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Comparison of WSM and Weight Product Methods with WSM-Score and Vector Approaches

Roziyani Setik[1], Asyahri Hadi Nasyuha[2*], Sri Redjeki[2]

[1] Faculty of Communication, Visual Art and Computing Universiti, Selangor, Malaysia
[2] Faculty of Information Technology, Information of System, Universitas Teknologi Digital Indonesia, Yogyakarta, Indonesia
Email: [1]roziyani@unisel.edu.my, [2*]asyahrihadi@gmail.com, [3]dzeky@utdi.ac.id
Correspondence Author Email: asyahrihadi@gmail.com

Abstract−Fertilizer is a material that is given to the soil or plants to meet the nutritional needs of the plant. Fertilization needs to be carried out rationally according to the needs of the plant. In the supply of fertilizers, farmers have difficulty in determining the best fertilizer for their plants, making it difficult to choose which fertilizers are good for their plants. In determining the best fertilizer, the decision support system (DSS) can be used as an alternative to help someone make decisions more effectively and efficiently by utilizing certain data and models. To solve the existing problems, it is necessary to conduct research in decision making using the Weighted Sum Model (WSM) and Weight Product (WP) Methods which can produce decisions based on the best fertilizer criteria that will be purchased by customers. The Weighted Sum Model (WSM) method is one of the simplest and easiest methods to understand its application, this method is also part of the MCDM (Multi-Criteria Decision Making) method in evaluating the value of each alternative. The Weight Product (WP) method is a method using multiplication to relate the attribute rating, where the rating of each attribute must be ranked with the attribute weight in question. From the results of the implementation of this system, it can be concluded that using the Weighted Sum Model and Weight Product method can help customers in the decision-making process for choosing the best fertilizer to use on their plants.

Keywords: DSS; Firtilizer; WSM; WP

1. INTRODUCTION

Fertilizer is a material that is given to the soil or plants to meet the nutritional needs of the plant[1]. Fertilization needs to be carried out rationally according to the needs of the plant, the ability of the soil to provide nutrients, soil properties and cultivation by farmers. The Best Firtilizer is a fertilizer that is used on any type of plant, this fertilizer can be solid or liquid[2]. The Best Firtilizer can also produce better plants, because the nutrients provided by plants are sufficient. Fertilizers contain a lot of substances that are needed by plants to provide nutrients to plants. Fertilization of plants can be done using organic fertilizers and inorganic fertilizers. Organic fertilizers are fertilizers resulting from the change or breakdown of plant and animal parts, for example manure, green manure, compost, meal, guani, bone meal and so on[3]. Meanwhile, inorganic fertilizers are fertilizers that are made from factories whose ingredients come from inorganic materials and are formed by a chemical process. Fertilizer is the main ingredient in plants in order to provide nutrients to plants[4]. The choice of fertilizer can be seen from the type of plant and what nutrients the plant needs, so to determine what fertilizer is good for these plants a decision support system is applied. Fertilizer plays a critical role in agriculture by enhancing soil fertility and meeting the nutritional needs of plants, ensuring healthy growth and optimal yield. Fertilizers are applied to the soil or directly to plants, and their proper usage requires careful consideration of several factors, such as the specific nutritional needs of the plant, the soil's nutrient-providing capacity, soil properties, and the cultivation practices employed by farmers. Rational fertilization involves using fertilizers judiciously to achieve maximum benefit while avoiding environmental damage. The term "The Best Fertilizer" refers to fertilizers that are suitable for use on various types of plants. These fertilizers can be found in solid or liquid forms, providing flexibility in their application.

The Best Fertilizer enhances plant growth and productivity by ensuring that plants receive sufficient nutrients, which are vital for their development. A well-nourished plant is more likely to produce higher yields and better quality crops, which are essential for food security and sustainable agriculture. Fertilizers are composed of substances that provide essential nutrients to plants. These nutrients include macronutrients like nitrogen (N), phosphorus (P), and potassium (K), which are needed in larger quantities, as well as micronutrients like zinc (Zn), iron (Fe), and manganese (Mn), required in smaller amounts[5]. Proper fertilization replenishes soil nutrients that are depleted during plant growth, thereby maintaining soil fertility over time. Fertilizers can be broadly categorized into two types: organic and inorganic[6]. Organic fertilizers are derived from the natural decomposition or breakdown of plant and animal materials[7]. Examples include manure, green manure, compost, bone meal, guano, and other organic residues. Organic fertilizers are valued for their ability to improve soil structure, increase water retention, and enhance microbial activity. They release nutrients slowly, providing a steady supply to plants over time, which helps reduce the risk of over-fertilization and nutrient leaching. In contrast, inorganic fertilizers are synthetic products manufactured in factories using chemical processes. These fertilizers are made from inorganic materials and are formulated to provide nutrients in specific ratios, ensuring precision in nutrient application[8]. Inorganic fertilizers are highly effective in delivering nutrients quickly to plants, making them ideal for addressing immediate nutrient deficiencies. However, their overuse can lead to environmental issues such as water pollution, soil degradation, and the loss of beneficial soil organisms. The choice between organic and inorganic fertilizers depends on various factors, including the type of plant, the soil's existing nutrient levels, and the desired outcome.

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For example, organic fertilizers may be preferred in sustainable or organic farming practices, while inorganic fertilizers are often used in intensive agricultural systems where rapid nutrient availability is crucial. To optimize fertilization practices and select the most appropriate fertilizer for specific crops, decision support systems (DSS) can be employed. A DSS integrates data on plant nutrient requirements, soil characteristics, and environmental conditions to provide recommendations for fertilizer application. By leveraging technology, farmers can make informed decisions about the type, quantity, and timing of fertilizer use, thereby improving efficiency and reducing waste. In summary, fertilizers are indispensable in modern agriculture, enabling farmers to meet the nutritional needs of plants and enhance crop productivity. Both organic and inorganic fertilizers offer distinct advantages, and their proper use depends on the specific context of cultivation. By incorporating advanced tools like decision support systems, the agricultural sector can achieve sustainable fertilization practices that balance productivity with environmental stewardship.

2. RESEARCH METHODOLOGY

2.1 Fertilizer

The need for fertilizers in agriculture is very important to help soil fertility and plants so get great results. Fertilization needs to be carried out rationally according to the needs of the plant, the ability of the soil to provide nutrients, soil properties and management by farmers. Fertilization on plants can be done using organic fertilizers or inorganic fertilizers. Organic fertilizers are man-made fertilizers that can restore soil fertility. Meanwhile, inorganic fertilizers are fertilizers made from chemicals. Broadly speaking, the purpose of fertilization is for:
1. Increase soil fertility,
2. Increase the productivity and quality of planting products,
3. Avoiding environmental pollution.

2.2 Decision support systems

A Decision Support System (DSS) is an interactive information system that provides information, modeling, and data manipulation[9]–[11] The system is used to assist decision-making in semi-structured and unstructured situations, where no one knows exactly how decisions should be made. Decision Support System (DSS) is an interactive computer-based system, which helps decision makers utilize data and models to solve unstructured and semi-structured problems[12]. Basically, DSS is designed to support all stages of decision making starting from identifying problems, selecting relevant data, determining the approach used in the decision-making process, to evaluating the selection of alternatives[13]. So the conclusion of this decision support system is a computer-based system that collects various information from several sources and is able to solve problems from several alternatives, so that it can bring up new solutions[14][15].

2.3 Metode Weighted Sum Model (WSM)

Weighted Sum Model Method is a very common method, and is widely used to assist decision makers in making a decision[16]. WSM is one of the simplest and easily understood methods of application which is part of the MCDM (Multi-Criteria Decison Making) method in evaluating the value of each alternative[17][18]. This method is widely used in completing decision making[19]. This situation is caused by the simple concept, easy to understand and efficient computation. In conducting the ranking process, the WSM method has three stages that must be done to calculate the WSM method, namely:
1. Step I: Identify in advance the Criteria and Alternatives used in problem solving.
2. Step II: Calculate the WSM-Score Value. The formulas used in this method are:

   $$A_i^{WSM-score} = \sum_{j=1}^{n} w_j x_{ij} \quad (1)$$

   Where variable n is the number of criteria, wj is the weight of each criterion and xij is value of matrix x
3. Step III: Ranking.

2.4 Weight Product Method (WP)

The Weighted Product method is a method using multiplication to relate the attribute rating, where the rating of each attribute must be ranked with the attribute weight in question[20][21]. The Weighted Product (WP) method is one of the solutions offered to solve the Multi Attribute Decission Making (MADM) problem. The Weighted Product (WP) method is similar to the Weighted Sum (WS) method, it's just that the Weighted Product, there is a multiplication in the mathematical calculation[22]. The Weighted Product method is also called dimensional analysis because the mathematical structure eliminates the unit of measure.
The stages of the Weight Product method in decision making are:
a. Determine the criteria first.
   Normalize each alternative value by improving the weight with the formula

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$$W_j = \frac{W_j}{\sum W_j} \quad (2)$$

Where variable W_j is Attribute weight and $\sum W_j$ is Summation of attribute weights

b. Calculating the preference weight value for each alternative with the variable W is the rank of positive values for the profit attribute and negative value for the cost attribute. The preferences for the Si alternatives are given as follows:

$$S_i = \prod_{j=1}^{n} X_{ij}\, W_j \quad (3)$$

Where variable S_i is Alternative preference is anologized as vector S, X_{ij} is Criteria value, W_j is weight of criteria / subcriteria, i is Alternative and j is Criteria.

c. Ranking the largest value that is selected as the best alternative. With formulas:

$$V_i = \frac{Si}{\prod_{j=1}^{n}(Xj*)wj} \quad (4)$$

Where variable V is alternative preference is analogous to a vector V, X is Criteria Value, W is attribute weight, i is Alternative, j is Criteria and n is Number of criteria.

3. RESULT AND DISCUSSION

3.1 Problem Analysis

The system algorithm is an explanation of the steps to solve a problem in designing a decision support system in choosing a back-end programmer using the Weighted Sum Model (WSM) and Weight Product (WP) methods. This is done to increase the effective and efficient assessment to determine the best fertilizer.

Table 1. Weighting Criteria

Criteria Code	Criteria	Weight
C1	Price	5
C2	Quality	4
C3	Easy to get	4
C4	Form of Fertilizer	3

Table 2. Weighting Scale

Criteria	Scale	Weight
Price	0 - 100.000	1
	101.000 - 200.000	2
	201.000 - 300.000	3
	301.000 - 400.000	4
	≥500.000	5
Quality	Very Good	5
	Good	4
	Cukup Baik	3
	Pretty good	2
	Not Good	1
Easy to get	Yes	5
	Sometimes	3
	Not	1
Form of Fertilizer	Solid	5
	Liquid	1

Table 3. Primary Fertilizer Data

No	Alternative Code	Alternative	Criteria			
			Price (C1)	Quality (C2)	Easy to Get (C3)	Form of Fertilizer (C4)
1	A1	Urea	200.000	Good	Yes	Padat
2	A2	Kompos	100.000	Very Good	Yes	Padat
3	A3	TSP	370.000	Good	Sometimes	Padat
4	A4	KCL	350.000	Pretty Good	Sometimes	Padat
5	A5	Gandasil	450.000	Good	Sometimes	Cair
6	A6	NPK	300.000	Good	Yes	Padat
7	A7	ZA	195.000	Good	Yes	Padat

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Table 4. Data Conversion

No	Alternative Code	Alternative			
		Price (C1)	Quality (C2)	Easy to Get (C3)	Form of Fertilizer (C4)
1	A1	4	4	5	5
2	A2	5	5	5	5
3	A3	2	4	3	5
4	A4	2	3	3	5
5	A5	1	4	3	1
6	A6	3	4	5	5
7	A7	4	4	5	5

3.2 Calculation using the Weighted Sum Model (WSM) Method

Based on the initial weight table that has been determined from each criterion, the decision maker gives the preference weight is w = [5,4,4,3] where W = (W1, W2, W3, W4).

1. Weight Value Improvements

   Improvements to the initial weight value will be fixed by:

   $Wj = \frac{wj}{\sum wj}$

   For price :

   W1 = "5" / "5 + 4 + 4 + 3" = "5" / "16" = 0.3125

   For Quality:

   W2 = "4" / "5 + 4 + 4 + 3" = "4" / "16" = 0.25

   For easy to get:

   W3 = "4" / "5 + 4 + 4 + 3" = "4" / "16" = 0.25

   For fertilizer form:

   W4 = "3" / "5 + 4 + 4 + 3" = "3" / "16" = 0.1875

   From the weighting process above, the final weight is obtained as follows:

Table 5. Changes in Weight Value (∑Wj = 1)

No	Criteria	Weight
1	Price	0,3125
2	Quality	0,25
3	Easy to Get	0,25
4	fertilizer form	0,1875
	Total	1

2. Calculating the WSM-Score value with the formula:

   $A_j^{WSM-score} = \sum_{j=1}^{n} W_j X^{ij}$

   $A1 = (0{,}3125 * 4) + (0{,}25 * 4) + (0{,}25 * 5) + (0{,}1875 * 5) = 4{,}44$

   $A2 = (0{,}3125 * 5) + (0{,}25 * 5) + (0{,}25 * 5) + (0{,}1875 * 5) = 5$

   $A3 = (0{,}3125 * 2) + (0{,}25 * 4) + (0{,}25 * 3) + (0{,}1875 * 5) = 3{,}31$

   $A4 = (0{,}3125 * 2) + (0{,}25 * 3) + (0{,}25 * 3) + (0{,}1875 * 5) = 3{,}06$

   $A5 = (0{,}3125 * 1) + (0{,}25 * 4) + (0{,}25 * 3) + (0{,}1875 * 1) = 2{,}25$

   $A6 = (0{,}3125 * 3) + (0{,}25 * 4) + (0{,}25 * 5) + (0{,}1875 * 5) = 4{,}13$

   $A7 = (0{,}3125 * 4) + (0{,}25 * 4) + (0{,}25 * 5) + (0{,}1875 * 5) = 4{,}44$

   From the results of calculations carried out based on the Weighted Sum Model (WSM) method, the values of the alternatives are obtained as follows:

Table 6. Ranking Based on Preference Value

No	Code Alternative	Alternative	Preference Value	Description
1	A2	Kompos	5	Rank 1

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No	Code Alternative	Alternative	Preference Value	Description
2	A1	Urea	4,44	Rank 2
3	A7	ZA	4,44	Rank 3
4	A6	NPK	4,13	Rank 4
5	A3	TSP	3,31	Rank 5
6	A4	KCL	2,06	Rank 6
7	A5	Gandasil	2,25	Rank 7

3.3 Calculation using the Weight Product (WP) Method

At the time of observation, the data was given initial weight in selecting the best fertilizer as follows:
Initial weight or W = [5,4,4,3].

1. Weight Value Improvements
   The weight improvement formula in the WP method is as follows:

   $Wj = \frac{wj}{\sum wj}$

   Then do the weighting process.
   For price :

   W1 = "5" / "5 + 4 + 4 + 3" = "5" / "16" = 0.3125

   For Quality:

   W2 = "4" / "5 + 4 + 4 + 3" = "4" / "16" = 0.25

   For easy to get:

   W3 = "4" / "5 + 4 + 4 + 3" = "4" / "16" = 0.25

   For fertilizer form:

   W4 = "3" / "5 + 4 + 4 + 3" = "3" / "16" = 0.1875

Table 7. WP Criteria Weight Value

No	Criteria	Weight
1	Price	0,3125
2	Quality	0,25
3	Easy to Get	0,25
4	fertilizer form	0,1875
	Total	1

Table 8. Weights of Criteria for Each Alternative

No	Alternative Code	Alternative			
		Price (C1)	Quality (C2)	Easy to Get (C3)	Form of Fertilizer (C4)
1	A1	4	4	5	5
2	A2	5	5	5	5
3	A3	2	4	3	5
4	A4	2	3	3	5
5	A5	1	4	3	1
6	A6	3	4	5	5
7	A7	4	4	5	5

2. Calculate the vector value
   Perform the steps to calculate the vector S, which is the value of each alternative. This calculation is done by multiplying all the attributes (criteria) for an alternative with W (weight) as the positive rank for the profit attribute and the negative weight for the cost attribute. In this case, the selection of this fertilizer, W (weight) is the positive rank because there is no cost attribute (the attribute whose value is greater the more detrimental). Here's how to calculate a vector S with the following formula:

   $S_i=\prod_{j=1}^{n} X_{ij}\ W_j$

   S1 = $(4^{0,3125})\ (4^{0,25})\ (5^{0,25})\ (5^{0,1875})$ = 4,41

   S2 = $(5^{0,3125})\ (5^{0,25})\ (5^{0,25})\ (5^{0,1875})$ = 5

   S3 = $(2^{0,3125})\ (4^{0,25})\ (3^{0,25})\ (5^{0,1875})$ = 3,13

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S4 = $(2^{0,3125})\ (3^{0,25})\ (3^{0,25})\ (5^{0,1875})$ = 2,91

S5 = $(1^{0,3125})\ (4^{0,25})\ (3^{0,25})\ (1^{0,1875})$ = 1,86

S6 = $(3^{0,3125})\ (4^{0,25})\ (5^{0,25})\ (5^{0,1875})$ = 4,03

S7 = $(4^{0,3125})\ (4^{0,25})\ (5^{0,25})\ (5^{0,1875})$ = 4,41

3. Calculating the preference value
   After getting the vector value S, then determining the alternative ranking by dividing the value V (the vector value used for ranking) for each alternative by the total value of all alternative values (vector S). The ranking calculation uses the following formula:

$$V_i = \frac{Si}{\prod_{j=1}^{n} (Xj*)wj}$$

Alternative 1

$$\mathrm{V1} = \frac{4{,}41}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{4{,}41}{25{,}75} = 0{,}17$$

Alternative 2

$$\mathrm{V2} = \frac{5}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{5}{25{,}75} = 0{,}19$$

Alternative 3

$$V3 = \frac{3{,}13}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{3{,}13}{25{,}75} = 0{,}12$$

Alternative 4

$$\mathrm{V4} = \frac{2{,}91}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{2{,}91}{25{,}75} = 0{,}11$$

Alternative 5

$$\mathrm{V5} = \frac{1{,}86}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{1{,}86}{25{,}75} = 0{,}07$$

Alternatif 6

$$\mathrm{V6} = \frac{4{,}03}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{4{,}03}{25{,}75} = 0{,}16$$

Alternatif 7

$$\mathrm{V7} = \frac{4{,}41}{4{,}41 + 5 + 3{,}13 + 2{,}91 + 1{,}86 + 4{,}03 + 4{,}41} = \frac{4{,}41}{25{,}75} = 0{,}17$$

From the results of calculations carried out based on the WP method, the value of each alternative is obtained as follows:

Table 9. Ranking Results of Alternative Fertilizers

Rank	Alternative	Result
1	Kompos	0,19
2	Urea	0,17
3	ZA	0,17
4	NPK	0,16
5	TSP	0,12
6	KCL	0,11
7	Gandasil	0,07

From the calculation results of the WSM and WP methods in determining the best fertilizer, different results are obtained. In the WSM method, the selected fertilizer is Compost Fertilizer with a value of 5 and the calculation in the WP Pupuk method selected is Compost Fertilizer with a value of 0.21. With the same data, the results of the comparison between WSM and WP methods result in the same decision but with different results.

From the results of the above calculations, it is known that the result value for Compost Alternative = 5 in the calculation of the WSM method and Alternative Compost = 0.19, in the calculation of the WP method, thus the Compost alternative has the highest value equal to the result of manual calculation of the alternative selected as The Best Firtilizer of calculations using the WSM method and calculations using the WP method. Thus the results of the comparison of the two methods show the same results in determining The Best Firtilizer.

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4. CONCLUSION

The thesis titled *"Decision Support System Comparison of the Weighted Sum Model Method and the Product Weight Method in Determining The Best Fertilizer Using the WSM-Score and Vector Approach"* concludes several key findings. First, determining the best fertilizer for plants can be achieved through direct field observations by applying specific criteria such as the price of fertilizers, quality, ease of availability, and the form of the fertilizer. The study focused on alternatives including Urea, Compost, TSP, KCL, Gandasil, NPK, and ZA, providing relevant and practical insights. The research highlights that both the Weighted Sum Model (WSM) method and the Weight Product (WP) method are effective tools for decision-making in this context. By clearly defining the criteria and alternatives, these methods allow for the systematic calculation of results, aiding the decision-making process. The application of these methods provides valuable guidance in identifying the optimal choice for a given situation. Furthermore, the analysis conducted in this study can serve as a useful reference for other researchers tackling similar problems related to alternative selection. Although the numerical results from the two methods differ, they consistently identify the same alternative as the best option. This finding underscores the reliability of both approaches in supporting decision-making processes. Ultimately, the study emphasizes the practicality and flexibility of these methods in selecting the best fertilizer, ensuring their applicability in real-world scenarios while providing a foundation for future research.

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