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Structure of the Analytic Hierarchy Process (AHP) for Natural Disaster Management in Making Decisions on Military Operations Other than War in the TNI

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A B S T R A C T

Disasters have direct consequences that affect human life and the environment. Vulnerability to disasters happens due to a lack of proper disaster management, various environmental impacts, or people's negligence. The amount of losses in every catastrophe depends on the resilience capacity of the community against disasters. The Indonesian National Military (TNI) as the nation's guardian and defense component has two main tasks, namely (1) Military Operations for War (Operasi Militer Perang/OMP) and Military Operations Other Than War (Operasi Militer Selain Perang/OMSP). In this case, TNI is carrying out the MOOTW duties, based on RI Law Number 34 of 2002 which states that the TNI is a force that helps the government in handling disasters. TNI plays a significant role in Military Operation Other Than War (MOOTW) that includes leading in disaster management, increasing organizational capacity and operational management in supporting disaster management, boosting cooperation, education and training on disaster management, providing facilities and infrastructure including budget planning and support from the top command of the central and regional governments. This paper is using the Analytic Hierarchy Process (AHP) by determining the goals, criteria, and the overall sub-criteria for each of the MOOTW criteria/factors and considering options for increasing the budget or cooperation. The results are then used as a reference for decision-making in handling the disasters.

INTRODUCTION

This study discusses Natural Disaster Management in Decision Making for Military Operations Other than War in the TNI using the Analytic Hierarchy Process (AHP) Structure approach. The country of Indonesia, which is located at three confluence of earth's plates, namely the Eurasian, Pacific and Indo-Australian Plates, makes Indonesia an area prone to natural geological disasters (Adri et al., 2020; Alif et al., 2021; Maarif et al., 2012). In addition, Indonesia is in a row of Pacific volcanoes (Pacific Ring of Fire), where there are 129 volcanoes which can erupt at any time. So natural phenomena are a particular challenge faced by the people of Indonesia because they are in an area prone to natural disasters due to natural events such as earthquakes, tsunamis, volcanic eruptions, floods, hurricanes, landslides, and droughts (Lasaiba & Arfa, 2022). To overcome this disaster, the Indonesian National Armed Forces (TNI), together with the regional government, worked together during the disaster emergency response period (Zaqy et al., 2018). (Djalante, et al., 2020; Zaqy et al., 2018)

During the disaster emergency response period, the role of the TNI as one of the components of the nation and state instruments in the field of defence has the main task of upholding state sovereignty, maintaining the territorial integrity of the Unitary State of the Republic of Indonesia based on Pancasila and the 1945 Constitution of the Republic of Indonesia, and protecting all nation and all of Indonesia's bloodshed from threats and disturbances to the integrity of the government and state (Manurung et al., 2022). The main tasks of Military War Operations (OMP) and Military Operations Other Than War (OMSP) are contained in RI Law 34 of 2004 concerning the Indonesian National Armed Forces. Mainly in Military Operations Other than War carried out by the TNI consisting of 14 types of operations, one of the tasks in point 7 (seven) is to help overcome the consequences of natural disasters, evacuation and providing humanitarian assistance (Fauzi, 2014; Priambodo et al., 2020).

The implementation of MOST tasks carried out by the TNI, especially in disaster management, is a task that maintains humanitarian principles, does not use violence, and applies the principles of management (Djuyandi et al., 2019). Also conducted a similar study looked at how the implementation of MOM was in overcoming environmental problems, especially in the revitalization of the Citarum River. However, an essential point in implementing MOM is the need to emphasize the principle of military professionalism, whereby the tasks carried out must be based on law and based on assignments given by civil political authorities (Diamond & Plattner, 2001; Djuyandi et al., 2019).

Support efforts to deal with natural disasters that occur in the region or in the regions requires the readiness of all existing resources, namely from the aspect of human resources, through methods such as education and training on the ability and expertise on natural disaster management, SAR (Search and Rescue) field health, and others related to personnel capabilities (Hollnagel & Fujita, 2013; Kusumasari & Alam, 2012). From the aspect of infrastructure (surprise), namely the need to submit and apply for the development and construction of the existing sarpras both through the top command and in collaboration with regional and provincial governments both at the provincial and district/city levels in each region in fulfilling the required samples (Arifin et al., 2021; Prakoso & Dohamid, 2021).

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Meanwhile, from the software aspect, it is necessary to prepare an SOP (Standard Operation Procedure) as a guide in supporting the handling of each type of natural disaster that regulates the movement of personnel in the field, including command control with side units/agencies and local governments in involving the TNI in each region in supporting disaster relief efforts nature that happened (Ruttenberg & Rice, 2019; Subiyakto, 2020).

However, efforts to comply with Facilities, Technology and SOP are not easy. Then each criterion is analyzed to determine whether the criterion requires a budget or cooperation that must be increased (Belay et al., 2022). In analyzing these criteria, the AHP (Analytic Hierarchy Process) approach is used. The results of the analysis of each of these criteria are expected to be able to provide clear directions for decision-makers in TNI institutions to determine attitudes in making choices. The process of collecting data during the research was carried out by way of interviews and focus group discussions (FGD) with selected informants who have certain scientific backgrounds in their fields. Furthermore, each participant is invited to make a comparison between the factors that influence whether these criteria will be budgeted or collaborated on. The results of this comparison are then analyzed using the AHP method to determine which factors have the dominant influence on the decision.

AHP is a method that considers many objective and subjective factors in alternative rankings (Parameshwaran et al., 2015). In addition, AHP can assist the decision-making process through a hierarchical decision model (Singh & Nachtnebel, 2016). The AHP method uses a pairwise comparison matrix which forms a reciprocal matrix in changing qualitative ratio data. Eigen Value is used to access the final weight of the criteria and measure the level of consistency obtained through the consistency index (Vaidya & Kumar, 2006; Yavuz, 2015).

METHOD

The research uses qualitative methods, and data processing uses the Analytic Hierarchy Process (AHP) approach as a super decision in which there are aspects of qualitative assessment and calculation which aim to get a value or viewpoint represented by the participants (Teknomo, 2006). The Analytic Hierarchy Process (AHP) method, with the emergence of several MOM criteria in determining decisions, makes the problem of choosing to increase the budget or cooperation of an element of disaster management in the MOM context complex. The process of making a decision in a situation like this needs to be prioritized for each criterion. For this purpose, AHP can be used as a decision-making system using a mathematical model. With this mathematical model, quantitative results can be obtained from criteria that are mostly qualitative in nature. AHP, which was introduced by Saaty in 1980, is a method that helps decision makers which is popular and widely used (Golden, et al., 1989; Vargas, 1990).

AHP combines subjective and objective criteria into one measure in a hierarchical framework. The AHP method is carried out based on ratio scales and pairwise comparisons provided by decision-makers verbally and numerically. This method is carried out by following four stages, starting with compiling a hierarchical structure and then continuing to collect pairwise comparison data, looking for priorities using the Eigen Value method and ending by combining priorities into a combined measure to determine the ranking of each decision alternative (Erensal & Albayrak, 2007).

RESULTS AND DISCUSSION

ANALYTIC HIERARCHY PROCESS (AHP)

Hierarchical Structure

This research begins by creating a hierarchical structure beginning with the primary goals (goals). After compiling the main goal as the top level, a hierarchical level of criteria and sub-criteria will be arranged below it. Data processing results produce Normalized Geometric Mean values for each criterion and sub-criteria, and ranking is carried out. The hierarchical structure in this study can be seen in Figure 1.

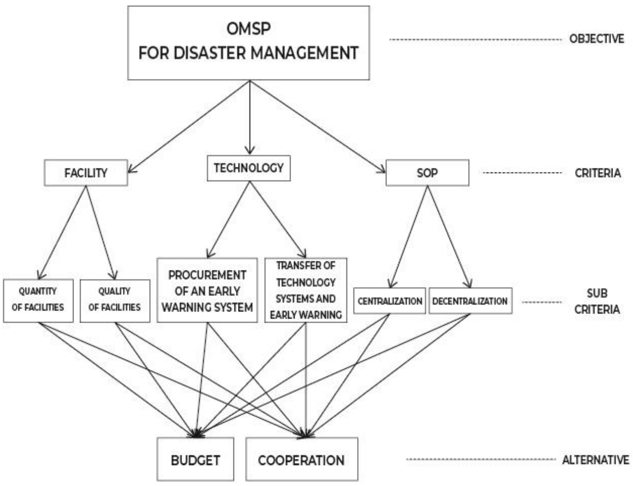

Figure 1. Hierarchical structure of the problem
Source: Researcher, 2023.

Weighting of Criteria and Sub-Criteria

Retrieval and verification of disaster events experienced in several places in Indonesia related to disaster management consist of prevention, emergency response and post-disaster rehabilitation/recovery. These parameters were then analyzed using the AHP (Analytical Hierarchy Process) method. In the weighting of each parameter, the reciprocal axiom law applies. That is, if a parameter is considered five times more important than other parameters, the more critical parameter becomes 1/5 times. If a parameter is as important as others, each is worth 1 (Table 1).

Table 1. Given Weighting Criteria

No.	Quality	Definition	Keterangan
1.	1	Equal Importance	Both elements have an equal contribution
2.	2	Approaching a little more important than	Preferences approach slightly more importantly one element over the other
3.	3	Slightly more important than	Preference is slightly more important one element over the other
4.	4	Approaching is more Important	Preferences approach the more important one element over the other

			elements
5.	5	More important	Preference is more important one element over the other elements
6.	6	Approaching Strong importance	Preferences approach the strong importance of one element over the other elements
7.	7	Strong importance	Preferences place one element over the other
8.	8	Very strong importance	Preference is very strong in the importance of one element over another, in which its predominance is markedly reflected
9.	9	Absolute importance	Absolute preference for domination of interests over other elements

Source: Researcher, 2023.

Comparison of each of the Criteria and Sub-Criteria

Shetty et al., (2021), participants were asked to provide a comparative assessment of each sub-criteria at this stage. This comparative assessment is based on a Likert scale of 1-9, according to the suggestions of Value 1 means that both elements are equally important, value 3 means that one element is slightly more important than the other elements, value 5 means that one element is more important than the other elements, value 7 means that one element is more important than the other elements, value 9 means that one element is essential than the other elements and the other value means that it is in two adjacent consideration values.

If the weighting process has been completed, the next step is the preparation of a pairwise comparison matrix to normalize the importance level weights for each parameter in each of its hierarchies. After the pairwise comparison matrix is compiled, a consistency test is carried out on the weighting. It benchmarks with the Consistency Index (CI), which is a comparison between the Ratio Index (RI) or the Consistency Ratio (CR), as in Table 2. Details of the weighting and calculations can be seen in Table 3 and Table 4.

Table 2. Constant Consistency Ratio (CR)

Ukuran Matrik	Random Index
1,2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Source: Researcher, 2023.

Table 3. Pairwise comparison matrix

Criteria	A1	A2	....	A7
A1	1			
A2		1		
...				
A7				1

Table 4. Pairwise Weighting and Comparison of Criteria

CRITERIA/EXPERT		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	GEOMEAN
FACILITIES - TECHNOLOGY	A									1									1,000
	B								2										
	C										0,50								
	D									1									
FACILITIES - SOP	A										0,50								1,565
	B								2										
	C							3											
	D								2										
TECHNOLOGY - SOP	A										0,50								0,707
	B									1									
	C										0,50								
	D									1									

Source: Researcher, 2023.

Table 5. Verification of Normality and Calculation Rating on Criteria

CRITERIA	FACILITY	TECHNOLOGY	SOP	EIGEN VALUES (λ)			AMOUNT	RATAS	RANK	CRITERIA PRIORITY VECTOR
FACILITY	1	1,000	1,565	0,369	0,369	0,393	1,132	0,377	1	FACILITY
TECHNOLOGY	1,000	1	1,414	0,369	0,369	0,355	1,094	0,365	2	TECHNOLOGY
SOP	0,707	0,707	1	0,261	0,261	0,251	0,774	0,258	3	SOP
AMOUNT	2,707	2,707	3,979	1,000 = Normal = The calculation process is correct				1,000		

Source: Researcher, 2023.

After calculating the weight of each criterion from pairwise comparisons with the AHP method, a weighting matrix is carried out on the sub-criteria; 1. Facilities (Quantity and Quality), 2. Technology (Early Warning System Procurement and Technology Transfer), and 3. SOP (Centralization and Decentralization). The results of the analysis of the Sub-Criteria can be seen in Table 6.

Table 6. Pairwise Weighting and Comparison of Sub-Criteria

Sub Criteria	Geomean
quantity of facilities quality of facilities	1,189
quantity of provision of early warning system facilities	1,565
quantity of technology transfer facilities	1,414
sop centralization facility quantity	2,449
sop decentralized facility quantity	2,000
quality of provision of early warning system facilities	3,130
quality of technology transfer facilities	2,913
the quality of the centralized sop facility	1,480
SOP decentralized facility quality	1,189
procurement of technology transfer early warning systems	1,000
Procurement of a centralized early warning system SOP	2,060
Procurement of a decentralized early warning system SOP	2,280
sop centralized technology transfer	1,189
SOP decentralized technology transfer	2,632

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centralized soup decentralized soup	1,316

Source: Researcher, 2023.

Table 7. Normality Verification and Calculation Rating on Sub-Criteria

SUB-CRITERIA	QUANTITY OF FACILITIES	QUALITY OF FACILITIES	PROCUREMENT OF EARLY WARNING SIS	TECHNOLOGY TRANSFER	CENTRALIZATION	DECENTRALIZATION
QUANTITY OF FACILITIES	1	1,189	1,565	1,414	2,449	2,000
QUALITY OF FACILITIES	0,841	1	3,130	0,343	1,480	1,189
PROCUREMENT OF EARLY WARNING SIS	0,639	0,319	1	1,000	2,040	2,280
TECHNOLOGY TRANSFER	0,707	2,913	1,000	1	1,189	2,632
CENTRALIZATION OF SOP	0,408	0,676	0,485	0,841	1	0,760
DECENTRALIZATION OF SOP	0,500	0,841	0,439	0,380	1,316	1
AMOUNT	4,095	6,938	7,619	4,978	9,495	9,861

EIGEN VALUES (λ)						AMOUNT	RATAS	RANK	SUB-CRITERIA
0,244	0,171	0,205	0,284	0,258	0,203	1,366	0,22765	1	QUANTITY OF FACILITIES
0,205	0,144	0,411	0,069	0,156	0,121	1,106	0,18429	3	QUALITY OF FACILITIES
0,156	0,046	0,131	0,201	0,217	0,231	0,982	0,16372	4	PROCUREMENT OF EARLY WARNING SIS
0,173	0,420	0,131	0,201	0,125	0,267	1,317	0,21947	2	TECHNOLOGY TRANSFER
0,100	0,097	0,064	0,169	0,105	0,077	0,612	0,10201	6	CENTRALIZATION OF SOP
0,122	0,121	0,058	0,076	0,139	0,101	0,617	0,10287	5	DECENTRALIZATION OF SOP
1 = Normal = The calculation process is correct							1,000		

Source: Researcher, 2023.

Consistency Ratio on Criteria and Sub-Criteria.

The Consistency Ratio (CR) value of the pairwise comparison matrix can be seen in each matrix. From each CR, a price ≤ 0.1 was obtained, so that it could be concluded that the participants were consistent in providing pairwise comparisons on the Criteria (Figure 2) and pairwise comparisons on the Sub-Criteria (Figure 3). The calculated results are as follows:

MEASURING *CONCISTENCY INDEX* (CI)

FORMULA :
CI = (Lamda Maks - n)/(n - 1) or CI = (λ - n) / (n-1)
Lamda Maks = 0,932 + 1,279 + 1,247 + 1,093 + 0,969 + 1,014
= 6,534
So CI = 0,107

MEASURING *CONCISTENCY RATIO* (CR)
CR = CI / RI (The RI value is obtained from the Random Consistency Index table)
CR = 0,086 (because the CR is smaller than 0.1 (CR < 0.1), the comparison ratio is declared CONSISTENT)

Figure 2. Consistency Ratio Pairwise comparison values on Criteria
Source: Researcher, 2023.

The results of the pairwise comparison analysis above (figure 2) for the criteria domain (facilities, technology, and sops) show the consistency of the subjective assessment of the participants (4 people). Thus they can be processed/analyzed further for analysis in the sub criteria domain (quantity of facilities, quality of facilities, procurement, technology transfer, centralization, and decentralization).

MEASURING *CONCISTENCY INDEX* (CI)

FORMULA :
CI = (Lamda Maks - n)/(n - 1) or CI = (λ - n) / (n-1)
Lamda Maks = (Number of FACILITIES x Ratas FACILITIES) + (Total TECHNOLOGY x Ratas TECHNOLOGY) + (Number of SOPs x Ratas SOP)
Lamda Maks = 1,022 + 0,987 + 1,026
= 3,035
So CI = 0,018

MEASURING *CONCISTENCY RATIO* (CR)
CR = CI / RI (The RI value is obtained from the Random Consistency Index table)
CR = 0,030 (because the CR is smaller than 0.1 (CR < 0.1), the comparison ratio is declared CONSISTENT)

Figure 3. Consistency Ratio Nilai perbandingan berpasangan pada Sub-Kriteria 7
Source: Researcher, 2023.

Based on the 3 criteria that have been determined, it shows that the highest priority for implementing omsp disaster management is facilities by considering the basic needs of the community affected by the disaster, which is immediate when a disaster occurs. the results of the pairwise comparison analysis above (figure 3), namely in the sub criteria domain, quantity of facilities, quality of facilities, procurement of early warning systems, transfer of technology, centralization of sops, and decentralization of sops, show the consistency of the subjective assessment of the participants (4 people). thus, they can be further processed/analyzed for priority scale analysis in the alternative method domain, namely budget or cooperation. ahp for sub-criteria shows that the highest priority in the context of implementing disaster management is to fulfill the number of facilities needed, considering the immediate basic needs of disaster victims for disaster events or during the emergency response phase of disaster management.

Comparison Matrix on Alternatives

Langkah berikutnya penentuan skala prioritas (utama) pada 2 Alternatif yang dipilih, yaitu metode pemecahan masalah melalui metode Anggaran atau Kerjasama. Hasil perhitungan data pembobotan dari para partisipan dengan cara pengukuran yang mempertimbangkan hasil hitung aspek Sub-Kriteria, diperoleh seperti pada Tabel 8, dan 9.

Table 8. Comparison between Alternatives on Each Sub-Criterion (Pairwise Comparison)

Alternative	Sub-Criteria Facility Quantity	Geomean
Budget - Cooperation	Facility Quality	2,213
	Procurement of Early Warning System	1,565
	Technology Transfers	5,000
	Centralized Soup	0,639
	Sub-Criteria	2,213

Table 9. Consistency Ratio on Criteria and Sub-Criteria

A. QUANTITY OF FACILITIES	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE PRIORITY VECTOR
BUDGET	1	0,689	0,689	1,378	0,689	1	BUDGET
COOPERATION	0,452	0,311	0,311	0,622	0,311	2	COOPERATION
AMOUNT	1,452	1,000 = Normal = The calculation process is correct			1,000		
B. QUALITY OF FACILITIES	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE
BUDGET	1	0,610	0,610	1,220	0,610	1	BUDGET
COOPERATION	0,639	0,390	0,390	0,780	0,390	2	COOPERATION
AMOUNT	1,639	1,000 = Normal = The calculation process is correct			1,000		
C. PROCUREMENT OF AN EARLY WARNING SYSTEM	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE
BUDGET	1	0,833	0,833	1,667	0,833	1	BUDGET
COOPERATION	0,200	0,167	0,167	0,333	0,167	2	COOPERATION
AMOUNT	1,200	1,000 = Normal = The calculation process is correct			1,000		
D. TECHNOLOGY TRANSFER	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE
BUDGET	1	0,390	0,390	0,780	0,390	2	BUDGET
COOPERATION	1,565	0,610	0,610	1,220	0,610	1	COOPERATION
AMOUNT	2,565	1,000 = Normal = The calculation process is correct			1,000		
E. CENTRALIZATION OF SOP	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE
BUDGET	1	0,311	0,311	0,622	0,311	2	BUDGET
COOPERATION	2,213	0,689	0,689	1,378	0,689	1	COOPERATION
AMOUNT	3,213	1,000 = Normal = The calculation process is correct			1,000		
F. DECENTRALIZATION OF SOP	BUDGET		EIGEN VALUES (λ)	AMOUNT	RATAS	RANK	ALTERNATIVE
BUDGET	1	0,806	0,806	1,613	0,806	1	BUDGET
COOPERATION	0,240	0,194	0,194	0,387	0,194	2	COOPERATION
AMOUNT	1,240	1,000 = Normal = The calculation process is correct			1,000		

CI = (Lamda Maks - n) / (n - 1)
Maximum Lamda = (alternatif-1 x ratasalternatif-1) + (alternatif-2 x ratas alternatif-2)

A. QUANTITY OF FACILITIES
Maximum Lamda = 2,000
CL = 0,000
Consistency Ratio (CR) = CL / CR
CR = 0,000

B. QUALITY OF FACILITIES
Maximum Lamda = 2,000
CL = 0,000
CR = 0,000

C. PROCUREMENT OF AN EARLY WARNING SYSTEM
Maximum Lamda = 2,000
CL = 0,000
CR = 0,000

D. TECHNOLOGY TRANSFER
Maximum Lamda = 2,000
CL = 0,000
CR = 0,000

E. CENTRALIZATION OF SOP
Maximum Lamda = 2,000
CL = 0,000
CR = 0,000

F. DECENTRALIZATION OF SOP
Maximum Lamda = 2,000
CL = 0,000
CR = 0,000

Source: Researcher, 2023.

The results of calculating the consistency of the index for the 2 alternatives based on pre-defined sub-criteria show all consistent values, because the CR value is less than 10% (0.1). Therefore, the assessment/judgment data input for each comparison meets the AHP requirements. Furthermore, the results of AHP in Alternatives are as shown in Table 10.

Table 10. Alternative Hierarchy and Rating

	QUANTITY OF FACILITIES			QUALITY OF FACILITIES			PROCUREMENT OF AN EARLY WARNING SYSTEM			TECHNOLOGY TRANSFER			CENTRALIZATION OF SOP			DECENTRALIZATION OF SOP			AMOUNT	RANK
	AVG	EIGEN		AVG	EIGEN		AVG	EIGEN		AVG	EIGEN		AVG	EIGEN		AVG	EIGEN			
BUDGET	0,228	0,689	0,157	0,184	0,610	0,112	0,164	0,833	0,136	0,219	0,390	0,086	0,102	0,311	0,032	0,103	0,806	0,083	0,606	1
COOPERATION		0,311	0,071		0,390	0,072		0,167	0,027		0,610	0,134		0,689	0,070		0,194	0,020	0,394	2

Source: Researcher, 2023.

CONCLUSION

After testing and analyzing decision support systems using the AHP method, it can be concluded:

1. The results of FGDs with participants regarding the implementation of disaster management, both in the prevention, emergency response, and recovery/rehabilitation phases, which are used as a reference in decision making are simplified into 3 criteria raised, including: Facilities, Technology and Standard Operating Procedures (SOP), with the Sub-Criteria for Quantity and Quality of Facilities, Procurement of Early Warning Systems and Transfer of Technology, SOP Centralization and Decentralization.
2. The results of the analysis using AHP, the consistency ratio (CR) value obtained is less than 0.1 (CI/RI ‹0.1) at each stage of the analysis so that the calculated results can be declared valid.
3. The results of the Consistency Vector calculation, a comparison between criteria obtained Eigenvalues of 0.37737 (Facilities), 0.36473 (Technology), and 0.25790 (SOP). Thus the main priority scale is the fulfillment of facilities both in quantity and quality in the implementation of disaster management, especially in the emergency response phase.

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4. The results of the Consistency Vector calculation, the comparison between the sub-criteria is obtained Eigenvalue 0.22765 (quantity of facilities), 0.18429 (quality of facilities), 0.16372 (procurement of early warning systems), 0.21947 (transfer of technology), 0.10201 (centralized SOP) and 0.1028 (decentralized SOP). From these calculations, the sub-criteria for the number of facilities is the main priority scale in the implementation of disaster management, especially during the emergency response phase.
5. The results of the Consistency Vector calculation, a comparison of alternative methods (budgeting and cooperation), obtained Eigenvalues of 0.60592 (budget) and 0.39408 (cooperation). Thus the priority scale to meet the needs of disaster management is a method of fulfilling the budget both in activities for fulfilling facilities, technology, and SOPs, but also a method of collaboration with related parties is also needed as an important complement in disaster management.

The research produces an alternative view on budget criteria that can be approached with TOT (Transfer of Technology) and SOP (Standard Operating Procedure) updates. Simultaneously, this research pays attention to quality and quantity issues in a holistic way to increase the ability of CSOs to deal with natural disasters. Meanwhile, it can also be seen that the AHP method approach can be used to provide convenience in deciding on the choice of a multi-criteria decision system in the field of modeling a measuring tool for OMSP objectives with the framework of the AHP approach in dealing with alternative options for increasing budgets and or cooperation.

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