

# A Decision Support System on Employee Assessment Using Analytical Network Process (ANP) and BARS Methods

I Made Dwi Putra Asana<sup>1</sup>, I Gede Iwan Sudipa<sup>\*2</sup>, Kadek Ari Prayoga Putra<sup>3</sup>

<sup>1,2,3</sup>Informatics Departement, STMIK STIKOM Indonesia, Jl. Tukad Pakerisan No.97, Panjer, Kec. Denpasar Sel., Kota Denpasar, Bali 80225, Indonesia

Email: [iwansudipa@stiki-indonesia.ac.id](mailto:iwansudipa@stiki-indonesia.ac.id)\*

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## ABSTRACT

Employee assessment is needed in evaluating performance and granting rewards to employees. PT. Kupu-Kupu Taman Lestari conducts an employee performance appraisal using Microsoft Excel. The growth of employee data and assessment variables resulted in the calculation method that was carried out could not provide employee ranking information quickly. The application of Microsoft Excel in processing employee valuation data has weaknesses in data documentation. The purpose of this study is the company has a website-based decision support system that makes it easy for companies to get employee performance appraisal information. The employee performance data ranking method used is the Analytical Network Process (ANP) and the performance evaluation criteria are prepared based on the Behaviorally Anchor Rating Scale (BARS) approach. BARS is used in determining criteria along with a scale of behavior that represents the performance of each criterion. ANP is used to process data of importance between criteria so that it can produce criteria weights based on a comparison between criteria. The results of this study are website-based decision support systems that can be accessed by company management via a web browser. System testing is built based on testing manual calculations with the system and testing the user's system according to the McCall model. The system calculation test shows that the system has produced the same calculation value as the manual calculation. System user testing shows that the system built meets user needs, displays information according to user input correctly, is safe from unauthorized parties, and the system is easy to use.

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## 1. Introduction

Human Resources (HR) is a crucial aspect of the progress and development of a company. In essence, HR is employed in an organization as a person who moves, thinks and plans to achieve the company goals[1]. Good service and performance are the main supporting factors that are very important in business processes[2][3]. As well as the service and performance of Human Resources (HR), especially for the employees. PT. Kupu Kupu Taman Lestari is a recreational park that preserves various kinds of butterflies, which is located on Jl. Batukaru, Sandan Lebah Hamlet, Sesandan Village Tabanan, Bali. The park also exhibits various types of insects such as beetles, grasshoppers, tarantulas and scorpions.

Human resource management at PT. Kupu-Kupu Taman Lestari is done through employee assessment. It can help the company to evaluate the performance of the employees individually[4][5]. Employee assessment can also be used as information to analyze and identify employee needs and provide rewards for employees who contribute more to the company[6][7]. Therefore, it can develop the motivation of employees at PT. Kupu-Kupu Taman Lestari. One of the HR management systems for employee assessment is the Decision Support System.

Employee performance appraisal at PT. Kupu-Kupu Taman Lestari is done every three months. Assessment data processing using Microsoft Excel. The assessment process has not been able to provide direct employee performance ranking recommendations[8]. The number of employees that reach 40 people makes it difficult for managers to process data with the Microsoft Excel. Apart from the large amount of data that must be calculated, it is also difficult for managers to compare assessment histories for each employee because data is stored in many excel files and sheets[9]. Therefore, we need a decision support system that can make it easier for managers to produce employee performance rankings and assessment history that can be accessed at any time[10].

Several discussions regarding the employee appraisal decision support system have been carried out by [11]. This study concluded that the priority weights of the 5 criteria and 15 assessment sub-criteria were

generated using the Analytical Network Process (ANP) method, employee appraisal using the Rating Scale with a value of 1 -5. Subsequent research by [12] concluded that the Rating Scale is a simple technique in providing performance appraisals for each employee. A comparative study of the AHP and ANP methods conducted by concluded that the criteria weights generated by the two methods were almost the same, but the results of the priority weights for the main criteria were different because the ANP method calculates the weight based on the weight of the relationship between each criterion and the supermatrix calculation stage. Research using the BARS method in determining the criteria for employee appraisal by [13][14] in this study concluded that the BARS method is considered very effective in supporting human resource improvement strategies. Another study discussing performance measurement using the AHP and ANP methods concluded that the ANP method can extend the functionality of the AHP method in solving multi-criteria problems involving interdependent or related criteria relationships [15].

**2. Literature Review**

**2.1 Decision Support System**

Decision making is a process of selecting from various alternatives against several criterion, so as to get the best alternative [16] [17]. Decision support systems are defined as systems that can help provide consideration for decision-makers in solving semi-structured problems [18][19].

**2.2 Analytical Network Process (ANP)**

ANP is a new qualitative approach developed by Professor L. Saaty. ANP was developed from the Analytic Hierarchy Process (AHP) [20]. The advantages of ANP are the ability to assist in decision making in measuring and synthesizing a number of factors in the ANP network consisting of two parts [15], the first part consists of a hierarchy or control network that controls the interaction between criteria, the second part is a form of network that shows the interrelationship and influence each other between elements [21].

Weighting using ANP requires a model that represents the interrelationships between its criteria. There are two modeling controls that can be used to generate weights. The first control can be done by building a hierarchy that shows the relationship of criteria, the other control is a control that shows the relationship between criteria, elements, or clusters.

The influence of one element to another in the cluster will be shown in a scale of priority vector ratio resulting from the pairwise comparison matrix process. The ratio scale priority vector forms a network that has high complexity, due to the feedback from one cluster to another [22].

**A. Priority Setting**

Priority setting is done by finding the relative weights between the elements in order to know the level of interest (preference) of each element in the overall problem [22]. The initial step in determining the priority order of elements (criteria) is to construct pairwise comparisons by comparing all of the criteria for each subsystem hierarchy and transformed themselves into the form of a matrix to be analyzed numerically. Table 1 is a comparison matrix that shows examples of priority setting between criteria.

**Table 1**  
Matrix Of Comparison

C	C1	C2	C3	Eigen Vector
C1	1	2	1/3	EV1
C2	1/2	1	2	EV2
C3	3	1/2	1	EV3
Total	$\sum C_{i,j}$	$\sum C_{i,j}$	$\sum C_{i,j}$	$\sum EV$

$$EV_i = \frac{\sum C_{i,j}}{n} \tag{1}$$

Information:

n = the number of criteria

The numerical values assigned to the comparisons in Table 1 obtained from the scale of a comparison made by [23] are shown in Table 2.

**Table 2**  
Comparative Value Scale

Level of Importance	Definition	Information
1	Equally Important	Both elements have the same effect.
3	Slightly More Important	Experience and judgment are only slightly more favorable to one element.
5	More Important	Experience and judgment are very partial to one element.

Level of Importance	Definition	Information
7	Very Important	One very popular and dominating element when compared with other elements.
9	Absolute More Important	One element proves to be absolutely preferable to the others.
2,4,6,8	Middle Score	Awarded if there is doubtful judgment between two adjacent assessments
Inverse	An = 1/An	

### B. Consistency Testing

Consistency index calculation is intended to measure how big the consistency of decision-makers to calculate and compare the elements in the matrix assessment [23]. Furthermore, the consistent index is calculated according to the order matrix and becomes the consistency ratio. The resulting consistency ratio must amount to  $\leq 10\%$ , otherwise, the pairwise ratio needs to be improved.

$\lambda$  max deviation of n is a parameter of the Consistency Index (CI), there is a table for Random Index to compare CI and RI.

**Table 3**  
List of consistency random index

Matrix Size	Score (IR)
1	0.00
2	0.00
3	0.58
4	0.90

By calculating the CI and RI, the standard score is obtained in determining the level of matrix consistency, which is called the Consistency Ratio (CR). The RI score can be seen in Table 3 according to the size of the criteria matrix. The calculation of the CI score is shown in formula 2. A comparison matrix is stated to be consistent if the CR score is not more than 0.10 ( $CR \leq 0.10$ ).

$$CI = \frac{\lambda_{maks} - n}{n - 1} \tag{2}$$

Information :

CI = Consistency Index

$\lambda$  maks =  $\sum(\sum C_{i,j} \times EV_i)$

n = the number of matrix

To calculate the consistency ratio, the formula in formula 3 is used.

$$CR = \frac{CI}{RI} \tag{3}$$

Information :

CI = Consistency Index

RI = Random Index

### 2.3 Rating Scale

Rating Scale is an assessment based on a particular scale score from the lowest to the highest score. Rating Scale uses raw data in the form of numbers which are then interpreted in a descriptive sense [11].

**Table 4**  
Performance assessment scale

Scale	Information
1	Unsatisfactory / Very Bad
2	Need Improvement / Bad
3	Fulfilling Expectations / Sufficient
4	Exceeding Expectations / Good
5	Excellent / Very Good

Table 4 is a scale ratings and descriptions used in the Rating Scale. The advantages of implementing this method are simple, easy to design, easy to use. Rating Scale is used to reduce the potentially objective assessment because, in the process of determining the scale, the characteristics of the assessment are often considered equally important.

### 2.4 Behaviorally Anchor Rating Scale (BARS)

BARS is an assessment method that aims to combine qualitative methods such as narrative approaches and critical events and to compare individual performance against examples of certain behaviors associated with a measured scale [24]. This scale establishes a standard rating of a specific behavior, good or bad performance which is shown in a numerical rating. The BARS method defines behavior in definite, observable, and measurable performance. An example of behavior related to work and work dimensions is found by asking the company to provide a specific explanation of employee behavior which can be said to be effective and ineffective behavior [12].

### 3. Research Method

The decision support system proposed in this study was built based website and used a relational database management system MySQL. System development phase through two stages: the stage of weight calculation priority criteria and the stage of the calculation process of employee performance appraisal.

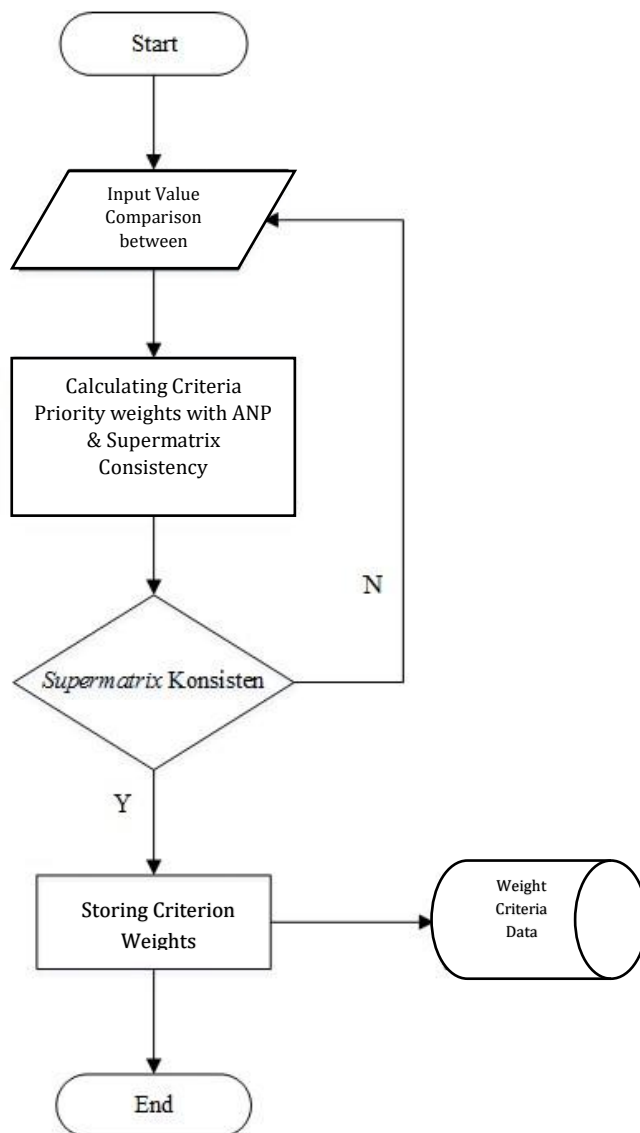


Fig 1. Criteria Weighting Flowchart

Figure 1 shows the flow of data formation criteria weights priority. The user enters the pairwise comparison score between the criteria and the system calculates the consistency score of the supermatrix. If the score generated by the system is in accordance with the standard score of the consistency ratio, then the criteria weights priority score is stored in the criteria weight data. Criteria weight data is used in the calculation of employee performance appraisal.

**Table 5**  
Employee Assessment Criteria

No	Criteria
C1	Attendance
C2	Service
C3	Activeness
C4	Cooperation
C5	Emotion Control

At the stage of calculating the criteria weight, the criteria used are based on the BARS method approach. The BARS criterion were formed based on the policies that have been applied to the PT. Kupu-Kupu Taman Lestari. The assessment criteria refer to the company, such as, Attendance (C1), Service (C2), Activeness (C3), Cooperation (C4), and Emotional Control (C5), which can be shown in Table 5.

**Table 6**  
The interrelationship of network elements

No	Network
C1	C1,C3
C2	C2,C3,C4
C3	C1,C3,C4
C4	C2,C3,C4
C5	C5
Alternatif	C1,C2,C3,C4,C5

Table 6 shows the interrelationships and interplays between the elements in the calculation of the decision support system that is built.

**Table 7**  
Unweighted supermatrix weight calculation

Criteria (C)	C1	C2	C3	C4	C5	Eigen Vector
C1	1,00	0,00	0,33	0,00	0,00	<b>0,06</b>
C2	0,00	1,00	3,00	3,00	0,00	<b>0,38</b>
C3	3,00	0,00	1,00	1,00	0,00	<b>0,23</b>
C4	0,00	0,33	1,00	1,00	0,00	<b>0,13</b>
C5	0,00	0,00	0,00	0,00	1,00	<b>0,20</b>
<b>Total</b>	<b>4,00</b>	<b>1,33</b>	<b>5,33</b>	<b>5,00</b>	<b>1,00</b>	<b>1,00</b>

Weight calculation begins with the weighting calculation priority Unweight Supermatrix, shown in Table 7. Eigen Vector calculated by a formula in formula 1.

The next stage is to determine the weighted matrix by multiplying all the elements in the unweighted matrix by the scores contained in the matrix cluster, the weighted matrix is shown in Table 8.

**Table 8**  
Weighted supermatrix weight calculation

Criteria (C).	C1	C2	C3	C4	C5	Eigen Vector
C1	1,12	0,00	0,37	0,00	0,00	<b>0,06</b>
C2	0,00	1,12	3,36	3,36	0,00	<b>0,38</b>
C3	3,00	0,00	1,12	1,12	0,00	<b>0,23</b>
C4	0,00	0,33	1,12	1,12	0,00	<b>0,13</b>
C5	0,00	0,00	0,00	0,00	1,12	<b>0,20</b>
<b>Total</b>	<b>4,12</b>	<b>1,45</b>	<b>5,97</b>	<b>5,60</b>	<b>1,12</b>	<b>1</b>

The stage after the weighted matrix is to calculate the limiting supermatrix, at this stage it will produce an eigenvector that is used as the weight value for each criterion. Limiting Supermatrix is shown in Table 9.

**Table 9**  
Limiting supermatrix weight calculation

Criteria (C).	C1	C2	C3	C4	C5	Eigen Vector
C1	3,48	0,00	0,37	0,00	0,00	<b>0,10</b>
C2	0,00	3,48	3,36	3,36	0,00	<b>0,33</b>
C3	3,00	0,00	3,48	3,48	0,00	<b>0,23</b>
C4	0,00	0,33	3,48	3,48	0,00	<b>0,13</b>
C5	0,00	0,00	0,00	0,00	3,48	<b>0,20</b>
<b>Total</b>	<b>6,84</b>	<b>3,48</b>	<b>10,32</b>	<b>10,32</b>	<b>3,48</b>	<b>0,99</b>

Calculation details determine the eigenvector in the limiting supermatrix stage:

- Attendance Priority Weights (C1):  

$$\frac{\left(\frac{3.48}{6.84} + \frac{0.00}{3.48} + \frac{0.00}{10.32} + \frac{0.00}{10.32} + \frac{0.00}{3.48}\right)}{\left(\frac{1}{5}\right)} = 0.10$$

- Service Priority Weights:  

$$\frac{\left(\frac{0.00}{6.84} + \frac{3.48}{3.48} + \frac{3.36}{10.32} + \frac{3.36}{10.32} + \frac{0.00}{3.48}\right)}{\left(\frac{1}{5}\right)} = 0.33$$

- Activeness Priority Weights :  

$$\frac{\left(\frac{3.36}{6.84} + \frac{0.00}{3.48} + \frac{3.48}{10.32} + \frac{3.48}{10.32} + \frac{0.00}{3.48}\right)}{\left(\frac{1}{5}\right)} = 0.23$$

- Cooperation Priority Weights :  

$$\frac{\left(\frac{0.00}{6.48} + \frac{0.00}{3.48} + \frac{3.48}{10.32} + \frac{3.48}{10.32} + \frac{0.00}{3.48}\right)}{\left(\frac{1}{5}\right)} = 0.13$$

- Emotional Control Priority Weights:  

$$\frac{\left(\frac{0.00}{6.48} + \frac{0.00}{3.48} + \frac{0.00}{10.32} + \frac{0.00}{10.32} + \frac{3.48}{3.48}\right)}{\left(\frac{1}{5}\right)} = 0.20$$

Determine the λmax score:

$$(6,84 * 0,10) + (3,48 * 0,33) + (10,32 * 0,23) + (10,32 * 0,13) + (3,48 * 10,20) = 6,34$$

Determine the Consistency Index CI value (Equation1) :

$$CI = \frac{6,34 - 5}{5 - 1} = 0,33$$

Determine the Consistency Ratio CR value (Equation 2):

Due to the number of criteria are 5 criterion, the Random Index (RI) value used is 1.12 according to table 3.

$$CR = \frac{0,33}{1,12} = 0,30$$

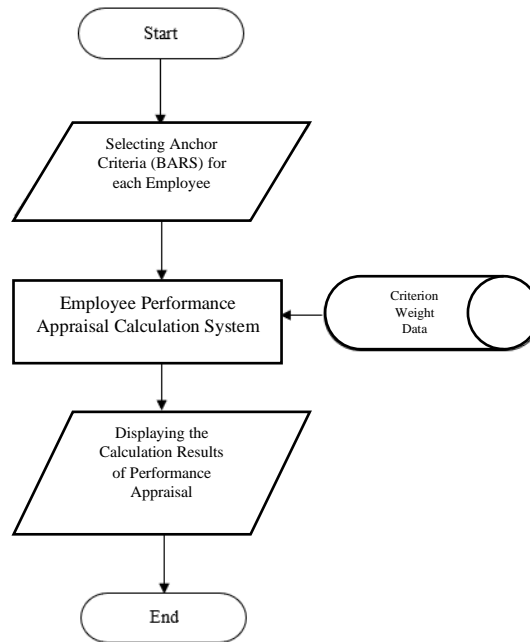
After the consistency ratio score is obtained, then the next eigenvector calculation results at the limiting supermatrix stage can be used as the criteria weight, it can be shown in Table 10.

**Table 10**  
Priority Weight Calculation Results

No.	Criteria	Criteria Weights
1	Attendance	0.10
2	Service	0.33
3	Activeness	0.23
4	Cooperation	0.13
5	Emotional Control	0.20

The data in Table 10 is implemented in the system to determine the criteria weights based on the ANP method calculation, the criteria weight score are stored in the system. Furthermore, to assess the

performance of each employee, the user determines the appropriate criteria anchor based on the BARS method for each employee assessment. Figure 2 shows a flowchart for calculating employee performance appraisal.



**Fig 2.** Performance Appraisal Calculation Flowchart

The anchors of employee performance appraisal are prepared as a reference for the process of calculating employee performance based on the appraisal criteria in Table 10, in this study the anchor used for each criterion are 5 anchors. The anchor selected in Figure 2 is a behavior that shows performance for each criterion that has been determined by the BARS approach. Table 11 shows the anchor rating scale for Attendance criteria (C1) to determine the percentage of employee attendance.

**Table 11**  
Attendance performance rating scale

Criteria	Scale	Keterangan
Attendance	1	Attendance rate over 50%
	2	Attendance rate over 30%
	3	Attendance rate over 15%
	4	Attendance rate below 5%
	5	Attendance rate 0 %

The anchor rating scale for service criteria is intended to determine customer response to the employee concerned, shown in Table 12.

**Table 12**  
Service criteria rating scale

Criteria	Scale	Information
Service	1	There are 10 or more complaints from visitors
	2	There are 5 or more complaints from visitors
	3	There are 3 or more complaints from visitors
	4	There are 1 to 2 complaints from visitors
	5	No complaint from visitors

The anchor rating scale for the activeness criteria is intended to determine employee compliance with the regulations in the company, shown in Table 13.

**Table 13**  
Activeness rating scale

Criteria	Scale	Information
Activeness	1	Violating the rules or not following work procedures more than 10 times
	2	Violating the rules or not following work procedures 7 to 10 times
	3	Violating the rules or not following work procedures 3 to 6 times
	4	Violating the rules or not following work procedures 1 to 2 times
	5	No rules violation and always follow work procedures

The anchor rating scale for the cooperation criteria is intended to determine employee performance in teamwork, shown in Table 14.

**Table 14**  
Cooperation rating scale

Criteria	Scale	Information
Cooperation	1	Complaints from other employees for 7-10 times
	2	Complaints from other employees for 4-6 times
	3	Complaints from other employees for 2-3 times
	4	Complaints from other employees for 1 time
	5	No complaint from other employees

The anchor rating scale for the emotional control criteria is intended to determine the employees' attitude at work, especially in controlling emotions so that there are no disputes with visitors or other employees, shown in Table 15.

**Table 15**  
Emotional control rating

Criteria	Scale	Information
Emotional Control	1	Having problems with visitors or with other employees more than 8 times
	2	Having problems with visitors or with other employees for 6-8 times
	3	Having problems with visitors or with other employees for 3-5 times
	4	Having problems with visitors or with other employees for 1-2 times
	5	No problems with visitors or other employees

The final calculation of the employee performance score (alternative) on each criterion is obtained by calculating the anchor score of the rating scale for each criterion then multiplying by the weighted score of the criteria. Formula 4 is used for calculating the alternative final score for each criterion.

$$nilai = \sum(Bobot\ Kriteria \times Nilai\ Rating\ Scale) \tag{4}$$

Table 16 shows an example of an employee assessment calculation based on the criteria weight and anchor criteria selected in the assessment process.

**Table 16**  
Example of employee appraisal

Name	Criteria	Criteria Weight	Anchor Rating Scale	Score
Kadek Suparsa	Attendance	0,10	3	0,30
	Service	0,33	2	0,66
	Activeness	0,23	3	0,69
	Cooperation	0,13	2	0,26
	Emotional control	0,20	2	0,40
Final Score				2,31
I Gede Asmara	Attendance	0,10	3	0,30
	Service	0,33	2	0,66
	Activeness	0,23	1	0,23
	Cooperation	0,13	2	0,26
	Emotional Control	0,20	5	1,00
Final Score				2,45

The score in the Criteria Weight column refers to the score presented in Table 9. The column of the Anchor Rating Scale is based on the behavior (anchor) of each criterion. Each anchor has a predetermined rating scale from 1 to 5. The score refers to the anchor score of each criterion listed in Table 10, Table 11, Table 12, Table 13, and Table 14. The score collum is the multiplication of the criterion weight score with



the anchor. The final score is obtained from the sum of the scores in the Score column, according to Formula 3.

#### 4. Result and Discussion

The development stage of the decision support system on employee assessment uses the PHP programming language and MySQL database. The implementation stage begins by discussing the user interface display (the decision support system on employee assessment interface uses the ANP method and the web-based Rating Scale. The initial login display for users is shown in Figure 3.

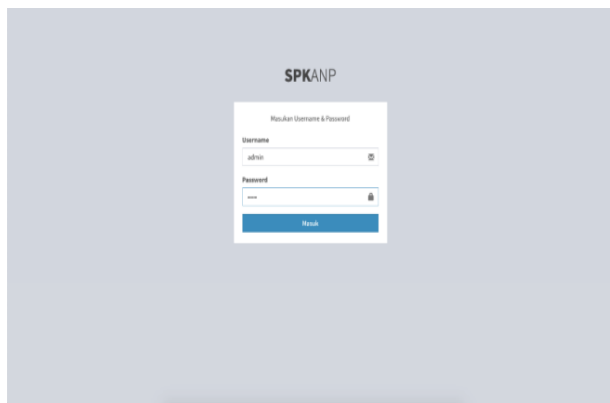


Fig 3. Admin Login View

The next view is the criteria page view that can be used to see the criteria used and the weighted score of each criterion, shown in Figure 4.

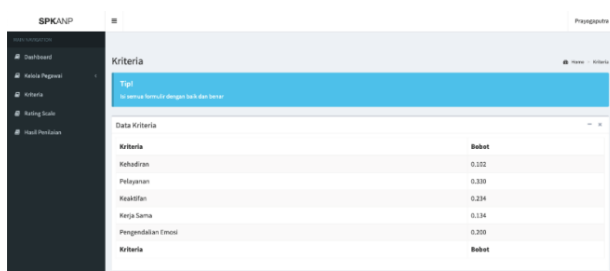


Fig 4. Criteria Page View

The rating scale page view is intended to provide alternative scores on each criterion scale, shown in Figure 5.

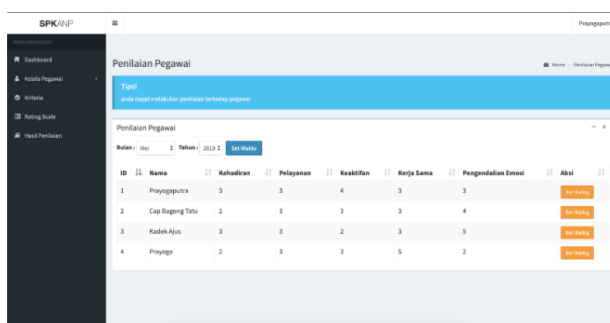


Fig 5. Rating Scale Page View

The rating scale process on page view is intended to describe each criterion of the rating scale, shown in Figure 6.

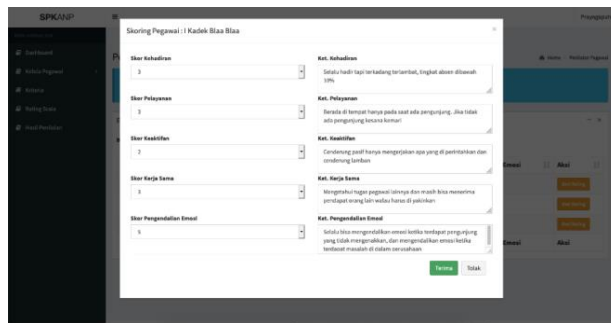


Fig 6. Rating Scale Process Page View

The next view is a process page view that displays the results of the employee assessment SPK calculation, the report page can be determined based on the selected selection period. The report page view is shown in Figure 7.

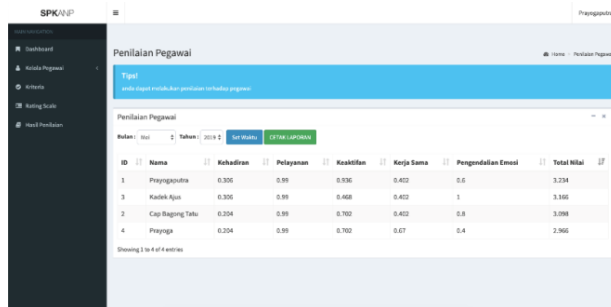


Fig 7. The Report Page View

Testing on the decision support system on employee assessment that has been built in this study is manual calculation testing with the system and user perceptual testing. In the test results, manual and system calculations are not much different, it is just different behind the comma, for example, Putu Usada's employees get a score of 4.96 whereas the system gets a score of 5 then Kadek Suparsa is calculated manually gets a score of 2.31 whereas the system gets a score of 2.336 then I Gede Asmara is calculated manually gets a score of 2.45 whereas the system gets a score of 2.468 then Ni Ketut Susmini gets a score of 0.99 manually, whereas the system gets a score of 1 and Anak Agung Darma Putra gets a score of 2.97 manually whereas the system gets a score of 3. The difference between the results of manual and system assessments is calculated as an average score of 0.025. The comparison of the results of manual and system calculations is shown in Table 17.

Table 17  
The comparison of manual and system calculations

No.	Employee	Manual Assessment Result	System Assessment Result	Different
1	Putu Usada	4,96	5	0,040
2	Kadek Suparsa	2,31	2,336	0,026
3	I Gede Asmara	2,45	2,468	0,018
4	Ni Ketut Susmini	0,99	1	0,010
5	Anak Agung Darma Putra	2,97	3	0,030
Difference Average				0,025

In user testing is done by giving a questionnaire to the manager of PT. Kupu-Kupu Taman Lestari as the system user. The questionnaire items were arranged based on the software quality factors by McCall. McCall's factor model classified all software requirements into 11 quality factors [17]. In this article, the factor category used is the product operation factor. The questionnaire uses an answer scale of Strongly Disagree (STS), Disagree (TS), Agree (S), and Strongly Agree (SS). The score for each answer from STS to SS is 1 to 4. Each aspect is calculated as the average score of the results of the user questionnaire answers.

Based on user testing (Table 18), the result shows that correctness gets an average score of 3.5 with a percentage of 87.5% of the maximum score of 4. Correctness shows the accuracy of the calculation process and the reports generated by the system. Reliability gets an average score of 3.67 with a percentage of 91.67%. From the results of the reliability assessment, the system functionality has been achieved as needed. Integrity gets a score of 4 with a percentage of 100%, this shows the level of data security on the system is achieved with the username and password features that are only owned by managers. Usability

gets an average score of 3.33 with a percentage of 83.33%. The results of the usability assessment indicate that the ease of use of the system has been achieved.

The testing results show the decision support system built meets user needs, displays information according to user input appropriately, is safe from unauthorized parties, and the system is easy to use.

**Table 18**  
User testing questionnaire results

Aspect	Question Point	STS (1)	TS (2)	S (3)	SS (4)
Correctness	The system generates a corresponding value to manual calculations			✓	
	The system helps in the employee performance appraisal process				✓
	The application of BARS in the system can represent the standard of employee performance appraisal at the company			✓	
	The system generates employee assessment reports based on the period				✓
Reliability	The information provided is accurate			✓	
	The system displays the results of ANP and BARS processing according to the input				✓
	The system displays the final result in the form of a ranking				✓
Integrity	The system can be accessed only by managers				✓
	Attractive system display			✓	
Usability	Easy management of employee data				✓
	Input criteria using the ANP and BARS methods are easy to do			✓	

## 5. Conclusion

In this study, a web-based decision support system on employee performance assessment with ANP and BARS methods has been built. There are 5 criterion used with service criteria as the criteria that have the highest priority weight, namely 0.33. The alternative employees selected were 5 employees with the highest final score is Putu Usada with a score of 4.96 (Table 17). The system and manual test results show a small difference of 0.025 (Table 17) due to the difference in the numbers behind the comma. Perception testing of system users with the McCall model approach shows the system built to meet user needs displays information according to user input appropriately, is safe from unauthorized parties, and the system is easy to use. With this decision support system, it can provide benefits for the HR department in recording and evaluating employees for the next process. Suggestions for further developments are expected to be able to build features for dynamic criteria and anchor scale, and assessment data can be used as a reference in the criteria sensitivity analysis so that it can be an alternative decision in improving employee performance according to the criteria determined by the company.

## 6. References

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