

THE APPLICATION OF LINEAR PROGRAMMING IN THE AGRICULTURAL SECTOR: A STUDY OF SONGHAI FARM BUNU, TAI LOCAL GOVERNMENT AREA OF RIVERS STATE

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ABSTRACT

A key problem faced by many organizations is how to allocate scarce resources among alternative uses. Linear programming is one of the methods of optimal resource allocation. The objective of the study was to find solutions to linear programming problems using the graphical method in this case to find out the best allocation that yields the highest profit to Songhai farm in Bunu, Tai Local Government Area of Rivers State). In this instance, there were two variables (Pineapple and Plantain) requiring the use of the scarce resource(land) which necessitated the use of the graphical method of linear programming in determining the best production mix of the variables to make optima profit. It was proved that linear programming can be applicable to real life situations, and that it helps to minimize losses as a result of wrong combination. The paper recommended the use of linear programming in other organizations that are facing allocation problems.

INTRODUCTION

Background of the Study

The problem of resource allocation is an everyday phenomenon faced by everybody either in the course of his business or in his ordinary daily life.-This is as a result of scarcity of resources in supply as well as competition among alternatives for the use of the available resources. For example, the primary problem of a student is how to allocate his time in any day or week among several activities that require his attention. Such activities include; studying, eating, recreation and sleeping. The need for his effective and efficient use of his time is mainly on the account that available time in a day is limited only to 24 hours. And he needs to allocate at least minimum time to the activities in order to keep both healthy and soundness in his pursuit. Also a student may be faced with the problem of allocating his limited financial resources among the competing needs so as to ensure the best utilization of the available find.

Linear programming is a mathematical technique useful for allocation of scarce or limited resources, to several competing activities on the basis of a given criterion of optimally (Sharma, 2010). Linear programming is one of the most widely used mathematical programme techniques used by management scientists to assist management in reaching managerial decisions which are to the best advantage of the organization (Okere, 2008).

Linear programming in its attempt to get the best possible solution is an optimization techniques which considers number of possible decisions or feasible solutions which could be put into practice, e.g ($d_1, d_2, d_3 \dots d_n$) and selects the best possible of these sets of solution which seems to promise the highest degree of economic efficiency either by highest minimizing costs or by maximizing profit production volume. It assures the range of feasible solutions under certain conditions called constraints (Nwekpa, 2010).

Programming in this circumstance does not refer to computer programme, rather, it is essentially a synonym to planning. Thus, linear programming means the planning of activities represented by a linear mathematical model. The major elements of any constant optimization problem are: Objective function, decision variables, constraints and parameters (Stevenson, 2005).

The linear programming problem can be solved using either the algebraic method, graphical method, simplex method, transportation model or the assignment model. This paper, however concentrated on the application of the graphical method of linear programming.

Statement of the Problem

Human wants are infinite but the resources to satisfy these wants are finite. This pose a great challenge to both individuals and organizations and calls for a better utilization of limited resources available.

The problem posed here is to determine production quantities, what product mix to produce out of available raw material and the combinations of other resources to aid optimal operations. Linear programming is designed to assist management in solving optimization problem, that is in deciding how to achieve the desired objective subject to the limitations imposed in terms of limited resources available and/or desired quantities and/or qualities of output.

In this paper the problem posed is determining the allocation of land (scarce resources) for the cultivation of the two crops (pineapple and plantain),

Objective of the Study

The major objective of this study was to critically look into linear programming models and its applicability to real life situations in an organization and how it can help organizations such as Songhai farm reposition itself in a competitive environment.

Also, it highlighted the benefits of linear programming models in solving resource allocation problems.

Specifically, the study seeks to:

1. To formulate linear programming problems from contextual problem.
2. To able to identify feasible regions for Linear programming problems:
3. To find solutions to linear programming problems using the graphical method. In this case to find out the best allocation that yields the highest profit contribution to the organization.

Scope of the Study

The organization under review is Songhai Farm, located in Bunu, Tai Local Government Area of Rivers State. The farm which was established in 2007, is not only for agricultural produce but it also serves as research and recreational centres. However, our study is limited to the agricultural section of the farm.

Significance of the Study

The importance of linear programming cannot be overemphasized as it highlights the different ways of effectively and efficiently allocating scarce resources.

The study can help Songhai farm to formulate Linear programming problem, identify feasible regions and identify the best allocation of resources that will yield the highest profit contributions to the organization.

Besides, this system can be a reference to analyze the current method of resource allocation and improve on it.

Generally, this study have further enriched management literature on linear programming. This work is of practical significance to scholars, managers, businessmen and students alike.

REVIEW OF RELATED LITERATURE

Conceptual Framework

The Linear Programming Model

Linear programming involves setting up the problem in the form of a set of linear equations and then solving them graphically, if only two variables are involved or by using the simplex method when more than two variables are involved (Khanna, 2010).

Structure of the linear Programming Model

The general structure of an LP (linear programming) model consists of three basic elements or components. These are:

(a) Decision variables (Activities): We need to evaluate the various alternatives (courses of action) for arriving at an optional value of objective function. Obviously if there are no alternatives to select from, we would not need an LP. The evaluation of the various alternatives is guided by the nature of objective function and availability of resources. For this we presume certain activities (also called decision variables) which is usually denoted by X_1, X_2, \dots, X_n . The values of these activities represents the extent to which each of these is performed.

The value of certain variables may or may not be under the decision maker's control. These decision variables, usually interrelated in terms of consumption of limited resources, require simultaneous solutions. In LP model all decision variables are continuous, controllable and non-negative. That is, $X_1 \geq 0, X_2 \geq 0, \dots, X_n \geq 0$.

(b) The objective function: The objective (goal) function of each LP problem is expressed in terms of decision variables to optimize the criterion of optimality (also called measure of performance) such as profit, cost, revenue, distance etc. In its general form, it is represented as:

Optimize (Maximize or Minimize) $Z = C_1 X_1 + C_2 X_2 + \dots + C_n X_n$, where z is the measure of performance variable, which is a function of X_1, \dots, X_n .

(c) The constraint: There are always certain limitations (or constrains) on the use of resources e.g labour machine raw material, space, money etc, that limit the degree to which an objective can be achieved. Such constraints must be expressed as linear equalities or inequalities in terms of decision variables. The solution of an LP model must satisfy these constraints (Sharma, 2010).

Assumptions of Linear Programming

The following are the assumptions of an LP model.

- a. Proportionality assumes that the consumption of resources and contribution are proportional to the level of activity.
- b. Linearity assumes that linear relationship between the output of each product and the total quantity of each resources consumed.
- c. Additivity assumes that consumption and contribution by activities are additive.
- d. Non-negativity assumes that activities cannot have negative values.
- e. Single objective assumption state that the problem involves only one objective.
- e. Simple cost function assumes that the total relevant cost function can be divided into fixed and variable elements.
- f. Certainty assumes all quantities and values are known with certainty.
- g. External factors assumes that all external factors are unchanging.

General format of LP Model

Max $P_1 X_1 + P_2 X_2 + \dots + P_n X_n$
 or Min $C_1 X_1 + C_2 X_2 + \dots + C_n X_n$
 subject to $a_{11} X_1 + a_{12} X_2 + \dots + a_{1n} X_n = b_1$
 $a_{21} X_1 + a_{22} X_2 + \dots + a_{2n} X_n = b_2$
 $a_{m1} X_1 + a_{m2} X_2 + \dots + a_{mn} X_n = b_m$
 $X_1, X_2, \dots, X_n \geq 0$ (non negativity constraint) where
 R_j $j = 1, 2, \dots, n$ decision variables
 P_j $j = 1, 2, \dots, n$ unit profits associated with each
 C_j $j = 1, 2, \dots, m$ (costs) decision variable

Arj = j 1, 2 n input/output confident on constraints,
 Bi = 1 1, 2..... mn units of resources

Theoretical Framework

This work is supported by George B Dantzing theory of mathematical programming (graphical method of linear programming) which was originally developed between 1945 and 1955 primarily for solving military logistics problems and later industry and economic planning. Many such problems involve constraints on the size of the workforce, the quantities of raw materials available, the number of machines available and so on.

The problems that will be solved usually have two variables in them and were solved graphically, but problems occurring in industry have many more variables and have to be solved by computer. For example, in oil refineries, problems arise with hundreds of variables and tens of thousands of constraints.

Empirical Review

Hassan, Hashim and Mustapha (2009), conducted a study on potential of idle land for mixed vegetable and fruit farming using linear programming. This study aspired to unveil the economic potential of idle land which is cultivated with a combination of cash crops-vegetables and fruits by young enterprising individuals. Linear programming is employed to derive optima solution for a combined crop harvests. The return from crop combination of corn, cucumber, eggplant, and carrot grossed at RM 61, 984. If land can be further increased because of the availability of idle land while financial capital can be borrowed from the State Authority or agriculture bank, with existing labor cash returns for these farms can be raised to RM 81, 581 per year. Sensitivity analysis on the corn price as an important crop showed that a fall in the corn price from RM 5,700 to RM 5,000 per metric ton, farm is income will be reduced to RM 56,734.

Abiedu (2010), conducted a study on application of linear programming techniques in the effective use of resources for staff training in the Ghanaian polytechnics. The study employed the application of linear programming in the area of personnel management in minimizing the cost of staff training.

The method gave an integer optimum solution to all the models formulated. The study recommends to the management of Koforidua Polytechnic, the number of staff (Junior and Senior) training in the academic and non-academic departments of the institution to be sent for training programmes when there is the need.

Bassey (2012), conducted a study on the application of Linear programming model in manufacturing firm: A case of Ushie table water Bekwarra Local Government Area, Cross Rivers State. The aim of the study was to determine the applicability of linear programming to the problem of allocating scarce resources among two different products or product mix problem. In line with the objectives of this study the graphical method was used to determine the best production mix of the variables to make optional profit. It was proved that linear programming can be applicable to real life situation, and that it help to minimize losses as a result of wrong combination. The paper recommended the use of linear programming in other firms that are facing allocation problems.

METHODOLOGY

Techniques for Accomplishing the Stated Objectives

To accomplish the stated objectives, the researcher must evaluate the relevant data to aid our position. This study made use of secondary data obtained from the management of the farm.

The available record shows that Songhai farm has 20 hectares for growing pineapples and plantain. The management of the farm have to decide how much of each

to grow. The cost per hectare for pineapples is given as N30 ('000) and N20 ('000) for plantain. They have budgeted N480 ('000).

Pineapples requires 1 man-day per hectare and plantain requires 2 man-day per hectare. There are 36 man-days available.

The profit on pineapples is N100 ('000) per hectare and on plantain N120 ('000) per hectare. Our objective here is to find the number of hectares of each crop songhai farm should sow to maximize profit.

Calculation

The problem is formulated as a linear programming problem:

(a) Unknowns

X = number of hectares of pineapples,

y = number of hectares of plantain.

(b) Constraints

Land $x + y \leq 20$

Cost $30x + 20y \leq 480$

Manpower $X + 2y \leq 36$

(c) Profit

$P = 100x + 120y$

Maximize $P = 100x + 120y$

Subject to $x + y \leq 20$

$30x + 20y \leq 480$

$X + 2y \leq 36$

$X > 0$

$Y \geq 0$

The feasible region is identified by the region enclosed by the five inequalities as shown below. The profit lines are given by

$P = 100x + 120y$

and again you can see that C increases as the line (shown dotted) moves to the right. Continuing in this way, the maximum profit will occur at the intersection of

$x + 2y = 36$ and $x + y = 20$

Maximize $P = 100x + 120y$

Subject to $x + y \leq 20$

$30x + 20y \leq 480$

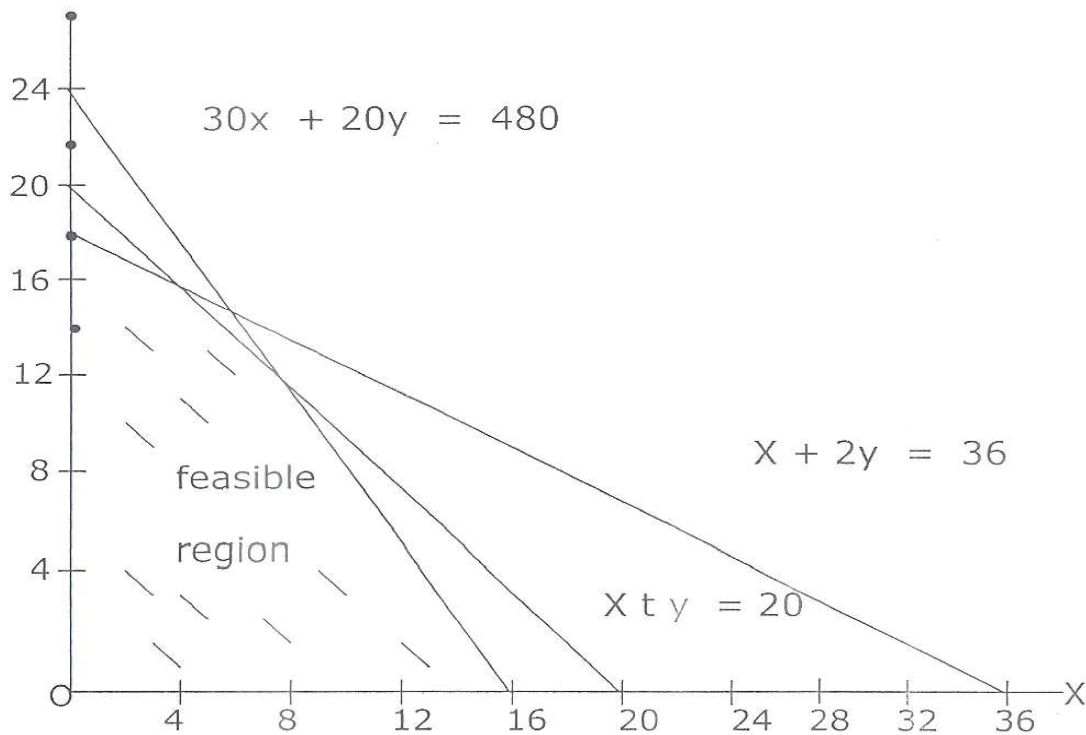
$X + 2y \leq 36$

$X \geq 0$

$y \geq 0$

Mono Product Quantifies (MPQS)

	X	y
FC ₁	20	20
FC ₂	16	24
FC ₃	36	18



$$P_D = 100(16) + 120(0)$$

$$= 1600$$

Optimal configuration

4 units of x and 16 units of y.

This implies that the maximum profit is N2,320,000.

Songhai farm should therefore show 4 hectares with pineapples and 16 hectares with plantain.

Discussion on Theoretical Framework

The graphical method of linear programming is appropriate for this study. This is because there are two decision variables; sowing of pineapples and sowing of plantain. Generally the graphical method can be used to solve any linear programming problem having only two decision variables.

Besides, graphical method of linear programming was suitable because, the researcher was able to translate the available data into a linear programming problem by firstly identifying the unknowns, the constraints and then the objective function. Hence he was able to determine the maximum profit.

Whilst, the graphical method of linear programming is convenient to apply, it is clearly not perfect. Besides, it is not ideal when the decision variables are more than two.

However, the graphical method of linear programming is useful in the optimal allocation of scarce resources, especially when the decision variables are two.

Gap in the Review Literature

The reviewed literature extensively emphasized on the use of mathematical programming models for solving the problem of resource allocation without giving cognizance to human and environmental factors.

Besides, the models found in the literature are based on certain assumptions such as one objective, additivity etc, hence the models are over-simplified and are not intended for complex problems with many decision variables.

CONCLUSION

Linear programming is a powerful technique for aiding managerial decision making for certain kinds of problems. The basic approach is to formulate a mathematical model called a linear programming model to represent the problem and then to analyze this model.

Any linear programming model includes decision variables to represent the decision to be made, constraint to represent the restrictions on the feasible values of these decision variables and an objective function that expresses the overall measures of performance for the problems. This study examined the application of linear programming in Songhai farm. From the result of the study, it can be seen that the graphical method of linear programming can be used when the decision variables are two.

The graphical method can be used to solve a linear programming model having just two decision variables. This method provides consideration insight into the nature of linear programming models and optimal solution.

RECOMMENDATIONS

Linear programming which is a method of allocating resources in an optimal way. It has been used successfully as a decision making aid in all industries and in financial and service organization.

Problems with three variables also can be graphed, but three dimensional graphs quickly become cumbersome. Problems with more than three variables cannot be graphed. Most real world problems contain numerous objective criteria and resources, so they are too complicated to represent with only two or three variables. Thus, for all practical purposes, with complex nature the simplex method should be applied. The underlying concepts are geometrical, but the solution algorithm, developed by George Dantzig in 194, is an algebraic procedure.

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