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DETERMINATION OF MAINTENANCE PRIORITY INDONESIAN NAVY SHIP DEPO LEVEL USING FUZZY MCDM

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ABSTRACT

The Indonesian Navy as a defense and security force of the sea has combat tools and supporting facilities projected in the Integrated Fleet Weapon System (Sistem Senjata Armada Terpadu/SSAT) with several components including Indonesian navy ships, marines, aircraft and bases. Depo level maintenance is comprehensive maintenance that can only be carried out by personnel who are experts in their field and supported by complete and sophisticated equipment and facilities. Maintenance at this level includes complete overhaul repairment, repowering MLM (mid life modernization), calibration of all equipment, and repairs to all parts thoroughly. Depo Level Maintenance is the nature of maintaining technical conditions based on rotary hours. If the repair schedule specified in the SPT (System for Planned Maintenance), the schedule must be carried out. This research aimed to present a priority setting solution in Depo level maintenance wherein the highest Indonesian Navy Ship ranking is determined from the level of the decision makers. Fuzzy MCDM is a method developed for decision making on several alternative decisions to get an accurate and optimal decision. In Indonesian Navy Ship Hardepo priority ranking process taken from the level of data processing decision makers using the Fuzzy MCDM method, the 5 highest priority values in implementation were obtained. Hardepo with the highest scores were KRP-812 0.111, BDU-841 0.108, LAM-374 0.107, KRS-624 0.097 and TJA-541 0.073.

Keywords: *Indonesian Navy Ship, Depo level maintenance, Fuzzy MCDM*

1. INTRODUCTION.

The Indonesian Navy National Army or abbreviated as the Indonesian Navy is a state defense tool under the command of the Indonesian National Army which has duties in the fields of defense, police, and diplomacy. In carrying out its duties, the Indonesian Navy has an organizational structure composed of the Integrated Fleet Weapon System (SSAT) which is the main component of the Indonesian Navy's organization, which consists of Base, Marines, Aircraft and Indonesian Navy Ship (KRI).

The fleet (*Armada* in Indonesian) as one of the Indonesian Navy's organizations that has Indonesian Navy Ship is an important element needed in carrying out the tasks performed by the Indonesian Navy. In carrying out its duties, the Fleet is divided into 3 parts, namely I / West Fleet Command (*Komando Armada I/Barat*) in Jakarta, II/Central Fleet Command (*Komando Armada II/Tengah)* in Surabaya and III/East Fleet Command (*Komando Armada III/Timur*) in Sorong, West Papua.

As for the Navy, the optimal maintenance mechanism is needed to maintain the technical conditions of the KRI in order to maintain a high level of reliability and combat readiness in the long age range at an efficient cost. The maintenance system used by the Indonesian Navy today is a Planned Maintenance System (SPT).

Depo level maintenance is comprehensive maintenance that can only be carried out by personnel who are experts in their field and supported by complete and sophisticated equipment and facilities. Maintenance at this level includes complete overhaul repairment, repowering MLM (mid life modernization), calibration of all equipment, and repairs to all parts thoroughly.

Currently, there are many obstacles in the implementation of Hardepo so that maintenance becomes less optimal and does not meet the 5T criteria, namely on time, place, number, quality, and type. Hardepo has not been implemented well because of several factors including:

a. KRI often experiences delays in maintenance or repairs according to the schedule specified in the SPT. This happens because of the limited number of KRIs whose conditions are ready to carry out operations/sailing. So that the KRI that is ready to be ordered to carry out operations/sail continuously regardless of the Harmen/Hardepo schedule in accordance with JOP (Maintenance Hours) and JOG (Motion Hours). In other words, JOP has not been implemented with JOG consequently. Even if it is already there, the implementation is constrained by at least the KRI being ready, so that the KRI will continue to be prepared for operations until it ignores maintenance activities.

b. Priority determination of depo level maintenance has not run optimally because prioritization is based on the subjectivity of the decision maker of damage reports from KRI.

c. The criteria for prioritizing maintenance at Depo KRI level have not been standardized at a limited level of unit and time so that not all damage can be repaired in its implementation, but using priority scale.

d. KRI which has been determined to implement Harmen/Hardepo, is often used as a spare KRI to support other KRI readiness prepared for operations.

e. The budget is limited, so that it should be carried out on a priority scale to perform repairment.

This research aimed to present a priority determination solution in Depo level maintenance wherein the selection is done on each unit by using weighting on the criteria so that the highest KRI ranking is obtained. The ranking is subsequently performed from the level of decision makers from Mabesal Dismatal , Satharmatim Mabesal (East Maintenance and Material Unit), Asops Koarmada II (Operational Assistant), Disharkap Koarmada II (KRI Maintenance Service), Dopusbektim (East Supply Center Depo) and Pasharmat Unit (Material Maintenance Assistant Officer) in determining the right KRI priority scale to implement Hardepo.

Researchers who conducted the study used the Borda Method approach and the Fuzzy MCDM Method. Fuzzy MCDM is a method developed for decision making on several alternative decisions to get an accurate and optimal decision. Study about Fuzzy MCDM method including (Gulcin B 2016) Application of a new combined intuitionistic fuzzy MCDM approach based on axiomatic design methodology for the supplier selection problem. (Suharyo, D. Manfaat 2015) Fuzzy Multi Criteria Decision Making (FMCDM) Application in Modeling Determination of Naval Base Development. (Sri Kusumadewi dan Idham Guswaludin 2005) Fuzzy Multi-Criteria Decision Making. (Abbas Mardani et al. 2015) Fuzzy multiple criteria decision-making techniques and applications – Two decades review from 1994 to 2014. (Ahmed Mostafa dan Nasruddin Hassan 2016). The trapezoidal fuzzy soft set and its application in MCDM (Chiou, T. d. 2004).

Evaluating sustainable fishing development strategies using fuzzy MCDM approach (Gulcin B dan Sezin G 2016). Fuzzy Multi Criteria Decision Making Approach for Evaluating Sustainable Energy Technology Alternatives. (Harish Garg, N. A. 2015). Entropy Based Multi-criteria Decision Making Method under Fuzzy Environment and Unknown Attribute Weights. (Hsiu Mei et al. 2016). The Optimization Of Multipurpose Building Development On Project Scheduling Using Precedence Diagram Method (PDM) (Arica Dwi Susanto, 2018). A Fuzzy MCDM Approach for Green Supplier Selection from the Economic and Environmental Aspects (Jiann Liang Yang et al. 2008). Vendor selection by integrated fuzzy MCDM techniques with independent and interdependent relationships. (Karishma C et al. 2015). Fuzzy MCDM Approach for Air Quality Assessment. (Kainz.W. 2003). Introducing to Fuzzy Logic And application in GIS. Department of Geography and Regional Research. (Mehtap Dursun, E. K. 2011). A Fuzzy MCDM Approach for Health-Care Waste Management. (Pejman Rezakhani 2012). Fuzzy MCDM Model for Risk Factor Selection in Construction Projects. (R. V. RAO, d. T. 2009). Software Selection in Manufacturing Industries Using a Fuzzy Multiple Criteria Decision Making Method, PROMETHEE. (Sałabun, d. W. 2014). Application of the Fuzzy Multi-criteria Decision-Making Method to Identify Nonlinear Decision Models. (Silvio, J. d. 2014). Sequential use of ordinal multicriteria methods to obtain a ranking for the 2012 Summer Olympic Games. (Sotoudeh Gohar, K. 2011). A Fuzzy MCDM for Evaluating Risk of Construction Projects. (Toklu, M. C. 2017). Determination of Customer Loyalty Levels by Using Fuzzy MCDM Approaches. (Tsen Tsao dan Chung Chuan 2002). An Improved Fuzzy Mcdm Model Based On Ideal And Anti-Ideal Concepts. (Walid Serrai, et al. 2017). Towards an efficient and more accurate web service selection using MCDM methods.

2. MATERIALS/METHODOLOGY.

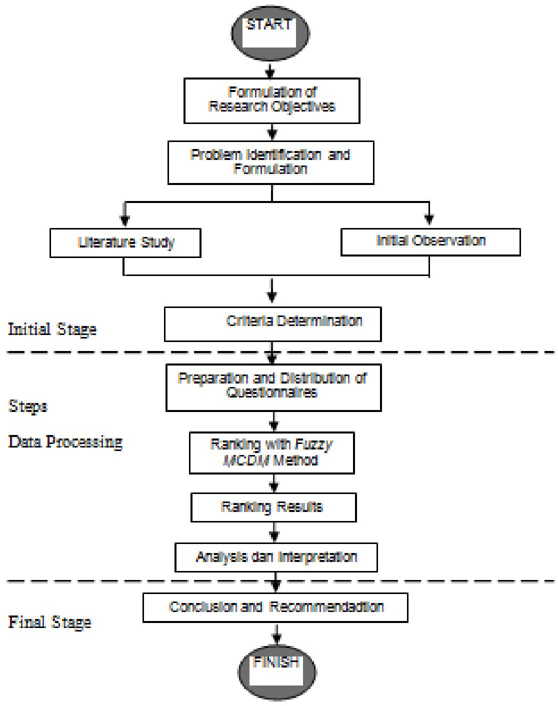

Fig. 1 Research Flow Chart.

2.1. Problem Identification and Formulation.

At this stage, an initial field study was carried out to identify and observe the problems that occur in the object of research. Based on these observations, the problems than can be formulated and the limitation of the research objects to be examined so that the problem becomes clear.

2.2. Formulation of Research Objective.

This stage is the determining stage of the direction to be used from the results of the completion of the research. The formulation of the purpose of this study is intended so that researchers can focus their research so that they do not experience expansion and change.

2.3. Initial Observation.

In this section, both primary and secondary data observation were carried out. Primary data is data obtained directly from data sources by various methods carried out in research activities. The questionnaire was distributed to Dismatal Mabesal, Satharmatim Mabesal, Sops Koarmada, Disharkap Koarmada, and Dopusbektim Mabesal. The questionnaire that the author provides contained a number of questions or statements that must be answered or responded by the respondent. Secondary data is data obtained by the author in research activities through various open sources available and possibly obtained by the author, such as KRI documents, literature studies and so forth. The data obtained include: Technical Condition Reports, KRI, JOP, and JOG Technical Data and other data that support research.

2.4. Criteria Determination.

Determination of criteria for priority determination of Hardepo on KRI elements used criteria that have been developed, namely: Operational Aspects and Technical Aspects. Determination of these criteria was done by taking KRI document data, library studies and so on. The criteria are as follows

1) Operational Aspect.
   a) JOP (Maintenance Hours).
   b) JOG (Motion Hours).
   c) Spare parts availability.
2) Technical Aspect.
   a) Floating Boat
   b) Decent Ship Operations for Marine Security
   c) Combatable Ship

2.5. Questionnaire Preparation and Distribution

The distribution of this questionnaire was conducted to get an assessment from several respondents to assess the 14 KRIs that will be on Hardepo, namely LAM-374, HBS-382, NPS-403, NGL-402, TJA-541, TSR-542, KRS-624, SPR-628, PRU-724, PRP-712, BDU-841, KRP-812, SGG-906, and ARN-903.

2.6. Ranking of Fuzzy MCDM Method

In this study, the weight of each questionnaire was obtained from the level of importance given subjectively by the decision makers for each ranking KRI. Based on the results of the questionnaire data from the decision makers, the next step is to rank the KRI using the Fuzzy MCDM method. To determine the KRI ranking used in this study, the method was formulated using Microsoft Excel software tools, producing 5 KRI priorities that will implement Hardepo was done to obtain ranking values for each KRI.

2.7. Data Analysis and Interpretation

The results obtained from data processing were then further analyzed. In this study, the analysis to make KRI ranking was most suitable for implementing Hardepo and the results obtained by the KRI priority scale will implement Hardepo.

3. RESULT AND DISCUSSION.

3.1. The Concept of Fuzzy Theory

The concept of the fuzzy theory was initiated by Lotfi A. Zadeh in 1965 with his papers "Fuzzy Sets" (Zadeh, 1965). With fuzzy theory, it can be shown that all theories can be used as the basic concept of fuzzy or continues membership function.

3.2. Membership Function

The membership function is a curve that shows the mapping of data input points into its membership value (often also called a membership degree) which has an interval between 0 and 1.

3.3. Triangular Fuzzy Number (TFN)

In TFN, every single value (crisp) has a membership function consisting of three values, each of which represents the lower value, middle value, and top value.

A = (a1, a2, a3)

3.4. Value of Defuzzification

There are several commonly used defuzzification methods:

a. Centroid Method (Center Of Gravity/COG)

In this method, the crisp solution is obtained by taking the center point (z) of the fuzzy region.

b. Bisector Method

In this method, the crisp solution is obtained by taking a value on the fuzzy domain that has a membership value of half of the total membership value in the fuzzy area.

c. Mean of Maximum Method (MOM)

In this method, the crisp solution is obtained by taking the average value of the domain that has a maximum membership value.

d. Largest of Maximum (LUM) Method

In this method, the crisp solution is obtained by taking the largest value from the domain that has the maximum membership value.

e. Smallest of Maximum (SOM) Method

In this method, the crisp solution is obtained by taking the smallest value from the domain that has the maximum membership value.

3.5. Linguistic Variable

Linguistic variables are variables that have a description in the form of fuzzy numbers and more generally a word represented by a fuzzy set. For example, descriptions of linguistic variables for temperature can be LOW, MEDIUM, and HIGH where the description is expressed as a fuzzy value. As with algebraic variables that use numbers as values while linguistic variables use words or sentences as values that form a set called the "term" set each value of the "term" is a fuzzy variable defined based on the base variable. While the variable base defines the universe of conversation for all fuzzy variables in the "term set" (Jantzen, 1998).

Table 1. TFN Expert for Criteria Assessment

No	LEVEL	EX 1			EX 2			EX 3			EX 4			EX 5		
	LINGUISTIC	ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt
1	VERY LOW															
2	LOW															
3	MEDIUM	1,0	6,0	7,6	1,0	6,0	7,0	1,0	6,0	7,6	1,0	6,0	7,5	1,0	6,0	7,6
4	HIGH	6,0	7,6	9,5	6,0	7,0	9,0	6,0	7,6	9,0	6,0	7,5	9,0	6,0	7,6	9,5
5	VERY HIGH	7,6	9,5	10	7,0	9,0	10	7,6	9,0	10	7,5	9,0	10	7,6	9,5	10

Table 2. TFN Expert for Assessing Every Alternative Based on Qualitative Criteria

No	LEVEL	EX 1			EX 2			EX 3			EX 4			EX 5		
	LINGUISTIC	qit	oit	pit	qit	oit	pit	qit	oit	pit	qit	oit	pit	qit	oit	pit
1	VERY LOW															
2	LOW															
3	MEDIUM	1,0	5,7	7,4	1,0	5,5	7,4	1,0	5,6	7,4	1,0	5,6	7,3	1,0	5,7	7,3
4	HIGH	5,7	7,4	9,0	5,5	7,4	9,0	5,6	7,4	9,0	5,6	7,3	9,0	5,7	7,3	9,0
5	VERY HiGH	7,4	9,0	10	7,4	9,0	10	7,4	9,0	10	7,3	9,0	10	7,3	9,0	10

Table 3. Aggregate Weight of Qualitative Criteria

NO	CRITERIA	WEIGHT AVERAGET		
		ct	at	bt
1	JOP (Maintenance Hours)	5,000	7,167	8,833
2	JOG (Motion Hours)	4,000	7,000	8,500
3	Spare Parts Availability	6,333	7,767	9,400
4	*Floating Boat*	4,000	6,833	8,567
5	*Decent Ship Operations for Marine Security*	6,867	8,633	9,600
6	*Combatable Ship*	7,500	9,200	10,000

Table 4. Alternative Preferance Value

NO	CRITERIA	ALT	AVERAGE		
			qit	oit	pit
1	JOP (Maintenance Hours)	LAM-374	5,623	7,384	9,000
		HBS-382	1,905	6,005	7,698
		NPS-403	1,000	5,623	7,384
		NGL-402	1,000	5,623	7,384
		TJA-541	5,949	7,720	9,200
		TSR-542	4,704	7,038	8,665
		KRS-624	5,949	7,720	9,200
		SPR-628	1,465	1,800	2,000
		PRU-724	1,000	5,623	7,384
		PRP-712	2,857	6,314	8,036
		BDU-841	6,294	8,037	9,400
		KRP-812	5,949	7,720	9,200
		SGG-906	1,000	5,623	7,384
		ARN-903	1,000	5,623	7,384
2	JOG (Motion Hours)	LAM-374	5,623	7,384	9,000
		HBS-382	1,938	5,949	7,720
		NPS-403	1,919	5,969	7,719
		NGL-402	1,923	5,985	7,698
		TJA-541	2,857	6,296	8,055
		TSR-542	2,857	6,314	8,036
		KRS-624	4,685	7,058	8,664
		SPR-628	3,795	6,640	8,372

		PRU-724	2,857	6,314	8,036
		PRP-712	2,843	6,331	8,033
		BDU-841	5,623	7,384	9,000
		KRP-812	5,623	7,384	9,000
		SGG-906	2,861	6,312	8,034
		ARN-903	1,000	5,623	7,384
3	Spare Parts Availability	LAM-374	4,719	7,002	8,686
		HBS-382	3,800	6,656	8,352
		NPS-403	1,919	5,969	7,719
		NGL-402	1,000	5,623	7,384
		TJA-541	2,857	6,296	8,055
		TSR-542	2,857	6,314	8,036
		KRS-624	3,781	6,675	8,351
		SPR-628	4,700	7,022	8,686
		PRU-724	1,919	5,969	7,719
		PRP-712	3,766	6,694	8,348
		BDU-841	3,747	6,714	8,347
		KRP-812	5,623	7,384	9,000
		SGG-906	1,000	5,623	7,384
		ARN-903	3,800	6,656	8,352
4	*Floating Boat*	LAM-374	6,294	8,037	9,400
		HBS-382	1,938	5,949	7,720
		NPS-403	1,000	5,623	7,384
		NGL-402	1,000	5,623	7,384
		TJA-541	2,823	6,351	8,032
		TSR-542	6,312	8,034	9,400
		KRS-624	6,294	8,037	9,400
		SPR-628	1,905	6,005	7,698
		PRU-724	1,938	5,967	7,702
		PRP-712	3,795	6,640	8,372
		BDU-841	6,294	8,037	9,400
		KRP-812	6,294	8,037	9,400
		SGG-906	1,000	5,623	7,384
		ARN-903	2,823	6,351	8,032
5	*Decent Ship Operations for Marine Security*	LAM-374	5,623	7,384	9,000
		HBS-382	1,938	5,949	7,720
		NPS-403	1,000	5,623	7,384
		NGL-402	1,000	5,623	7,384
		TJA-541	2,823	6,351	8,032
		TSR-542	2,861	6,330	8,016
		KRS-624	5,623	7,384	9,000
		SPR-628	1,905	6,005	7,698
		PRU-724	1,938	5,967	7,702
		PRP-712	3,780	6,658	8,369
		BDU-841	6,675	8,351	9,600
		KRP-812	5,949	7,720	9,200
		SGG-906	1,000	5,623	7,384
		ARN-903	2,823	6,351	8,032
	Combatable Ship	LAM-374	5,623	7,384	9,000

6		HBS-382	1,919	5,969	7,719
		NPS-403	1,000	5,623	7,384
		NGL-402	1,000	5,623	7,384
		TJA-541	6,675	8,351	9,600
		TSR-542	3,780	6,676	8,351
		KRS-624	6,294	8,037	9,400
		SPR-628	1,905	6,005	7,698
		PRU-724	1,938	5,967	7,702
		PRP-712	2,842	6,332	8,033
		BDU-841	6,677	8,368	9,600
		KRP-812	5,985	7,698	9,200
		SGG-906	1,000	5,623	7,384
		ARN-903	2,823	6,351	8,032

Table 5. Value of Forming Evaluation

ALT	**INDEX**								
	Yi	**Qi**	**Zi**	**Hi1**	**Ti1**	**Hi2**	**Ui1**	**Ti2**	**Ui2**
LAM-374	31,075	57,599	82,430	2,898	3,903	6,193	2,181	22,621	-27,012
HBS-382	12,799	47,218	71,592	1,551	8,391	5,568	2,404	26,028	-26,778
NPS-403	7,199	44,525	68,563	1,461	9,516	5,446	2,430	27,809	-26,468
NGL-402	6,232	44,095	68,009	1,460	9,659	5,433	2,424	28,204	-26,338
TJA-541	23,336	53,892	77,894	1,902	6,359	5,827	2,253	24,196	-26,255
TSR-542	21,049	52,439	76,897	2,093	6,052	5,956	2,241	25,338	-26,700
KRS-624	30,570	58,199	82,390	2,673	4,353	6,247	2,105	23,276	-26,296
SPR-628	14,542	43,673	64,548	1,775	6,403	5,911	1,929	22,728	-22,805
PRU-724	10,696	46,342	70,504	1,573	8,596	5,517	2,408	27,049	-26,570
PRP-712	18,661	50,442	75,022	1,813	6,871	5,713	2,357	24,911	-26,937
BDU-841	33,131	60,906	84,446	2,959	4,015	6,426	1,986	23,761	-25,526
KRP-812	33,128	59,460	83,869	2,992	3,771	6,347	2,087	22,561	-26,497
SGG-906	6,858	44,476	68,485	1,511	9,353	5,447	2,426	28,265	-26,436
ARN-903	14,154	48,003	72,123	1,523	8,368	5,585	2,372	25,482	-26,492

Table 6. Defuzzification Calculation Criteria Weights

NO	**CRITERIA**	**DEFUZZIFICATION BOTTOM**
1	JOP (Maintenance Hours)	6,999
2	JOG (Motion Hours)	6,500
3	Spare Parts Availability	7,833
4	Floating Boat	6,467
5	Decent Ship Operations for Marine Security	8,367
6	Combatable Ship	8,900

Table 7. Defuzzification Calculation of Alternative Weights

ALTERNATIVE DEFUZZIFICATION													
LAM-374	**HBS-382**	**NPS-403**	**NGL-402**	**TJA-541**	**TSR-542**	**KRS-624**	**SPR-628**	**PRU-724**	**PRP-712**	**BDU-841**	**KRP-812**	**SGG-906**	**ARN-903**
7,336	5,202	4,669	4,669	7,623	6,802	7,623	1,755	4,669	5,736	7,910	7,623	4,669	4,669
7,336	5,202	5,202	5,202	5,736	5,736	6,802	6,269	5,736	5,736	7,336	7,336	5,736	4,669
6,802	6,269	5,202	4,669	5,736	5,736	6,269	6,802	5,202	6,269	6,269	7,336	4,669	6,269
7,910	5,202	4,669	4,669	5,736	7,915	7,910	5,202	5,202	6,269	7,910	7,910	4,669	5,736
7,336	5,202	4,669	4,669	5,736	5,736	7,336	5,202	5,202	6,269	8,209	7,623	4,669	5,736
7,336	5,202	4,669	4,669	8,209	6,269	7,910	5,202	5,202	5,736	8,215	7,628	4,669	5,736

Table. 8 Value $fG_i(x)$ and G_i

	LAM-374	HBS-382	NPS-403	NGL-402	TJA-541	TSR-542	KRS-624	SPR-628	PRU-724	PRP-712	BDU-841	KRP-812	SGG-906	ARN-903
Gi	55,021	40,467	36,343	35,647	48,950	47,465	54,934	38,298	39,030	45,095	57,517	56,887	36,224	41,377
Ut(Gt)	1,537	0,790	0,722	0,714	1,047	1,008	1,389	0,717	0,785	0,931	1,550	1,589	0,733	0,804

ALT	Sti
KRP-812	0,111
BDU-841	0,108
LAM-374	0,107
KRS-624	0,097
TJA-541	0,073
TSR-542	0,070
PRP-712	0,065
ARN-903	0,056
HBS-382	0,055
PRU-724	0,055
SGG-906	0,051
NPS-403	0,050
NGL-402	0,050
SPR-628	0,050

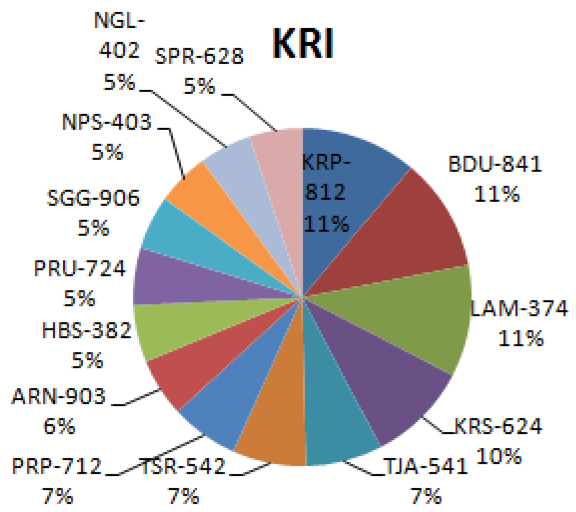

Fig. 2 Alternative Rand Based on Qualitative Criteria

From Figure 2 above, the 5 highest priority values in the implementation of Hardepo with the highest score are KRP-812 0,111, BDU-841 0,108, LAM-374 0,107, KRS-624 0,097 dan TJA-541 0,073.

4. CONCLUSION.

In the Hardepo KRI priority ranking process taken from the level of data processing of decision makers using the Fuzzy MCDM method of 14 KRIs which are LAM-374, HBS-382, NPS-403, NGL-402, TJA-541, TSR-542, KRS-624, SPR-628, PRU-724, PRP-712, BDU-841, KRP-812, SGG-906 and ARN-903, resulted in the results of the 5 highest priority values obtained in the implementation of Hardepo with the highest value which are KRP-812 0,111, BDU-841 0,108, LAM-374 0,107, KRS-624 0,097 and TJA-541 0,073.

5. ACKNOWLEDGEMENTS.

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