.7 | 74.4 | 87.7 | 3985 | 860 | 21.5 | 0.326 | - | 2.356 | - | 2.397 | - | 1.320 | - |
| March | 84.7 | 80.3 | 94.8 | 4090 | 2352 | 57.5 | 0.326 | - | 2.356 | - | 2.397 | - | 1.320 | - |
| April | 84.7 | 80.0 | 94.5 | 3920 | 3647 | 93 | 0.326 | - | 2.356 | - | 2.397 | - | 1.320 | - |
| May | 84.7 | 70.8 | 83.6 | 5425 | 3638 | 67.1 | 0.326 | - | 2.356 | - | 1.758 | 0.639 | 1.320 | - |
| June | 84.7 | 62.1 | 73.3 | 6710 | 2417 | 36 | 0.326 | - | 2.356 | 0.020 | 2.379 | - | 1.320 | - |
| July | 84.7 | 75.2 | 88.8 | 6065 | 3869 | 67 | 0.326 | - | 2.356 | - | 2.379 | - | 1.320 | - |
| August | 84.7 | 72.2 | 85.2 | 4199 | 2302 | 55 | 0.326 | - | 2.356 | - | 2.379 | - | 1.320 | - |
| September | 84.7 | 62.5 | 73.8 | 3805 | 996 | 26 | 0.326 | - | 2.356 | - | 2.379 | - | 1.320 | - |
| October | 84.7 | 53.7 | 63.4 | 3805 | 1331 | 35 | 0.326 | - | 2.356 | - | 2.379 | - | 1.320 | - |
| November | 84.7 | 35.5 | 41.9 | 3640 | 1024 | 28 | 0.326 | - | 2.356 | - | 1.918 | 0.479 | - | 1.320 |
| December | 84.7 | 15.4 | 18.2 | 3387 | 446 | 13 | 0.326 | - | 2.336 | 0.020 | 0.639 | 1.758 | - | 1.320 |
| Total | 1015.4 | 7081 | 69.6 | 52091 | 23101 | 44 | 3.912 | - | 28.243 | 0.040 | 25.891 | 2.876 | 13.201 | 2.620 |
| Average/ Month | 84.7 | 59 | 69.6 | 4340 | 1925.08 | 44 | 0.326 | - | 2.353 | 0.003 | 2.157 | 0.2396 | 1.10 | 0.2 |

Source: Computer program output, program LNP7/RHS/6.8.74.

DIAGRAM 7 : MAN WORKING DAYS ( MWD ) EMPLOYED BY THE PROGRAMME TO SIMULATE THE CHOOSEN CROPPING PATTERN FOR EGYPT




Source : Computer results obtained from the programme LINPROG 7/6.8.74/RHS 1&2

$L_{kj}$ is the land constraint of type k in month j;
$M_j$ is labour constraint in month j in 1970;
$I_j$ is water constraint in month j;
$P_{ik}$ is the level of profitability of crop i in land type k in 1970;
N is the area of cotton in 1970 which provided the farmer and the country with cash and foreign exchange;
E is the area of clover which can provide farmers with their requirements of animal feed;
F and Y are the areas of rice which can provide Egypt with her domestic and export requirements of rice over the next three decades;
D and Q are areas of millet and maize, which can provide the population with its needs over the next three decades.

The requirements of rice, millet and maize were calculated on the basis of:

(i) the projected level of consumption purchased in the following two decades⁻, multiplied by the projected population in 1975 and the year 2000[1].

(ii) the projected yield/ feddan over the next ten years and in the case of rice in the next two decades.

(iii) analysis of the export trade between 1960 and 1970 and the projection of its development in the next twenty years[2].

The following section evaluates the identified cropping pattern and makes policy recommendations in the light of it.

VII: <u>Evaluation of The Solution And Policy Recommendations</u>

The basic objective of this research was to investigate

1. This was obtained by the application of the projection model, see Arman, I. (1976).
2. <u>Ibid</u>.

the possibility of a revised cropping pattern which could increase labour absorption in Egyptian agriculture. The final result of the linear programming exercise was to achieve a solution which meets that objective. The number of man-working days employed in cultivating and servicing the chosen crops has increased by 48 per cent over the level of 1970 (table 12 and 13). This figure represents an increase of 44 per cent over the projected number of job opportunities which would be available in 1985 if the present framework of agriculture production continues.

Moreover, a partial solution to the seasonality of employment is provided. Full-time employment is provided for an average of 59 million man-working days per worker, equivalent to 69.6 per cent of the estimated agricultural effective supply of labour in 1985. Although employment would be below the average of 69.6 percent in the months of November, December and January, the level in these three months is increased by 43.9 percent over the 1970 figure.

The secondary objective, to improve the aggregate profit of the agricultural sector, has also been achieved. Substantial increases in farmers' incomes are achieved by improving the efficiency of currently underutilized resources. The optimal solution provides an increase of 14.23 per cent over 1970, if farmers diverted their land to the nine selected crops. This could substantially increase the funds available to accelerate the rate of development of the agricultural sector either by individuals through private investment or by the government through increased revenue from taxation.

Major capital investments would not be required. Additional improvements to the irrigation system would not be needed, as irrigation requirement amounts to an average of 44 per cent of both the monthly and annual discharges from the High Dam. This implies an average saving of 24 per cent of water used in 1970, which represents 68 per cent of the total water resources. The saved water could be redeployed to irrigate land reclamation projects in the northwest and western desert regions leading to eventual further increases in output and employment.

By cultivating only the nine selected crops Egypt could enjoy the benefits of specialization to gain a comparative advantage over the other producing countries. With lower production costs she could sell her output at lower cometitive prices, which at the same time were more profitable to Egyptian farmers. Although many existing crops are replaced, surpluses of the commodities produced would increase revenue sufficiently to replace them with imported supplies where necessary. In any case the selected crops would provide farmers with their main requirements of food and feed crops and permit an increased surplus for the market.

The amounts of food and feed currently imported would be reduced overall, whilst exports would be increased. Thus, assistance would be given to both sides of the balance of payments which has caused the severe problems discussed earlier. In the case of the staple foodstuffs-grains, wheat and rice, dependence on imports would be reduced. The proposed cropping pattern would guarantee a sufficient level of domestic production to meet the expanding requirements of consumption.

A further advantage of the selected crops is that they are mainly those which become increasingly important in the last twenty years, and for which international consumption has steadily expanded. For example, bananas have become the most important fruit in the world market, and consumption has expanded considerably over the last 70 years[1]. Similarly vegetable oils, rice and onions have become important commodities whose consumption in the industrialised countries has gone up during the past five years[2]. Consequently, Egypt would be able to take advantage of the growing world market for these commodities.

Turning to possible criticisms of the solution, a major one might concern the fact that a single value for the profit

1. Commission on the European Community (1974),pp. 1-46.
2. *Ibid.*, also FAO (1974).

for each crop was used and that to that extent extent the solution may be unrealistic. Yet, there was no alternative, given the lack of information in Egypt. However, a sensitivity analysis was carried out on the chosen crops to explor the effect of changes in prices on profitability. It was found that with up to 25 per cent price changes the selected activities changed only slightly. But outside the 25 per cent range the combination of selected activities changed basically. A price range limit of 25 per cent, particularly in a downwards direction, is realistic in that over the last ten years price fluctuations in Egypt have not exceeded ten to 15 per cent of the price levels in 1965.

In addition to the sensitivity test the prospects for every crop selected have been studied carefully. Local and international demand and predicted futur changes were examined. For example, one of the selected crops is cotton which is the main cash crop both for farmers and the government. The proposed area amounts to 1.8 million feddans, producing output equal to that in 1973. The Egyptian authorities[1] consider this to be the optimal level. Any increase could leave Egypt with unmarketed cotton. Any decrease could lead to the rise of competitors, and cause a drop in foreign exchange earning. Again, the programme suggests an expansion of the output of some of the selected crops, such as bananas, onions, sesame, and rice, which would be in excess of the increase in domestic consumption. But because Egypt has a comparative advantage due to low cost of production and shipment to export markets, she would be able to expand her exports by the amount of the increased output.

This increase in exports would present one problem which would have to be tackled. At present the quality of Egyptian agricultural exports is variable and frequently below the standards required by importing countries, mainly the industrialised countries, and achieved by the major exporting countries. Improvements in production through the selection of better quali-

1. Despite that recently i.e. during November 1981 arguments are stating that cotten is left in abandancy; yet specialised studies prove that such arguments are not correct, where on the conterary international demand did not drop.

ties of seed and increased use of fertilizers are required. These improvements should not be too costly. Discovery of better varieties of seed is already part of the research programme of the Ministry of Agriculture and better techniques would be financed from the existing credit funds[1]. Improvements in marketing would also be required but that topic is outside the scope of the present study.

A final potential point of criticism should be mentioned: that to put the proposed cropping pattern into practice would require skills which are not currently available in sufficient quantities in Egypt. This is true. But it should not be used as a reason to prevent the progress which, it is submitted, the new pattern would represent. On the contrary, Egypt should alter its educational policies to provide the personel with the necessary skills in farm production and marketing.

To summaries the advantages of the proposal, it would increase overall labour absorption, reduce seasonal unemployment, raise farm income, increase self sufficiency in food, increase the agricultural sectors contribution to capital formation and the balace of payments, and as a bonus save water.

In view of the major advantages which would result from the application of the new cropping pattern, the major recommendation must be that Egypt should put that pattern in effect and specialize in only nine crops- cotten, millet, rice, clover, potatoes, onions, sesame, marrows and bananas- in place of the existing 75 crops. It should be noted that the change would obviously be a fundamental one which would take time; and a great deal of thought would have to go into developing the details of the policy for its implementation. Such detailed policy would be beyond the scope of this research and only pointers in the directions in which changes would be required can be

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1. See Arman, I. (1966)

given here. To put the policy into effect and evaluate its performance would require approximately ten years: two years to work the details of the policy, three years to phase in the new cropping pattern, and afurther five years during which opperational difficulties could be sorted out and results evaluated. In the end it should be stressed here that the success of such plan will require a lot of changes such as changing the educational system to meet the required skills and changing the taxation system and credit system to guaranttee the effectiveness of such plan.

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