A Decision Support Application for Teak Log Supplier to Simulate Scenarios of Utilizing Forest Resources by Considering the Sustainability of Teak Log Supply

Silvester A.S. Herjuna, Muhammad Hisjam, Dyah N.E. Putri, Wahyudi Sutopo, Kuncoro H. Widodo

***Abstract*—We proposed an application to generate alternative solutions for helping teak log supplier (TLS). This paper focuses on developing an application based on the mathematical model of supplier - manufacturer relationship that developed using Powersim® software. The application is needed because it was really hard to control the model connected to dynamic forest age classes, dynamic demand, the growth of tree that has natural characteristics, and the uncertainty of illegal logging. The TLS application aimed to help user in operating mathematical model in generating alternative solutions by considering the sustainability of teak log supply. The TLS application has to judge and examine some alternative decisions related to crop and/or maintain the teak wood. The TLS application is a network-based decision support systems that incorporate database, model base, analysis tool, and graphical user interface (GUI). The TLS application is capable to determine the decision variables that are conserved forest, planted forests, harvested forest, carbon trade area, and time to attend carbon trading. The application is capable of processing data it can show by the small gap test results between TLS application and mathematical model application.**

***Index Terms*— sustainable supply chain application, teak log supplier, decision support system, furniture**

I. Introduction

THIS study discusses the relationship of supplier-manufacturer furniture industry, where suppliers are Perum Perhutani I as a TLS to supply raw materials in Central Java, while manufacturers are producing industrial furniture teak furniture. In this connection, suppliers face problems in meeting the demand of manufacturers, teak because it takes time to grow. In addition to having the responsibility to meet the demands of manufacturers, suppliers also have the responsibility to preserve the forest. Though manufacturers produce furniture every day [1], [2], [3].

Silvester Adi Surya Herjuna is Undergraduate Student, Department of Industrial Engineering, Sebelas Maret University, Surakarta, Indonesia

Muhammad Hisjam and Wahyudi Sutopo are with Laboratory of Logistic and Business System, Department of Industrial Engineering, Sebelas Maret University, Surakarta, Indonesia

Dyah Nurrahmawati Eka Putri is Alumnae, Department of Industrial Engineering, Sebelas Maret University, Surakarta, Indonesia

Kuncoro Harto Widodo is with Department of Agroindustrial Technology, Gajah Mada University, Yogyakarta, Indonesia

(Corresponding authors: phone/fax: +62-271-632110; e-mail: hisjam@uns.ac.id; mhisjam@yahoo.com)

Much research has been done to find a solution of this problem. References [3] and [8] have considered economic, social, and environmental aspects of sustainability to develop their model. Reference [9] has the added aspect of carbon trading in the model. However, these studies use analytical methods to solve the model. Usually the use of analytical methods in real cases is generally impractical, because it is usually too complex to solve using mathematical models. While in reference [10] which uses a mathematical model, the decision-making is influenced by many assumptions, the right decisions are rarely taken. While in reference [3] has used a simulation model to solve the problem. Simulation modeling is able to provide flexibility to the models and to the desired level of complexity in uncertainty, dynamic, and distributed environment [3]. Therefore, in this paper, we use a simulation model to generate several alternative decisions.

Unfortunately, the model contained in [3] involves a complex simulation model. To operate the model required an understanding of the depth of sustainable supply chain. Not to mention the model in the form of a desktop application that is not connected to the network. Though Perum Perhutani I has 20 offices spread in 20 cities in Central Java [16]. Therefore, it required the development of a model [3] are easy to use suppliers and can accommodate all existing offices. The model in the form of a decision support system to Simulate Scenarios of Forest Resources by Utilizing Considering the Sustainability of Teak Logs Supply. Decision support systems (DSS) is a system to utilize a model with internal and external databases, emphasizing flexibility, effectiveness, and adaptabilities [14], [15]. An application based DSS can be developed in environments that support data storage, data analysis, solution method, and graphical user interface. The application of teak furniture industry model that considers the carbon sequestration capacity of teak forests should be developed so that the stability and productivity of forest ecosystems can also be improved. The paper is organized as follows. In Part 1, we describe the background research and outlining the problems in the real system. In Section 2, we discuss the model of supplier-manufacturer relationships that will be developed into a TLS application. In Section 3, we discuss the application development methodology TLS. For a discussion and analysis are provided in Section 4. And in Section 5, we give conclusions and future research.

II. Model Based

We extend our previous work in [3] by developing a user interface to simplify the process inputs and outputs for the numerical simulation of the policy. In previous work, which considers the three aspects of sustainability to calculate profit suppliers. Equation (1) is the total income earned by the supplier to sell teak logs and (2) is the total revenue from the sale of carbon suppliers. Total investment costs are shown in equation (3). Plantation area is equal to the area of forest that is harvested from the previous period. Equation (4) is to calculate the total cost of harvesting. Harvested forest area, depending on the demand from manufacturers. Total forest maintenance costs generated by (5) and (6) is to calculate the total cost of the minimum wage for workers suppliers. Equation (7) is the gross profit suppliers. Equation (8) shows the formula for calculating the CSR. Equation (8) is calculated as a fixed percentage of (7). Net profit supplier, which is calculated by (9) which is generated by subtracting (7) with (8).

$$\sum_{i=1}^{30} TR_t^L = \sum_{a=1}^{2} \sum_{t=1}^{30} D_{at}^L \ x \ P_a^L \tag{1}$$

$$\sum_{i=1}^{30} TR_t^{CT} = \sum_{t=1}^{30} CTA_t \ x \ \rho \ x \ P^C \tag{2}$$

$$\sum_{t=1}^{30} TC_t^P = \sum_{t=1}^{30} PA_t \ x \ C^P \tag{3}$$

$$\sum_{t=1}^{30} TC_t^H = \sum_{t=1}^{30} HA_t \ x \ C^H \tag{4}$$

$$\sum_{t=1}^{30} TC_t^M = \sum_{t=1}^{30} MA_t \ x \ C^M \tag{5}$$

$$\sum_{t=1}^{30} TC_t^{PPE} = \sum_{t=1}^{30} W_t \ x \ C^{PPE} \tag{6}$$

$$\sum_{t=1}^{30} GTP_t = \sum_{t=1}^{30} TR_t^L + \sum_{t=1}^{30} TR_t^{CT} - \sum_{t=1}^{30} TC_t^P - \sum_{t=1}^{30} TC_t^H - \sum_{t=1}^{30} TC_t^M - \sum_{t=1}^{30} TC_t^{PPE} \tag{7}$$

$$\sum_{t=1}^{30} TC_t^{CSR} = 0{,}02 \ x \ \sum_{t=1}^{30} GTP_t \tag{8}$$

$$\sum_{t=1}^{30} NTP_t = \sum_{t=1}^{30} GTP_t - \sum_{t=1}^{30} TC_t^{CSR} \tag{9}$$

Where,

TR_t^L : Total supplier's revenue from selling log in period t (IDR)
D_{at}^L : Demand of teak log in period t (m^3)
P_a^L : Selling price of teak log type a (IDR/ m^3)
TR_t^{CT} : Total supplier's revenue from selling carbon credit in period t (IDR)
CTA_t : Carbon trading area in period t (ha)
ρ : Carbon density (tC/ha)
P^C : Selling price of carbon (IDR/tC)
TC_t^P : Total planting cost in period t (IDR)
PA_t : Planted area in period t (ha)
C^P : Planting cost (IDR/ha)
TC_t^H : Total harvesting cost in period t (IDR)
HA_t : Harvested area in period t (ha)
C^H : Harvesting cost (IDR/ha)
TC_t^M : Total maintenance cost in period t (IDR)
MA_t : Maintenance area in period t (ha)
C^M : Maintenance cost (IDR/ha)
TC_t^{PPE} : Total PPE cost in period t (IDR)
W_t : Total supplier's workers in period t (worker)
C^{PPE} : PPE cost (IDR/worker)
GTP_t : Gross total profit (IDR)
TC_t^{CSR} : Total the supplier by supplier (IDR)
NTP_t : Net total profit (IDR)
t : period (t = 1...30)
a : type of teak log (a = 1...3)

III. Methodology

The approach used in the development of TLS application teak furniture industry, which considers sustainability of production and carbon sequestration capacity and reviewing the Sustainable Supply Chain Management will be used for evaluating and managing supplier relationships and contract manufacturers in order to produce a business framework that can used for: financial value (FV), people value (PV), and environmental value (EV). The researcher also did modeling using simulation methods developed from the initial model using a simulation model. A goal to be achieved is the purpose in the model's third-SC (economic, environmental, and social aspects). In GP objective function does not maximize or minimize the objective function directly, but to minimize the deviation between the number of goals that can be achieved within the existing constraints. While the simulation method in modeling real systems made near the real system to generate random numbers within a certain range that represents the dynamics of the real system. Simulation modeling allows for flexibility to the model that was built and how the level of complexity desired in an uncertain environment, dynamic and dispersed [10].

Simulations performed on a number alternative alternative solutions and selected the best of a number of alternatives. The latter is the design of TLS application prepared by the method of object-oriented modeling is done in six steps is to identify actors, making use case diagram, activity diagram making, making interaction diagrams, normalization and create class diagrams [9]. The TLS application will be developed as a tool for TLS and Furniture Company in taking decisions in an accurate, inexpensive, and fast. Here is an overview of Web-based DSS Application for TLS are illustrated in Fig. 1.

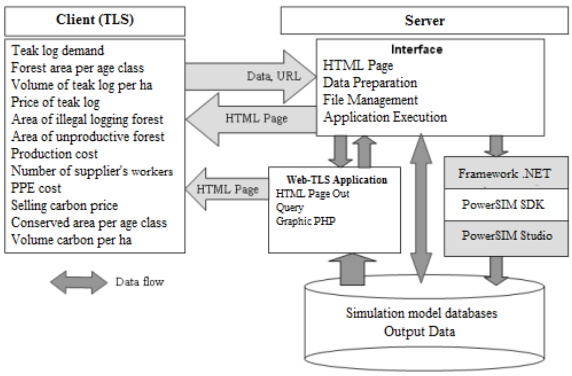

Fig. 1. Web-based DSS Application for TLS

This application is developed using HTML and PHP programming language. For processing the data using Powersim SDK, Microsoft Framework.NT components, and Microsoft Visual Studio. While the database server was developed using localhost web server and MySQL. The TLS application consists of five major components: database, the base model, an analytical tool, the Graphical User Interface (GUI) and user.

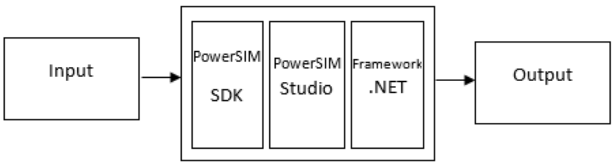

Fig. 2. Proccess of TLS Application

ISBN: 978-988-19253-9-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Initially, only the user interacts with the application's page on the Home-SC to fill in the values of model parameters. Users can input data, such as all the parameters and set the parameters of the growers and modern retailers. Display the input data can be seen in Fig. 3.

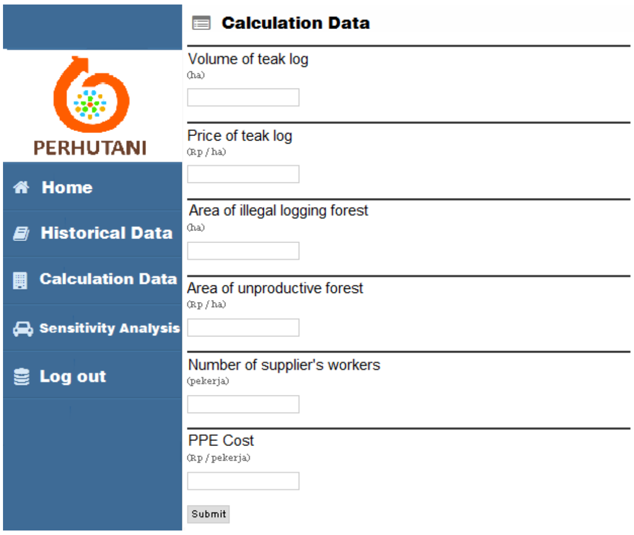

Fig. 3. Display the home page in the TLS application

Numerical data collected from the Perum Perhutani I of Central Java, Forest Management Unit (KPF) Kendal and from literature. The data collected from suppliers consist of 4 years. Table I presents data teak forests PP I KPH Kendal 20X1-20X4 period [16]. Table II shows the data request from the manufacturer of teak logs for 4 years. Suppliers must comply with the same request conversion of forest volume. Because teak trees can be harvested at least 30 years, then we need data conversion of forest volume Age Class (AC) IV to VI. Volume conversion teak forest area for AC IV is 80 m3 / ha, AC V is 113 m 3 / ha, and AC VI is 121 m3 / ha.

TABLE I
FOREST AREA THAT ARE MANAGED BY SUPPLIER OF TEAK LOG

Age Class (Year)	Area (Ha)			
	20X1	20X2	20X3	20X4
KU I (1-10)	7,551.79	8,193.48	8,358.78	8,131.98
KU II (11-20)	2,226.8	2,344.6	2,612.3	3,025.2
KU III (21-30)	1,419.3	1,560.2	1,578.5	1,635.5
KU IV (31-40)	1,092.1	1,007.8	936.5	818.4
KU V (41-50)	916.7	957.6	951.9	1,049
KU VI (51-60)	319.1	381.9	407.7	460.2

TABLE II
TEAK LOG DEMAND FROM MANUFACTURER

Year	Volume (m^3)
20X1	9,042.9
20X2	6,944.3
20X3	6,643.2
20X4	14,466.5

TABLE III
CARBON DENSITY

Age Class (KU)	Carbon Density (tC/ha/yr)
KU I	7.81
KU II	10.753
KU III	10.241
KU IV	9.0047
KU V	7.279
KU VI	10.815

TABLE IV
SELLING PRICE OF TEAK LOG

Teak Log Class	Price (IDR/m^3)
Teak log AI	1,368,000
Teak log AII	3,214,000
Teak log AII	4,706,000

TABLE V
PRODUCTION COST

Production Cost	Cost (IDR/ha)
Planting cost	7,437,600
Maintenance cost	160,000
Harvesting cost	16,785,300

Table III shows the average carbon density in the three carbon trading hours for each class of age [17]. Carbon trading hours will determine the volume of carbon that can be separated. More time to trade carbon, more carbon can be separated. The sale price of carbon is 46 955 rupiah / ton C. [18]. All cost parameters measured in Indonesia Domestic Rupiah (IDR). Table IV shows the sale price of teak logs. The larger the diameter of the log, the more expensive teak log prices. All production costs used in this study are presented in Table V. Charge APD used by suppliers' employees is 430,000 IDR / ppl / yr. Based on government regulations, corporate Social Responsibility (CSR) is a supplier of 2% of the gains suppliers.

IV. DISCUSSION

In this section, we analyze the impact of changing the parameters in solving the TLS to simulate policy. The output of the application is the recommendation for the forest area should be maintained to be sold in carbon trading.

A number of performance measures that are used to analyze and evaluate decision alternatives. Sustainability, which consists of economic, social, and environmental aspects, has been considered in this performance measure. The performance is measured are profit suppliers and the fulfillment of the demand producers.

The advantage of only the basic scenario of selling teak logs to meet the needs of the plant. This scenario has not been considered yet revenue from carbon trading. The percentage of 100% compliance with the request. Based on the results of the baseline scenario analysis, several scenarios were proposed to study the effects of changes in carbon trading areas related to supplier profits and fulfillment of requests. Fig 4 illustrates the outputs of TLS application. Fig 5 illustrates the sensitivity analysis for log production costs and demand.

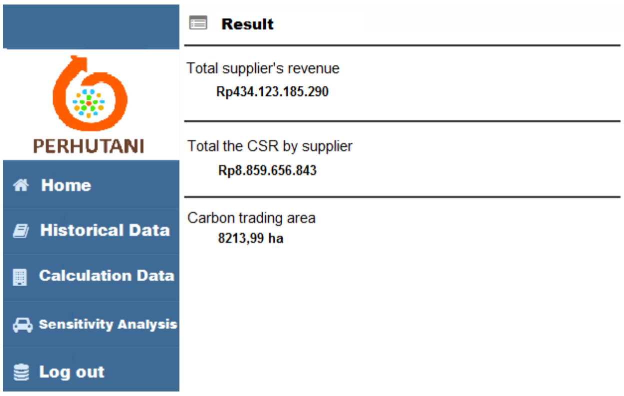

Fig. 4. The results of simulation on the output of the TLS application

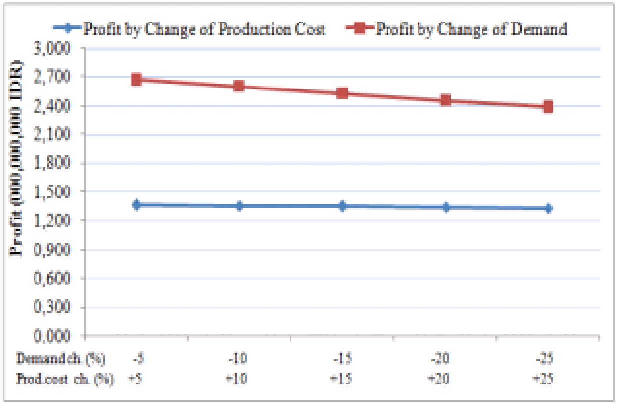

Fig. 5. The results of the sensitivity analysis on the output of the TLS application

V. Conclusion

In this study, we investigated the TLS web-based decision support systems to simulate scenarios of utilizing forest resources by considering the sustainability of teak log supply. The TLS can utilize the application to make decisions in supplier - manufacturer relationships. The test results of case examples also give good results, where the application is capable of processing data based on the mathematical model to help TLS in accepting teak log demand.

Acknowledgment

Thanks to Sebelas Maret University for the financial support in HIBAH UNGGULAN PERGURUAN TINGGI Research Program FY 2014 Contract No. 3385a/UN27.16/PN/2014.

References

[1] A. Turban and Liang. Decision Support Systems and Intelligent Systems, 7th Edition, USA: Prentice Hall, 2005.
[2] B. Kurniawan, M. Hisjam, and W. Sutopo. "Integration of production and supply chain strategic planning for renewable resources under sustainability considerations: teakwood case study", in Proc. of IEEE, International Conference on Industrial Engineering and Engineering Management, Singapore, December 2011, pp. 433-437.
[3] D. N. E. Putri, M. Hisjam , W. Sutopo, K. H. Widodo, "Simulation of Supplier - Manufacturer Relationship Model for Securing Availability of Teak Log in Furniture Industry with Sustainability Consideration", in the International Conference on Industrial Engineering and Engineering Management, (10-13 Dec 2013,Bangkok, Thailand), 978-1-4799-0986-5/13/$31.00©2013 IEEE.
[4] G. M. Marakas, Decision Support Systems in the 21st Century, USA: Prentice Hall, 2003.
[5] M. Hisjam, A.D. Guritno, H. Simon, dan S.D. Tandjung, "A framework for the development of sustainable supply chain management for business sustainability of export-oriented furniture industry in indonesia (a case study of teak wooden furniture in central java province)", in Proc. the 1st International Conference on Industrial Engineering and Service Science, 2011, Solo, Indonesia, pp. 286-290.
[6] M. Hisjam, A.D. Guritno, dan S.D. Tandjung, "The development of sustainable supply chain model of the relationship between wood supplier with furniture industry in indonesia: a case study," In Proc. of IGSCI, Indonesia, November, 2011.
[7] M. Hisjam, I. Ota, A.D. Guritno, H. Simon, dan S.D. Tandjung, "Comparing the practices of forest product certification between perum perhutani and yusuhara forest owner's cooperative", in Proc. Sustainable Bio-resources for Global Welfare Conf., 2010, Bali, Indonesia, pp. 85-92.
[8] M. Hisjam and W. Sutopo, "A framework of performance measurement system to measure the sustainability of furniture production in small-medium enterprises (SMEs)", in Proc. Sustainable Bio-resources for Global Welfare Conf., 2010, Bali, Indonesia, pp. 72-78.
[9] Sholiq, Object-Oriented Information Systems Modeling with UML. Yogyakarta: Graha Ilmu , 2006.
[10] Cope, D., Fayez, M. S., and Mollaghasemi, M., "Supply chain simulation modelling made easy: An innovative approach," in Proceeding the 2007 Winter Simulation Conference, 2007.
[11] C. Thierry, G. Bel, and A. Thomas, "The Role of Modeling and Simulation in SCM", SCS M&S Magazine, Vol. 10, pp. 2-8, 2010.
[12] K. Ginoga, Y.C. Wulan, and D. Djaenudin, "Carbon and the role of carbon in improving feasibility plantation teak in KPH Saradan, East Java, "Journal of Social & Economic Research, Vol. 2, pp. 183-202, 2005.
[13] A. Razak, "Feasibility of compensation offered in carbon trading, "Natural Res. Cons. And Env. Prog., UGM., 2007.
[14] G.M. Marakas, Decision Support System in the 21st Century, USA: Prentice Hall, 2003.
[15] A. Turban and Liang. Decision Support System and Intelligent System, 7th Edition, USA: Prentice Hall
[16] KPH Kendal, "Management Plan 2011-2015," Perum Perhutani Unit I, FMU Kendal, Indonesia, 2011.H. Poor, *An Introduction to Signal Detection and Estimation*. New York: Springer-Verlag, 1985, ch. 4.