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Implementation Weighted Product Method for theBest Carrot Seed Recommendations

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***Abstract*— Farmers currently lack the proper tools or methods to determine and identify criteria for good/excellent seeds. The selection of good/superior seeds is primarily based on personal experience and perspectives. Even some of the Sinabung refugees who grow carrots are unaware of the seed sources they utilize. There are almost 40 different varieties of carrots, each with distinct growth criteria and requirements. Consequently, this presents an additional challenge in determining the quality of carrot seeds to be planted, which ultimately impacts the harvest production. The production of carrots does not correspond proportionately to the land area used. To address the issues, the search for superior seeds employs a decision support algorithm to provide recommendations. This algorithm utilizes the Weighted Product (WP) method, which offers recommendations based on predetermined criteria. The assigned weights are derived from research findings and expert knowledge. The algorithm's calculations generate several recommendations for potential carrot plants, sorted based on their outcomes. These recommended varieties can serve as superior seeds, leading to increased production. The study aims to enhance carrot production and contribute to the economic resilience of farmers displaced by Mount Sinabung.**

***Index Terms*- Artificial Intelligence; Carrot Seeds; Decision Support System; Mount Sinabung Refugee Farmers, and Weighted Product Method.**

I. INTRODUCTION

Tanah Karo, which is well-known as a vegetable producer,is the main source of vegetable suppliers in North Sumatra, even vegetables are exported to the national region and abroad. Nowadays, many farmers switch to carrot plants for various reasons, such as the planting age of only three months, practical ways of working and the wide export market in various cities in Indonesia, such as Jakarta, Bandung, Surabaya, Bali and even Papua. Based on previous research, farmers can produce Rp. 7,450,500/harvest/ha [1]. The age of carrots until the harvest period is 2.5 - 3 months, judging from the results that can be obtained by farmers in growing carrots, of course this is very supportive of their economic resilience.

Most of the farmers in the land are still farming semi- modern, using tractor tillage, spraying machine showers and mostly with human labor. No one has yet fully utilized modern farming methods such as utilizing an IT system. Thisthe case found in the relocation of karo in the relocation ofrefugees from Mount Sinabung in the village ofNangbelawan. Things that need to be considered in carrot cultivation to get maximum production, is the optimum temperature for carrot plant growth is 15-21oC. This temperature is suitable for the growth of roots and the top of the plant so that the color and shape of the roots can be optimal [2]. Soil that is suitable for growing carrots is soil thatis well drained, rich in organic matter and fertile with an altitude of 1200-1500 m above sea level. Sandy loam soil is suitable for carrot cultivation because it is easy for root penetration so that its growth can reach optimal length and size. This plant can grow well in soil with a pH of 5-8 [3]. Soil moisture is very important for the growth of carrot plants,including during seeding to obtain seeds with uniform growthand fast growth after planting in

the field. Apart from the above requirements, good seeds cannot be separated from thesuccess of obtaining maximum production [4].

The fact that found at the location of this research, generally the farmers follow the correct proceduresin farming, especially in the selection of good seeds. Determining and searching for criteria for good/excellent seeds, the farmers do not have the tools or methods to get them. The selection of good/superior seeds is done based on personal experience and views, even some of the Sinabung refugees who cultivate carrots do not know the source of theseeds they use [3, 4]. This of course affects the production of carrots at harvest.Harvest production is not proportional to the area of land used. Based on the above problems, the search for superior seeds uses decision support algorithms and recommendations. This algorithm will provide recommendations for the quality of superior carrot seedsbased on the criteria or characteristics that must be prepared in the selection of plants. The algorithm developed uses the Weighted Product (WP) algorithm. The WP method is a recommendation method with weighting againstpredetermined criteria [5]. Previous research conducted by for the selection of instant cameras, in this study concluded that the final result of the application evaluation was the overall value of system user satisfaction which obtained a percentage score of 87.98% with a very good predicate [6]. The second research is a study for the selection of ornamentalplants, in this study it was concluded that with a system success percentage of 84,409% the system was considered successful in implementing the WP method and the criteria used in the recommendation system were appropriate. The WP method is used in the design of this recommendation system because it is considered to have fast computing and is suitable for making ornamental plant recommendations. Theadvantages of this WP method provide clarity on the weightsof costs and benefits on each criterion [5].

This study determines the variables or criteria to determinethe characteristics of superior carrot seeds, then the process of determining superior seeds is carried out using the WP method. The results of the recommendations will be used fortrial planting with ordinary seeds, not classified as superior according to the WP system testing with the same land and the same treatment. From the results of trials conducted afterthe harvest period, the production of superior carrot seeds willbe compared with seeds without the WP process. From the results of this trial, it can be seen whether superior seeds canproduce greater production or not [4].

In general, carrot farmers displaced by Mount Sinabung donot have standards in procuring superior seeds in their agricultural business. Most of them get carrot seeds from unknown sources. Usually buy seeds from traders. Some of them also produce their own seeds but do not meet proper standards in producing superior seeds. As a result, crop yieldsare not optimal, the area of land planted is not proportional toharvest production. The crop yields are suboptimal, and the price of the carrots has been negatively affected by the impact o Covid-19. There is a lack of demand both locally and from java. As a result, it greatly affects the economic resilience of theMount Sinabung refugees. One of the appropriate solutions to overcome the above problems is to produce superior seeds from carrots themselves using the WP method, for that it can be stated that the problem formulation of this research is How to Design a System Implementation to Get Superior Carrot Seeds with a Weighted Product Algorithm?

II. THEORETICAL BASIS

A. Carrot Seeds

Basically, the carrot varieties commonly consumed by theworld's population are of many types, both in shape and color, not just one type as we usually find in Indonesia [2]. To get maximum production in planting carrots, it is necessary to know the stages that must be done in planting carrots. First, efforts should be made to use superior seeds. From a land thathas been planted with carrots and before the post-harvest, a search for carrots can be carried out which will be used as superior seeds.

The steps that can be taken in finding sources of superiorseeds are as follows [7]:

1. Age after planting day at least 100 days
2. The tuber texture is straight, dense
3. The thickness of the tuber diameter>=3 cm
4. Glowing bright reddish
5. The shape of the carrot leaves is straight and bright

While the method of seeding carrots, as follows:

1. Carrot leaves cut to about 10 cm
2. Roots that have been selected, cut in thirds
3. The land is loosened, sown with compost
4. Made a bed for planting seeds
5. Plant tubers with about 50 cm

Roots that will be used as seeds must be selected properly; the planting period is at least 100 days. Roots that are not oldenough will easily rot and get disease. To know the planting period of carrots can be known from the date of planting. In addition, from the physical texture, whether it has hardened and looks ripe, it can be a reference that the carrot is old

enough. Physical texture that is straight, dense, and shiny canbe seen after the carrots that are old enough are removed [8].Select from several carrots that have been removed to get thebest tuber texture. Before the carrots are removed, it can be known which carrots can be used as a source of seeds from the texture of the leaves, which are fresh, not dense and decomposed [8].

From several carrot tubers that have met the criteria to be used as a source of superior seeds, the leaves are cut until theremaining about 10 cm and the tubers are cut one third of thelength of the tubers. Then dried for about 24 hours. Cutting the tubers to rejuvenate the carrots and will produce flowers from the growth of carrot shoots. Before planting the roots, prepare enough beds and composted soil to allow good growth and avoid rotting from waterlogging. Normal tuber growth and good if there is leaf growth, new shoots to produce flowers. Soil fertility must be maintained for good flower development. Cutting branches / shoots need to be done to get good flower seeds. It is enough to only use the main branch, about 5-6 branches [7].

Wide petals and large flower seeds will produce superior seeds. Old flowers with brown color can be picked by cuttingthe stems. Then it can be dried in the hot sun until it is completely dry for several days. Flowers that are completelydry when rubbed between dried carrot flowers will easily destroy the outer layer of the flower seeds. It is necessary to clean the seeds with hand friction in order to produce good quality seeds, not fibrous/lots of fibrous roots around the carrot tubers when planted [9].

B. Weighted Product Method

The research model uses the Weighted Product (WP) method in determining a decision based on several attributes.This method requires the decision maker to determine the weight for each attribute. WP evaluates m alternatives Ai (i=1,2,..,m) against a set of attributes Cj (j=1,2…,n) where each attribute is independent of one another [5]. In the WP method normalization is still carried out, where the rating of each attribute must be raised to the first power with the weightof the attribute in question. The normalization formula is as follows

$$S_i = \prod_{j\$1}^{n} = X_{ij}^{Wj} \qquad (1)$$

In performing calculations using the WP method, severalstages must be carried out, including:

1. Define criteria and assign categories to each criterion. The categories in each criterion are cost, and benefit. Then give weight to each criterion.

Table 1. Weight Of Alternative Criteria

ALTERNATIVE	KRITERIA		
	C_1	C_2	C_N
ALTERNATIVE 1	X_{11}	..	..
ALTERNATIVE 2	..	..	..
ALTERNATIVE M	X_{M1}	..	X_{MN}

2. Determine the priority level of weight for each criterion, then correct the weight with the following formula.

$$W_{ij} = \frac{Wi}{\sum Wi} \qquad (2)$$

Description:

Wi = Criteria weight to wij

∑Wj = Total sum of criteria weights

Wij = The final result of the corrected value

3. Calculating the value of the Si vector, the criterion is raised to the power and multiplied by the weight that has been fixed previously.

$$S_i = \prod_{j\$1}^{n} X_{ij}^{Wj} \qquad (3)$$

Description:

Si = Alternative preferences.

Xij = Criteria value.

Wj = Weight of criteria.n = Number of criteria

4. Calculate the vector Vi, then choose the highest value asthe best alternative in making decisions.

$$V_i = \frac{S_i}{\sum_{i\$1}^{n} S_i} \; with \; i = 1,2,\dots m \qquad (4)$$

Description:

Vi = Alternative preferences

Si = Alternative preference on the vector S

n = Number of criteria

m = Number of alternatives

III. METHOD

A. *Research Stages*

The following is the order from the beginning to the conclusion of the research to be carried out.

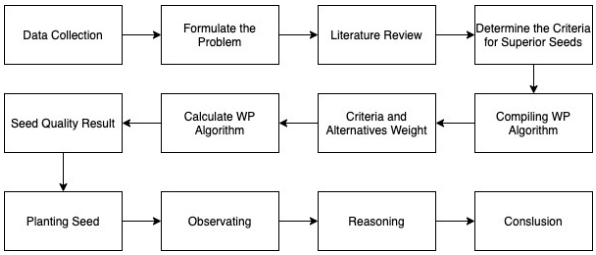

Figure 1. Research Stages

In Figure 1. Research Stages, the first step is to collect initial data. This research is a case study, so we look at the phenomena that occur in the object or place of research. Next formulate existing problems to observe reality with a literature review or actual science and theory. The result of the literature review is to determine the criteria for superior seeds from carrot plants and computer computationalalgorithms that can be used to solve problems.

The next process is to find the value of the criteria for prospective seeds for computational calculations using the WP algorithm to produce recommendations for the quality ofprospective seeds. These prospective seeds will be planted and observed to measure the results of the recommendations.The final stage is to reason about the results of plants that have grown to draw conclusions

B. System Design

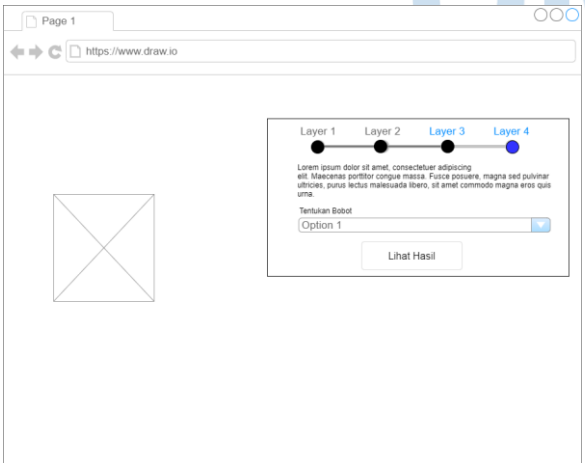

Figure 2. User Dashboard Mockup

Figure 2. User Dashboard Mockup is the initial user interface design when opening the website. On this page thereis a button that functions to start the recommendation process,after the button is pressed, a stepper will appear to guide the user in filling in the desired criteria weights. After allprocesses are complete, the recommendation results willappear to replace the stepper component

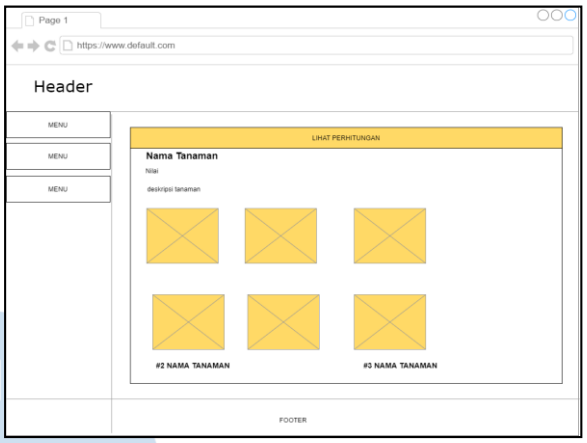

Figure 3. Admin Dashboard Mockup

Figure 3. Admin Dashboard Mockup is an interface design for the results page on the admin dashboard. This page will display the 5 criteria for the best carrot seed varieties, picturesof carrot plants and the final WP weight value of the existing varites. At the top there is a button to display the modal that contains the recommendation calculation process in detail.

C. *Criteria and Weighted Scale*

The following are the criteria and the value of each criterion weight designed in this study:

Table 2. Criteria And Weighted Scale

Code	Criteria	Weighted	Description	Weighted Score
C1	Root Texture	1-5	Benefit	1-5
C2	Root thickness	1-5	Cost	3,8,11,15,18
C3	Root Color	1-5	Benefit	1-5
C4	Leaf Color	1-5	Benefit	1-5
C5	Plant Age	1-5	Cost	59,69,79,90,110

Based on the results of interviews with farmers/experts who have done planting and research for more than 20 years, there are 5 criteria in determining the quality of candidate carrot seeds. C2

and C5 are cost criteria because the root thickness and plant age, the higher the cost for planting and land use. so that the resulting value is higher, but the weight of the criteria is getting lower in the WP calculation [10].

IV. Result and Discussion

A. Implementation of Weighted Product

In choosing the best carrot seed candidate to be the best carrotseed recommendation based on 5 criteria inputted by the user, 10 alternatives were used. One of these alternatives will be selected and then sorted based on the final weighted score ofthe WP. Each alternative is given the necessary criteria and weights in performing calculations so that the results obtainedare as follows:

Table 3. Criteria Description

Criteria	Description
Root Texture	The texture of the tuber is an essential factor for the growth and development of prospective carrot seeds. The texture of the tuber plays an important role in the growth resistance and strength of the carrot plant against pests or temperatures.
Root thickness	The thickness of the tuber affects the nutritional quality of the carrot plant. The thickness of the tubers is proportional to the texture of the tubers to provide strong resistance to the would-be carrot plant.
Root Color	The color of the tubers affects the criteria for carrot plants. A good tuber color is a bright color and reddish or yellow depending on the carrot variety produced.
Leaf Color	Leaf color is an important factor. Leaf color affects the quality of the carrot tubers produced.
Plant Age	Each type of carrot plant variety has a different age to be categorized as mature or old enough.

The selected alternatives from various varieties of carrot plants have the following criteria weights:

Table 4. Weighted Scale Of Each Alternatives

Code	Alternatives	C1	C2	C3	C4	C5
A1	Imperator	5	11	5	5	110
A2	Chantenay	4	8	4	4	79
A3	Danvers	5	5	5	3	89
A4	Mini Carrot	5	5	3	2	59
A5	Nantes	4	11	5	5	110
A6	Hercules	5	15	3	5	69
A7	Oxheart	3	15	1	5	110
A8	Red-cored	2	15	3	2	79
A9	Merida	4	8	1	1	110
A10	Rainbow	3	11	5	4	110

Next, the process of calculating the WP based on the weight of the criteria inputted by the user. From the results of the weights of the inputted criteria, normalization of theweights of each criterion will be sought.

Table 5. Input Level Criteria By User

Code	Lv.1	Lv.2	Lv.3	Lv.4	Lv.5
C1	Branch two	Double bend	One Bend	Not straight	Straight unbranched
C2	1-3 cm	4-5 cm	6-8 cm	9-11 cm	12-15 cm
C3	Pale Yellow	Less bright	Pale red	bright and less red	bright and red
C4	Dark green brown	Dark Green and not fresh	Not Fresh and Dark Green	Not Fresh and Dark Green	Fresh and Light Green
C5	50-59 days	60-69 days	70-79 days	80-89 days	90-110 days

In this calculation simulation, the level value inputted bythe user is:

1. C1: Level 5, straight unbranched
2. C2: Level 4, 9-11 cm
3. C3: Level 5, bright and red
4. C4: Level 5, fresh and light green
5. C5: Level 5, 90-110 days

Then the calculation starts from weight normalization, the first step is to normalize the weights of the criteria that have been entered. The normalization process can be seen in table 6 Normalization Process.

Table 6. Normalization Process

Code	Normalization	Result
C1	5/(5+2+5+5+1)	0.278
C2	2//(5+2+5+5+1)	0.111
C3	5/(5+2+5+5+1)	0.278
C4	5//(5+2+5+5+1)	0.278
C5	1/(5+2+5+5+1)	0.056

Next the normalization process is complete, then the S vector value is calculated. The calculation process is carried out by raising the alternative weight value to the normalized weight value, for the weight with the cost rank attribute to benegative while the benefit attribute to the positive rank. The process of calculating the value of the vector S can be seen in Table 7. Vector Si Calculation Process.

Table 7. Vector V Calculation Process

No.	Calculation Vector S	Result
S1	$(5^{0.278})(11^{-0.111})(5^{0.278})(5^{0.278})(110^{-0.056})$	2.256
S2	$(4^{0.278})(8^{-0.111})(5^{0.278})(4^{0.278})(79^{-0.056})$	1.976
S3	$(5^{0.278})(5^{-0.111})(5^{0.278})(3^{0.278})(89^{-0.056})$	2.162
S4	$(5^{0.278})(5^{-0.111})(3^{0.278})(2^{0.278})(59^{-0.056})$	1.715
S5	$(4^{0.278})(11^{-0.111})(5^{0.278})(5^{0.278})(110^{-0.056})$	2.12
S6	$(5^{0.278})(15^{-0.111})(3^{0.278})(5^{0.278})(69^{-0.056})$	1.94
S7	$(3^{0.278})(15^{-0.111})(1^{0.278})(5^{0.278})(110^{-0.056})$	1.209
S8	$(2^{0.278})(15^{-0.111})(3^{0.278})(2^{0.278})(79^{-0.056})$	1.157
S9	$(4^{0.278})(8^{-0.111})(1^{0.278})(1^{0.278})(110^{-0.056})$	0.898
S10	$(3^{0.278})(11^{-0.111})(5^{0.278})(4^{0.278})(110^{-0.056})$	1.839

After getting the results from the calculation of vector S, the next process is calculating the value of vector V bydividing each vector S by the total sum of all vectors S. The calculation of vector V can be seen in Table 8. Vector V Calculation process:

Table 8. Vector S Calculation Process

No.	Calculation Vector V	Result
V1	2.256/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.13
V2	1.976/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.114
V3	2.162/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.125
V4	1.715/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.099
V5	2.12/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.122
V6	1.94/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.112
V7	1.209/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.07
V8	1.157/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.067
V9	0.898/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0,073
V10	1.839/(2.256+1.976+2.162+1.715+2.12+1.94 +1.209+1.157+0.898+1.839)	0.106

Based on the results of calculations and results of sorting outthe WP method above that carrot seeds which are selected tobe the best carrot seeds is:

Table 9. Weighted Scale of Each Alternatives

Code	Alternatives	Result	Rank
A1	Imperator	0.13	1
A2	Chantenay	0.114	4
A3	Danvers	0.125	2
A4	Mini Carrot	0.099	7
A5	Nantes	0.122	3
A6	Hercules	0.112	5
A7	Oxheart	0.07	9
A8	Red-cored	0.067	10
A9	Merida	0,073	8
A10	Rainbow	0.106	6

B. Implementation of Algorithm on Website

Figure 4. User Dashboard Website

The website page for the carrot seed recommendationsystem is divided into two, namely for users and admins. Theuser only has a feature to search for the best weight of carrotseeds, while the features that the admin has are adding alternative data and seeing detailed calculations fromsearching for the best weight of carrot seeds.

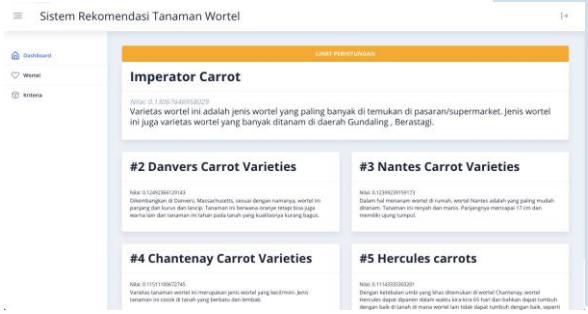

Figure 5. Admin Dashboard Website

V. CONCLUSION

Based on the results of research that has been successfullycarried out, the conclusions of this study are as follows:

1. Implementation weighted product method for the best carrot seed recommendations is determined based on 5 criteria's: root texture, root thickness, root color, leaf color and plant age.
2. The process of selecting carrot plants uses the Weighted Product (WP) method which helps in making decisions from several alternatives that must be taken by considering the criteria.
3. The user satisfaction using EUCS (End user computing System) for the application is 80.5%, which falls under the category of excellent.
4. For further system development, giving weights to alternatives and criteria can use fuzzy values. In addition, the weight of the criteria can also be obtained using the Analytical Hierarchy Process (AHP) questionnaire, not just interviews so that it can consist of several sources people [11].

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