Decision Support System Scheme Using Forward Chaining And Simple Multi Attribute Rating Technique For Best Quality Cocoa Beans Selection

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***Abstract*— Cocoa is a crop plantation originating from the tropical forests of Central America and northern part of South America. In general, cocoa grouped into three types namely Forastero, Criollo, and Trinitario which is the result of a cross between Forastero with Criollo. Cocoa (Theobroma cacao L.) is one of the comodity that has an important role in the Indonesian economy. The Indonesian's processing directorate, and the programs related to the 2015–2019 development are the Increased Production and Productivity of Sustainable Plantation Crops. This program is conducted to increase the production, productivity of cocoa and other plantation crops. One of the focus activities is Inventory of postharvest data of plantation. In the selection of cocoa beans based on the best quality, Indonesian Coffee and Cocoa Research Center is often missed so that there are some cocoa beans that should not pass the quality but still processed into processed products. In that case we proposed a new scheme for Decision Support System by using Forward Chaining method and Simple Multi Attribute Rating Technique (SMART). The combination of these two methods proved to be able to do a very good selection of cocoa beans. Where the selection is done with two stages proven can really filter the cocoa beans are good for health.**

Keywords—Cocoa Bean, DSS, Forward Chaining, SMART

I. INTRODUCTION

Indonesia is one of the world's top cocoa producers after Ivory Coast and Ghana, with 13% of world cocoa production. The production of Ivory Coast and Ghana are 39% and 19% respectively [1]. Therefore, Indonesia's cocoa production is highly calculated in the world cocoa market. Jember Regency is one of the big cocoa bean producing cities in East Java Province. Almost all areas in Jember Regency are plantation area, especially cocoa bean plantation. Plantation in Jember Regency is not a plantation owned by an individual (farmer) but rather a smallholder plantation, which is a collection of small gardens owned by several farmers. The farmers each have a plantation area of approximately 1 - 2 hectares. In quantity, cocoa products in Indonesia at this time the results are quite encouraging, but the quality is not satisfactory. So in the world market is still difficult to compete with products from other countries that have good quality standards. Jember regency, known as a cocoa producer, should be able to improve the quality of cocoa beans into a product in order to compete with other cocoa producing countries. One of the products produced from the processing of cocoa beans is chocolate. Chocolate with the content of cocoa (cocoa beans) more than 70% also has health benefits, because chocolate is rich in antioxidant content of fenoldan flavonoids that can boost the immune system is very large. With the presence of antioxidants will be able to capture free radicals in the body. Given the various benefits of the importance of the content contained in cocoa beans and derivatives products for the health of the human body, the thing that must be maintained is the selection of cocoa beans with the best quality. Determining cocoa beans with the best quality according to Indonesian's standard must be appropriate with predefined standards and criteria. In the selection of cocoa beans based on the best quality, Indonesian Coffee and Cocoa Research Center is often missed so that there are some cocoa beans that should not pass the quality but still processed into processed products. In addition, the inventory process for managing reports on cocoa beans still uses manual systems that can lead to errors and lack of time efficiency. This manual process is considered inefficient, requiring the system to support the process of selecting the best cocoa beans based on quality. The existence of this system is expected to support the process becomes more optimal and efficient.

Inventory management affects all functions of the cocoa operating system. As a managerial process, an inventory is necessary in a series of planning processes to the elimination of an inventory. However, the reality that occurs in the field of most agencies less attention to the importance of inventory. Based on the explanation of the above problems, a system is needed to assist the selection process of the best cocoa bean selection as well as to manage the digital data inventory for an information presented in graph form showing good quality cocoa quality for health produced from year to year as center evaluation material research coffee and cocoa Indonesia. Utilization of technology that can be used for this problem is to create a system that will be able to combine tools (tools) information systems and models to evaluate the various options. This system is known as Decision Support System (DSS)[2] . In that case we proposed a new scheme for Decision Support System by using Forward Chaining method and Simple Multi Attribute Rating Technique (SMART). Forward Chaining method is run by gathering the facts to draw conclusions. Forward Chaining method is used for the process of determining the quality requirements of cocoa beans based on the beans.

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While the Simple Multi Attribute Rating Technique (SMART) method is looking for the weighted summaries and rankings determined through each alternative on all predefined criteria and subcriteria. The Simple Multi Attribute Rating Technique (SMART) method in this research is used for the process of determining specific quality requirements. The combination of Forward Chaining method and Simple Multi Attribute Rating Technique (SMART) is expected to facilitate decision making in making the best decision to determine the best cocoa beans selection based on quality.

II. METHOD

A. Decision Support System

Decision Support System (DSS) according to [3], can be described as a system capable of supporting ad hoc data analysis, and decision modeling, decision-oriented, future planning orientation, and use at unusual moments. DSS are tools that an organization uses to support and enhance decision-making activities [4]. Early use of decision support analysis was marketing. DSS was defined by Power [5] as a coordinated collection of data, system, tools and technology, with supporting software and hardware by which an organization gathers and interprets information from business and environment and turns it into a basis for marketing action. Little [6] defined the DSS as a "model-based set of procedures for processing data and judgments to assist a manager in his decision-making."

B. Forward Chaining

The solution to some problems naturally starts with the collection of information. Reasoning is applied to this information to obtain logical conclusions. For example, a doctor usually begins to diagnose a patient by asking him about the symptoms he or she suffers from, such as high blood pressure, temperature, headache, sore throat, coughing …etc. Then the doctor uses this information to draw a reasonable conclusion or to establish a hypothesis to explore further. This way of reasoning is called in an expert data driven system, forward-chaining [7].

Forward chaining can also be called advanced trace or search driven data (driven search). So the search starts from the premises or information input (if) first then to the conclusion or derived information (then). Forward Chaining means using the set of conditions-action conditions. In this method, data is used to determine which rule to run or by adding data to working memory to be processed to find a result.

The process of search by forward chaining method departs from left to right, ie from the premise to the final conclusion, this method is often called datadriven that search is controlled by the data provided. Forward chaining is also called advanced reasoning that rules are tested one by one in a certain order. The infrared machine will try facts or statements inside knowledge base in a situation expressed in the IF section rule [8]. If the facts in the knowledge base are in accordance with IF rules, then the rule is stimulated and the next rule is tested. The process of testing the rules one by one continues until one complete round through the entire rule device.

C. Simple Multi Attribute Rating Technique (SMART)

The Simple Multi Attribute Rating Technique (SMART) is a multi criteria decision making method developed in 1997 by Edward [9][10]. The SMART method is based on the theory that each alternative consists of a number of criteria that have value and each criteria has a weight that describes how important the value of the weight is compared to other criteria. SMART Method is more useful because of its simplicity in responding to the needs of decision makers and how it responds. The analysis involved is transparent so that this approach provides a great understanding of the problem and is acceptable to the decision maker [9][11]. SMART method is used more often because of its simplicity in responding to the needs of decision makers and analyzing responses. SMART uses a linear additive model to forecast the value of each alternative and its decision-making methods are flexible. The steps to solve the SMART method in general are as follows:

1. Determine the problem
2. Determine the criteria to be used
3. Determine alternative to be used
4. Determine the value of scale 0-100 based on priority to assess the weight
5. Give weight to each criteria on each alternative then in normalization. Normalization of weights can be seen in equation 1.

$$nwj = \frac{wj}{\sum wj} \quad (1)$$

annotation:
nwj = normalization *i* criteria
wj = weighting criteria
∑wj = sum of all the criteria

6. Calculate the value of utiliy by using equation 2.

$$u_{(a_i)} = 100\,\frac{(C_{max} - C_{aut_i})}{(C_{max} - C_{min})}\% \quad (2)$$

annotation:
ui = utility or sub criteria value of criteria *i*
ai = alternatives *i*
Cmax = maximum value of sub criteria
Cmin = manimum value of sub criteria
ui(ai) = value from alternative *i*

7. Calculate the final value of each criteria and subcriteria using equation 3.

$$\sum_{j}^{k} = 1^{wjuiai},\ i = 1,2,\ldots,k \quad (3)$$

annotation:
ai = alternatives *i*
wj = weighting criteria *j*
ui = utility or sub criteria value of criteria *i*
ui(ai) = value of criteria *i*

D. Proposed Scheme

The data analysis phase begins by examining the overall data that has been obtained from the data collection stage. The data is used to select the cocoa beans, the data used are the data of general quality criteria and specific quality criteria. General quality criteria data consist of insects life, moisture content, smelled of smoke, foreign object, and levels of broken beans. Specific quality data consists of the content of moldy bean, slaty bean, the content of insect-damage bean, waste bean, and germinated bean. To obtain the best cocoa beans that meet all the criteria mentioned above, we propose a new Decision Support System Scheme using a combination of Forward Chaining and SMART methods. The initial step is to make selection of cocoa beans by using a general quality test by Forward Chaining method. Cocoa beans that passed the general quality test are then selected again by using specific tests with SMART method with strict feasibility test to produce the best cocoa beans. The proposed Decision Support System Scheme can be seen in Figure 1.

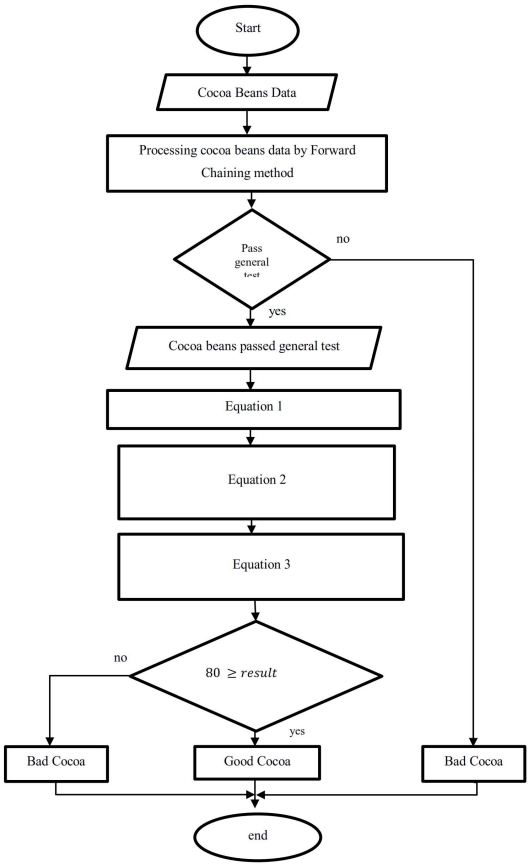

Figure.1 Proposed Scheme

III. RESULT AND DISCUSSION

System design will be done after the analysis is done. The design is done to provide a general description of the system to be built. This software development adopts the development pattern of waterfall method. Waterfall method is a systematic and sequential method that starts at the level and progress of the system until the analysis, design, code, test and maintenance. This chapter describes the results of research that has been done and discussion of decision support system that has been made. The discussion was conducted to explain and explain how this study answers the problem formulation as well as the purpose and benefits of this research as what has been determined at the beginning of the study.

A. Data Sampling

The sampling data were taken from the Indonesian cocoa research center with the amount of 13 and each cocoa beans were coded. General test criteria data used in making decision support system of quality selection of cocoa beans for health can be seen in Table 1 and the sampling data can be seen in Table 2.

Table 1 General Quality Test Criteria

No.	Type of Test
1	Insects Life
2	Moisture Content
3	Smelled of Smoke
4	Foreign Object
5	Level of Broken Beans

Tabel 2 Sample Data of Cocoa Beans

Cacao Code	Insect Life	Moisture Content	Smelled of Smoke	Foreign Object	Broken Beans
KA_001	No	3,5	No	No	1
KA_002	No	7,6	No	No	1
KA_003	No	4	No	No	3
KA_004	No	4	No	No	2
KA_005	No	7	No	No	4
KA_006	No	4	No	No	1
KA_007	No	4	No	No	1
KA_008	No	5	No	No	2
KA_009	No	3	Yes	No	1
KA_010	No	3	No	No	1
KA_011	Yes	2	No	Yes	2
KA_012	Yes	2	No	Yes	4
KA_013	Yes	3	No	No	3

B. General Quality Testing

At the cocoa beans selection stage based on the quality of commonly used Forward Chaining method. Implementation of Forward Chaining Method on Decision Support System for Good Quality Selection of Cocoa Beans is obtained from establishing a complete and good base of rules and knowledge base so that the general quality test process of cocoa bean gets good accuracy. The test mechanism in this decision support system is to do forward reasoning using rules based on a particular order and pattern.

The first step is to determine the criteria that will be tested at the quality selection stage of cocoa beans general test. The data on the general quality test criteria of cocoa beans is shown in Table 3. The second step is to determine the rules to represent knowledge using the production rule method which is usually written in the if-then form. Table 3 describes the quality of cocoa beans based on general quality requirements. The terms in the table are then represented in the facts or Forward Chaining rules that can be seen in Figure 2.

Table 3 General Requirements Good Cocoa Beans

No.	Type of Test	Units	Requirement
1	Insect Life	Beans	No
2	Moisture Content	%	Max 7,5
3	Smelled of Smoke	Beans	No
4	Foreign Object	Beans	No
5	Broken Beans	Beans	Max 2

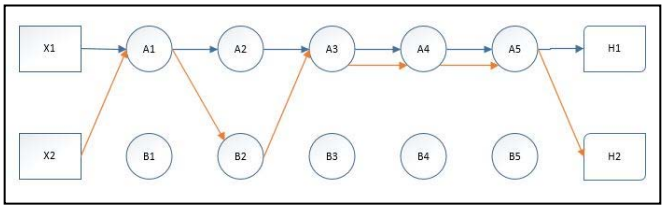

Figure 2 Forward Chaining rule

Annotation:
X1 = Cocoa Beans 1
X2 = Cocoa Beans 2
A1 = No Insect
A2 = Moisture Content ≤ 7.5
A3 = No smell of smoke
A4 = No foreign object
A5 = Broken beans ≤ 2
B1 = Insect
B2 = Moisture Content ≥7.5
B3 = Smell of smoke
B4 = Foreign object
B5 = Broken beans ≥ 2

The requirements for passing the general test shall meet the five prescribed conditions: no live insects, moisture content ⩽ 7.5, no smoke-free beans, no foreign object, and broken beans content ⩽ 2. If there is one condition that is not fulfilled, then the cocoa beans otherwise not passed the general test. Table 2 is a sample of cocoa beans data. From the predetermined criteria and rules it can be collected that the cocoa beans that passed the general quality test selection can be seen in Table 4.

Table 1 Cocoa Beans Pass the General Quality Selection

Cocoa Code	Selection
KA_001	Pass
KA_002	No
KA_003	No
KA_004	Pass
KA_005	No
KA_006	Pass
KA_007	Pass
KA_008	Pass
KA_009	No
KA_010	Pass
KA_011	No
KA_012	No
KA_013	No

C. Specific Quality Testing

After the general test the next step is a specific quality test. This specific quality test is aimed to get the best quality cocoa beans. At the stage of selection of cocoa beans based on specific quality used Simple Multi Attribute Rating Technique (SMART) method. The data criteria used in making decision support system of good quality cocoa beans selection for health at specific selection stage can be seen in Table 5.

Table 5 Criteria, Value and Weight

No.	*Criteria*	*Requirements*	*Value*	*Weight*
1	Mouldy Cocoa Bean (bean)	0 – 2	0	30
		3 – 4	20	
		> 4	100	
2	Slaty Cocoa Bean (bean)	0 – 3	0	20
		4 – 8	20	
		9 – 20	50	
		> 20	100	
3	Insect-Damaged Cocoa Bean (bean)	0 – 1	0	30
		= 2	20	
		> 2	100	
4	Waste Content (bean)	0 – 1,5	0	10
		1,6 – 2	20	
		= 3	50	
		> 3	100	
5	Germinated Cocoa Bean (bean)	0 – 2	0	10
		= 3	20	
		> 3	100	

The first step in the implementation of the SMART method of cocoa quality selection is to assess each cocoa beans based on predetermined criteria. The rating scale is 1-100 for each criteria. From the assessment conducted by the researchers obtained results as shown in Table 6.

Table 6 Value of each Cocoa Beans

Cocoa Code	Criteria				
	Mouldy bean	Slaty bean	Insect-damaged bean	Waste bean	Germinated bean
KA_001	0	50	20	20	100
KA_004	0	50	100	50	100
KA_006	0	20	0	100	20
KA_007	0	20	0	50	100
KA_008	0	50	100	50	20
KA_010	100	0	0	50	0

The second step is to determine the weight and calculate the value of the weight improvement of each criteria. The weight of each criteria can be seen in Table 5. To calculate the value of weighted improvement is using equation 1, so that we get the weight improvement as in Table 7.

Table 7 New Weight

Criteria	Weight
Mouldy bean(K_1)	0,3
Slaty bean (K_2)	0,2
Insect-damaged bean (K_3)	0,3
Waste bean (K_4)	0,1
Germinated bean (K_5)	0,1

The third step is to determine the utility value for each sub criteria using the formula as in equation 2 or directly assign a utility value based on the priority. The result of the preference value is entered in the utility value calculation table. The utility calculation table is shown in Table 8.

Table 8 Utility Calculation

Cocoa Code	Criteria				
	Mouldy bean	Slaty bean	Insect-damage bean	Waste bean	Germinated bean
KA_001	0	50	20	20	100
KA_004	0	50	100	50	100
KA_006	0	20	0	100	20
KA_007	0	20	0	50	100
KA_008	0	50	100	50	20
KA_010	100	0	0	50	0

The fourth step is to calculate the preference value of each cocoa beans by using the utility value that has been obtained previously. To calculate the SMART result is use equation 3. The result of the preference value is entered into Table 9.

Tabel 9 SMART Result

Cocoa Code	value
KA_001	72
KA_004	45
KA_006	84
KA_007	81
KA_008	53
KA_010	65

Table 9 shows the total final value of SMART result calculation. The SMART preference value is the reference used for ranking derived from the total utility value multiplied by the weight of the criteria. SMART calculations that have been obtained then sorted from the largest to the smallest. If the smart results obtained more or equal to 80 then the cocoa beans are considered worthy of specific tests as well as considered as cocoa beans are good for health. But if the smart results obtained less than 80 then the cocoa beans are considered unfit for health. Selection ranking results can be viewed in Table 10.

Tabel 10 Sorting Results

Cocoa Code	SMART result	Rank	Feasibility
KA_006	84	1	Yes
KA_007	81	2	Yes
KA_001	72	3	No
KA_010	65	4	No
KA_008	53	5	No
KA_004	45	6	No

From the calculations that have been done with Forward Chaining and SMART method, the best cocoa beans that passed the general test and specific test are cocoa beans with code KA_006 and KA_007 with the final value of 84 and 81.

D. System Implementation

The designed Decision Support System is implemented in web form making it easier to access. System is designed using php (laravel framework) and mysql programming language.

IV. CONCLUSION

Implementation of Forward Chaining Method in the general test is to check the criteria referring to the Indonesian National Standard on the quality of cocoa beans so that from the facts that have been previously known can produce a new conclusion. Implementation of Simple Multi Attribute Rating Technique (SMART) method in specific test starts from cocoa bean data collection that has passed general test to be processed in specific test phase. After the cocoa beans that have passed the general test have been collected it will be added weight and value for each criteria. Where the assessment criteria refers to the Indonesian National Standard on the quality of cocoa beans. The calculation using the Simple Multi Attribute Rating Technique (SMART) method refers to the utility value of each subcriteria. The combination of these two methods proved to be able to do a very good selection of cocoa beans. Where the selection is done with 2 stages proven can really filter the quality cocoa bean from the not quality one.

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