Application of Linear Programming Techniques in Agriculture

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DOI: 10.29322/IJSRP.13.05.2023.p13715
http://dx.doi.org/10.29322/IJSRP.13.05.2023.p13715

Paper Received Date: 5th April 2023
Paper Acceptance Date: 7th May 2023
Paper Publication Date: 14th May 2023

Abstract- It was seen the Linear Programming (LP hereafter) as a part of a distinct revolutionary advancement for the mankind to achieve the capability to state wide-ranging goals and to arrange a pathway of comprehensive decisions to grasp the order to "best" accomplish its goals when confronted with practical situations of wonderful complexity. Our apparatuses for doing this are conducts to formulate actual problems in comprehensive mathematical terms (models), approaches for resolving the models (algorithms), and mechanisms for executing the steps of algorithms (computers and software).

Linear Programming is a significant branch of operational research and to carry out scientific management, by which people get help from this by using as a mathematical method. General Algebraic Modelling System (GAMS hereafter) is an advanced modeling system for mathematical encoding and optimization. It comprises a linguistic compiler and a steady of integrated high-definition solvers. GAMS is personalized for complex and large-scale modeling applications as well. It also allows you to build great workable models which can be adapted rapidly to new conditions. GAMS is designed for modeling LP, nonlinear programming and mixed integer optimization problems.

During the Second World War, Linear Programming was developed, and the most important thing was to efficiently maximize the resources by this system. The new war-related projects gained high attention and blow-out the resources narrowly. Linear Programming has appeared at the exact moment whilst mankind provoked the problem to determine which action could be satisfactory under certain conditions. The authentic invention of LP can be copied back again to 1939 while Russian mathematics expert L. V. Kantorovich recommend that a category of LP models may be used for manufacturing planning and exhibited the dividing-multiplication technique, which had a class of LP models can be used for production making plans and described the dividing-multiplication technique, which had a reflective impact on the advancement of contemporary applied mathematics and economics. Before revealing the very renowned simplex method by George B. Dantzig an affiliate of the U.S. Air Force, it was turned to keep secret till 1947 and the theory of duality developed by John von Neumann as a linear optimization solution. In 1947, George Dantzig, build up the Simplex method of optimization in order to deliver an effective algorithm for solving programming difficulties that had linear structures. Since then, professionals from the different field, particularly mathematics and economics, have improved the theory behind "linear programming" and discovered its applications. We will try to cover the core concepts of linear programming including appropriate examples when necessary.

Index Terms- Land, resource allocation, linear programming model, Optimization techniques, GAMS, Objective function, Simplex Method, Graphical Method.

I. Introduction

Linear Programming (LP) is a mathematical technique for figuring out the ultimate distribution of unusual resources and attaining proficiency in production forecasting. Especially in reaching improved agricultural production of food crops (Rice, wheat, Pulses, Maize, and as well as other crops). Use of Linear Programming engaging the simplex and graphical methods under application of optimization procedures in agriculture for profit intensification or loss minimization is being carried out since long. It offers a prospect for making plans and improved allocation of resources in agriculture because one receives a possibility to become aware of the interventions in agriculture, which can be extra profit oriented either because of lower input cost or greater profits from outputs. In this paper, in order to achieve the highest profits, an LP approach is applied to determine the optimum land distribution of some foods via the use of agriculture information with respect to numerous factors. It is monitored that the anticipated LP model is suitable for locating the optimal land distribution to the main food crops and it was noticed that existing procedure is least profitable and there is honestly a sound scope of profit development from land.

Linear programming is called a relaxing class of mathematical complications, wherein maximization (or minimization) of a linear function dependent on the given linear constraints. Class of programming problems compacts where both the objective function to be improved is linear and all interactions among the variables communicating to the resources are linear. Once a while to improve the theoretical and mathematical development simultaneously within a short time such as practical business, trade, and industrial applications. Nowadays, different types of problems like capital budgeting technique, the design of diets, resource conservation, strategic games, the prediction about economic growth and to improve transportation system are being solved by Linear Programming theory. In recent situations, many unresolved applications have been resolved and combined with the help of linear programming approach. Economical activities of land where is producing the crops and maximize its returns will be examined in this paper with the help of linear programming technique. The research inquiry is whether in the wake of applying the econometric simulation the returns of the economic movement is higher or not. Enhancing crops' shape using linear programming is extensively concerned in economic research.

II. LITERATURE REVIEW:

As it is all acknowledged, in literature linear programming (Dantzig, 1963; Kantorovich, 1987; von Neumann, 1954) as an exact methodology was created by a Russian mathematician Leonid Kantorovich, who settled linear programming problems in 1939, Simplex method was published by George B. Dantzig in 1947, and the theory of the duality was developed by John von Neumann. Nowadays, many modifications have transmuted the landscape of optimization approaches and software since Dantzig, due to the Internet and the Web advantages World Wide.

Gill et al. (2008) consider that it is no longer necessary for the critical mass of people to be collocated since researchers and operators can swap code electronically as well as carry on problems on a machine from a remote place by using software written by someone else. Even so, Dantzig's perception of a systems optimization research laboratory lives on. The work of Dantzig (1963) is acknowledged to be the most appropriate. Linear programming is applied in agriculture including all fields.

In 1982, Montazemi and Wright put on mathematical encoding in agriculture, as an example in developing countries the use of operational research. Researchers (Voicu et al., 2010; Dobre et al., 2011; Istudor et al., 2007) indicate the Romanian involvement in the field. In ecosystems, ongoing production of useful plants or animals that have been formed by people. Cultivating the soil, raising livestock, cultivating and harvesting crops may include in agriculture. Agriculture is called the art and science of production of livestock and crops. In its wide-ranging sense, agriculture includes the complete range of technologies connected with the production of beneficial products from animals and plants, together with crop and livestock management, soil cultivation, and the activities of processing and marketing. In many places, agriculture was developed independently, including East Asia, South Asia, Middle East, and the Americas. The initial evidence for agriculture has been found in between 14,500 and 12,000 BP in the Middle East. Primary cultivars include wild barley (Middle East), millet (China), and squash (the Americas). During roughly the same period, the domestication of various animals now well-thought-out to be livestock occurred, though dogs were pet considerably earlier. The example of early agricultural techniques covers Slash-and - Burn land-clearing procedures and crop replacement as well. Over the 100 years, Stable developments in apparatuses and methods augmented agricultural productivity, as did in the 20th century beginning of systematization, selective breeding and hybridization by the use of herbicides and insecticides.

III. STATEMENT OF PROBLEM:

In recent times, agriculture sector has been confronted with low profitability as a result of miscalculations due to the error of the managerial level. No doubt that in this sector there is numerous problems. Due to the lack of absolute knowledge about agriculture some problems are faced. Farmer was not happy due to some uncontrollable forgoing problems. Farmers who are not making good profit and feeling unsatisfied which is creating nervousness and stress among them. Lack of satisfaction lead to frustration among workers and arise disagrees of roles. Therefore, a study that systematically inspects and make available ways of augmenting the turnover in agriculture.

IV. OBJECTIVE OF STUDY:

This study objects at using Simplex Method and graphical Method as one of the Linear Programming Techniques to generate a Mathematical approach that will enhance the return of the production of crops.

V. METHODOLOGY:

The several data we are primarily concerned with are the following:

1) Cost of crops.
2) Raw materials and their cost per each acre.
3) Number of workers.
4) Count of Season.
5) Amount of Profit
6) Measurement of cultivate land.

Mathematical Formulation:

Let us illustrate this by the example of selecting the best possible production plan which is reproduced.

Table-1: Baseline data for planning

Products	Decision variable	cost	Man-days	Profit
Rice	R	5,000	8	3,500
Wheat	W	3,000	12	2,800
Available capacity		45,00	160	

For the sake of convenience, we tabulate the data in the following manner: Objective Functions:
Z = 3,500R +2,800W
Subject to constraints: 5,000R + 3,000W ≤ 45,000
8R + 12W ≤ 160 R + W ≤ 10
And R, W ≥ 0
The inequalities expressing constraints are converted into equalities by adding slack variable we get,
5,000R + 3,000W + S1 = 45,000
Or, 5,000R + 3,000W + S1 +0S2 +0S3 = 45,000 8R + 12W + S2 = 160 Or, 8R + 12W + 0S1 + S2 +0S3= 160 R + W + S3 = 10
Or, R + W + 0S1 + 0S2 + S3 = 10
Now, Z= 3,500R + 2,800W + 0S1 + 0S2 + 0S3

By using the Simplex method, we get:

Table-2

Solution Mix	**→Cj↓**	**R**	**W**	**S1**	**S2**	**S3**	**R.H.S.**	**Ratio**
		3,500	2,800	0	0	0		
S1	0	5,000	3,000	1	0	0	45,000	9 ←
S2	0	8	12	0	1	0	160	20
S3	0	1	1	0	0	1	10	10
	Zj	0	0	0	0	0	0	
	Cj-Zj	3,500 ↑	2,800	0	0	0		

So, the elements of entering variable(R) are 5,000/5,000, 3,000/5,000, 1/5,000, 0/5,000, 0/5,000 & 45,000/5,000 or 1, .6, .0002, 0, 0 & 9.
Calculation of new:
S2 S3
8 -8×1= 0 1-1×1=0
12-8×.6= 7.2 1-1×.6=.4
0-8×.0002= -.0016 0-1×.0002= -.0002
1-8×0=1 0-1×0= 0
0-8×0=0 1-1×0= 1
160-8×9= 88 10-1×9= 1

Table-3

Solution Mix	**→ Cj↓**	**R**	**W**	**S1**	**S2**	**S3**	**R.H.S .**	**Ratio**
		3500	2800	0	0	0		
R	3,500	1	.6	.0002	0	0	9	15
S2	0	0	7.2	-.0016	1	0	88	12.22
S3	0	0	.4	-.0002	0	1	1	2.5 ←
	Zj	3,500	2,100	.7	0	0	31,500	
	Cj-Zj	0	700 ↑	-.7	0	0		

So, the elements of entering variable (W) are 0/.4, .4/.4, -.0002/.4, 0/.4, 1/.4 & 1/.4 or 0, 1, -.0005, 0, 2.5 & 2.5.
Calculation of new:
R S2
1-.6×0=1 0-7.2×0=0
.6-.6×1=0 7.2-7.2×1=0
.0002-.6× (-.0005) =.0005 -.0016-7.2× (-.0005)=.002
0-.6×0=0 1-7.2×0=1
0-.6×2.5=-1.5 0-7.2×2.5=-18
9-.6×2.5=7.5 88-7.2×2.5=70

ISSN 2250-3153

Table-4

Solution	**→**	**R**	**W**	**S1**	**S2**	**S3**	**R.H.S.**	**Ratio**
Mix	**Cj↓**	**3,500**	**2,800**	**0**	**0**	**0**		
R	**3,500**	**1**	**0**	**.0005**	**0**	**-1.5**	**7.5**	
S2	**0**	**0**	**0**	**.002**	**1**	**-18**	**70**	
W	**2,800**	**0**	**1**	**-.0005**	**0**	**2.5**	**2.5**	
	Zj	**3,500**	**2,800**	**.35**	**0**	**1,750**	**33,250**	
	Cj-Zj	**0**	**0**	**-.65**	**0**	**-1750**		

Problem solve by using the graphical method:

Objective Functions: Z = 3,500R + 2,800W
Subject to constraints: 5,000R + 3,000W $\leq$ 45,000
8R + 12W $\leq$ 160

R + W $\leq$ 10

And R, W $\geq$ 0

The inequalities expressing constraints are converted into equalities and we get,

5,000R + 3,000W =45,000 ….. … (1)
8R + 12W =16 .... ….(2)
R + W =10 …………………………………. (3)

From (1) equation we get,

5,000R + 3,000W = 45,000

Or, 5,000R/45,000 + 3,000W/45,000 = 45,000/45,000 Or, R/9 + W/15 = 1

So, equation (1) is passing by A (9, 0) and B (0, 15). (Let)

From (2) equation we get, 8R + 12W = 160
Or, 8R/160 + 12W/160 = 160/160 Or, R/20 + 3W/40 = 1
Or, R/20 + W/ (40/3) = 1
So, equation (2) is passing by C (20, 0) and D (0, 40/3). (Let)

From (3) equation we get,

R + W + = 10

Or, R/10 + W/10 = 10/10 or, R/10 + W/10 = 1

So, equation (3) is passing by E (10, 0) and F (0, 10). (Let) From equation (1) & (3) we get,
5,000R + 3,000W = 45,000
Or, 5,000R + 3,000W - 45,000 = 0 Or, R + W = 10
Or, R + W – 10 = 0
R/ (3,000 × -10 -1 × -45,000) = W/(-45,000 × 1 –5,000 × 10) = 1/(5,000 × 1 – 3,000 × 1)
Or, R/ (-30,000 + 45,000) = W/(-45,000 + 50,000) = 1/(5,000 – 3,000) Or, R/ 15,000 = W/5,000= 1/2,000
Or, R/ 15 = W/5 = ½
So, R = 15/2 & W = 5/2 or, R =7.5 & W = 2.5. So on equation (1) & (3) are passing through by G (15/2, 5/2).

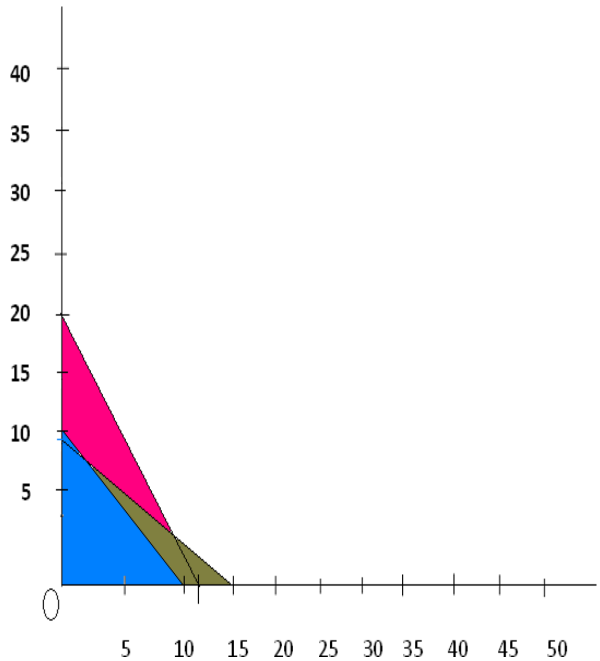

Fig-1: Graphical representation of the above problem.

Now, put the points **A (9, 0), B (0, 15), C (20, 0), D (0, 40/3), E (10, 0) and F (0, 10)** in a graph in which R is shown on the horizontal axis and W is shown on the vertical axis. And add A, B; C, D; E, F. AB and EF are intersecting by G (15/2, 5/2).

According to the condition of the question the area of FGAO is the possible solution area which is shown by shadow. The corner points of the possible solution area are F (0, 10), G (15/2, 5/2), A (9, 0) &
O (0, 0).

Now the value of Z,
At Point F (0, 10),
Z = 3,500R + 2,800W or, Z = 3,500 × 0 + 2,800 × 10
or, Z = 0 + 28, 000
or, Z =28,000

At point G (15/2, 5/2),
Z=3,500R+2,800W
or, Z = 3,500 × 15/2 + 2,800 × 5/2 or, Z =26,250 + 7, 000
or, Z = 33,250.

At point A (9, 0),
Z = 3,500R + 2,800W
or, Z = 3,500 × 9 + 2,800 × 0
or, Z =31,500 + 0 or, Z = 31,500.
At point O (0, 0),
Z = 3,500R + 2,800W
or, Z = 3,500 × 0 + 2,800 × 0
or, Z = 0 + 0
or, Z = 0

The maximum value of Z is 33,250 where R = 15/2 & W = 5/2 or, R =7.5 & W = 2.5.

VI. Result and Discussion:

From the above empirical data, it has been evidently articulated that resource allocation complications can be optimally and proficiently analyzed to develop the decision-making criteria of the management. It would have been problematic or unmanageable to identify what to do with such data or statistics without skill application of optimization model (in this case linear programming). So, the farmer should be allocated 7.5 acres rice and 2.5 acres wheat to maximize total profit. The total maximizes profit is Tk.33, 250.

VII. Conclusions:

The main objective of this study is to put on efficiently the linear programming methods practicing effectively for the use of resources for significant food crops. It has been detected that a smaller number of iterations needed for simplex methods of Leaner Programming problems compared to other technologies. In the contemporary study, we wished-for LP model for optimum land allocation to the two main food crops in agriculture. The results are gained by Simplex method and graphical method. From the above-stated problem & explanation, it can be said that if Bangladeshi farmer wants to get maximum profit by cultivating in their land they should use Linear Programming efficiently. If they do so, we are confident that in near future, they might be able to eliminate their poverty problem

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