ARAB REPUBLIC OF EGYPT

THE INSTITUTE OF NATIONAL PLANNING

التخطيط القومي

Memo No. (1318)

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

I.M.I.Arman

January 1982

CAIRO
SALAH SALEM St.-NASR CITY

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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

*The Author whishes to extend his thanks and gratitude to Mr. R.F.De La Mare, Senior Lecturer in Bradford University who has helped the author in building the model.

** 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 $Z = (j = 1, \ldots, n)$ that maximize:

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

Subject to:

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

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

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 $\leqslant$ and $\geqslant$. 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

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

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

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

$$\sum_{i=1}^{75} \qquad \sum_{k=1}^{4} b_{ik} \quad X_{ik} \quad \leqslant R_{i}$$

Where:

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

(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.

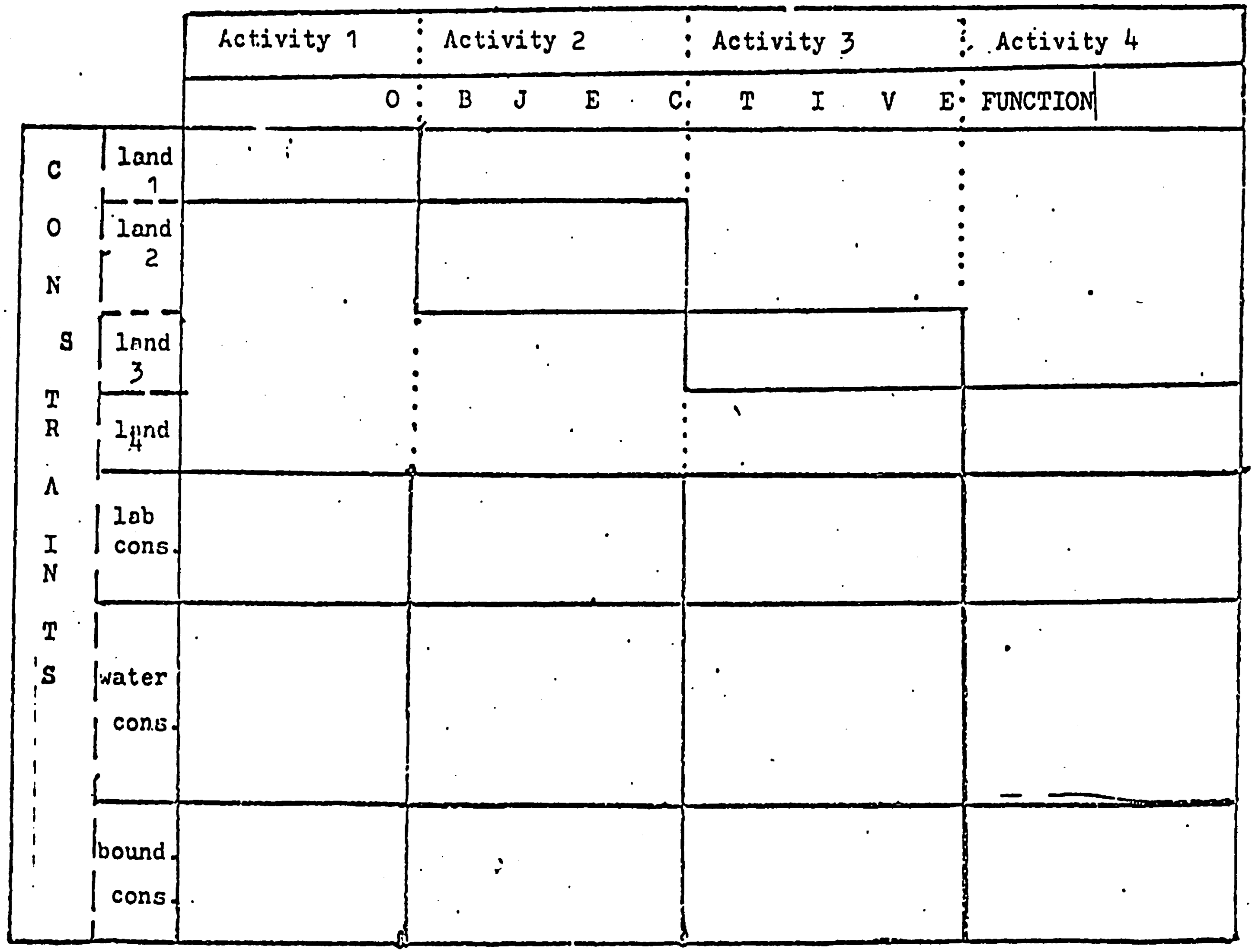
The validity and viability of the model will be discussed in the following part of this paper.

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