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RESEARCH ARTICLE

EXPONENTIAL COMPARISON METHOD AND TFN FOR SELECTION OF REGIONAL SUPERIOR PRODUCTS BASED ON PROCESSED SEAWEED

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Abstract

Determining superior regional products is expected to increase competitiveness and absorb labor, improving people's income.The processed seaweed products are identified and selected using an exponential comparison approach with TFN.Alternative assessment of superior seaweed processed products in this area uses 12 criteria and 27 sub-criteria, with alternative seaweed processed products being unprocessed food, processed culinary ingredient, processed food, and ultra-processed food. Theresult is that unprocessed food is the best alternative, with a score of 0.030.

Introduction:-

The government has proclaimed economic development through regional autonomy for a long time. Economic development policies are issued as a form of support for regional development based on local potential. Each region has a tremendous and diverse potential resource, which can be utilized for economic improvement and regional competitiveness. This policy provides direction and guidance on regional economic development by developing superior regional products.Based on (Permendagri Nomor 9 Tahun 2014, no date), Regional Leading Products (PUD) means products and services produced by small and medium enterprises that utilize natural resources, human resources and local cultureto generate income for the community and the government. Regional Leading Products are expected to become a strengths economy for the region and the local community so that the products produced have competitiveness, marketability, and impetus to enter the global market(Suparman& Prawira, 2014). Regional superior products are usually made by small and medium enterprises, involving a lot of labor from the local community. The success and sustainability of this excellent regional product depend on small and medium enterprises managing and developing their business to optimize superior regional products.

Seaweed is one of Indonesia's leading commodities with excellent potential for development due to its comparative advantage. The nutritional composition of seaweed is very potential for food raw materials or processed directly into various healthy foods that have nutritional value that is not inferior to land plants (Matanjun et al., 2009)(Rasyid, Ardiansyah, and Pangestuti, 2019)(Sudarwati et al., 2020).

Processing seaweed into various processed products can be developed and used as a choice of superior regional products. One of the seaweed-producing areas that have the potential to be developed is the Thousand Islands (W Sudarwati, 2021).

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Based on existing conditions, the local government has not determined seaweed as a superior product with an excellent product selection method. This is because up to now, seaweed production is only marketed in salted dry form, and only a few are traditionally processed into various processed food products. This traditional processing is not many but has the potential to be developed because the variety of production results can be used as an alternative to seaweed products.The purpose of this article is to determine products based on local resources, in this case, seaweed, which has the potential to be developed optimally so that they become superior products that are competitive and can improve people's welfare.In this context, selecting products is a complex, multi-objective decision-making process; several conflicting criteria must be considered and evaluated (Lin et al., 2009). In addition, decisions from experts are mapped by linguistic logic, which requires processing information that is incomplete, inaccurate, vague, and uncertain.

Therefore, this study will propose the application of the Exponential Comparison (MPE) method with fuzzy sets to overcome ambiguity in the decision-making process for determining superior seaweed products. In addition, the results obtained with this fuzzy approach allow for more concrete (Kaya, Çolak, and Terzi, 2019). Fuzzy is a mathematical theory designed with a model of imprecision or ambiguity of human cognitive processes pioneered by (Zadeh, 1965). Fuzzy set theory was introduced to include the uncertainty of human thinking in the modeling. The most critical contribution of fuzzy set theory is its ability to represent inaccurate or unclear data. These two methods are integrated to increase flexibility and sensitivity in decision-making. With this method, the government can find out what seaweed processed products can be developed with a more focused program to be used as a lever for regional economic development that can encourage and accelerate economic growth and improve community welfare. Based on the description above, it can be formulated that the problems in the Thousand Islands are that there is no or it has not been determined what seaweed products can be superior. Therefore, this study aimed to determine the superior seaweed processed products in the Thousand Islands Regency, which can be developed optimally using the Exponential Comparison Method approach with the Fuzzy triangular set.

This paper consists of sections: Section 2 provides information about alternative seaweed processed food products. Section 3 provides a literature review of the proposed multi-criteria decision-making model. Section 4 presents research methods that include applying real cases to rank alternative superior processed seaweed products. Section 5 presents the results obtained. Section 6 presents a sensitivity analysis of the seaweed product determination model. Section 7 conclusions and further research

Literatur Review:-

There are many decision-making approaches used in research to determine superior regional products. Some of these studies are summarized as follows:

Research(Layoo et al., 2018) examines the determination of superior regional products. It determines the priority scale of the agricultural sector based on the availability of raw materials, market potential, human resource support, uniqueness, and economic contribution using the AHP method. Research (Lamatinulu et al., 2019) selects superior products for the IKM scale that are competitive and can provide high profits. The decision of the flagship product of the IKM scale is determined based on the criteria that have been identified using the Delphi method and analyzed using the AHP method. (Lamaakchaoui, Azmani and Jarroudi, 2018) presents the application of the multi-criteria decision-making method (MCDM), which is used to help customers choose the best complementary set of products through an evaluation process of alternatives according to some criteria. (Dokuzlu et al., 2020) presents the methodology used in selecting pilot products to support the development of sustainable geographic indication projects. In this study, the qualitative data obtained were converted into quantitative data for product selection because the data for local products were insufficient, and standard data were unavailable for each product. The data is then processed using the AHP method.

Research (Fasyah, Daryanto and Suprayitno, 2016) combines the AHP and MPE methods to determine superior regional products. AHP is used to weigh the criteria for deciding select products. In contrast, MPE assesses each superior alternative product and then chooses the priority of superior products based on the highest score. (Ahdan, 2015) integrates three methods, namely LQ, AHP and MPE for determining regional superior products. LQ is used to see the description of the existence of the base sector. There are 5 agricultural sub-sectors which then become alternatives to be selected using the AHP method. The results of the AHP are in the form of the most superior sector priorities. The various commodities from the priority sectors are then selected using MPE. A study conducted by (Khairati, Rahmanta and Ayu, 2018)(Sudarta, Tenri Sompa and Riduansyah Syafari, 2021) presents the

determination of superior commodities using LQ. (Gunawan, Cahyono and Santoso, 2018) presents a conceptual analysis of determining local superior commodities using the location quotient technique.

Research (Anissudin et al., 2019) uses a fuzzy inference system to determine potential commodities in the city of Sukapeace. (Sutoni, 2018) uses the Location Quotation approach to determine priority areas or sectors and fuzzy logic to determine regional superior products. (Zhu, Li and Feng, 2016) uses fuzzy optimization, to overcome subjective, uncertain, and inappropriate judgments in the selection of various products. (Ramli et al., 2018) the determination of processed fishery products uses a fuzzy approach and combines it with TOPSIS. (Umam et al., 2018) presents the decision making for selecting superior regional products using the Vikor method.

The following percentage figures present the analysis of several methods used to determine superior regional products. Figure 1 shows the methods commonly used for decision making in determining the superior products of the AHP and LQ regions. However, there are differences between the two methods. The LQ method is more widely used to determine superior commodities or sector priorities. While AHP is an MCDM method that can be used to determine alternative priorities for superior regional products based on various criteria. This AHP method can be combined with other methods. Other methods that follow are Fuzzy, Topics, and Vikor.

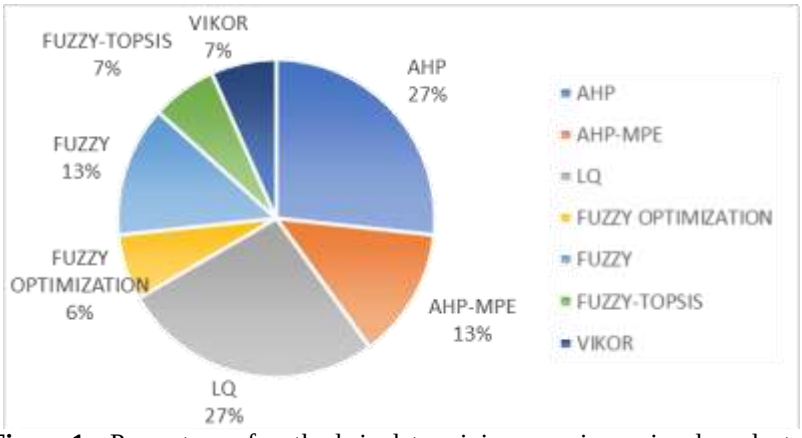

Figure 1:- Percentage of methods in determining superior regional products.

From various existing studies, the exponential comparison method itself has not been widely used in research to determine regional superior products. MPE is a method for determining the priority order of decision alternatives with multiple criteria, which has the advantage of reducing bias that may occur in the analysis (Marimin and Maghfiroh, 2011)(Rangkuti, 2011). In the Exponential Comparison Method, the difference in values between criteria can be distinguished depending on the ability of the assessor. The resulting score will describe the order of priority that becomes large, this results in the order of priority of the decision alternatives becoming clearer (Sari, 2018) . However, in determining the alternative score using an ordinal scale where there can be inaccuracies in the assessment. Fuzzy sets help decision-makers to deal with uncertainty in the decision-making process

Methodology:-

This research was conducted in the Thousand Islands Regency which consists of 2 sub-districts, namely the South Thousand Islands District and the North Thousand Islands District. The data used in this study are primary data and secondary data. Primary data is data obtained through field observations by conducting interviews with aquaculture farmers, collectors and seaweed farmers. In addition, interviews, questionnaires and discussions with experts were conducted. The experts involved in the research were academics, the KPKP department, and the PPKUKM department. While secondary data is obtained from BPS data, KPKP sub-dept., PPKUKM, Journals, Reports, etc. The approach used to determine the priority of processed seaweed products in the Thousand Islands is the Exponential and Fuzzy Comparison Method to calculate the alternative value scores. The steps taken refer to the MPE stage, namely:

Step 1. Determine the regional superior product alternatives by identifying the seaweed processed products that exist in the sub-districts of the North Thousand Islands and the South Thousand Islands along with the potential for processed seaweed food products that can be developed in these areas. The results of the identification of processed

seaweed products and their potential are grouped into processed product categories including unprocessed food, processed culinary ingredient, processed food, ultra-processed food (Monteiro et al., 2018).

Step 2. Determine the criteria to be considered in determining alternative decisions (Marimin and Maghfiroh, 2011).The decision criteria were obtained from the identification process, which was carried out by collecting various literature from journals, proceedings, government regulations and reports. All of the criteria collected were selected and adjusted to the conditions and problems studied. The results of the identification of these criteria are then verified based on expert opinion with the stipulation that the criteria deemed important according to the expert's assessment will be used as criteria in the evaluation of the selection of processed seaweed products and conversely the criteria that are considered unimportant are not used as criteria for the evaluation of the selection of processed seaweed products.

Step 3. determine the weight of the criteria. The weight of the criteria is the score of each criterion that describes the high and low importance of the criteria in decision making(Marimin and Maghfiroh, 2011). The assessment of the weight of this criterion uses a scale of 1 (not important) to 5 (very important). This assessment allows for different opinions to be generated, so an approach that can incorporate expert opinions is needed. Mathematical approaches through mathematical methods can be used to combine different expert opinions. This model was chosen because there is empirical evidence showing that aggregation using the mathematical method gives better results than the behavioral method(Ouchi and Bank, 2004). The mathematical approach used in this research is the geometric mean model. The formula for calculating the geometric average is as follows:

GM= √(n&(X_1))(X_2)……(X_n)……. (1)
Dengan :
GM = Geometrik mean
X1 = Expert 1
X2 = Expert 2
X3 = Expert 3
Xn = Expert n
n = Number of experts/participants

Step 4. Assessment of all alternatives on each decision criteria. Alternative scores on certain criteria are done by assigning a value to each alternative based on the value of the criteria. The assessment of alternative seaweed products uses linguistic attributes, where the value of each variable is in the form of words or sentences in natural language, for example raw materials as fuzzy variables with linguistic values for raw material variables, namely very low, low, medium, high, very high (Zadeh, 1975). The assessment is then considered as a representation of the expert / decision-maker.

The linguistic values are then mapped into different linguistic classes through membership functions. The membership function is a curve that shows the mapping of data input points into the membership value or membership degree which has an interval between 0 to 1. In this study the form of membership function used is Triangular Fuzzy Number (TFN) (Marimin, 2002). This TFN approach is implemented to compare alternatives against each criterion. Each set represents a description of the preference level of one alternative over another. As shown in the figure below, the membership functions are constructed in such a way that the sets overlap each other. Each value of x € R has a degree of membership in two different sets (Sarfaraz, Mukerjee and Jenab, 2012).

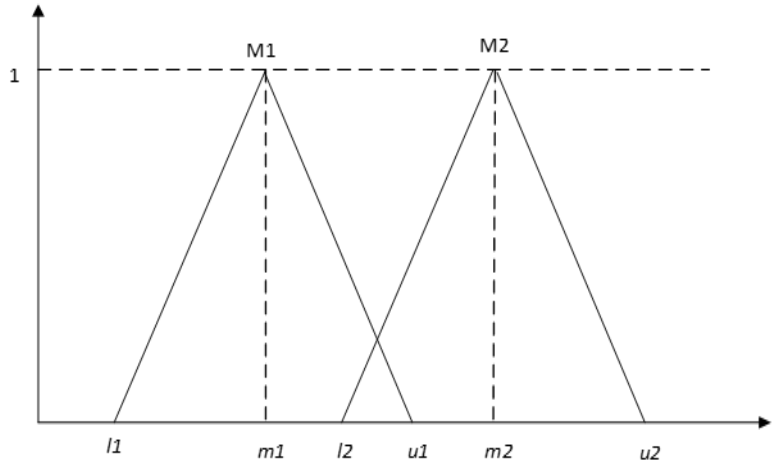

Figure 2:- Triangular Fuzzy Number (TFN) M= (1, m, u).

The symbol representing the fuzzy set receives the wave sign ˜ above it. A triangular fuzzy number symbolized as $\tilde{M}$ = (l, m, u) is defined as follows , where l and u represent the lower and upper values of $\tilde{M}$ respectively and m is the modal value . $\tilde{M}$ = (l, m, u) has a value of l ≤ m ≤ u has a membership function of triangular type with equation 2

$$\mu F(x) = \begin{cases} 0 & x < l \\ (x-l)/(m-l) & l \le x \le m \\ (u-x)/(u-m) & m \le x \le u \\ 0 & x > u \end{cases} \quad \text{……..……(2).}$$

The required operations defined on the two fuzzy numbers M1 = (l1, m1, u1) and M2 = (l2, m2, u2) are (Sarfaraz, Mukerjee and Jenab, 2012).

$(l_1, m_1, u_1) \oplus (l_2, m_2, u_2) \approx (l_1 + l_2, m_1 + m_2, u_1 + u_2)$……..(3)

$(l_1, m_1, u_1) \odot (l_2, m_2, u_2) \approx (l_1 l_2 + m_1 m_2 + u_1 u_2)$……..(4)

$(\lambda, \lambda, \lambda) \odot (l_1, m_1, u_1) = (\lambda l_1, \lambda m_1, \lambda u_1) \lambda > 0, \lambda \in R$……..(5)

$(l_1, m_1, u_1)^{-1} \approx (1/u_1, 1/m_1, 1/l_1,)$……..(6)

The linguistic value given by the expert on each criterion needs to be converted into crips form. Defuzzification is the process of converting the fuzzified output into a single-valued (crisp) output with a non-fuzy scalar value. One method of defuzzification is weight average. This method applies to fuzzy sets with symmetrical output membership functions and produces results that are very similar to the COA (Center of Area) method (Leekwijck and Kerre, 1999). Thismethod is less computationally intensive. Each membership function is measured by its maximum membership value. The defuzzification value is defined as (Mizumoto, 2004)(Chakraverty, Sahoo and Mahato, 2019):

$$x' = \frac{\sum \mu(x) x}{\sum \mu(x)} \text{ ……..(7)}$$

where :

x' is the crisp value

μ(x) is the degree of membership of the crisp x value.

Step 5. calculate the score or total value of each alternative. The greater the alternative value, the greater the alternative score. The total score of each decision alternative will be significantly different because of the exponential function. The formula for calculating scores for each alternative in the Exponential Comparison Method adopted from (Marimin and Maghfiroh, 2011) is as follows:

$$TotalNilai(TNi) = \sum_{j=1}^{m} \left(RK_{ij}\right)^{TKK_j} \text{ ……. ……..} \quad (8)$$

Where :

TN = Total Alternative Value to i

Kij = the degree of relative importance of the -j criterion in the ith decision

Tj = degree of importance of decision criteria j , TKK > 0 ; round,

n = number of decision choices

m = number of decision criteria
i = 1,2,3...

Step 6. determine the order of priority decisions based on the score or total value of each alternative. The order of priority is determined based on the total score of each alternative starting from the largest to the smallest.The stages of conducting the research are as set out in Figure 2 below:

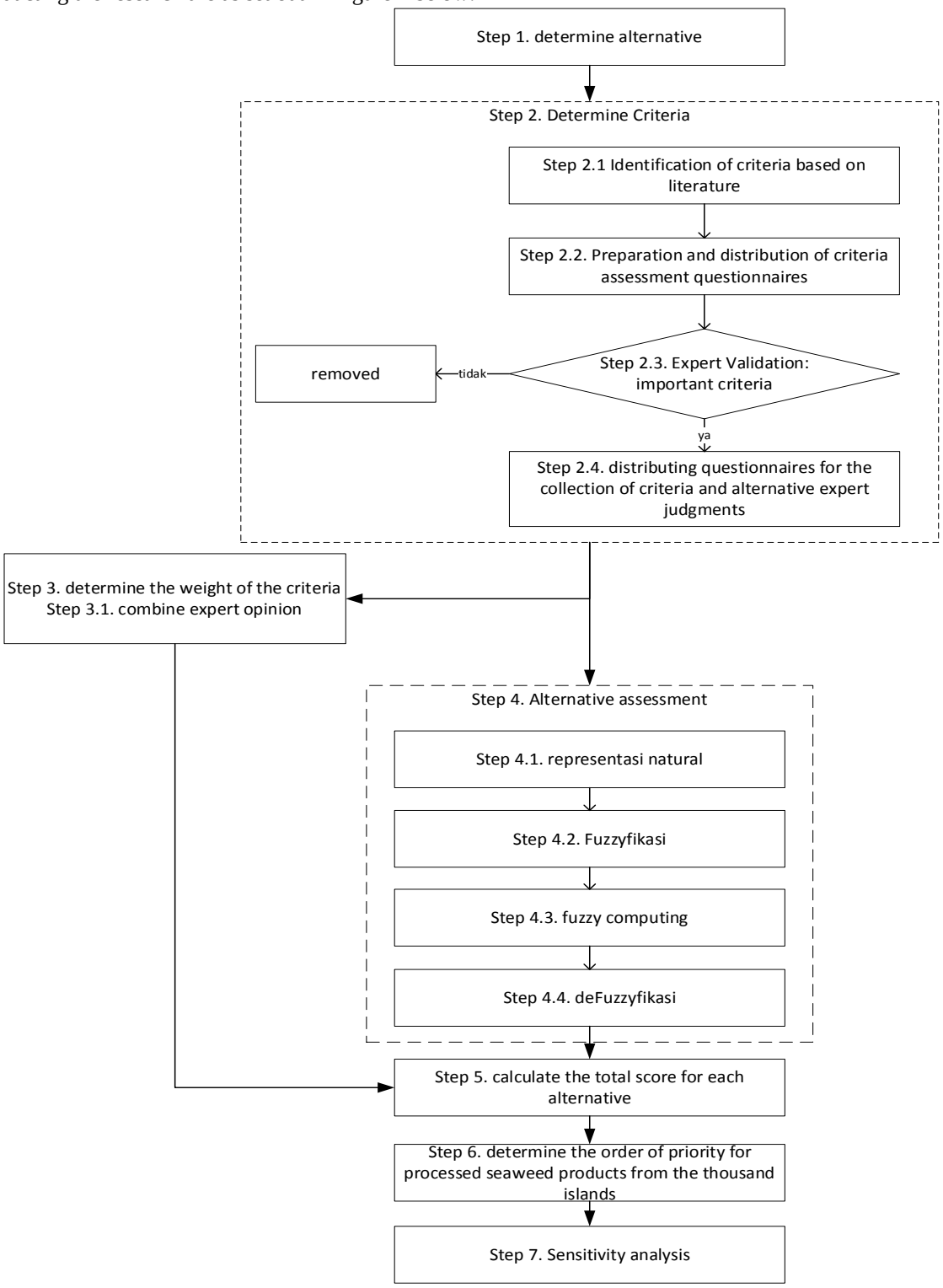

Figure 3:- The stages of the MPE fuzzy method.

Result And Discussion:-

The results of this study were obtained from the implementation of the stages of the MPE and Fuzzy methods described above. In detail the results of each stage carried out are discussed as follows:

Develop decision alternatives

Alternative decisions for superior seaweed products are obtained based on the identification of processed seaweed products in the Thousand Islands and the potential for processed seaweed products that are possible to be developed in the Thousand Islands. Seaweed products currently available in the Thousand Islands include dried red and white salted seaweed, seaweed lunkhead, and cocktails. Meanwhile, the potential of processed seaweed products that can be developed include jam, seaweed crackers and seaweed syrup and others. The results of the identification of processed seaweed products and other processed potentials are grouped according to (Monteiro et al., 2016), as follows:

Table 1:- Alternative groups of seaweed products.

ALTERNATIVE	ALTERNATIVE GROUP	SEAWEED PRODUCTS
A1	UNPROCESSED FOOD	SALTY RED DRIED SEAWEED
		SALTY WHITE DRIED SEAWEED
		VEGETABLES, SALADS
A2	PROCESSED CULINARY INGREDIENT	CARRAGEENAN
A3	PROCESSED FOOD	DODOL
		COCKTAILS, SEAWEED ICE
A4	FROZEN FOOD	SEAWEED MEATBALLS
A5	SNACK	SEAWEED CRACKERS
A6	SOFTDRINK	SYRUP, JUICE

Determine the criteria for selecting superior products

All the criteria for determining superior products obtained from various literatures are listed and presented in the form of a questionnaire which is then given to the expert to assess the level of importance of all the criteria, as a form of validation. Based on the list of criteria discussed in the literature and the evaluation of experts, 12 criteria were obtained that can be used as indicators for the assessment of the determination of superior seaweed food products in the Thousand Islands region. Table 2 presents the final set of criteria for determining the most appropriate seaweed processed food product.

Table 2:- Description of criteria and sub-criteria.

CRITERIA	SUB CRITERIA	RELATED REFERENCE
C1. RAW MATERIAL	C11.AVAILABILITY	(SUTONI, 2018)(RAMLI ET AL., 2018)(LAMATINULU ET AL., 2019)
	C12.QUALITY	(SUTONI, 2018)
	C13.PRICE	(RAMLI ET AL., 2018)
	C14.CONVENIENCE	
	C15. CONTINUITY	(RAMLI ET AL., 2018)(DOKUZLU ET AL., 2020)
C2. LABOR	C21.AVAILABILITY	(SUTONI, 2018)(RAMLI ET AL., 2018)(LAMATINULU ET AL., 2019)(LAYOO ET AL., 2018)
	C22.SKILL NEEDS	(SUTONI, 2018)(RAMLI ET AL., 2018)
	C23.NEED FOR NUMBER OF WORKERS	(RAMLI ET AL., 2018)
C3. CAPITAL	C31.CAPITAL REQUIREMENT	(RAMLI ET AL., 2018)
	C32.EASY ACCESS TO FINANCING	(DOKUZLU ET AL., 2020)
C4. INFRASTRUCTURE	C41. AVAILABILITY	(LAMATINULU ET AL., 2019)(LAYOO ET AL., 2018)
	C42.EASE OF GETTING INFRASTRUCTURE	(RAMLI ET AL., 2018)(PERMENDAGRI NOMOR 9 TAHUN 2014, NO DATE)
	C43.PRICE	(PERMENDAGRI NOMOR 9 TAHUN

		2014, NO DATE)
C5. TECHNOLOGY	C51.AVAILABILITY	(RAMLI ET AL., 2018)
	C52. EASE OF OPERATION	(LAMATINULU ET AL., 2019)
	C53. EASE OF GETTING	
C6. BUSINESS MANAGEMENT	C61.EASE OF MANAGEMENT	(RAMLI ET AL., 2018)
C7. ENVIRONMENTAL IMPACT	C71.POLLUTION	(RAMLI ET AL., 2018)
C8. SOCIO-CULTURAL	C81. REFLECTING THE CHARACTERISTICS OF LOCAL CULTURE	(LAMATINULU ET AL., 2019)(LAYOO ET AL., 2018)
	C82.COMMUNITY ACCEPTANCE	(DOKUZLU ET AL., 2020)
C9.MARKET	C91.MARKET POTENTIAL	(SUTONI, 2018)(LAMATINULU ET AL., 2019)(LAYOO ET AL., 2018)(DOKUZLU ET AL., 2020)(FASYAH, DARYANTO AND SUPRAYITNO, 2016)
	C92.EASE OF BEING ABSORBED INTO THE MARKET	(SUTONI, 2018)
C10.PRICE	C101. VALUE-ADDED	(SUTONI, 2018)(RAMLI ET AL., 2018)(LAMATINULU ET AL., 2019)(DOKUZLU ET AL., 2020)
	C102 ABILITY TO GENERATE OPERATING PROFIT	(SUTONI, 2018)(RAMLI ET AL., 2018)
C11.SALES TURNOVER	C111 ABILITY TO GENERATE TURNOVER	(SUTONI, 2018)(DOKUZLU ET AL., 2020)
C12.ECONOMIC IMPACT	C121.EMPLOYMENT	(SUTONI, 2018)(FASYAH, DARYANTO AND SUPRAYITNO, 2016)
	C122.NUMBER OF OTHER TYPES OF BUSINESSES AFFECTED	(DOKUZLU ET AL., 2020)

Determining Criteria Weight

Each criterion selected as an indicator for determining the determination of seaweed processed food products is given a weight based on its level of importance. The weight of these criteria was assessed by experts using a Likert scale ranging from 1 (not important), 2 (less important), 3 (quite important), 4 (important), and 5 (very important). This weight value is not measured using fuzzy numbers, given that the criteria for weighting criteria in the MPE method must be integers and the value is more than 0 (Marimin and Maghfiroh, 2011). Assessment The weight of the criteria from each expert is combined using equation (1) to get the final weight of each criterion. Based on the results of the combined expert assessment, the weight value for the criteria (C1) for raw materials is 5 (very important), criteria (C2) for labor is 4 (important), criteria (C3) for capital is 4, criteria (C4) for production facilities is 4 , criteria (C5) technology weighs 4, criteria (C6) business management weighs 4, criteria (C7) environmental impacts weighs 4, criteria (C8) socio-cultural weights 4, criteria (C9) Market weighs 5, criteria (C10) value-added and profit has a weight of 5, the criterion (C11) of turnover has a weight of 4, the criterion (C12) of the economic impact has a weight of 4.The results of the weight assessment show that the criteria for raw materials, markets and prices have a very important weight (5). While other criteria have the same level of importance to be used as an assessment of determining alternatives to processed seaweed products.

Assessment of regional superior product alternatives

Alternative score assessment is done by giving a value for each alternative based on the value of the criteria. This assessment uses a triangular fuzzy number 1 - 5 which is defined in linguistic language with provisions such as table 3. Where this table is a conventional 5 scale development.

Table 3:- Rating Scale with Linguistic Language.

Fuzzy Number	$\tilde{1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{5}$
Membership number	(0, 1, 2)	(1, 2, 3)	(2, 3, 4)	(3, 4, 5)	(4, 5, 6)
Availability of raw	not available	Few	Sufficiently	available	Many

material		available	available		available
Raw material quality	Not quality	Poor quality	Quality enough	quality	Very good quality
Raw material price	Very expensive	expensive	quite expensive	inexpensive	very cheap
easy access to raw materials	Very difficult	difficult	enough	easy	very easy
Sustainability of raw materials	Unsustainable	not sustainable	enough	sustainable	very sustainable
availability of manpower	not available	Few available	quite available	available	Many available
workforce skills	Very high	high	high enough	low	very low
labor needs	The least	a little	currently	many	a huge amount
Capital requirement	Very large	big	currently	small	Very small
Easy access to financing	Very difficult	difficult	enough	easy	very easy
Availability of infrastructure	not available	Few available	Sufficiently available	available	Many available
Ease of getting infrastructure	Very difficult	difficult	enough	easy	very easy
Prices for infrastructure	Very expensive	expensive	currently	inexpensive	very cheap
Availability of technology	not available	Few available	Sufficiently available	available	Many available
Ease of operating technology	Very difficult	difficult	enough	easy	very easy
Ease of getting technology	Very difficult	difficult	enough	easy	very easy
Ease of business management	Very difficult	difficult	enough	easy	very easy
Impact of pollution	Very large	big	currently	small	No impact
Reflecting the characteristics of local culture	There are no specialties and many in the market	There is nothing special in the market	There are special and many in the market	There are special and few in the market	There are special and not in the market
Community acceptance	Not accepted	not accepted	Quite acceptable	accepted	accepted and supported
Market potential	No potential	less potential	enough	potential	very potential
Ease of being absorbed into the market	Very difficult	difficult	enough	easy	very easy
Product added value	Very small	small	currently	Big	very large
Ability to generate operating profit	Very small	small	currently	Big	very large
Ability to generate turnover	Very small	small	currently	Big	very large
Employment	Very small	small	currently	big	very large
Number of other types of businesses affected	No one is affected	a little	currently	many	a huge amount

The definition and membership function of fuzzy numbers is shown in the following figure:

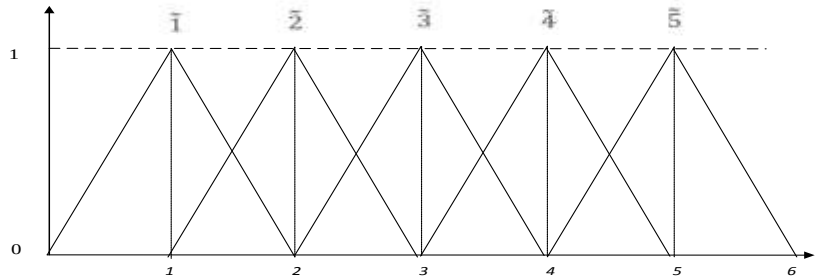

Figure 4:- Linguistic scale of triangular fuzzy numbers.

All alternatives to seaweed processed food products are assessed by experts based on predetermined criteria using a linguistic scale. The assessment provides separate results for each expert. Therefore, to get an assessment, it is necessary to combine alternative values from all experts using the geometric average as in equation (1). An example of the geometric mean assessment is as follows.

$GM_l = \sqrt[3]{(4)}(4)(4) = 4$

$GM_m = \sqrt[3]{(5)}(5)(5) = 5$

$GM_u = \sqrt[3]{(6)}(6)(6) = 6$

The results of combining expert opinions as a whole are shown in table 5. From the results of the merger, it is not clear how many total scores (l, m, u) for each criterion are. The total value (l, m, u) of each criterion can be combined by adding up the value (l, m u) of each alternative using equation (3). Examples of calculations for sub-criteria for the availability of raw materials are as follows:

$$T_{(L,M,U)} = (L_1 + L_2 + L_3 + L_4 + L_5 + L_6), (M_1 + M_2 + M_3 + M_4 + M_5 + M_6), (U_1 + U_2 + U_3 + U_4 + U_5 + U_6$$
$$= (4 + 0 + 4 + 0 + 2{,}3 + 0), (5 + 1 + 5 + 1{,}7 + 3{,}4 + 2{,}2), (6 + 2 + 6 + 2{,}9 + 4{,}5 + 3{,}3)$$
$$= (10{,}3\ ;\ 18{,}3\ ;\ 24{,}7)$$

The total value (l, m , u) of each criterion is used to find the inverse that functions to calculate the fuzzy weight. The inverse calculation uses equation (6). An example of calculating the inverse value of the sub-criteria for the availability of raw materials is as follows:

$$(L_1, M_1, U_1)^{-1} \approx (1/24{,}7; 1/18{,}3; 1/10{,}3)$$
$$= (0{,}04\ ;\ 0{,}05\ ;\ 0{,}10)$$

Calculating fuzzy weight

Calculation of the fuzzy weight on each criterion of each alternative, equation (5) is used, with an example of calculating the fuzzy weight on the sub-criteria of the availability of raw materials as follows

$$(\Lambda, \Lambda, \Lambda) \odot (L_1, M_1, U_1) = \big((0{,}04 * 4); (0{,}05 * 5); (0{,}1 * 6)\big)$$
$$= (0{,}16\ ;\ 0{,}27\ ;\ 0{,}58)$$

The fuzzy weights that have been obtained in table 6 are then averaged using the equation (7). The results of the average fuzzy weight, which is the fuzzy output, are then normalized to obtain an alternative score for superior seaweed processed food products. Based on equation (8) the score of each alternative is raised to the power of the criteria weights and added up to obtain the total score of each alternative.

The results of the weighting of criteria and scoring of each alternative obtained from normalization in table 6 are summarized in table 7 below:

Table 7:- Assessment of alternatives to processed seaweed products.

No	Criteria	Sub Criteria	Weights (Ni)	**Featured product alternative scores**					
				Unprocessed food	Processed culinary ingredient	Processed food	Frozen	Snack	Soft drink

C1	Raw Material	availability	5	0.27	0.07	0.27	0.10	0.19	0.12
		quality	5	0.17	0.15	0.16	0.17	0.17	0.17
		price	5	0.18	0.11	0.18	0.18	0.18	0.18
		convenience	5	0.22	0.11	0.17	0.15	0.17	0.17
		continuity	5	0.21	0.12	0.19	0.13	0.22	0.13
C2	Labor	availability	4	0.21	0.11	0.21	0.13	0.22	0.13
		workforce skills	4	0.11	0.23	0.14	0.18	0.16	0.18
		labor needs	4	0.23	0.15	0.21	0.13	0.16	0.13
C3	Capital	Capital requirement	4	0.19	0.09	0.19	0.17	0.19	0.19
		easy access to finance	4	0.11	0.18	0.16	0.21	0.16	0.19
C4	infrastructure	Availability of infrastructure	4	0.23	0.08	0.21	0.13	0.21	0.13
		Ease of getting infrastructure	4	0.22	0.08	0.22	0.13	0.21	0.13
		Prices for infrastructure	4	0.21	0.08	0.19	0.14	0.19	0.19
C5	technology	Availability of technology	4	0.22	0.09	0.20	0.14	0.20	0.16
		Ease of operating technology	4	0.18	0.07	0.19	0.19	0.19	0.19
		Ease of getting technology	4	0.20	0.06	0.18	0.18	0.18	0.18
C6	business management	Ease of business management	4	0.18	0.06	0.18	0.19	0.19	0.19
C7	environmental impact	Impact of pollution	4	0.17	0.10	0.18	0.18	0.18	0.18
C8	socio-cultural	Reflecting the characteristics of local culture	4	0.10	0.10	0.24	0.15	0.26	0.15
		Community acceptance	4	0.17	0.12	0.18	0.17	0.18	0.17
C9	Market	Market potential	5	0.22	0.17	0.16	0.15	0.16	0.15
		Ease of being absorbed into the market	5	0.20	0.08	0.19	0.18	0.18	0.18
C10	Price	Product added value	5	0.11	0.22	0.16	0.16	0.16	0.18
		Ability to	5	0.12	0.24	0.16	0.16	0.16	0.16

		generate operating profit							
C11	turnover	Ability to generate turnover	4	0.18	0.13	0.18	0.15	0.20	0.16
C12	economic impact	Employment Number of other types of businesses affected	4	0.23	0.14	0.18	0.13	0.18	0.13
			4	0.20	0.14	0.21	0.13	0.19	0.13
TOTAL (score ^weight)				0.0296	0.0081	0.0291	0.0138	0.0285	0.0153
Priority				1	6	2	5	3	4

The total score of each alternative value of processed seaweed products is calculated based on equation (8), the results of the calculation are as follows:

Unprocessed food =	$(0,27)^5+(0,17)^5+(0,18)^5+(0,22)^5+(0,21)^5+(0,21)^4+(0,11)^4+(0,23)^4+(0,19)^4+(0,11)^4+(0,23)^4+(0,22)^4+(0,21)^4+(0,22)^4+(0,18)^4+(0,20)^4+(0,18)^4+(0,17)^4+(0,10)^4+(0,17)^4+(0,22)^5+(0,20)^5+(0,11)^5+(0,12)^5+(0,18)^4+(0,23)^4+(0,20)^4 = 0,030$
Processed Culinary Ingredient=	$(0,07)^5+(0,15)^5+(0,11)^5+(0,11)^5+(0,12)^5+(0,11)^4+(0,23)^4+(0,15)^4+(0,09)^4+(0,18)^4+(0,08)^4+(0,08)^4+(0,09)^4+(0,07)^4+(0,06)^4+(0,06)^4+(0,10)^4+(0,10)^4+(0,12)^4+(0,17)^5+(0,08)^5+(0,22)^5+(0,24)^5+(0,13)^4+(0,14)^4+(0,14)^4 = 0,008$
Processed Food =	$(0,27)^5+(0,16)^5+(0,18)^5+(0,17)^5+(0,19)^5+(0,21)^4+(0,14)^4+(0,21)^4+(0,19)^4+(0,16)^4+(0,21)^4+(0,22)^4+(0,19)^4+(0,20)^4+(0,19)^4+(0,18)^4+(0,18)^4+(0,18)^4+(0,24)^4+(0,18)^4+(0,16)^5+(0,19)^5+(0,16)^5+(0,16)^5+(0,18)^4+(0,18)^4+(0,21)^4 = 0,0291$
Frozen Food =	$(0,10)^5+(0,17)^5+(0,18)^5+(0,15)^5+(0,13)^5+(0,13)^4+(0,18)^4+(0,13)^4+(0,17)^4+(0,21)^4+(0,13)^4+(0,13)^4+(0,14)^4+(0,14)^4+(0,19)^4+(0,18)^4+(0,19)^4+(0,18)^4+(0,15)^4+(0,17)^4+(0,15)^5+(0,18)^5+(0,16)^5+(0,16)^5+(0,15)^4+(0,13)^4+(0,13)^4= 0,014$
Snack =	$(0,19)^5+(0,17)^5+(0,18)^5+(0,17)^5+(0,22)^5+(0,22)^4+(0,16)^4+(0,16)^4+(0,19)^4+(0,16)^4+(0,21)^4+(0,21)^4+(0,19)^4+(0,20)^4+(0,19)^4+(0,18)^4+(0,19)^4+(0,18)^4+(0,26)^4++(0,18)^4+(0,16)^5+(0,18)^5+(0,16)^5+(0,16)^5+(0,20)^4+(0,18)^4+(0,19)^4= 0,0285$
Softdrink =	$(0,12)^5+(0,17)^5+(0,18)^5+(0,17)^5+(0,13)^5+(0,13)^4+(0,18)^4+(0,13)^4+(0,19)^4+(0,19)^4+(0,13)^4+(0,13)^4+(0,19)^4+(0,16)^4+(0,19)^4+(0,18)^4+(0,19)^4+(0,18)^4+(0,15)^4+(0,17)^4+(0,15)^5+(0,18)^5+(0,18)^5+(0,16)^5+(0,16)^4+(0,13)^4+(0,13)^4= 0,015$

The priority of processed seaweed products is determined based on the order of the total score starting from the highest total score as the first priority to the lowest total score. Based on the total score developed with FMPE, it can be seen that the priority 1 seaweed product with a value of 0.030 is unprocessed food, namely unprocessed seaweed, which can be used as vegetables or sold as raw materials. The choice of unprocessed food cannot be separated from the type of seaweed produced in the thousand islands, namely Eucheuma spinosum. This type of seaweed is found not only on the roast islands but also on the islands of pari and kongsi islands (Zulpikar et al., 2020). Cultivation of Eucheuma sp in the Thousand Islands is easy to do because it uses simple technology or traditional tools that are

easily obtained at low prices so that experts rate 4 on these criteria, this is in accordance with research (Ngamel, 2012). Cultivation business capital is quite cheap, with small profits but this cultivation business is still feasible to run.

Eucheuma spinosum is an edible red seaweed. Seaweed is a variant of healthy food that is rich in vitamins, minerals and fiber (Ito and Hori, 1989). Based on the food safety aspect, Eucheuma spinosum is safe for health(Tuwo et al., 2021). Besides being sold as a raw material, the people of the Thousand Islands also use this seaweed as a vegetable for their daily diet. According to information from residents and seaweed food entrepreneurs, this Eucheuma spinosum seaweed can be processed into various vegetables, such as seaweed soup, urap, rujak, etc. The process of making it is quite easy, just wash it and then cook it with boiling water for a short time and then remove it. This seaweed has a soft texture so it should not be boiled for a long time because it will crumble. According to (White, 2015) Eucheuma spinosum is used for carrageenan. As a source of carrageenan, Eucheuma Spinosum contains high carrageenan, ranging from 65-67 percent. Carrageenan plays a very important role as a stabilizer, thickener, gelling agent, emulsifier and others. With these characteristics of seaweed, the added value of Eucheuma spinosum can be increased by processing and marketing it as vegetables or carrageenan. However, with the existing infrastructure in the Thousand Islands, it is possible that Eucheuma spinosum can be processed as a vegetable or sold in the form of dry material.

The second priority with a value of 0.0291 is processed food, namely seaweed processed with a few additional ingredients such as sugar, cooking oil, Garem or other ingredients so that it becomes ready-to-eat food. The 3rd priority with a value of 0.0285 is a snack, namely seaweed processed into seaweed crackers. The 4th priority with a value of 0.015 is soft drinks (drinks) including seaweed juice, seaweed syrup. The 5th priority with a value of 0.014 is Frozen Food, including meatballs. Priority 6 with a value of 0.008 is Processed Culinary Ingredient.

Sensitivity Analysis

Sensitivity analysis was carried out by changing the weight of the main criteria, with the aim of analyzing the impact of the weight of the criteria on the score and ranking of alternative regional superior products. For this purpose, each scenario is changed to the 2 weights of the criteria so that 66 different scenarios are obtained. The difference in scores and ratings obtained from this scenario is used to analyze the impact of the weighting criteria. After a change in the weight of the criteria, the score for each alternative is obtained as shown in Figure 5 . The change in the score for each alternative was followed by a change in the ranking of alternatives for processed seaweed products. The alternative ranking of superior products obtained from the results of sensitivity analysis is as shown in Figure 6.

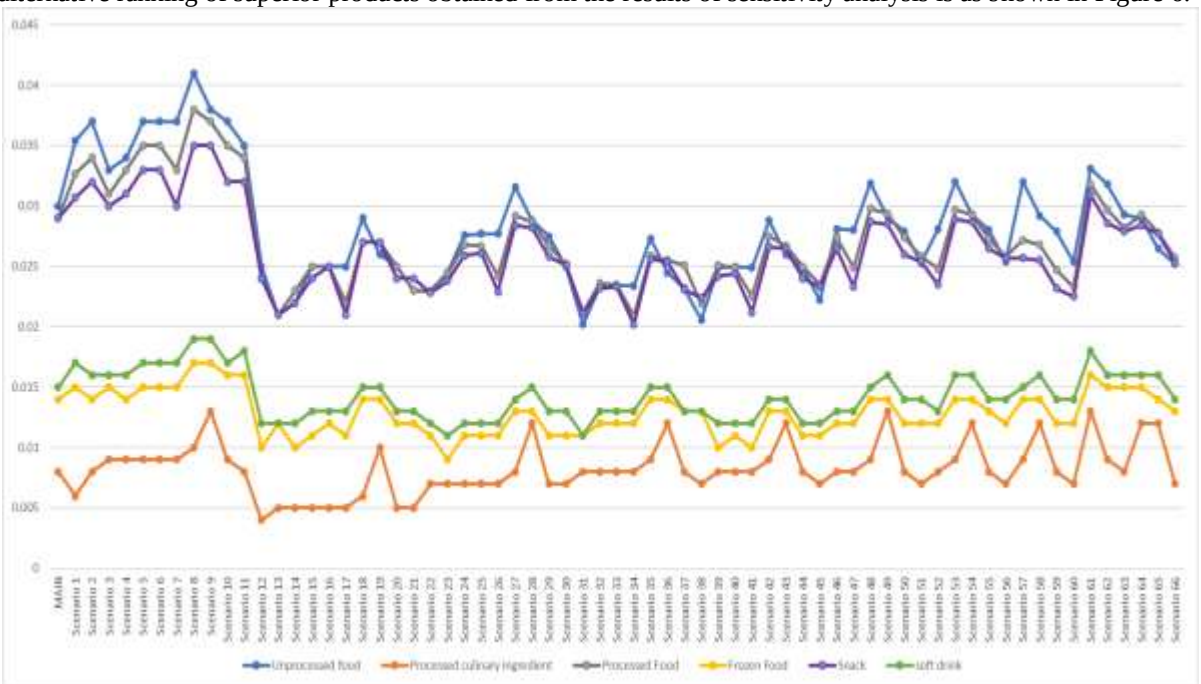

Figure 5:- The results of the sensitivity analysis for the value score of each alternative processed seaweed product of regional superiority.

The results of the sensitivity analysis in Figure 5 explain the change in the score for each alternative. For alternatives to soft drinks, frozen food and processed culinary ingredients, the score is below less than 0.02, fluctuates but does not intersect. So these three alternatives are not a top priority. Meanwhile, unprocessed food, processed food and snacks have a score that fluctuates, there are 49 scenarios that make unprocessed food have a higher score than others. On the other hand, there are 17 scenarios that make processed food have a higher score than others. And there is 1 scenario that makes the snack has a higher score than the others. This affects the ranking of alternatives to processed seaweed products. The results of the ranking of processed seaweed products are as shown in Figure 5 below:

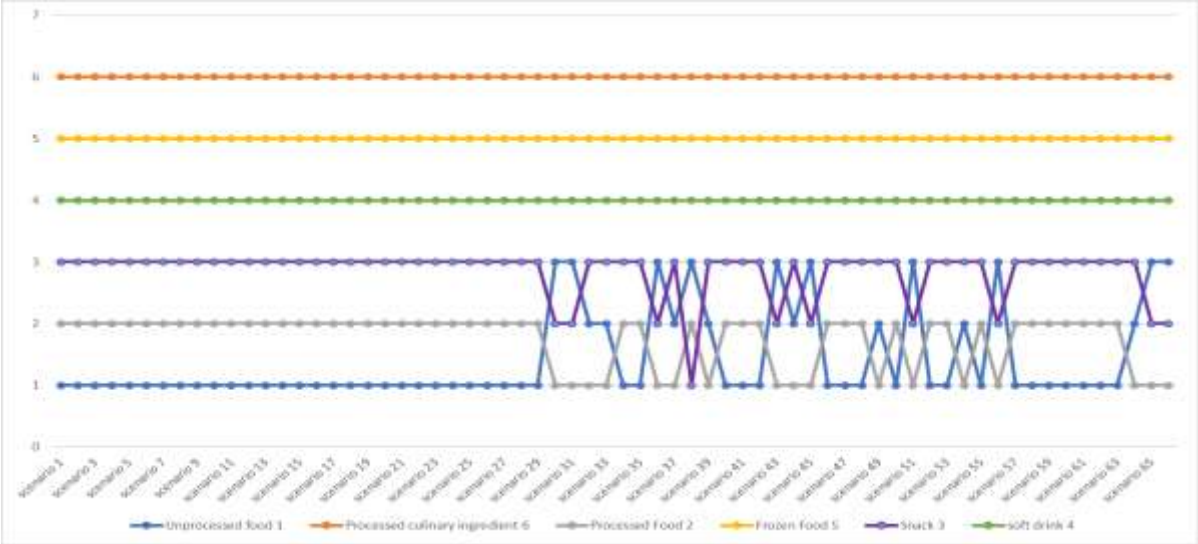

Figure 6:- The results of the sensitivity analysis for the ranking of regional superior processed seaweed products.

The results of the sensitivity analysis explain that the alternative "Unprocessed Food" is the first alternative for 49 scenarios, as the second alternative for 7 scenarios and is designated as the third alternative for other scenarios. Alternative "Processed Food" is generally determined as the second alternative, but there are still 18 scenarios that set processed food as the first priority. Alternative "Snack" is generally defined as alternative 3, but there are 9 scenarios that specify snack as alternative 2, and 1 scenario as the first alternative. While the other 3 alternatives have the same ranking for different scenarios, namely "Softdrink" ranks fourth, "Frozen Food" ranks fifth, and Processed Culinary Ingredient" ranks sixth.

Conclusion:-

In this paper, the priority of alternative superior processed seaweed products is determined according to the potential of the Thousand Islands Regency area. This research contributes to the policies that can be taken by the regional government of the Thousand Islands Regency regarding regional superior products based on seaweed. To achieve this goal, exponential and fuzzy comparison methods are proposed to determine the priority of regional superior seaweed processed products. Alternative assessment of superior seaweed processed products in this area uses 12 criteria and 27 sub-criteria, where the score of each alternative and criteria is used to determine the priority of alternative products. Alternatives for processed seaweed products are unprocessed food, processed culinary ingredients, processed food, ultra-processed food (snacks, frozen food, soft drinks). The main weights and sub-criteria used to solve the problem of decision making in determining regional superior products are calculated using the MPE methodology based on triangular fuzzy sets. The results of the alternative ranking suggested that the unprocessed food alternative was determined as the best alternative with a score of 0.030 for the Thousand Islands Regency. Other alternatives that follow are processed food scores with a score of 0.0291, snacks with a score of 0.0285, soft drinks (beverages) with a score of 0.015, Frozen Foods with a score of 0.014, and Processed Culinary Ingredients with a score of 0.008. This study has limitations on the number of experts. The more the number of experts will affect the assessment that has an impact on the decision to determine the regional superior product. The next weakness is that the weight of the sub-criteria is considered the same as the criteria so that the interpretation of the results becomes less detailed.

Future Research

The decision support system for determining the superior seaweed processed food products in this area can be developed into the following research topics:

1. Development of a decision support system application for determining regional superior seaweed processed food products that can be accessed via cellular phones.
2. Increasing the added value of seaweed through the development of the seaweed agroindustry value chain.

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