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Inventory Replacement Decision Support System Using Clustering and Analytical Hierarchy Process (AHP) Methods

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Abstract

The Center for Human Resources Development of Transportation Apparatus (PPSDMAP) still faces obstacles in manual inventory management, resulting in a long time required to determine which items are suitable or need to be replaced. This study aims to develop a web-based Decision Support System (DSS) to assist the inventory replacement decision-making process effectively and efficiently. The K-Means Clustering method was used to group inventory data based on age, condition, and value (price) attributes using 230 inventory data from January 1–November 30, 2023. The test results produced a Davies-Bouldin Index (DBI) value of 0.435 with six optimal clusters. Furthermore, the Analytical Hierarchy Process (AHP) method was used to determine the priority of handling strategies for less suitable or unsuitable inventory groups, with a Consistency Ratio (CR) below 10%, indicating a good level of consistency. The results of the study indicate that the developed system can assist PPSDMAP in grouping inventory objectively and support inventory replacement decision-making in a systematic, efficient, and measurable manner.

Keywords: Analytical Hierarchy Process (AHP), Clustering, Goods Inventory, K-Means, Decision Support System.

1. Introduction

PPSDMAP (Pusat Pengembangan Sumber Daya Manusia Aparatur Perhubungan) is one of the work units under the Pengembangan Sumber Daya Manusia Perhubungan located at Jl. Raya Kemang Parung Bogor No.13-5, Pd. Udik, Kec. Kemang, Bogor Regency, West Java 16310. Has the task of carrying out the preparation of technical policies, implementation, monitoring, evaluation and reporting in the field of managerial, structural and functional education and training for transportation apparatus human resources, as well as providing technical guidance to organizational units that handle the implementation of character building education and training (PPSDMAP, 2024).

Pusat Pengembangan Sumber Daya Manusia Aparatur Perhubungan (PPSDMAP) still faces several challenges, particularly in managing inventory. Inventory management is still manual, and it takes a significant amount of time to determine which items need to be replaced and which are still usable. Therefore, there is a significant need to develop a system that can assist in determining inventory replacements at PPSDMAP.

The K-Means Clustering algorithm is one of the most commonly used methods for clustering, which groups data into several groups based on similar features or attributes. This algorithm works by grouping data into k groups (clusters), where each data point will be included in the group with the closest centroid (Hendrastuty, 2024)

The K-Medoids algorithm is a clustering algorithm for partitioning data by assigning representative objects, in other words medoids, as center points or centroids. The K-Medoids algorithm partitions to minimize the number of differences between each object in the data and the nearest medoids. The K-Medoids algorithm is efficient enough to handle outlier data and each data will be calculated for its proximity to other data in each data. The central data that becomes a cluster is the result of randomly taken data, any data can become the central data in a cluster that complies with the provisions of the K-Medoids algorithm (Linarti et al., 2024).

The AHP method is a systems approach for decision-making that utilizes multiple variables in a multi-level analysis process. The analysis is conducted by assigning a value or priority weight to each variable, followed by pairwise comparisons of the variables and available alternatives. One advantage of using the AHP method in decision-making is that it can accommodate the interrelationships between criteria and sub-criteria of the problem (Afifah & Cahyana, 2024).

Previous research has been conducted using the K-Means method to cluster the useful life of infrastructure facilities carried out by researchers (Jaziroh, 2023).The study discusses the grouping of the useful life of infrastructure facilities, using several scenarios of the number of clusters with each k value in the range of 2 to 8. After being evaluated with the Davies Bouldin Index (DBI), the number of good clusters in the study is 2 clusters, therefore 2 clusters are considered as clusters that have a clearer structure and the data in this cluster has a higher similarity compared to the number of other clusters.

Research conducted (Handayani & Dari, 2024), in his research using the AHP method to simplify and accelerate the selection of the best product. This was done in several stages including: decomposition, comparative judgment, synthesis of priorities, and logical consistency. The level of accuracy obtained with this method is assessed from the Consistency Ratio Hierarchy/CRH 10% or 0.1, then the calculation results can be declared correct, in the calculation of the Consistency Ratio Hierarchy/CRH is 0.026 / 2.6%. According to (Handayani & Dari, 2024)The AHP method is relatively easy to understand and also easy to use, and there is a lot of literature that uses this method so that AHP is the ideal method to choose.

The purpose of this research is to develop a decision support system that can assist PPSDMAP in determining inventory replacement priorities more quickly, objectively, and in a structured manner. This system is designed by integrating the K-Means method to group inventory conditions based on their characteristics, as well as the AHP method to determine the weight and priority of item replacement. Through this approach, the research is expected to produce a system that not only simplifies the inventory evaluation process but also provides accurate and accountable recommendations so that the inventory management process at PPSDMAP becomes more efficient and effective.

2. Literature Review

2.1. Decision Support System

A decision support system (DSS) is a subset of computerized information systems, including knowledge-based systems, used to support decision-making within an organization or business (Kurniawijaya et al., 2023). A decision support system (DSS) is also defined as an integrated computing device that enables decision-makers to interact directly with a computer to generate useful information for decision-making, both structured and unstructured (Fu'adi & Diana, 2022).

Decision support systems (DSS) as computer-based systems consist of three interacting components, namely the language system (a mechanism for communication between users and other decision support system components), the knowledge system (a repository of problem domain knowledge that exists in the decision support system or as data or procedures), and the last problem processing system (the relationship between the other two components, consisting of one or more general problem manipulation capabilities required for decision making) (Sumarno & Harahap, 2020)

2.2. Center for Human Resources Development for Transportation Apparatus (PPSDMAP)

Pusat Pengembangan Sumber Daya Manusia Aparatur Perhubungan is one of the work units under Pengembangan Sumber Daya Manusia Perhubungan which is located at Jl. Raya Kemang Parung Bogor No.13-5, Pd. Udik, Kec. Kemang, Bogor Regency, West Java 16310. The Center for Human Resources Development of Transportation Apparatus is an institution or center that aims to develop and improve the capacity and quality of human resources (HR) working in the transportation sector. The main objective of this institution is to provide training, education, and skills development to apparatus or workers (PPSDMAP, 2024).

2.3. Clustering

Data mining is more meaningful as a means to gain knowledge from interdisciplinary subjects.(Tosida et al., 2017)Clustering is an important technique in data mining used to group data into similar subsets based on certain characteristics or patterns. The main goal of clustering is to identify hidden structures in the data, which can help in further understanding the groups or categories within it. The K-Means algorithm is one of the most common and simple clustering algorithms used in data analysis (Hendrastuty, 2024). The Knowledge Discovery in Database (KDD) approach and one of its components are widely known as Data Mining.

2.4. K-Means

K-means is a non-hierarchical clustering method that partitions data into one or more groups, so that data with the same characteristics are grouped into the same cluster and data with different characteristics are grouped into other groups.(Tosida et al., 2019).After analyzing the data to be used, the next step is to cluster the data using the K-Means algorithm. Clustering is performed with a number of k, or two clusters. The clustered data will be divided into two clusters: one suitable for use and one that needs to be replaced.

Below is the formula used in k-means clustering.

1) Euclidian Distance to determine the distance of an object to the centroid:

$$d = \sqrt{(xi - si)^2 + (yi - ti)^2} \quad (1)$$

Information:
i : number of objects
(x, y) : object coordinates
(s, t) : Centroid coordinates

2) Euclidian Distance to select the shortest distance from all centroids.

$$\text{mid} \sum d = \sqrt{(xi - si)^2 + (yi - ti)^2} \quad (2)$$

3) Calculate the cluster mean value.

$$C(x, y) = \frac{\sum xy}{n} \quad (3)$$

2.5. Elbow Method

The Elbow method is a method where at a certain point there is a significant decrease in the graph, in the form of a sharp curve. The value will then be the k value or the number of good clusters. Finding the optimal k value can be done by comparing the Sum of Square Error (SEE) values presented in graphical form. The Elbow method selects the smallest k value and has a low internal value. To determine the optimal number of clusters can be identified by considering the SSE comparison at each cluster value, the larger the k value, the smaller the SSE value will be.(Syahfitri et al., 2023).

$$SSE = \sum_{k=1}^{k} \Sigma_{Xi \epsilon Sk} ||X_1 - C_k|| \frac{2}{2} \quad (4)$$

Information:
k = number of clusters
x_i = attribute value of the i-th data
C_k = number of cluster i in the kth cluster
|| || = calculate Euclidean distance

2.6. Davies Bouldin Index

The Davies Bouldin Index (DBI) is a method for evaluating clustering models. Evaluation results are selected by comparing the smallest values of the created cluster models. The number of clusters is determined by looking at the smallest DBI value.(Tarigan, 2023).

2.7. Analytical Hierarchy Process (AHP)

Decision-making helps select the best alternative based on specific criteria with a hierarchical structure. This study uses three criteria and three alternatives. The criteria are Need, Quantity, and Availability. The alternatives are Order Quantity, Price Negotiation, and Consultation.

The following are several formulas that will be used in the Analytical Hierarchy Process (AHP) algorithm:

1) Calculating Eigen Values

$$\lambda maks = (A1 * Y1 + B1 * Y2 + C1 * Y3 \dots n) \quad (5)$$

Information:
A = Sum of each column
Y = Row Average

2) Calculating the Consistency Index (CI)

$$CI = \frac{\lambda maks - n}{n - 1} \quad (6)$$

Information:
CI = Consistency index (deviation)
$\lambda maks$ = The sum of the results of multiplying the number of columns by the row average
n = Order of matrix

3) Calculating the Consistency Ratio (CR)

(7)

$$CR = \frac{CI}{RI}$$

Information:
CR = Consistency ratio
RI = Random Index

The RI value is used to find the Consistency Ratio (CR) of the pairwise comparison matrix. This study includes the random index value from the Saaty researcher.(Wayan et al., 2021). The Random Index table can be seen in Table 1 below:

Table 1: RI (Random Index)

n	1	2	3	4	5	6	7	8	9	10	11	12	13
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.5	1.49	1.51	1.48	1.56

3. Materials and Methods

3.1. Materials

This research was conducted at the Center for Human Resources Development for Transportation Apparatus (PPSDMAP), under the auspices of the Ministry of Transportation of the Republic of Indonesia. The research object was inventory data recorded in the PPSDMAP administration system from January 1 to November 30, 2023.

The data used consists of 230 inventory entries with the following main attributes:

1. Age of item (years) – describes the length of time the inventory has been used since the date of purchase.
2. Item condition – categorized as Good, Poor, and Damaged.
3. Item value (price) – shows the estimated economic value of inventory in rupiah.

In addition, this study also uses additional information such as type of goods, year of acquisition, and unit of measurement, to support the analysis and validation of the grouping results.

The devices used in this study include:

1. Hardware: Laptop with Intel Core i5 processor, 8 GB RAM, and Windows 10 operating system.
2. Software:
3. PHP and JavaScript programming languages for web-based system development.
4. MySQL as a database management system.
5. Python and Google Colab for K-Means Clustering analysis and Davies-Bouldin Index (DBI) calculation.
6. Microsoft Excel for initial data processing.

3.2. Methods

This research method uses a quantitative approach through two main stages, namely the clustering process with

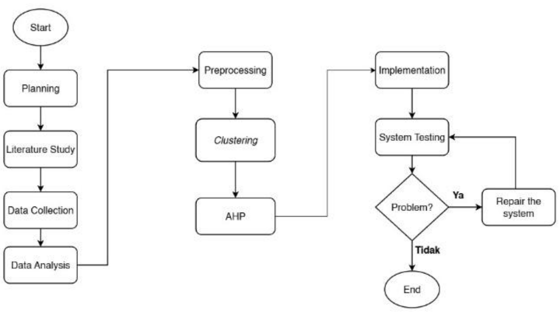

Figure 1: Research Flow

the K-Means algorithm and determining decision priorities using the Analytical Hierarchy Process (AHP) method.

3.2.1 Planning

The planning stage is designed to develop a decision support system for determining replacement priorities for goods, using the K-Means clustering method and the Analytic Hierarchy Process (AHP). The process begins with grouping goods data using K-Means, dividing the data into two groups. The resulting clustered data is used to determine criteria and alternatives in the AHP method. Furthermore, the AHP method is used to assign weights to the predetermined criteria. This planning stage aims to ensure that the decision-making process can be carried out systematically, structured, and relevant to the available data.

3.2.2 Literature Study

The literature review phase was conducted to identify previous studies related to the use of the K-Means and Analytical Hierarchy Process (AHP) methods in decision support systems. This literature review serves as a foundation for understanding previously used approaches, identifying research gaps, and ensuring that the methods used in this study are relevant and appropriate to the system development needs. The literature analyzed included journals, scientific articles, and research documents supporting DSS modeling and inventory data processing techniques.

3.2.3 Data collection

The research data was obtained from PPSDMAP in the form of inventory data for the period January 1–November 30, 2023. The data used was 230 entries, covering attributes such as item age, physical condition, and value. This data served as the basis for the clustering process and prioritizing inventory replacement.

3.2.4 Data analysis

The existing data was then analyzed to find information. Approximately 230 inventory items were collected. The following are the attributes used in this study. Ten inventory data samples were used, as shown in Table 2 below.

Table 2: Data Sample

Code	Description	Unit	Quantity	Mark	Age	Condition	Category
3010110003	Truck Crane	Item	3	IDR23,342,705	2	Good	Vehicle
3010303002	Portable Compressor	Item	4	IDR102,739,388	1	Good	Machine
3010305002	Portable Water Pump	Item	1	IDR1,078,000	2	Good	Machine
3020102001	Bus (30 Passengers and Above)	Item	2	IDR1,856,829,000	2	Good	Vehicle
3020102003	Mini Bus (14 Passengers and Under)	Item	5	IDR1,433,535,400	1	Good	Vehicle
3020103002	Pick Up	Item	1	IDR186,200,000	3	Good	Vehicle
3020104001	Motorcycle	Item	2	IDR28,532,000	1	Not good	Vehicle
3070105083	Doppler (Fetal Heart Sound Detector)	Piece	1	IDR. 4,000,000	2	Good	Equipment
3050104025	Drawer Box	Piece	12	IDR16,620,000	1	Not good	Furniture
3050201020	Wooden Dining Table	Piece	7	IDR23,294,348	2	Not good	Furniture

3.2.5 Preprocessing

Often, not all data in a database is used, so only data suitable for analysis is retrieved from the database. Data transformation is also performed by modifying or combining data into a format suitable for processing in data mining. This study uses an entropy-based method for data selection (Tosida et al., 2018) K-Means Clustering can only process data in numerical form. Therefore, before entering the clustering process, the collected data needs to be preprocessed first. In the K-Means application, the data must be numeric because the K-Means algorithm cannot process non-numeric data. Therefore, if the data to be processed is not numeric, it must first be converted into numeric form. The data after transformation can be seen in Table 3 below.

Table 3: Data After Transformation

Code	Unit	Quantity	Mark	Age	Condition	Category
3010110003	1	3	IDR23,342,705	2	1	2
3010303002	1	4	IDR102,739,388	1	1	1
3010305002	1	1	IDR1,078,000	2	1	1
3020102001	1	2	IDR1,856,829,000	2	1	2
3020102003	1	5	IDR1,433,535,400	1	1	2
3020103002	1	1	IDR186,200,000	3	1	2
3020104001	1	2	IDR28,532,000	1	2	2
3070105083	2	1	IDR. 4,000,000	2	1	4
3050104025	2	12	IDR16,620,000	1	2	3
3050201020	2	7	IDR23,294,348	2	2	3

OnThe preprocessing stage of data transformation involves converting categorical data to numeric data. After preprocessing inventory data, such as item unit descriptions, item conditions, and item categories, we convert them to numeric data. To understand the data converted from categorical to numeric data, see Table 4 below.

Table 4: Description of Unit, Condition, and Category

Unit Description		Condition Description		Category Description	
Item	1	Good	1	Machine	1
Unit	2	Not good	2	Vehicle	2
Piece	3	Damaged	3	Furniture	3
Set	4			Equipment	4

3.2.6 Application of K-means Clustering

After analyzing the data to be used, the next step is to cluster the data using the K-Means algorithm. Clustering is performed with a number of k, or two clusters. The clustered data will be divided into two clusters: one suitable for use and one that needs to be replaced.

3.2.7 Analytical Hierarchy Process (AHP)

Decision-making helps select the best alternative based on specific criteria with a hierarchical structure. This study uses three criteria and three alternatives. The criteria are Need, Quantity, and Availability. The alternatives are Order Quantity, Price Negotiation, and Consultation.

4. Results and Discussion

4.1. K-Means Clustering Results

Inventory replacement management in PPSDMAP requires the application of K-Means Clustering and the Analytic Hierarchy Process. The implementation is illustrated below. The K-Means flowchart can be seen in Figure 2 below.

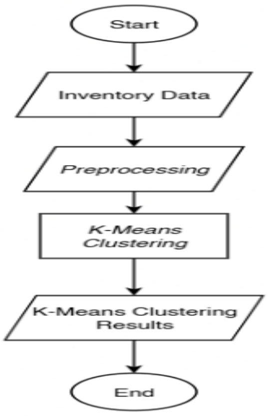

Figure 2: K-Means Clustering Flow

To determine the initial centroid, several methods can be used, namely randomly, taking the largest value, taking the average value, and the smallest value.(Natalis & Nataliani, 2022). Determining the initial centroid can be determined randomly or randomly from the existing data.(Ningsih et al., 2022.)

Table 5: Random Centroid

Centroid	Age	Condition
1	2	3
2	1	2
3	3	1
4	2	2
5	2	1
6	2	3

The centroid in Table 5 is the value that will be used in the calculation to determine the distance using the Euclidean Distance method, where the calculation uses the formula in equation (1).

C1 No.1 $= \sqrt{(2-2)^2 + (1-3)^2} = 2$

C2 No.1 $= \sqrt{(2-1)^2 + (1-2)^2} = 1.41$

C3 No.1 $= \sqrt{(2-3)^2 + (1-1)^2} = 1$

C4 No.1 $= \sqrt{(2-2)^2 + (1-2)^2} = 1$

C5 No.1 $= \sqrt{(2-2)^2 + (1-1)^2} = 0$

C6 No.1 $= \sqrt{(2-2)^2 + (1-3)^2} = 2$

Table 6: Results of Iteration 1

Code	Description	Age	Condition	Category	Distance From C1	Distance From C2	Distance From C3	Distance From C4	Distance From C5	Distance From C6	Cluster Membership
3010110003	Truck Crane	2	1	2	2	1.41	1	1	0	2	C5
3010303002	Portable Compressor	1	1	1	2	1	2	1.41	1	2.24	C2
3010305002	Portable Water Pump	2	1	1	2	1.41	1	1	0	2	C5
3020102001	Bus (30 Passengers and Above)	2	1	2	2	1.41	1	1	0	2	C5
3020102003	Mini Bus (14 Passengers and Under)	1	1	2	2	1	2	1.41	1	2.24	C2
3020103002	Pick Up	3	1	2	2	2.24	0	1.41	1	2.24	C3
3020104001	Motorcycle	1	2	2	1	0	2.24	1	1.41	1.41	C2
3070105083	Doppler (Fetal Heart Sound Detector)	2	1	4	2	1.41	1	1	0	2	C5
3050104025	Drawer Box	1	2	3	1	0	2.24	1	1.41	1.41	C2
3050201020	Wooden Dining Table	2	2	3	1	1	1.41	0	1	1	C4

Table 6 shows the results of the first iteration of K-Means Clustering, but because the results of the clustering in the first iteration are still not optimal, it is necessary to continue to the next iteration until the results do not change. Next, we must determine the Centroid of the second iteration using equation (3).

The clustering results with six clusters can be seen in Table 7, and the table shows that there are 66 inventory data in cluster 1, 62 in cluster 2, 15 in cluster 3, 63 in cluster 4, 15 in cluster 5, and 9 data in cluster 6.

Table 7: Number of Data per Cluster

Clutter	**Amount**
1	66
2	62
3	15
4	63
5	15
6	9

Cluster 1: Inventory included in this cluster has the characteristics of Good condition, but is quite old, namely 3 years.
Cluster 2: Inventory included in this cluster has the characteristics of Good condition with a young age, namely 1 year.
Cluster 3: Inventory included in this cluster has the characteristics of Poor condition with an age of 2 years.
Cluster 4: Inventory included in this cluster has the characteristics of Good condition with an age of 2 years.
Cluster 5: Inventory included in this cluster has characteristics of poor condition and is also damaged with an age of 3 years.
Cluster 6: Inventories included in this cluster have characteristics of Poor condition with a young age, namely 1 year.

4.2. Elbow Method Results

From the graph in Figure 3, it can be seen that at the number of clusters K = 1, the distortion value is very high (around 200). This indicates that all data is still considered as one large group, so the variation is still high. As the number of clusters increases to K = 2 to K = 4, there is a sharp decrease in the distortion value. This indicates that the clustering process is improving, because the distance between the data and the cluster center is getting smaller. After K = 4, the decline in the distortion value begins to slow down until it is relatively stable at K ≥ 6. This pattern indicates that increasing the number of clusters after this point no longer provides a significant improvement in the quality of data separation. Based on the shape of the graph, the elbow point appears to be around K = 4 or K = 6.

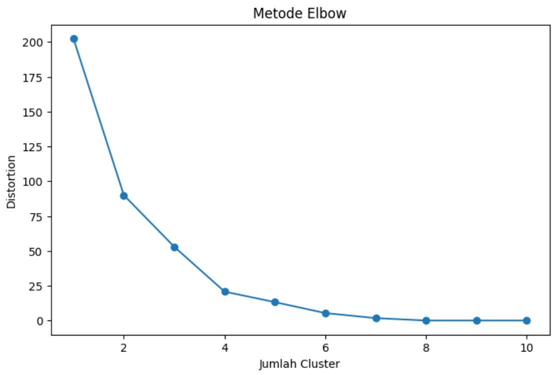

Figure 3: Elbow Method Results

4.3. DBI Testing

The DBI test was conducted on several cases of the number of clusters as can be seen in Table 8. In the table, it can be seen that the smallest DBI value was obtained in the K-Means algorithm with a k value of 6 which produced a DBI value of 0.435. Therefore, it can be concluded that the K-Means algorithm with a k value of 6 is the most optimal.

Table 8: DBI Testing

No	K-Means	Cluster
1	0.671	2
2	0.708	3
3	0.497	4
4	0.48	5
5	0.435	6

4.4. Analytic Hierarchy Process (AHP) Results

The stages in implementing AHP are shown in Figure 2 as follows:

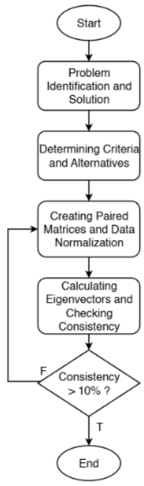

Figure 4: AHP Implementation Flow

The application of AHP in managing inventory replacement at the Transportation Apparatus Human Resources Development Center (PPSDMAP) requires interview data related to criteria and alternatives. The AHP implementation flow can be seen in Figure 4 above. AHP ranking is performed on inventory included in the cluster that must be replaced. In the calculation analysis using AHP, the first step is to determine a pairwise comparison matrix filled with the values in Table 4.

1) Building a Hierarchy starts with the main goal

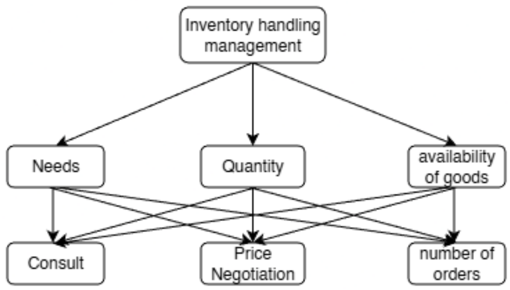

Figure 5: Inventory Replacement Management Hierarchy

Figure 5 shows the hierarchy of plans to be implemented in handling inventory replacement management. This hierarchy makes the inventory management process more structured, making it easier for decision-makers to determine the steps to be taken. Furthermore, this hierarchy also serves as a visual guide to map each activity stage, ensuring each step is carried out systematically and in accordance with established procedures. The results of the implementation or visual representation of this hierarchy can be seen in Figure 5, which shows the overall plan structure and the interrelationships between processes in inventory replacement management.

2) Determining Element Priorities

Table 9: Weighting Value

Mark	Information
1	Equal importance
3	A little more important (moderate)
5	Clearly more important (very strong)
7	Very clear important (very strong)
9	Absolutely more important (extreme)
2,4,6,8	When in doubt between two adjacent values
1/(1-9)	The inverse of the importance level value on a scale of 1 - 9

Determining element priorities is carried out by an expert in the field or problem being decided. According to Saaty (1998), a scale of 1 to 9 is the best scale for expressing opinions. This determination must be based on the AHP's importance intensity table, as shown in Table 9.

3) Creating a Pairwise Comparison Matrix

The pairwise comparison matrix is a basic concept used in the AHP method to generate relative weights between criteria and alternatives. Weighting is done by comparing pairs of entities. The relationship between the compared entities is then given a weight value based on the results of the previous element priority determination. In creating a pairwise comparison matrix, we only need to determine the upper triangular matrix, because the lower triangular matrix has the inverse of the upper triangular matrix. Furthermore, the diagonal value of the matrix is 1, because each entity is on its own diagonal. The criteria comparison matrix table can be seen in Table 10.

Table 10: Comparison of Criteria

Criteria	Need	Quantity	Availability of Goods
Need	1	3	5
Quantity	0.33	1	3
Availability of Goods	0.2	0.333	1
Total	1,533	4,333	9

4) Normalize data by dividing the value of each matching matrix element by the sum of the values of each column.

After filling in the comparison matrix table, the next step is to calculate the normalization value from the results of the number of comparisons of the criteria with the criteria column to obtain the normalization of the matrix.

K/TK = 1/ 1.533 = 0.65,K/TKU = 3/4.3 = 0.69, K/TKB = 5/9 = 0.63
KU/TK = 0.33/1.533 = 0.21, KU/TKU = 1/4.3 = 0.23, KU/TKB = 3/9 = 0.26
KB/TK = 0.2/1.533 = 0.13, KB/TKU = 0.33/4.3 = 0.07, KB/TKB = 1/9 = 0.10

5) Calculate the eigenvector values and check their consistency.

The eigenvalue is taken from the average column of the row multiplied by the number of column values using the formula Equation (5)

Eigenvalue =AvgrowK*TotalColumnK = 0.39*1.67 = 0.97
=MyRowAvg*MyColumnTotal = 0.22*4.5 = 1.12
=avgrowKB*TotalColumnKB = 0.18*9.3 = 0.95
= 0.97 + 1.13 + 0.95 = 3.05

6) Calculating the Consistency Index (CI)

Measuring ratio consistency in the AHP method requires the value of the consistency index. The matrix table showing the results of the criteria comparison can be seen in Table 11 below.

Table 11: Criteria Comparison Results Matrix

Criteria	Normalization			Amount	Priority/Avg	Eigenvalue
	Need	Quantity	Availability of Goods			
Need	0.65	0.69	0.5	1.9	0.63	0.97
Quantity	0.21	0.23	0.33	0.781	0.26	1.12
Availability of Goods	0.13	0.07	0.11	0.318	0.10	0.95
Total	1	1	1	3	1	3.05

After obtaining the eigenvalue, the next step is to find the CI (Consistency Index) value using the formula in equation (6).

$$\mathrm{CI} = \frac{\lambda\mathrm{maks} - \mathrm{n}}{\mathrm{n} - 1} = \frac{3{,}05 - 3}{3 - 1} = 0.027$$

7) Measuring Consistency Ratio (CR)

Calculating the consistency ratio is necessary to determine how consistent the resulting decision is. If the CR calculation result is <0.1 then it is consistent, if CR = 0.1 then it is quite consistent, and if CR > 0.1 then it is very inconsistent. After finding the CI value, the next step is to find the CR value using equation (7). The Random Index value is based on the number of criteria, because the number of criteria is three, the Random Index value is 0.58. The Random Index value can be seen in Table 4.

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} = \frac{0.027}{0{,}58} = 0.047$$

The result of the Consistency Ratio (CR) value is 0.047 where the value is below 0.1. Because the value is considered consistent if it is below 0.1 or below 10%, so 0.047 can be considered consistent. The next stage is to calculate the alternative comparison matrix for each criterion using the same method as in calculating the Criteria comparison table, the criteria comparison results table can be seen in Table 11. After calculating the Criteria comparison matrix, and the alternative comparison matrix for each criterion, the ranking results are obtained which can be seen in

Table 12.

Table 12:AHP Ranking Results

Alternative	Number of Hierarchies	Ranking
Consultation	0.43	1
Price Negotiation	0.29	2
Number of Orders	0.26	3

In this study, the Decision Support System uses K-Means Clustering and Analytic Hierarchy Process. The data used is data originating from PPSDMAP (Center for Human Resources Development of Transportation Apparatus) for the period January 1, 2023 to November 30, 2023. The K-Means Clustering algorithm helps in the process of grouping inventory data into 2 groups, namely inventory groups that are suitable for use, and also inventory groups that are suitable for replacement. The data attributes used are units, quantity, value, age, condition, and category. By calculating the distance using Euclidean Distance then evaluated using DBI. After seeing the grouped data, the next step is making decisions on inventory that is suitable for replacement using AHP with 3 criteria and 3 alternatives.

4.5. System Implementation

The homepage is the first page displayed when users open the system. On this page, users are greeted with a simple yet informative interface, displaying the PPSDMAP profile. The top of the page contains a navigation menu that makes it easy for users to navigate to other pages, such as the about page, contact & location, and login. The results of the homepage implementation can be seen in Figure 5.

The criteria and alternatives comparison page is one of the system's most important pages, helping users prioritize or weight each available criterion. This page features radio buttons that allow users to select which criteria are considered more important than others, as well as an input form for entering data or comparison values as needed. This page is designed to make the process of filling in and selecting criteria easier and more intuitive, with a clean layout and clear navigation. The results of the criteria comparison page design implementation can be seen in Figure 6.

Figure 6: Home Page

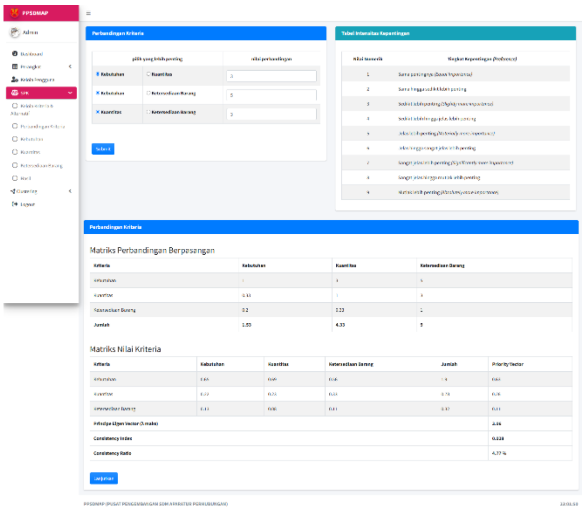

Figure 7: Comparison Page

The results page is the page displayed after the user has completed the entire weighting process, from criteria weighting to alternative weighting. This page serves to display a summary of the evaluation and comparison results performed by the user. The results of the results page can be seen in Figure 7.

The K-Means page allows users to perform interactive data clustering. On this page, users can upload an Excel file containing the data to be clustered, allowing the system to process and group the data into several clusters based on the K-Means algorithm. This page is designed to facilitate easy and efficient data uploading and processing, with a simple yet informative interface. The results of the K-Means page's display and functionality can be seen in Figure 8.

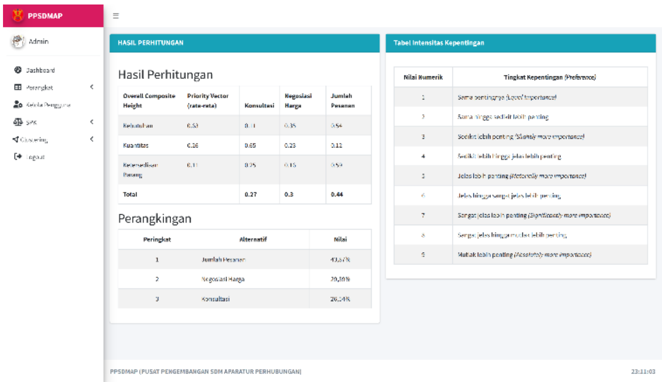

Figure 8. AHP Results Page

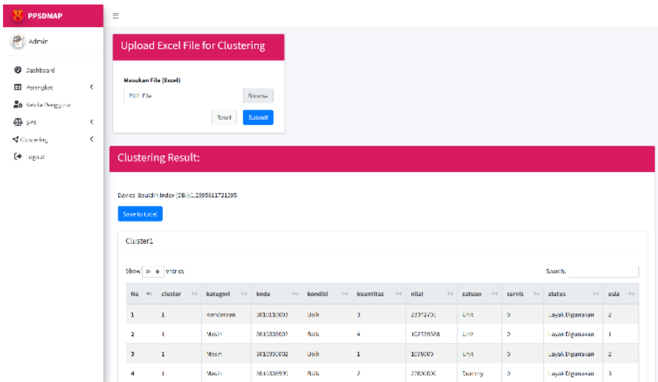

Figure 9. Clustering Page

5. Conclusion

The Inventory Replacement Decision Support System uses the k-means clustering method and the Analytical Hierarchy Process (AHP), using data from the Transportation Apparatus Human Resources Development Center. The research data obtained amounted to approximately 230 data, the data used was data for the period January 1, 2023 – November 30, 2023. The data attributes used were age, condition, and value (price). With K = 6 or the number of clusters was 6 clusters. From the results of K-Means clustering with the number of clusters, the results were 66 inventories for cluster 1, 62 for cluster 2, 15 for cluster 3, 63 for cluster 4, 15 for cluster 5, and 9 for cluster 6. Each cluster can be categorized as "Worthy of Replacement", "Needs Consideration", and "Worthy of Use". From Appendix 26, the validation of clustering results can be seen that the performance of the k-means algorithm is quite good when compared to the k-medoids algorithm because there is more valid data.
Clusters that fall into the “Worthy of Replacement” category are Cluster 5, because they contain items in Poor and Damaged condition with an age of 3 years. Clusters that fall into the “Need to be Considered” category are clusters 3 and 6 because they are in Poor condition with an age of 2 years, while cluster 6 is also Poor but is still 1 year old. Clusters that fall into the “Worthy of Use” category are clusters 1, 2 and 4 because they are in good condition, even though some are 3 years old. From the results of the research conducted, with a total of 6 clusters, the K-Means algorithm has a smaller DBI value compared to the K-Medoids algorithm where the K-Means algorithm has a DBI value of 0.435 in 6 clusters, while the DBI value of the K-Medoids algorithm is 0.596 with the same number of clusters. In AHP, 3 priority orders are generated based on the results of clustering and weighting calculations on alternatives and criteria. The first priority is Consultation with a weight of 43%, then the second priority is Price Negotiation with a weight of 29%, and finally the third priority is Consultation with a Number of Orders of 26%.

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