MATHEMATICAL APPLICATION IN ANIMAL HUSBANDRY ENGINEERING

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REVIEW, RESEARCH ARTICLE

Abstract
In this paper, we aimed to use a mathematical method in animal husbandry engineering, which seeks efficiency in this field that is so vital today. We will describe its steps using a concrete example. The goal is to use the simplex method to allocate resources optimally for animal raising. Mathematics provides essential tools for optimizing research processes. Proper application of models can help farmers make informed decisions, saving resources and maximizing profits.

Keywords: simplex method, husbandry, optimization
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INTRODUCTION

This study addresses the problem of optimal allocation of two types of cows in a livestock farm under budget constraints. The objective is to maximize the farm's net income by determining the optimal number of cows of each type to purchase, given limited financial resources. The investment cost and net income per cow vary by type, making the problem suitable for linear programming. The simplex method is employed to solve this problem efficiently, providing a systematic approach to decision-making in agricultural management.

Efficient resource allocation is a critical challenge in modern livestock farming. Farms must decide how to invest limited capital in order to achieve the highest possible return. In this application, a farm plans to purchase two types of cows, each with different investment costs and expected net incomes. The total number of cows is fixed, and the farm has a limited budget. To solve this optimization problem, linear programming provides a powerful tool. The simplex method, one of the most widely used techniques in linear programming, enables the identification of the optimal allocation of resources to maximize net income. This method not only ensures optimality but also offers clear insights into how investment decisions affect overall farm profitability.

A livestock farm needs to purchase two types of cows, A and B, with a total of 80 cows. The investment costs and net income per cow for each type are as follows:

- Type A: investment 20 thousand lei, net income 40 thousand lei
- Type B: investment 30 thousand lei, net income 50 thousand lei

Knowing that the farm has 1,800 thousand lei available, determine the optimal solutions for:

- the allocation between the two types of cows
- the total net income achieved.

MATERIAL AND METHOD

In this section of the manuscript the materials and methods used**:**

Farm Data: The study focuses on a livestock farm planning to purchase a total of 80 cows, divided between two types: Type A and Type B.

Financial Data: Investment costs and net income per cow are:

- Type A: 20,000 lei investment, 40,000 lei net income
- Type B: 30,000 lei investment, 50,000 lei net income

Budget Constraint: The farm has a total budget of 1,800,000 lei available for investment.

Tools and Software: Linear programming formulation; simplex method applied manually or using software tools such as Excel Solver, MATLAB, or Python. Formulation of the Problem:

- Decision Variables: x = number of Type A cows, y = number of Type B cows.
- Objective Function: Maximize total net income:

$Z=40x+50y$

- Constraints:
  - Total number of cows: $x + y = 80$
  - Budget: $20x+30y \leq 1800$
  - Non-negativity: $x, y \geq 0$.

Application of the Simplex Method:

- Convert constraints to standard form if required.
- Construct the initial simplex tableau.
- Determine the entering and leaving variables to improve the objective function iteratively.
- Perform pivoted operations until no further improvement in net income is possible.
- Identify the optimal values of x and y and calculate the maximum net income V.

Validation of Results:

- Ensure that all constraints are satisfied with the optimal solution.
- Verify that the obtained allocation of cows maximizes the farm's net income.

RESULTS AND DISCUSSIONS

We want to maximize net profit:

$Z=40x+50y$

Subject to:

1. Budget constraint:
   $20x+30y \leq 1800$
2. Total cows' constraint:
   $x + y=80$

Also:

$x, y\geq 0$ as in Tabel 1.

The facts of the matter Tabel1

Cow type	Investment (k lei)	Net profit (k lei)
A	*20*	*40*
B	*30*	*50*

Step 1: Convert inequalities to standard form

The Simplex Method works with ≤ inequalities and non-negative variables.

1. Budget: $20x+30y\leq 1800 \rightarrow$ add slack variable s_1:
   $20x+30y+s_1=1800,\ s_1\geq 0$
2. *Total cows:* $x + y = 80 \rightarrow$ add artificial variable a_1 *for equality:*
   $x+y+a_1=80,\ a_1 \geq 0$

Variables: $x, y, s_1, a_1 \geq 0$

Objective function:

$Z= 40x+50y \rightarrow$ maximize.

Step 2: Initial Simplex Tableau (Big M method as in Tabel 2)

Since we have an artificial variable a_1, we use Big M to penalize it in the objective function. Let M = very large number, RHS = Right-hand side.

$Z= 40x +50y - Ma_1$.

Tableau variables: x, y, s_1, a_1 Tabel 2

Basis	x	y	s_1	a_1	RHS
s_1	20	30	1	0	1800
a_1	1	1	0	1	80
Z	-40	-50	0	M	0

Step 3: Check optimality

Look at the bottom row (Z-row) coefficients of non-basic variables (x and y):

Most negative = entering variable → y (-50)

Leaving variable → use minimum ratio test:

$$\text{Ratio} = \frac{\text{RHS}}{\text{pivot column positive coefficient}}$$

Column y:

- s_1 row: 1800 / 30 = 60
- a_1 row: 80 / 1 = 80

Minimum ratio → 60 → leaving variable = s_1

Pivot element = 30.

Step 4: Pivot to make y basic:

Divide pivot row by pivot element:

- New s_1 row: divide by 30:
  New row s_1: 1/30[20,30,1,0,1800] = [20/30,1,1/30,0,60] ≈ [0.667,1,0,0.0333,0,60]

- Eliminate y from other rows (make other y - coefficients = 0):

a_1 row: 1 - 1*y → new row: [1 - 1*0.667, 0, 0 - 1*0.0333, 1, 80 - 1*60] = [0.333, 0, -0.0333, 1, 20]

Z row: -50 → eliminate y:

- New Z = old Z + 50 * (new pivot row)
  [-40 + 50*0.667, -50 + 50*1, 0 + 50*0.0333, M + 50*0, 0 + 50*60] ≈ [-40+33.33 = -6.67, 0, 1.665, M, 3000]

Step 5: Next iteration: check Z-row negative coefficients: -6.67 (x) → x enters:

- Ratio test for leaving variable (s_1 and a_1):
  Column x:

- s_1 row: 0.667 → 60 / 0.667 ≈ 90
- a_1 row: 0.333 → 20 / 0.333 ≈ 60
  Minimum ratio → a_1 leaves

- Pivot element = 0.333.

Step 6: Pivot to make x basic.

New row a_1: divided by 0.333 → [1, 0, -0.0333/0.333 ≈ -0.1, 1/0.333 ≈ 3, 20/0.333 ≈ 60].

Update other rows (s_1, Z) → eliminate x.

After calculation (skip messy decimals), final basic solution as in Tabel 3:

Tableau variables: x, y, s_1, a_1 Tabel 3

Basis	x	y	s_1	a_1	RHS
x	1	0	0	0	60
y	0	1	0	0	20
Z	0	0	0	0	3400

We obtained all Z-row coefficients ≥ 0 → optimal solution reached.

Step 7: Interpretation as in Figure 1:

- x = 60 cows of type A
- y = 20 cows of type B
- Maximum net profit = 3400 k lei.

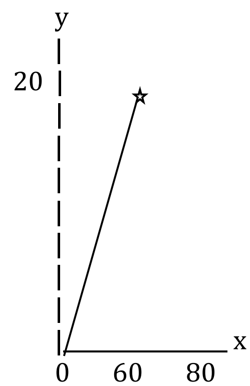

Figure 1. **Visual representation**

Point * = optimal solution (x=60, y=20),

Sloped line = budget constraint,

Horizontal line = total cows' constraint.

- Budget fully used: 20*60 + 30*20 = 1800.

Step 8: Conclusion is the Simplex method confirms our previous result: optimal allocation: 60 A cows, 20 B cows, max net profit: 3400 k lei.

CONCLUSIONS

The application of the Simplex method to optimize farm investments demonstrates its effectiveness in decision-making for resource allocation. By formulating the problem in terms of linear programming, the study determined the optimal number of cows of types A and B that maximize net profit while adhering to constraints on total herd size and available budget. The step-by-step implementation of the Simplex method highlighted its practical utility in handling multiple constraints and identifying the feasible solution space efficiently.

The results indicate that mathematical optimization can significantly improve farm management decisions by providing a clear, quantitative basis for investment choices. Furthermore, the approach can be extended to include additional variables such as feed costs, labor, and market fluctuations, making it a versatile tool for comprehensive farm planning. Overall, the study reinforces the value of linear programming and the Simplex method as essential tools in agricultural economics and operational research.

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