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A Linear Goal Programming Model to Multiple Objectives in Arable Farm Planning

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ABSTRACT
Other than profit maximization or cost minimization, farmers have a variety of other goals that may conflict with each other to achieve. Less attention has been paid to including these other goals in management models. A mix farm was modeled in this study utilizing the Lexicographic linear goal programming approach.Different crops, land allotment at each stage of farm growth, the number of seedlings and their cost, and the farming seasons were all taken into account and put into the model. The activities and requirements for the production of the farm products, such as the costs (purchase cost of the seedlings for each of the produce, Clearing of bush costs, Costs of Cultivating, Costs of Planting, Costs of Weeding, Costs of Harvesting, Costs of Processing, Costs of Transport/Logistics, Revenue generated from Sales, Total Costs and Total Profits, etc.) were included. In order to create objectives and link target goals to them, linear programming models were created for each of the aforementioned criteria.The targets for each of the developed objective goals were expressed based on the developed objective goals, and they were then turned to restrictions by adding deviational variables from the target values. The precise deviational variables included in the goal programming model were determined by examining the goals. These were assigned a pre-emptive priority and their importance was sorted in order.The Goal Programming model was created as a result. The model was then put to the test on a real-world farm situation, and the results showed that a compromise solution was reached.

Keywords: *Goal programming, Arable farming, Linear programming, compromised solution.*

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I. Introduction

Concerns about the imminent prospect of food crises have arisen during the past few years in numerous nations, including Nigeria (Attah, 2012). Low yields resulting from inefficient production processes caused by technical and allocative inefficiencies, insufficient agricultural investments, inappropriate and labor-intensive agricultural technology, and poor prioritization of farm objectives have all become symptoms of declining farm productivity.

With a population of over 130 million, Nigeria is the most populous country in Africa. Its domestic economy is dominated by agriculture, which accounts for over 40% of the country's Gross Domestic Product (GDP) and two-thirds of its labor force. According to research, mixed agricultural systems are the foundation of much of Nigeria's agriculture since they provide the majority of the population with food, raw resources, and a means of subsistence.

According to published figures, Nigeria is the most populous nation in Africa, home to more than 130 million people, with an agriculture-dominated domestic economy that accounts for 40% of GDP and 60% of the labor force. Onyagede tribe in the Ohimini local government areas of Nigeria's Benue Stateis a hub for the commerce of yams, cassava (manioc), corn, and other agricultural commodities. Concerns have also been expressed regarding the possibility of a food crisis in Nigeria. The low yield of farm products is a result of labor-intensive agricultural technology, technical and allocational inefficiencies, and poorly prioritized farm goals.

Although the need for food and the vast population are clear, mix farming necessitates the best use of the limited resources available. Mix Farming planning issues are quite complicated (Hazell and Norton, 1986). Along with producing various crops, farmers also have a range of methods from which to pick. The most prevalent multiobjective models were profit, risk, and sustenance (e.g., Brink and McCarl (2021).

In order to increase production and get the maximum yield out of limited resources, farming necessitates numerous decision-making procedures. Farmers have a variety of goals to pursue in addition to profit maximization or cost reduction.

However, numerous reviews have been written on the use of linear programming and goal programming in farming systems, including those by Kelechi Igwe (2013), Godlove Shu (2008), Peter et al (2013), Okpanachi, et al (2022), and many others.

In order to address issues with agricultural land allocation in India, Sharma Dinesh (2016) conducted a survey on fuzzy goal programming. In their study, Ibrahim and Omotesho (2011) identified the ideal company combination for vegetable production under Fadama in north central Nigeria. A LP model was also developed by Kaur et al. (2010) to recommend the ideal cropping strategy for maximizing net returns and assuring significant groundwater savings in Punjab, Pakistan. By utilizing the LP approach, Abdelaziz et al. (2010) in North Darfur State, Sudan, were able to produce the ideal crop pattern.In order to help small-holder farmers in Nigeria's Driver Savannah zone achieve their most crucial aim of feeding their families all year round, Adejobi et al. (2003) created a linear goal programming model for the best crop combinations under constraints of limited resources. For irrigation agriculture, Latinopoulos et al. (2005) developed a goal programming paradigm. Goal programming was used by Vivekandan et al. (2009) to improve the agricultural pattern for various areas. A linear programming model was created to predict the allocation of land to maximize farm productivity. Sofi et al. (2015) used the simplex technique to identify the solution.In their study, Tanko and Baba (2002) investigated how small-scale farmers who depend on arable crops used the resources available to them during the 2009 agricultural season in Niger State, North Central Nigeria. For the objective of selecting the ideal crop mix to maximize income, Phillip et al. (2019) applied linear programming to farm data obtained from 120 smallholder farmers in the 2017–18 cropping season in agricultural zone 4 (AZ4) of Adamawa state, Nigeria. Francis et al. (2021) create prototype farm plans based on the multi-objective production objectives of small-scale arable crop farmers in Nigeria's Kogi State. In the Nigerian Kwara State LGAs of Moro and Irepodun, Adewumi (2018) determined the best production schedules for farmers who grow cassava as a crop.Igwe and Onyenweaku (2013) used the linear programming technique on farms to maximize the gross margin from different combinations of arable crops and chosen animal companies. The ideal production strategy for farmers in Nigeria's Niger State growing maize-based crops was discussed in et al. (2019). Because the objectives were incommensurable, Orumie et al. (2022) used the Lexicographic linear goal programming approach to model a fish farm. A model for managing nutrients in rice production was utilized by Ghosh et al. Senegalese Subsistence Farms were the subject of a Goal Programming via Multidimensional Scaling application by Barnett, Douglas, et al. in 1982.

Additionally, a number of studies have been applied to natural resource planning (Romero, 1986), design of cattle rations (Rehman and Romero, 1984, 1987), and issues with sugar beet fertilizer combination (Minguez, 1988).

Due of the incomparability of the objectives, a farm will be modelled un this study utilizing the Lexicographic linear goal programming approach. All of the mixed farming strategies for various crops will be taken into consideration in the study. Production of farm products, realizing a specific rate of return on investment, effective resource allocation, accumulating financial income, spending on labor, yields, risks, operating profit, machine utilization, and using all available land for cultivation are the multi-objective goals that must be incorporated into the models that will be developed.

II. Methodology

Schniederjans and Kwaks (1982a) referred to the most commonly applied type of goal programming as "pre-emptive weighted priority goal programming". A generalized model for this type of programming is as follows:

minimize: $\mathbf{Z}=\sum_{i}^{m} w_i p_i (d_i^- + d_i^+)$ (1)

such that

$$\sum_{j}^{n} a_{ij} x_{ij} + d_i^- - d_i^+ = b_i \qquad (i = 1,2,...,m), \qquad (2)$$

$$x_{ij}, d_i^-, d_i^+ \geq 0, w_i > 0 \quad (3)$$

$$(i = 1,2,...,m: \quad j = 1,2,3...,n) \quad (4)$$

The farmer aims to avoid underutilizing labor and resources, reduce costs, increase sales income, and maximize profit.

The following provides information on the variables and objective functions that represent the different performance criteria:

2.1. Parameters and Variable Notations with Objective Functions

i = The type of crop i (i = 1, , n)
pi = The unit profit from ith produce
P = Total profit (Target Profit)
l = The type of labour (l = 1, , n)

L = Total available labour
L_k = The labour capacity required for ith produce
f = The type of fertilizer (f = 1, , F)
F = Total amount of accessible fertilizer, herbiside, pesticide, germicide
D = Land capacity
t_i = cost of transportation of produce i to market
T= total cost of transportation
P_i= profit per produce
P= Total profit
q_i = processing cost for ith product
Q = total processing cost

The model takes the following standards into account:
Cost of farming from planting to harvest, Required seedlings (resource usage), Seed cost type and crop type income from sales realized profit employment of labor, Shipping and receiving
Therefore, reduce production costs and resource usage are crucial criterion. maximize your use of labor, your use of land, your sales income, and your profit.

The above are stated as follows:

2.2 Multi-Objectives In A Farm Formulation

Farmers frequently do have many goals that are geared at meeting their diverse interests. Farmers, nevertheless, will undoubtedly desire to advance, endure, and enjoy security within their operational environment.
As a result, we take into account a variety of (different) farming goals while utilizing the farm's current infrastructure. The management intends to prevent underutilizing labor and resources, reduce costs, increase sales revenue, and maximize profit.
The following provides information on the variables and objective functions that represent the different performance criteria:
Minimize Production cost

$$\sum_{i}^{n} c_i x_i = C \quad . \quad . \tag{5}$$

Maximize Revenue

$$\sum_{i}^{n} R_i x_i = S \tag{6}$$

Resource Utilization (Fertilizer and pesticide).

$$\sum_{i}^{n} a_i x_i = A \tag{7}$$

$$\sum_{i}^{n} d_i x_i = D \tag{8}$$

Labour Utilization/weeding/clearing of bush

$$\sum_{i}^{n} l_i x_i = L \tag{9}$$

Maximize Profit

$$\sum_{i}^{n} p_i x_i = P \tag{10}$$

2.3 Model Formulation (Gp Model) For The Above Equations

2.3.1 Maximum Land Utilization

This is done to ensure that the crops don't utilize above the designated capacity limit (LAND). The objective of reducing the under- and overuse of the Land can be summed up as:

Min $d_1^+ + d_1^-$

s.t

$$\sum_{k}^{n} d_k x_k + d_1^- - d_1^+ = D \tag{11}$$

where
D is availab1e capacity of Lands (goal)
d_1^- is underutilization of Lands
d_1^+ is overutilization of Lands

2.3.2 Minimize purchase Cost/ Resource Utilization (cost of seedling/cost of seedling)
Min(d_2^+)
s.t

$$\sum_{k}^{n} a_k x_k + d_2^- + d_2^+ = A \qquad (12)$$

where,
d_2^- is under expenses on purchase / fertilizer
d_2^+ is over expenses on purchase / fertilizer

2.3.3Minimize Cost of Preparation/ labour cost
Mathematically, the goal constraints of preparation costs:

$$\sum_{i}^{n} l_i x + d_v^- - d_v^+ = L \quad :\text{v}=3, 4, \ldots \text{s}$$

The goal of minimizing the preparation cost for the ith crop type is represented as
Min d_v^+
s. t

$$\sum_{i}^{n} l_i x + d_v^- - d_v^+ = L \qquad (13)$$

where
d_v^- is underspending during farmingpreparation goal
d_v^+ is overspending during farming preparation goal

2.3.4Minimize Cost of Processing
. Mathematically, the goal constraints of precessing costs:

$$\sum_{i}^{n} q_i x + d_{s+1}^- - d_{s+1}^+ = Q$$

The goal of minimizing the production cost for the ith produce type is represented as
Min d_{s+1}^+
s. t

$$\sum_{i}^{n} q_i x + d_{s+1}^- - d_{s+1}^+ = Q \qquad (14)$$

where
d_{s+1}^- is underspending during processing goal
d_{s+1}^+ is overspending during processing goal

2.3.5 Minimize Transportation goal
. The goal of minimizing the production cost for the ith type is represented as

$$\sum_{i}^{n} t_i x + d_{s+2}^- - d_{s+2}^+ = T$$

And the deviational variable to include becomes
Min d_{s+2}^+
s. t

$$\sum_{i}^{n} t_i x + d_{s+2}^- - d_{s+2}^+ = T \qquad (15)$$

where
d_{s+2}^- is underspending on transportation
d_{s+2}^+ is overspending on transportation

2.3.6 Maximize Sales Revenue

Thus the goal is to minimize underachievement of the target, and it is represented thus:

Max d_{s+3}^{+}

s.t

$$\sum_{i}^{n} S_i x_i - d_{s+3}^{-} + d_{s+3}^{+} = S \qquad (16)$$

where

d_{s+3}^{-} is underachievement of the sales revenue goal

d_{s+3}^{+} is over achievement of the sales revenue goal.

2.3.7 Minimize total cost

. The goal of minimizing the production cost for the ith fish type is represented as

Min d_{s+4}^{+}

s. t

$$\sum_{i}^{n} C_i x + d_{s+4}^{-} - d_{s+4}^{+} = C \qquad (17)$$

where

d_{s+4}^{-} is underspending during farming goal

d_{s+4}^{+} is overspending during farming goal

2.3.8 Maximize Profit

This goal can be represented as

$Min\ d_{s+5}^{-}$

s. t

$$\sum_{k}^{n} p_i x_k + d_{s+5}^{+} - d_{s+5}^{-} = P \qquad (18)$$

where

d_{s+5}^{+} is overachievement on the profit target

d_{s+5}^{-} is underachievement on the profit target

Equation (11) to (l8) represent the Farmers goal.

2.4 Goal Priority Structure

A good priority structure reflects management choices in a hierarchical representation of the target priorities. Problem with rigid constraint should be designed as a goal in a way that it is being minimized and given high priority in the achievement function.

However, depending on the preferences that the management listed, a goal prioritization structure must be createdand which are described below:

P_1guarantees that the expenditures associated with clearing brush, cultivating land, planting, weeding, and harvesting are kept to a minimum.

P_2make sure to limit the underutilization of resources and land.

P_3 ensures that sales target is met

P_4ensure that the purchase cost target is fulfilled and that total cost overruns are kept to a minimum.

P_5make sure that the entire profit, processing expenses, transportation costs, and logistics costs are not breached.

As a result, the farm model's lexicographic goal is to minimize departures from various management-imposed objectives.

Thus;Min.

$$Z = P_1(d_v^{+}), P_2\,(d_1^{+} + d_1^{-}), P_3(d_{s+3}^{-}), P_4(d_2^{+}, d_{s+4}^{+}), P_5\,(d_{s+1}^{+}, d_{s+2}^{+}, d_{s+4}^{-})$$

S.t

Eqn (11) to (18) holds. hcAll variable are non-negative

III. Application Of The Formulated Model To A Farm/Data Collection

The study was carried out in a specific PLOT of farmland owned by the Onyagede tribe in the Ohimini local government areas of Nigeria's Benue State. The state's topography and climate make it ideal for growing a variety of arable crops, such as cassava, yam, maize, and sorghum, as well as millet, vegetables, rice, citrus fruits, palm produce, vegetables, and animals, earning Benue State the title of "Food Basket of the Nation.".

Their primary occupations outside of the Civil Service are farming and trading.

The information in the table below was taken from a farmer's prior farm records in 2021 at a specific farm in the state of Ohimini Benue. The mixed farming system problem, which involves eight different crops—cassava, yam, maize corn, cowpea, pigeon peas, Guinea corn, groundnut, and vegetables—is taken into account in the modeling.

The requirements, land distribution throughout each stage of farm growth, number of seedlings and associated costs, and criteria throughout farming eras are outlined in the table below (costs)

The farm produce is produced according to the activities and requirements listed in rows one through twelve, while the produce itself is listed in columns according to those requirements. For instance, the sort of agricultural food grown is shown in table 1's row 1. The amount of land allotted to each type of farm produce is shown in Row 2. The buying price of the seedlings for each of the produce is shown in Row 3. The rows corresponding to serial numbers three through twelve on the same table show the costs associated with clearing of brush, cultivating, planting, weeding (in four phases), harvesting, processing, transport/logistics, sales income earned, total costs, and total profits.The last column of the same table lists the availability of the aforementioned prerequisites.

Sales revenue is generated by converting the produce to monetary value by converting processed cassava floor from basins, tubers of yams, wheelbarrows of corn,and so on.

Total costs is obtaind by summing every other costs, whereas total profit is total sales minus total costs.

Table1: Activities in the farm

S/N	**Farm Produce** **Activities**	Groundnut	Cassava	Yam	Maize	Guinea Corn	Pigeon pea	Millet	Sorghum	Sign Of Const	Target Value
1	Land	1	1	1	0.5	0.5	1	0.5	0.5	=	6 plots
2	Purchase cost	1000	3,000	35,000	500	1000	1000	500	500	<=	42,500
3	Clearing of bush	2500	2500	2500	1250	1250	2500	1250	1250	<=	15,000
4	Cultivating	5833	5831	5500	3000	3000	5833	3000	3000	<=	35,000
5	Planting	1800	1800	2400	1000	1000	2000	1000	1000	<=	12000
6	Weeding 1-3 stages	6000	5000	5000	3500	3500	6000	3500	3500	<=	36,000
7	Harvesting	2500	3500	5500	1500	1500	3500	1500	1500	<=	21000
8	Processing		25,000							<=	25,000
9	Transport/ logistics	8000	8000	7000	2000					<=	25,000
10	Sales revenue	45,000	24basin 120,000	100 tubers @1,600 =160,000	5wheel @5000 25,000	17,000	31,000	21500	18000	>=	437,500
11	Total cost= 2+…+9	27,633	54,631	62,900	10000	9000	20,833	10750	10750	<=	210530
12	Total Profit = 10-11	20,367	68,369	99,100	12,500	8000	10167	10250	7250	>=	226,970

3.2 Formulation Of The Objectives

Let x_i be farm produce type such that i=1, 2, 3, . . . , 8, where ;

x_1 is Grandnut

x_2 is Cassava

x_3 is yam

x_4 is maize

x_5 is guinea corn

x_6 is pigeon pea

x_7 is millet

x_8 is sorghum

Then, from the table 2 above, the goal target for each of the objectives becomes

$x_1 + x_2 + x_3 + 0.5x_4 + 0.5x_5 + x_6 + 0.5x_7 + 0.5x_8$ <=6(Land goal (plots))

$1000x_1 + 3000x_2 + 35000x_3 + 500x_4 + 1000x_5 + 1000x_6 + 500x_7 + 500x_8$ <=42,500 (purchase cost (₦))

$2500x_1 + 2500x_2 + 2500x_3 + 1250x_4 + 1250x_5 + 2500x_6 + 1250x_7 + 1250x_8 <$ =15000 (clearing const (₦)$5833x_1 + 5831x_2 + 5500x_3 + 3000x_4 + 3000x_5 + 5833x_6 + 3000x_7 + 3000x_8 <$ =35000

(cultivating cost constraints (₦))
$1800x_1 + 1800x_2 + 2400x_3 + 1000x_4 + 1000x_5 + 2000x_6 + 1000x_7 + 1000x_8$ <=12000
(planting cost constraints (₦))
$6000x_1 + 5000x_2 + 5000x_3 + 3500x_4 + 3500x_5 + 6000x_6 + 3500x_7 + 3500x_8 <= 36,000$
(weeding cost constraints (₦)
$2500x_1 + 3500x_2 + 5500x_3 + 1500x_4 + 1500x_5 + 3500x_6 + 1500x_7 + 1500x_8$ <=21,000
(Harvesting cost constraints (₦))
$25000x_1$ <= 25000(processing cost goa constraints l (₦))
$8000x_1 + 8000x_2 + 7000x_3 + 2000x_6$ +<= 25000 (transport/ logistics cost goal constraints (₦))
$45,000x_1 + 120,000x_2 + 160,000x_3 + 25,000x_4 + 17,000x_5 + 31,000x_6 + 21,500x_7 + 18000x_8 =$ >437500
(sales revenue goalconstraints (₦))
$24,663x_1 + 51,631x_2 + 60,900x_3 + 12,500x_4 + 9000x_5$+$20833x_6 + 10,750x_7 + 10,750x_8$ <=201030
(total costs goal constraints (₦))
$20367x_1 + 68,369x_2 + 99,100x_3 + 12,500x_4 + 8,000x_5 + 10,167x_6 + 10250x_7 + 7250x_8$ =>236,003
(total bprofit goal constraints (₦))
$x_1, x_2, x_3, x_4, x_5, d_i^-, d_i^+$>=0

From the above model, the goal for each of the objective according to the management of the farm is represented in table 2 below

Table 2Summary of the goal targets for each of the objectives with priorities

		Target	Constraints Signs	**Deviational var to min**	**Priority level**
1	Land goal	6plots	=	$d_1^- + d_1^+$	P_2
2	Purchase cost goal	#42,500	<=	d_2^+	P_4
3	Clearing of bush goal	#15,000	<=	d_3^+	P_1
4	Cultivating goal	#35,000	<=	d_4^+	P_1
5	Planting goal	#12,000	<=	d_5^+	P_1
6	Weeding1-3 goal	#36,000	<=	d_6^+	P_1
7	Harvesting goal	#21,000	<=	d_7^+	P_1
8	Processing goal	#25,000	<=	d_8^+	P_5
9	Transport/logistics goal	#25,000	<=	d_9^+	P_5
10	Sales revenue goal	#437,500	>=	d_{10}^-	P_3
11	Total cost goal	#201,030	<=	d_{11}^+	P_4
12	Total Profit goal	#236,003	>=	d_{12}^-	P_5

From the table we have that :
Min.

$$Z = P_1(d_3^+, d_4^+, d_5^+, d_6^+, d_7^+), P_2\,(d_1^+ + d_1^-), P_3(d_{10}^-), P_4(d_2^+, d_{11}^+), P_5\,(d_8^+, d_9^+, d_{12}^-)$$

S.t
$x_1 + x_2 + x_3 + 0.5x_4 + 0.5x_5 + x_6 + 0.5x_7 + 0.5x_8 + d_1^- - d_1^+ = 6$
$1000x_1 + 3000x_2 + 35000x_3 + 500x_4 + 1000x_5 + 1000x_6 + 500x_7 + 500x_8 + d_2^- - d_2^+$ =42,500
$2500x_1 + 2500x_2 + 2500x_3 + 1250x_4 + 125x_5 + 2500x_6 + 1250x_7 + 1250x_8 + d_3^- - d_3^+$ =15000
$5833x_1 + 5831x_2 + 5500x_3 + 3000x_4 + 3000x_5 + 5833x_6 + 3000x_7 + 3000x_8 + d_4^- - d_4^+$ =35000
$1800x_1 + 1800x_2 + 2400x_3 + 1000x_4 + 1000x_5 + 2000x_6 + 1000x_7 + 1000x_8 + d_5^- - d_5^+$ =120000
$6000x_1 + 5000x_2 + 5000x_3 + 3500x_4 + 3500x_5 + 6000x_6 + 3500x_7 + 3500x_8 + d_6^- - d_6^+ = 36,000$
$2500x_1 + 3500x_2 + 5500x_3 + 1500x_4 + 1500x_5 + 3500x_6 + 1500x_7 + 1500x_8 + d_7^- - d_7^+$ =21,000
$25000x_1 + d_8^- - d_8^+ = 25000$
$8000x_1 + 8000x_2 + 7000x_3 + 2000x_6 + d_9^- - d_9^+ = 25000$
$45,000x_1 + 120,000x_2 + 160,000x_3 + 25,000x_4 + 17,000x_5 + 31,000x_6 + 21,500x_7 + 18000x_8 + d_{10}^- - d_{10}^+ = 437500$
$24,663x_1 + 51,631x_2 + 60,900x_3 + 12,500x_4 + 9000x_5$+$20833x_6 + 10,750x_7 + 10,750x_8x_8 + d_{11}^+ - d_{11}^-$ =201030
$20367x_1 + 68,369x_2 + 99,100x_3 + 12,500x_4 + 8,000x_5 + 10,167x_6 + 10250x_7 + 7250x_8 + d_{12}^- - d_{12}^+$ =236,003
$x_1, x_2, x_3, x_4, x_5, d_i^-, d_i^+$>=0

IV. Data Analysis/Results Output

The TORA 2007 software is used to examine the goal programming model in the order of highest priority to lowest priority, as illustrated below.
Thus,
Min.

$$Z = P_1(d_3^+, d_4^+, d_5^+, d_6^+, d_7^+)$$

S.t

$x_1 + x_2 + x_3 + 0.5x_4 + 0.5x_5 + x_6 + 0.5x_7 + 0.5x_8 + d_1^- - d_1^+ = 6$

$1000x_1 + 3000x_2 + 35000x_3 + 500x_4 + 1000x_5 + 1000x_6 + 500x_7 + 500x_8 + d_2^- - d_2^+ = 42{,}500$

$2500x_1 + 2500x_2 + 2500x_3 + 1250x_4 + 125x_5 + 2500x_6 + 1250x_7 + 1250x_8 + d_3^- - d_3^+ = 15000$

$5833x_1 + 5831x_2 + 5500x_3 + 3000x_4 + 3000x_5 + 5833x_6 + 3000x_7 + 3000x_8 + d_4^- - d_4^+ = 35000$

$1800x_1 + 1800x_2 + 2400x_3 + 1000x_4 + 1000x_5 + 2000x_6 + 1000x_7 + 1000x_8 + d_5^- - d_5^+ = 120000$

$6000x_1 + 5000x_2 + 5000x_3 + 3500x_4 + 3500x_5 + 6000x_6 + 3500x_7 + 3500x_8 + d_6^- - d_6^+ = 36{,}000$

$2500x_1 + 3500x_2 + 5500x_3 + 1500x_4 + 1500x_5 + 3500x_6 + 1500x_7 + 1500x_8 + d_7^- - d_7^+ = 21{,}000$

$25000x_1 + d_8^- - d_8^+ = 25000$

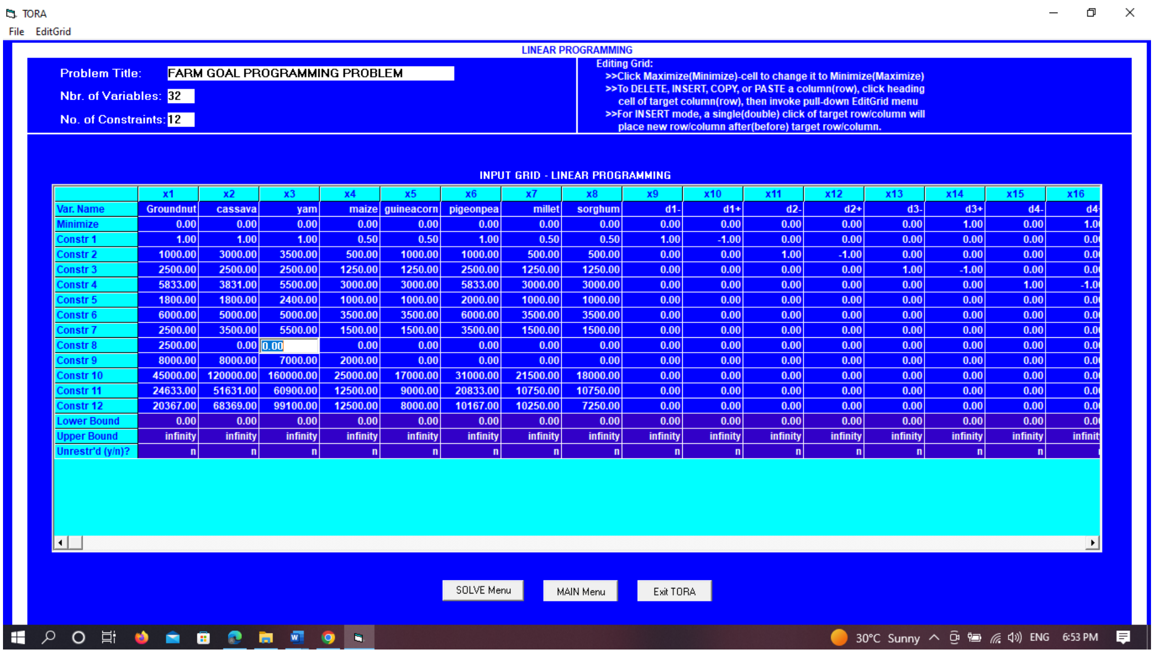
$8000x_1 + 8000x_2 + 7000x_3 + 2000x_6 + d_9^- - d_9^+ = 25000$

$45{,}000x_1 + 120{,}000x_2 + 160{,}000x_3 + 25{,}000x_4 + 17{,}000x_5 + 31{,}000x_6 + 21{,}500x_7 + 1800 + d_{10}^- - d_{10}^+ = 437500$

$24{,}663x_1 + 51{,}631x_2 + 60{,}900x_3 + 12{,}500x_4 + 9000x_5 + 20833x_6 + 10{,}750x_7 + 10{,}750x_8x_8 + d_{11}^+ - d_{11}^- = 201030$

$20367x_1 + 68{,}369x_2 + 99{,}100x_3 + 12{,}500x_4 + 8{,}000x_5 + 10{,}167x_6 + 10250x_7 + 7250x_8 + d_{12}^- - d_{12}^+ = 236{,}003$

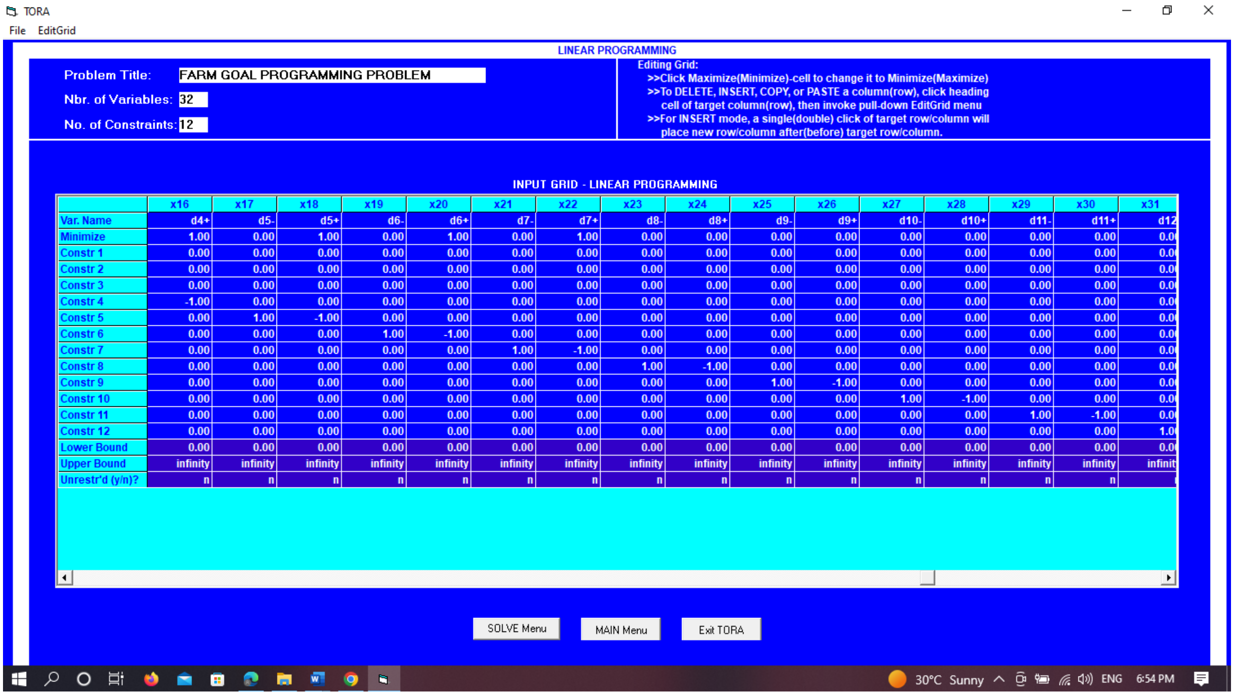
$x_1, x_2, x_3, x_4, x_5, d_i^-, d_i^+ >= 0$



	x1	x2	x3	x4	x5	x6	x7	x8
Var. Name	Groundnut	cassava	yam	maize	guineacorn	pigeonpea	millet	sorghum
Minimize	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constr 1	1.00	1.00	1.00	0.50	0.50	1.00	0.50	0.50
Constr 2	1000.00	3000.00	3500.00	500.00	1000.00	1000.00	500.00	500.00
Constr 3	2500.00	2500.00	2500.00	1250.00	1250.00	2500.00	1250.00	1250.00
Constr 4	5833.00	3831.00	5500.00	3000.00	3000.00	5833.00	3000.00	3000.00
Constr 5	1800.00	1800.00	2400.00	1000.00	1000.00	2000.00	1000.00	1000.00
Constr 6	6000.00	5000.00	5000.00	3500.00	3500.00	6000.00	3500.00	3500.00
Constr 7	2500.00	3500.00	5500.00	1500.00	1500.00	3500.00	1500.00	1500.00
Constr 8	2500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constr 9	8000.00	8000.00	7000.00	2000.00	0.00	0.00	0.00	0.00
Constr 10	45000.00	120000.00	160000.00	25000.00	17000.00	31000.00	21500.00	18000.00
Constr 11	24633.00	51631.00	60900.00	12500.00	9000.00	20833.00	10750.00	10750.00
Constr 12	20367.00	68369.00	99100.00	12500.00	8000.00	10167.00	10250.00	7250.00
Lower Bound	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n

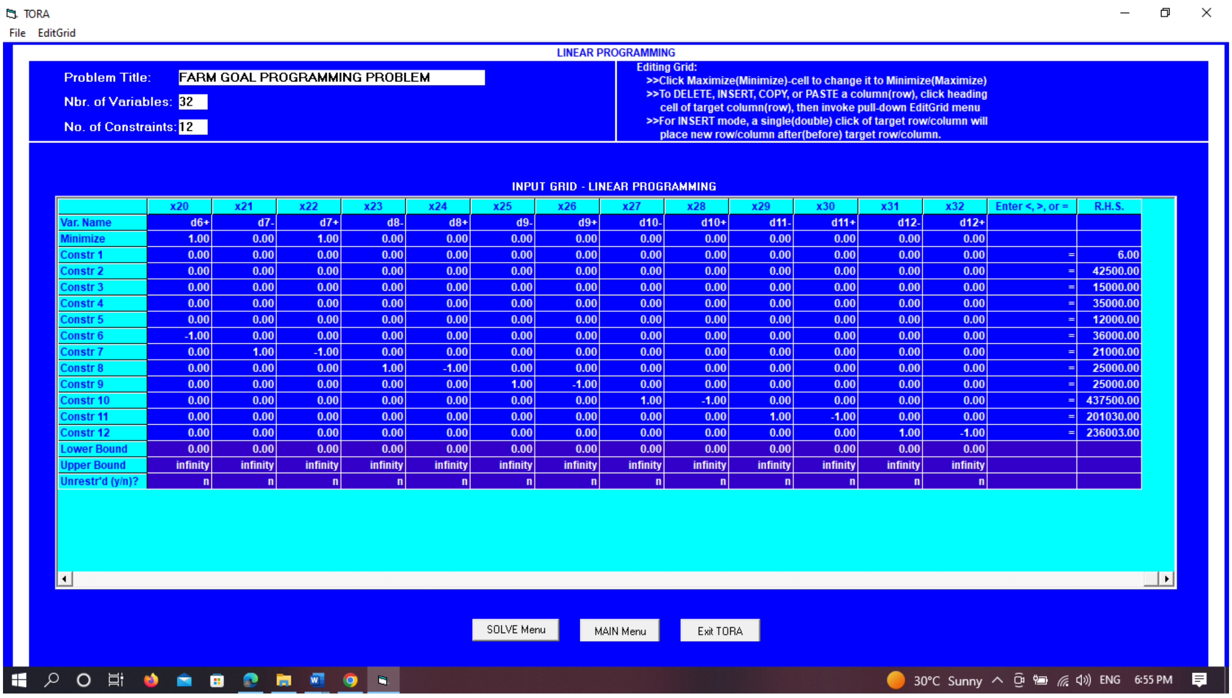
	x9	x10	x11	x12	x13	x14	x15	x16
Var. Name	d1-	d1+	d2-	d2+	d3-	d3+	d4-	d4
Minimize	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.0
Constr 1	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 2	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.0
Constr 3	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.0
Constr 4	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.0
Constr 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Lower Bound	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinit
Unrestr'd (y/n)?	n	n	n	n	n	n	n	

Figure 1. Input data for the goal programming model



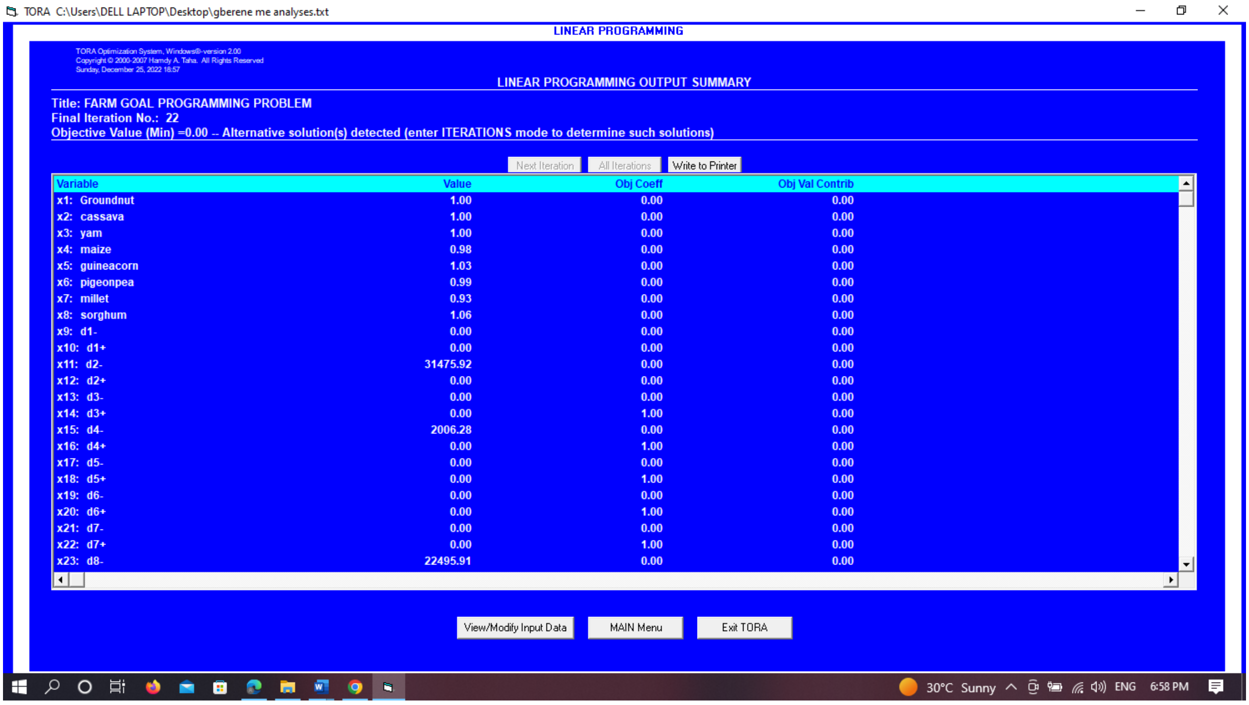
	x16	x17	x18	x19	x20	x21	x22	x23	x24	x25	x26	x27	x28	x29	x30	x31
Var. Name	d4+	d5-	d5+	d6-	d6+	d7-	d7+	d8-	d8+	d9-	d9+	d10-	d10+	d11-	d11+	d12
Minimize	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 4	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 5	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 6	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 7	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Constr 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.0
Constr 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.0
Constr 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.0
Constr 12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.0
Lower Bound	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinit
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	[illegible]

Figure 2. Continuation of Input data for the goal programming model



	x20	x21	x22	x23	x24	x25	x26	x27	x28	x29	x30	x31	x32	Enter <, >, or =	R.H.S.
Var. Name	d6+	d7-	d7+	d8-	d8+	d9-	d9+	d10-	d10+	d11-	d11+	d12-	d12+		
Minimize	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Constr 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	6.00
Constr 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	42500.00
Constr 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	15000.00
Constr 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	35000.00
Constr 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	12000.00
Constr 6	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	36000.00
Constr 7	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	21000.00
Constr 8	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	=	25000.00
Constr 9	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	=	25000.00
Constr 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	0.00	0.00	=	437500.00
Constr 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	0.00	0.00	=	201030.00
Constr 12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	-1.00	=	236003.00
Lower Bound	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity		
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n	n	n	n	n	n		

Figure 3. Continuation of Input data for the goal programming model


TORA C:\Users\DELL LAPTOP\Desktop\gberene me analyses.txt

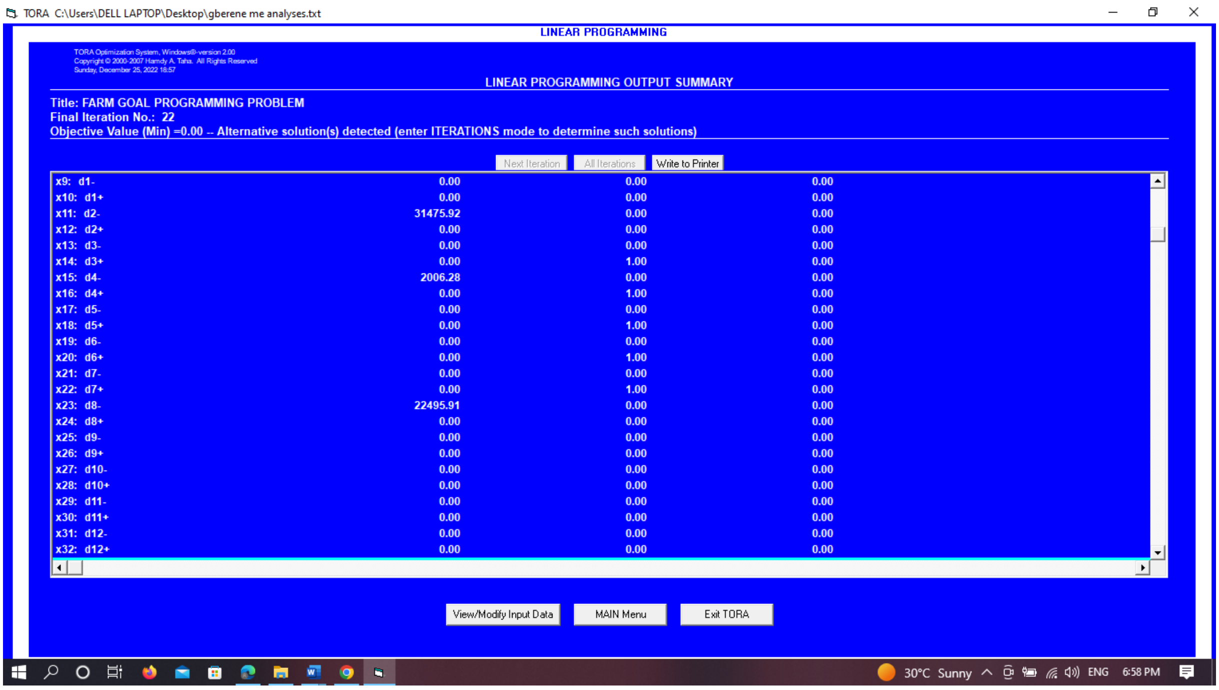
LINEAR PROGRAMMING

LINEAR PROGRAMMING OUTPUT SUMMARY

Title: FARM GOAL PROGRAMMING PROBLEM
Final Iteration No.: 22
Objective Value (Min) =0.00 -- Alternative solution(s) detected (enter ITERATIONS mode to determine such solutions)

Variable	Value	Obj Coeff	Obj Val Contrib
x1: Groundnut	1.00	0.00	0.00
x2: cassava	1.00	0.00	0.00
x3: yam	1.00	0.00	0.00
x4: maize	0.98	0.00	0.00
x5: guineacorn	1.03	0.00	0.00
x6: pigeonpea	0.99	0.00	0.00
x7: millet	0.93	0.00	0.00
x8: sorghum	1.06	0.00	0.00
x9: d1-	0.00	0.00	0.00
x10: d1+	0.00	0.00	0.00
x11: d2-	31475.92	0.00	0.00
x12: d2+	0.00	0.00	0.00
x13: d3-	0.00	0.00	0.00
x14: d3+	0.00	1.00	0.00
x15: d4-	2006.28	0.00	0.00
x16: d4+	0.00	1.00	0.00
x17: d5-	0.00	0.00	0.00
x18: d5+	0.00	1.00	0.00
x19: d6-	0.00	0.00	0.00
x20: d6+	0.00	1.00	0.00
x21: d7-	0.00	0.00	0.00
x22: d7+	0.00	1.00	0.00
x23: d8-	22495.91	0.00	0.00

Figure 4: Result output data for the goal programming priorities


TORA C:\Users\DELL LAPTOP\Desktop\gberene me analyses.txt

LINEAR PROGRAMMING

LINEAR PROGRAMMING OUTPUT SUMMARY

Title: FARM GOAL PROGRAMMING PROBLEM
Final Iteration No.: 22
Objective Value (Min) =0.00 -- Alternative solution(s) detected (enter ITERATIONS mode to determine such solutions)

x9: d1-	0.00	0.00	0.00
x10: d1+	0.00	0.00	0.00
x11: d2-	31475.92	0.00	0.00
x12: d2+	0.00	0.00	0.00
x13: d3-	0.00	0.00	0.00
x14: d3+	0.00	1.00	0.00
x15: d4-	2006.28	0.00	0.00
x16: d4+	0.00	1.00	0.00
x17: d5-	0.00	0.00	0.00
x18: d5+	0.00	1.00	0.00
x19: d6-	0.00	0.00	0.00
x20: d6+	0.00	1.00	0.00
x21: d7-	0.00	0.00	0.00
x22: d7+	0.00	1.00	0.00
x23: d8-	22495.91	0.00	0.00
x24: d8+	0.00	0.00	0.00
x25: d9-	0.00	0.00	0.00
x26: d9+	0.00	0.00	0.00
x27: d10-	0.00	0.00	0.00
x28: d10+	0.00	0.00	0.00
x29: d11-	0.00	0.00	0.00
x30: d11+	0.00	0.00	0.00
x31: d12-	0.00	0.00	0.00
x32: d12+	0.00	0.00	0.00

Figure 5 : Continuation of result output data for the goal programming priorities

V. Result Summary

The result output of this investigations are represented in figures 4 and 5. The result output in figure 4 and 5 were obtained by solving the MOGP developed using TORA 2007 software. Figure5 and 4 show that the first priority goal has been fully attained by minimizing all the deviational variables to zero.Thus the deviational variable $(d_2^-, d_4^- \ and \ d_8^-)(= 31475.92, 2006.28, \ and \ 22495.91 \text{ respectively})$. This implies that the purchase cost, cultivating costs and processing costs can be reduced from ₦42,500, ₦15,000 and ₦25,000 to ₦31475.92, ₦2006.28, and ₦22495.91 respectivelyThis means that the processing fee for cassava floor reduced from the initial cost by ₦2504.09. Also, the total purchase costs for all the produced can be minimized from the initial costs to₦11,024.08.

VI. Conclusions

The outcome indicates that the ideal answer has been found, and the model created is suitable for farms with many aim functions because it lowers all investment expenditures and raises sales, which boosts profit. Additionally, it is believed that the interpretation above will direct management's choices about business expansion.

However, other farmers with multiple resource usage, such as the use of machinery and equipment, and various crop varieties, can apply the created model in their farm management to meet market demand.

Referrences

[1]. Ibrahim F.D., Oformata A.O., Jirgi A.J. And Adewumi A (2019) Optimum Production Plan For Maize-Based Crop Farmers In Niger State, Nigeria Agro-Science Journal Of Tropical Agriculture, Food, Environment And Extension Volume 18 Number 3 Pp. 35-41

[2]. Abdelaziz, H.H., Abdalla, A.A., Abdellatif, M.A. (2010). Optimizing the Cropping Pattern in North Darfur State, Sudan: A Case Study of Dar Elslam District. Journal of Applied Sciences Research, 6(2): 156-164

[3]. Adejobi, A. O., Kormawa, P. M., Manyong, V. M. and Olayemi, J. K. (2003). Optimal crop combinations under limited resources conditions: Application of linear goal programming model to small holder farmers in the drier Savannah Zone of Nigeria. Deutscher Tropentag, Gottingen, Journal of Technological and Institution Innovation for Sustainable Rural Development, 17(1), 8–10.

[4]. Adewumi (2018) Optimum Production Patterns For Cassava-Based Crop Farmers In Irepodun And Moro Local Government Areas Of Kwara State, Nigeria, Ethiopian Journal Of Environmental Studies & Management 11(1): 111 – 122, 2018.

[5]. Attah, A. (2012). Food Security in Nigeria: The role of peasant farmers in Nigeria. African Research Review Journal, 6(4), 45-53.

[6]. Barnett, B. B. & Bruce, A. M. (2010).Goal Programming via Multidimensional Scaling Applied to Senegalese Subsistence Farms. American Journal of Agricultural Economics, 64(4), 720-727.

[7]. Bruck. A and Cheng, M., McCarl, (2021). Climate Change Effects on the U.S. Hog production, 2021 Annual Meeting, August 1-3, Austin, Texas 313966, Agricultural and Applied Economics Association.

[8]. Okpalachi, F., O. O., Likita, T., Faith, I., Adeoluwa, A. (2022) A Goal Programming Approach to Multi-Objective Farm Planning Among Small-Scale Arable Crop Farmers in Kogi State, Nigeria Contemporary Agriculture 71(1-2):117-126. DOI: 10.2478/contagri-2022-0017

[9]. Ghosh, D., Sharma, Dinesh K. and Mattison, D. (2005), ―Goal Programming Formulation in Nutrient Management for Rice Production,‖ International Journal of Production Economics, Vol. 95, No. 1, pp. 1-7.

[10]. Godlove S., Jules, R. M. N. & Ernest, L. M. (2018) Optimal Cropping Sequence in Pluriactive Non-specialised Vegetable Farms in the Northwest Region of Cameroon. International Journal of Agricultural Economics, 3(5), 112-117.

[11]. Hassan, I., Ahmad, B., Akhter M. & Aslam, M. (2005), Use of linear crop model to determine the optimum cropping pattern: A case study of Punjab. Electronic, Journal of Environmental Agricultural and Food Chemistry 4(1), 841 – 850.

[12]. Hassan, I., Raza, M.A., Khan, I.A., & Ilahi, R. (2005). Use of Linear Programming Model to Determine the Optimum Cropping Pattern, Production and Income Level: A Case Study from Dera Ghazi Khan Division. Journal of Agriculture & Social Sciences, 1813-2235/2005/01-1-32-34.

[13]. Hazell, P. B. R., & Norton, R. D. (1986). Mathematical Programming for Economic Analysis in Agriculture. New York: Macmillan Publishing Company.

[14]. Ibrahim, H.Y & Omotesho, O. A. (2011) Optimal Farm Plan For Vegetable Production Under Fadama In North Central Nigeria Trakia, Journal of Sciences, 9(4), 43-49.

[15]. Ignizio, J.. (1976). Goal Programming and Extensions, Lexington, MA: Lexington Books

[16]. Igwe, K. C. Onyenweaku, C. E. & Tanko, L. (2013), A linear programming approach to combination of crop, monogastric farm animal and fish enterprises in Ohafia agricultural zone, Abia State, Nigeria. Global Journal of Science Frontier Research Agriculture and Veterinary Sciences, 3(1), 13 – 25.

[17]. Kelechi Igwe(2013) A Linear Programming Approach to Food Crops and Livestock Enterprises Planning in Aba Agricultural Zone of Abia State, Nigeria. American Journal of Experimental Agriculture, 3(2): 412-431 DOI: 10.9734/AJEA/2013/1609.

[18]. Peter J. Johnson, Pascal A. Oltenacu, Harry M. Kaiser, Robert W. Blake (2013). Modeling Parasite Control Programs for Developing Nations Using Goal Programming, Journal of Production Agriculture, 10.2134/jpa1991.0033, **4**(1), 33-38.

[19]. Phillip, D. O, Peter, E. & Girei1, A. A. (2019) Determination of Optimum Crop Mix Using Linear (LP) Programming among Small Holder Farmers in Agricultural Zone Four of Adamawa State, Nigeria, Asian Journal of Agricultural Extension, Economics & Sociology, 34(2): 1-10.

[20]. Rehman and Romero, (1984, 1987) Goal Programming with penalty functions and livestock ration formula. Agricultural systems. 23 (1987) 117 – 132

[21]. Sharma, D. K. (2016). Fuzzy goal programming for agricultural land allocation problems. Yugoslav Journal of Operations Research, 17(1).

[22]. Sofi, N. A., Ahmed, A., Ahmad, M., & Bhat, B. A. (2015). Decision making in agriculture: A linear programming approach, International Journal of Modern Mathematical Sciences, 13(2), 160-169

[23]. Tanko, L. & Baba, K.M. (2002). Modeling Efficient Resource Allocation Patterns for Arable Crop Farmers In Niger State, Nigeria: A Linear Programming Approach

[24]. Vivekandan et al. (2009)Trophic level of fishes occurring along the Indian coast, J. Mar. Biol. Ass. India, 51 (1) : 44 - 51, January - June 2009.

[25]. Zikhali, P. (2008). Fast Track Land Reform and Agricultural Productivity in Zimbabwe. Environment for Development. Discussion Paper Series EfD DP 08-30.