EDUMATSAINS
JURNAL PENDIDIKAN MATEMATIKA DAN SAINS
E-ISSN:2527-7235
Volume 10 Issue. 4, April 2026, pp 328-340
http://ejournal.uki.ac.id/index.php/edumatsains

Determining the Ideal Nutritional Composition for Stunting Management Using the LU Decomposition Method

Santri Chintia Purba[1*], Hildegardis Ningsi Oefunan[2], Putri Artha Tondang[3]

[1,2,3] Pendidikan Matematika FKIP Universitas Kristen Indonesia

email: santri.purba@uki.ac.id

Article Info

Article history:
Received: January 13th, 2026
Revised: April 30th, 2026
Accepted: April 30th, 2026
Available online: April 30th, 2026

https://doi.org/10.33541/edumatsains.v10i4.7789

Abstract

Stunting remains a critical nutritional issue in Indonesia, particularly among children aged 1–3 years, where adequate macronutrient intake is essential for optimal growth and development. This study aims to model nutritional requirements using a system of linear equations and solve it through the LU decomposition method. The model is constructed based on the Recommended Dietary Allowance (RDA/AKG) and the Indonesian Food Composition Table (TKPI), using three variables representing the consumption of chicken eggs, white rice, and soybeans, and three equations representing protein, fat, and carbohydrate requirements. The system is formulated as a 3×3 linear model and solved using LU decomposition through matrix factorization and forward–backward substitution. The results show a unique solution, with values $x_1 = 2.15, x_2 = -8.75, x_3 = 2.26$. Although mathematically valid, the negative value indicates that the model does not fully represent real-world conditions due to the absence of constraints, particularly non-negativity conditions. These findings confirm that LU decomposition is effective for solving linear systems, but its practical application requires integration with constraint-based approaches to ensure feasible and realistic solutions.

Keywords: stunting, linear equations, LU decomposition, numerical analysis, nutritional modeling

1. Introduction

Stunting remains a major chronic nutritional problem in Indonesia and poses significant long-term consequences for the quality of human resources. It is defined as a condition of impaired physical and cognitive growth caused by prolonged malnutrition, resulting in a child's height being below the standard for their age (Anjani et al., n.d.). According to the 2024 Indonesian Nutritional Status Survey (PPN), the national prevalence of stunting was 19.8%, showing a decline from 21.5% in the previous year (Drastita et al., 2026; Paramita et al., 2023).

Efforts to prevent and address stunting require adequate nutritional intake tailored to a child's age and developmental stage, particularly for children aged 1–3 years. During this critical period, rapid physical growth and brain development demand a balanced intake of macronutrients, including proteins, fats, and carbohydrates (Bourre, 2006; Savarino et al., 2021) However, determining an appropriate nutritional composition remains challenging due to limited food variety and the lack of a systematic framework for identifying optimal food combinations.

Mathematically, the problem of determining nutritional composition can be represented as a system of linear equations (Pesti et al., 2009), where variables denote the quantities of food consumption and each equation represents a specific nutrient requirement. This formulation allows for a structured and quantitative analysis of the relationship between dietary needs and food sources. While previous studies have predominantly employed optimization techniques such as linear programming to solve diet problems, limited attention has been given to numerical linear algebra approaches, particularly matrix decomposition methods (Donkor et al., 2023; Ii et al., 1988).

Therefore, this study aims to determine the ideal nutritional composition for children aged 1–3 years by modeling the problem as a system of linear equations and solving it using the LU decomposition method (Golub, 1969; Rafique, 2015). The amazing matrix arises in many interesting problems in the field to solve a lot problem in real world to modelling it into mathematics (Al-kurdi & Kincaid, 2006; Ballarín et al., 2026; Li & Yin, 2020). This research also seeks to highlight the potential and limitations of linear mathematical models in representing real-world nutritional problems. The main contribution of this research is to demonstrate how mathematical approaches, particularly numerical methods, can be utilized to quantitatively model nutritional problems, while also identifying the limitations of unconstrained linear models in producing realistic solutions

2. Methods

This study employs a quantitative approach using mathematical modeling and numerical analysis. The primary objective is to model the problem of determining nutritional composition as a system of linear equations and to solve it using the LU decomposition method. This approach enables a structured and systematic representation of the relationship between nutritional requirements and food composition (Bourre, 2006; Donkor et al., 2023; Paramita et al., 2023; Pesti et al., 2009; Rafique, 2015; Savarino et al., 2021).

The focus of this study is children aged 1–3 years, as this period is characterized by rapid physical growth and brain development, requiring optimal nutritional intake. This research does not address clinical or medical aspects directly; instead, it emphasizes a quantitative approach to determining appropriate nutritional composition through mathematical modeling.

The selection of chicken eggs, white rice, and soybeans is based on methodological considerations and representation of macronutrient needs. Eggs provide animal protein, soybeans provide plant protein and fat, and rice provides carbohydrates as the main energy source.

The selection of these food items is further justified by the availability of complete and consistent nutritional composition data in the Indonesian Food Composition Table (TKPI), allowing for accurate utilization in the mathematical modeling process. In this study, the nutritional variables are limited to three main macronutrients—protein, fat, and carbohydrates—to align with the number of equations used, resulting in order 3×3 system of linear equations with a unique solution that can be solved using the LU decomposition method (Al-kurdi & Kincaid, 2006; Ballarín et al., 2026; Donkor et al., 2023; Golub, 1969; Ii et al., 1988; Li & Yin, 2020; Pesti et al., 2009; Rafique, 2015). These three macronutrient components are considered sufficient to represent the primary aspects of nutritional requirements. Conceptually, other nutritional variables are functionally related to these macronutrients and are therefore implicitly represented within the model. Consequently, the inclusion of additional variables is not expected to fundamentally alter the structure of the solution.

The data used in this study are secondary data obtained from official sources.

1. The study refers to the Peraturan Menteri Kesehatan Republik Indonesia Nomor 28 tahun 2019 concerning the Recommended Dietary Allowance (*Angka Kecukupan Gizi, AKG*), which is used to determine the required energy intake and macronutrient needs for children aged 1–3 years.
   Table1. The Recommended Dietary Allowance (AKG) serves as the baseline reference for constructing the system of equations representing nutritional requirements in this study.

Age Group	Body Weight (kg)	Height (cm)	Energy (kcal)	Protein (g)	Total Fat (g)	Omega-6 Fat (g)	Omega-3 Fat (g)	Carbohydrates (g)	Fiber (g)	Wat (ml)
0–5 months	6	60	550	9	31	4,4	0,5	59	0	700
6–11 months	9	72	800	15	35	4,4	0,5	105	11	900
1–3 years	13	92	1350	20	45	7	0,7	215	19	1150
4–6 years	19	113	1400	25	50	10	0,9	220	20	1450
7–9 years	27	130	1650	40	55	10	0,9	250	23	1650

Source: National Food Agency (2019).

2. The Indonesian Food Composition Table published by the National Food Agency, is used to obtain data on the protein, fat, and carbohydrate content of commonly consumed food items.

Table 2. The Indonesian Food Composition Table for children aged 1–3 years (per 100 g of edible portion) serves as the reference for determining the nutritional values of each food variable included in the mathematical model.

Food ingredient	Protein (g)	Fat (g)	Total carbohydrates (g)
Tuna	25.76	0.27	1.93
Milkfish	21.59	5.59	1.74
Tuna	23.91	0.42	3.26
Beef	22.51	0.30	3.95
Chicken Eggs	11.94	7.69	7.03
Soybeans	33.22	13.26	38.08
Rice (white/glutinous)	10.34 – 9.24	0.39 – 0.19	77.59 – 79.87
Potatoes	2.05	0.02	17.39
Sweet Potatoes	2.09	0.78	24.03
Sago	0.32	0.25	85.58
Green Mustard	3.09	0.59	3.46
Green Beans	1.41	0.22	4.29

Source: National Food Agency (2019).

The variables in this study consist of dependent and independent variables. Dependent variables are the nutritional requirements of children aged 1–3 years, including protein, fat, and carbohydrate intake. Independent variables are the quantities (portions) of food items used as sources of nutrients.

The data serve as the basis for developing the mathematical model and conducting simulation-based calculations, without direct field data collection.
The modeling process is carried out by transforming nutritional requirement data and food composition data into a system of linear equations. Let:
x_1 = portion of chicken eggs (per 100 g),
x_2 = portion of white rice (per 100 g),
x_3 = portion of soybeans (per 100 g).

Each equation represents the requirement for a specific macronutrient, namely protein, fat, and carbohydrates. Based on data from the Indonesian Food Composition Table (TKPI) and the Recommended Dietary Allowance (AKG), the following system of linear equations is obtained:

$$11.94x_1 + 9.24x_2 + 33.22x_3 = 20$$
$$7.69x_1 + 0.19x_2 + 13.26x_3 = 45$$
$$7.03x_1 + 79.87x_2 + 38.08x_3 = 215$$

Matrix form:

$$Ax = b$$
$$A = \begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 7.69 & 0.19 & 13.26 \\ 7.03 & 79.87 & 38.08 \end{bmatrix}, x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, b = \begin{bmatrix} 20 \\ 45 \\ 215 \end{bmatrix}$$

Where A represents nutritional content, x represents food portions, and b represents nutritional requirements.

The LU decomposition method is a numerical approach used to solve systems of linear equations by factorizing the coefficient matrix A into two triangular matrices: a lower triangular matrix L and an upper triangular matrix U, where A is an $n \times n$ matrix (Al-kurdi & Kincaid, 2006; Ballarín et al., 2026; Bourre, 2006; Donkor et al., 2023; Li & Yin, 2020; Paramita et al., 2023; Pesti et al., 2009; Rafique, 2015; Savarino et al., 2021).

The factorization process is performed such that the first matrix, L (lower), is a lower triangular matrix with all diagonal elements equal to one, while the second matrix, U (upper), is an upper triangular matrix (Depega, 2012). This decomposition can be expressed as:

$$A = LU$$

Which

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \dots & 0 \\ m_{21} & 1 & 0 & \dots & 0 \\ m_{31} & m_{32} & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & m_{n3} & \dots & 1 \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} & u_{13} & \dots & u_{1n} \\ 0 & u_{22} & u_{23} & \dots & u_{2n} \\ 0 & 0 & u_{33} & \dots & u_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & u_{nn} \end{bmatrix}$$

And obtained

$$LU_x = b$$

The steps of the LU decomposition method are as follows:

1. Formulating the system
   Construct the coefficient matrix A, the variable vector x, and the result vector b from the system of linear equations:

$$Ax = b$$

2. Decomposing matrices A into L and U
   Determine the lower triangular matrix L and the upper triangular matrix U from the coefficient matrix A.

$$A = LU$$

   For the upper triangular matrix U:

$$u_{ij} = 1, for\ i = j$$

$$u_{ij} = a_{ij} - \sum_{k=1}^{i-1} I_{ik} U_{kj}, for\ i \leq j$$

For the lower triangular matrix L:

$$l_{ij} = 1, for\ i = j\ and\ l_{ij} = 0\ for\ i > j$$

$$l_{ij} = a_{ij} - \sum_{k=1}^{j-1} I_{ik} U_{kj}, for\ i \leq j$$

3. Forward substitution
   Solve the intermediate system:

$$Ly = b$$

   to obtain the vector y.

4. Backward substitution

   Solve the system:

$$Ux = y$$

   to obtain the solution vector x.

This approach is selected to emphasize a clear conceptual understanding of the LU decomposition method while ensuring that the entire computational process can be systematically traced and verified.

3. Result and Discussion

3.1 Solution of Linear Equation

Based on the constructed mathematical model, the system of linear equations is expressed in matrix form as:

$$Ax = b$$

where:

$$A = \begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 7.69 & 0.19 & 13.26 \\ 7.03 & 79.87 & 38.08 \end{bmatrix}, b = \begin{bmatrix} 20 \\ 45 \\ 215 \end{bmatrix}$$

To solve this system, the LU decomposition method is applied by factorizing matrix A into:

$$A = LU$$

3.2 Solving the System Using LU Decomposition

The given system of linear equations is:

$$\begin{gathered} 11.94x_1 + 9.24x_2 + 33.22x_3 = 20 \\ 7.69x_1 + 0.19x_2 + 13.26x_3 = 45 \\ 7.03x_1 + 79.87x_2 + 38.08x_3 = 215 \end{gathered}$$

The system of linear equations is solved using the LU decomposition method through the following procedural steps:

Step 1: Matrix Representation.

The system is written in matrix form:

$$A = \begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 7.69 & 0.19 & 13.26 \\ 7.03 & 79.87 & 38.08 \end{bmatrix}, b = \begin{bmatrix} 20 \\ 45 \\ 215 \end{bmatrix}$$

Step 2: LU Factorization

Matrix A is decomposed into a lower triangular matrix L and an upper triangular matrix U:

$$A = LU$$

$$\begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 7.69 & 0.19 & 13.26 \\ 7.03 & 79.87 & 38.08 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ l_{21} & 1 & 0 \\ l_{31} & l_{32} & 1 \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ 0 & u_{22} & u_{23} \\ 0 & 0 & u_{33} \end{bmatrix}$$

From the first row:

$$u_{11} = a_{11} = 11.94$$
$$u_{12} = a_{12} = 9.24$$
$$u_{13} = a_{13} = 33.22$$

From the second row:

$$l_{21} = \frac{a_{21}}{u_{11}} = \frac{7.69}{11.94} = 0.64$$
$$u_{22} = a_{22} - l_{21}u_{12} = 0.19 - (0.64)(9.24) = -5.72$$
$$u_{23} = a_{23} - l_{21}u_{13} = 13.26 - (0.64)(33.22) = -7.98$$

From the third row:

$$l_{31} = \frac{a_{31}}{u_{11}} = \frac{7.03}{11.94} \approx 0.58$$
$$l_{32} = \frac{a_{32} - l_{31}u_{12}}{u_{22}} = \frac{79.87 - (0.58)(9.24)}{-5.72} \approx -13.02$$

$$u_{33} = a_{33} - l_{31}u_{13} - l_{32}u_{23}$$

$$= 38.08 - (0.58)(33.22) - (-13.02)(-7.98)$$
$$\approx -85.08$$

Thus, the matrices L and U are:

$$L = \begin{bmatrix} 1 & 0 & 0 \\ 0.64 & 1 & 0 \\ 0.58 & -13.02 & 1 \end{bmatrix} and\ U = \begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 0 & -5.74 & -7.98 \\ 0 & 0 & -85.08 \end{bmatrix}$$

Step 3: Forward Substitution (Ly = b)

$$Ly = b$$

Solving yields:

$y_1 = 20$, $y_2 = 32.2$, $y_3 = -192.64$

Step 4: Backward Substitution ($Ux = y$)

$$Ux = y$$

Solving yields:

$$\begin{bmatrix} 11.94 & 9.24 & 33.22 \\ 0 & -5.74 & -7.98 \\ 0 & 0 & -85.08 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 32.2 \\ -192.64 \end{bmatrix}$$

$$x_3 = \frac{y_3}{u_{33}} = \frac{-192.62}{-85.08} \approx 2.26$$
$$x_2 = \frac{y_2 - u_{23}x_3}{u_{22}} = \frac{32.2 - (-7.98)(2.26)}{-5.74} \approx -8.75$$
$$x_1 = \frac{y_1 - u_{12}x_2 - u_{13}x_3}{u_{11}} = \frac{20 - 9.24(-8.74) - 33.22(2.26)}{11.94} \approx 2.15$$

Thus, the solution is: $x_1 = 2.15$, $x_2 = -8.75$, $x_3 = 2.26$

This result indicates that the system has a unique solution that satisfies all equations mathematically.

Verification of the Solution

To validate the solution, the values are substituted back into the original equations:

First equation:

$$11.94\,x1 + 9.24x2 + 33.22\,x3 = 20$$
$$11.94(2.15) + 9.24(-8.75) + 33.22(2.26) = 20$$
$$19.89 \approx 20$$

Second equation

$$7.69x_1 + 0.19x_2 + 13.26x_3 = 45$$
$$7.69(2.15) + 0.19(-8.75) + 13.26(2.26) = 45$$
$$44.83 \approx 45$$

Third equation

$$7.03x_1 + 79.87x_2 + 38.08x_3 = 215$$

$$7.03(2.15) + 79.87(-8.75) + 38.08(2.26) = 215$$
$$214.77 \approx 215$$

The results show that the left-hand side of each equation is approximately equal to the right-hand side, confirming that the solution is mathematically valid.

Final Result

The solution of the linear system is:

$$x_1 = 2.15, x_2 = -8.75, x_3 = 2.26$$

where x_1, x_2 and x_3 represent the quantities of chicken eggs, white rice, and soybeans, respectively, that satisfy the equation $Ax = b$.

The results of this study demonstrate that the system of linear equations derived from the nutritional model can be effectively solved using the LU decomposition method. The method provides a structured and computationally efficient approach to obtaining a unique solution, as reflected in the values $x_1 = 2.15, x_2 = -8.75, x_3 = 2.26$. From a mathematical standpoint, the existence of a unique solution is consistent with linear algebra theory, which states that a system $Ax = b$ has a unique solution when the coefficient matrix A is non-singular (i.e., $det(A) \neq 0$)(Al-kurdi & Kincaid, 2006; Ballarín et al., 2026; Donkor et al., 2023; Li & Yin, 2020; Pesti et al., 2009; Strang, 2000). The verification step further confirms that the computed solution satisfies the system within an acceptable numerical approximation.

However, despite its mathematical validity, the solution reveals a critical limitation when interpreted in a real-world nutritional context. The negative value obtained for x_2 (white rice) is not physically meaningful, as food quantities cannot be negative. This issue is well recognized in mathematical modeling and operations research, where unconstrained linear systems may produce infeasible solutions if practical constraints are not incorporated (Hillier & Lieberman, 2001). In the context of diet modeling, feasibility constraints—particularly non-negativity constraints ($x_i \geq 0$)—are essential to ensure realistic outcomes.

This limitation highlights an important distinction between solving a system of equations and solving an optimization problem. Classical diet problems, originally introduced by George Stigler and later formalized using linear programming by George Dantzig, explicitly incorporate constraints such as non-negativity, minimum nutritional requirements, and cost minimization (Darmon & Ferguson, 2002). Numerous studies have since demonstrated that linear programming is highly effective in determining optimal and feasible dietary compositions (Ballarín et al., 2026; Darmon & Ferguson, 2002; Donkor et al., 2023; Pesti et al., 2009).Compared to these approaches, the present study focuses on solving the structural system rather than optimizing under constraints, which explains the emergence of non-physical solutions.

From a numerical analysis perspective, the use of LU decomposition is well justified. LU decomposition is a fundamental matrix factorization technique widely used for solving systems of linear equations due to its computational efficiency and numerical stability (Al-kurdi & Kincaid, 2006; Ballarín et al., 2026; Bourre, 2006; Darmon & Ferguson, 2002; Donkor et al., 2023; Pesti et al., 2009; Rafique, 2015). It allows the system to be solved through forward and backward substitution, making it particularly suitable for repeated computations or structured systems. In educational and analytical contexts, LU decomposition also provides transparency in the solution process, enabling step-by-step verification and interpretation.

Nevertheless, the absence of constraints in the model significantly limits its applicability to real-world nutritional planning. In nutrition science, dietary recommendations must consider not only macronutrient balance but also portion feasibility, dietary diversity, cultural acceptability, and micronutrient adequacy (Al-kurdi & Kincaid, 2006; Anjani et al., n.d.; Bourre, 2006; Livy & Vale, 2011; Paramita et al., 2023; Rafique, 2015; Savarino et al., 2021). By restricting the model to three macronutrients—protein, fat, and carbohydrates—the study adopts a simplified representation of nutritional needs. While this simplification is methodologically useful for constructing a solvable 3×3 system, it may overlook important nutritional dimensions such as vitamins, minerals, and bioavailability.

The findings of this study therefore suggest that LU decomposition is best viewed as a complementary analytical tool rather than a standalone solution for dietary optimization. It is particularly useful for understanding the structural relationships between variables and for diagnosing potential inconsistencies in the model. However, to obtain feasible and implementable solutions, future research should integrate constraint-based approaches, such as linear programming or nonlinear optimization. Hybrid models that combine matrix decomposition techniques with optimization frameworks may offer a more comprehensive approach to solving complex nutritional problems. The study highlights both the strengths and limitations of applying a linear mathematical model and LU decomposition to nutritional composition problems. While the method successfully produces a mathematically consistent solution, the presence of non-physical values underscores the necessity of incorporating realistic constraints. Future work should aim to bridge the gap between theoretical modeling and practical application by integrating numerical methods with optimization techniques and broader nutritional considerations.

4. Conclusion

This study successfully models the problem of meeting the nutritional requirements of children aged 1–3 years as a system of linear equations, representing the relationship between the nutrient content of food items and macronutrient requirements based on the Recommended Dietary Allowance (RDA/AKG). The model is then solved using the LU decomposition method, which proves to be effective in providing a systematic solution through matrix factorization and sequential substitution processes. The results indicate that the system has a unique solution, confirming that the constructed model is mathematically consistent and solvable within the framework of linear algebra.

However, the obtained solution includes a negative value, indicating that it cannot be fully interpreted in a practical nutritional context. This limitation arises from the absence of constraints—particularly non-negativity constraints—resulting in a solution that lies outside the feasible region. This finding highlights that unconstrained systems of linear equations are more suitable as analytical mathematical tools rather than direct decision-making models for real-world dietary planning.

Furthermore, this study demonstrates that while LU decomposition is effective and efficient for solving systems of linear equations, it is not sufficient as a standalone method for determining realistic nutritional compositions. The results emphasize the importance of incorporating constraint-based approaches to ensure feasibility and applicability.

In conclusion, this research contributes to the application of numerical linear algebra in nutritional modeling by demonstrating both its strengths and limitations. Future studies are recommended to integrate LU decomposition with optimization methods, such as linear programming, and to incorporate additional variables and realistic constraints in order to produce more accurate, feasible, and implementable dietary solutions.

5. References

Al-kurdi, A., & Kincaid, D. R. (2006). *LU-decomposition with iterative refinement for solving sparse linear systems*. *185*, 391–403. https://doi.org/10.1016/j.cam.2005.03.018

Anjani, D. M., Nurhayati, S., & Immawati. (n.d.). Penerapan Pendiidkan Kesehatan nterhadap Pengetahuan Iu tentang Stunting pada balita di Wilayah Kerja UPTD Puskesmas Rawat Inap Banjarsari Metro Utara. *Jurnal Cendikia Muda*, *4*, 62–69.

Ballarín, J., Delgado, J., Liu, Y., & Orera, H. (2026). An accurate method for the LU decomposition of amazing matrices. *Linear Algebra and Its Applications*, *740*, 1–10. https://doi.org/10.1016/j.laa.2026.03.014

Bourre, J. M. (2006). *Effects Of Nutrients (In Food) On The Structure And Function Of The Nervous System : Update On Dietary Requirements For Brain . Part 2 : Macronutrients*. *10*(5).

Darmon, N., & Ferguson, E. L. (2002). *Nutritional Models A Cost Constraint Alone Has Adverse Effects on Food Selection and Nutrient Density : An Analysis of Human Diets by Linear Programming 1*. *June*, 3764–3771. https://doi.org/10.1093/jn/132.12.3764

Depega, Y. (2012). *Interval Dengan Metode Penyelesaian Sistem Persamaan Linier Interval Dengen Metode Dekomposisi*. Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau.

Donkor, L., Essien, E., & Afrifah, N. S. (2023). *A Systematic Review of Linear Programming Techniques as Applied to Diet Optimisation and Opportunities for Improvement*. *2023*. https://doi.org/10.1155/2023/1271115

Drastita, P. S., Sesay, M., & Putra, W. A. (2026). *The Influence Of Proper Sanitation Access On Stunting Prevalence In East Java , Indonesia*. *10*(1), 61–70. https://doi.org/10.20473/imhsj.v10i1.2026.61-70

Golub, G. H. (1969). *I 00 00:] : : 5*.

Hillier, F. S., & Lieberman, G. J. (2001). *INTRODUCTION TO OPERATIONS RESEARCH* (seventh ed). Mc Graw Hill.

Ii, V., Preston, L., & Dodds, J. (1988). *the*. *II*.

Li, H., & Yin, S. (2020). Single-pass randomized algorithms for LU. *Linear Algebra and Its Applications*, *595*(11671060), 101–122. https://doi.org/10.1016/j.laa.2020.03.001

Livy, S., & Vale, C. (2011). First year pre-service teachers' mathematical content knowledge: methods of solution to a ratio question. *Mathematics Teacher Education and Development*, *13*(2), 22–43. http://dro.deakin.edu.au/eserv/DU:30044057/vale-firstyearpreservice-2011.pdf

Paramita, M., Helmyati, S., Basrowi, R. W., & Dilantika, C. (2023). *Risk Factors for Stunting among Infants on Java Island : A Cross- Sectional Study using the 2021 Indonesian Nutritional Status Survey Data Faktor Risiko Stunting pada Baduta di Pulau Jawa : Studi Cross-Sectional menggunakan Data Studi Status Gizi Indonesia Tahun 2021*. *7*(3), 20–29. https://doi.org/10.20473/amnt.v7i3SP.2023.20-29

Pesti, G. M., Vedenov, D., Cason, J. A., & Billard, L. (2009). *A comparison of methods to estimate nutritional requirements from experimental data*. *1668*. https://doi.org/10.1080/00071660802530639

Rafique, M. (2015). *The Solution of a System of Linear Equations by an Improved LU-Decomposition Method*. *i*, 23–24. https://doi.org/10.5251/ajsir.2015.6.2.23.24

Savarino, G., Corsello, A., & Corsello, G. (2021). *Macronutrient balance and micronutrient amounts through growth and development*. *0*, 1–14.

Strang, G. (2000). *Introduction to Linear Algebra* (Fourth Edi). Wellesley-Cambridge Press.