SISTEM DINAMIS PENILAIAN KINERJA PRODUKSI TEH KEBUN BANTARAN PT PERKEBUNAN NUSANTARA XII

by Aulia Briliantina

Dynamic System Model for Performance Measurement of Tea Agroindustry

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Abstract. The problems of decrease in tea quality and tea productivity agroindustry have become a quite complex system problems. The dynamic system approach provides an analytical framework in order to understand the linkage of managerial policies of tea agroindustry. It applied dynamic system model by using tool powersym studio 2005. The simulation is done in the period of 2019-2025. Furthermore, performance dynamic model of tea agroindustry consists of production process linkage, finance, and human resources. The system produces three scenarios (aggressive, moderate, and pessimistic) based on management's response to strategic planning in 2011-2016. The result of this research is the model can be used to provide insight for management to monitor dynamic behavior of tea agroindustry. The simulation of dynamic behavior of scenarios recommended aggressive scenario as the best recommendation. The best scenario is the aggresive scenario. The measures were 10% rejuvenation increase, 10% production cost decrease, minimum tea selling price on export quality, increase in HR investment cost as much as 20%. **Keywords** : Dynamic System, Tea Agroindustry, performance measurement

1. Introduction

In an agroindustry subsystem, tea products are able to produce a total value of production as much as 2.1 trillion rupiahs, employment absorption reaching 51,422 people, and added value reaching 1.2 trillion rupiahs. Similarly, tea agribusiness has a linkage value of front and back directly or indirectly that is greater than 1 reaching 1.5 to 3. An increase in demand in agroindustry of bulk and processed tea as much as one unit will increase output at all industries towards itself that is relatively large, 1.5 to 3 times [17].

The performance and role of tea commodities in the national economy have tended to decrease since 2000. Total of tea plantation area decreased as much as 1.7% per year [9]. Similarly, Indonesian tea production decreased as much as 2.3% per year that is higher than the decrease of tea plantation area. In line with the decrease in the tea production, export volume also decreased affecting Indonesia's market share of tea in the world decreased significantly, from 7.9% to 6.1% [1].

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The decrease in the tea performance in Indonesia could be caused by a weakness of Indonesian tea marketing system, low quality of Indonesian tea, quality and types of Indonesian tea products that are not in accordance with market tastes, less conducive fiscal policy, and weak competitiveness of Indonesian tea [8].

The tea quality and productivity as a measurement of the success of tea agroindustry are handled by two parts, namely plant and processing. Cooperation of both parts become a key to success in increasing the performance of tea agroindustry reflected from the rendement performance of quality I and tea plant productivity. Achievement of rendement performance of quality I becomes the source of the trigger of financial performance reflected from the acquisition of profit value. The linkage of performance measurement among parts influences the performance measurement of the other parts, which is translated from the area of success with the tea agroindustry management [3].

An initial assessment of the measurement system illustrates that the performance in the tea agroindustry is a complex and dynamic linkage between all parts involved in the garden or factory. For example, the complexity is about PTP (Pick, Transport, Process) activities. In that process, the measurement value of its performance can change rapidly from time to time so that it can decrease the quality of the tea produced. However, ideally, if handling PTP activities is well-coordinated among those parts, it actually can increase the quality of tea produced [2].

Given the complexity and performance dynamics of tea agroindustry, agroindustry management usually formulates the best and proper policies in its strategic planning to minimize the potential inefficiencies of these aspects through several strategic options. [16], conducted research on the development of dynamic model of sugar mill performance as a tool to recognize the behavioral pattern of managerial performance problems of sugar factory.

Taking into account the reality of tea agroindustry performance, this research aims to develop the dynamic model of tea agroindustry performance as a tool to recognize the behavioral pattern of managerial problems of tea agroindustry performance. Furthermore, a dynamic system model with simulation analysis tools can help tea agroindustry management to obtain the best policy composition for the coming year by piloting several scenario options.

2. Methods

The methods of dynamic system is a simulation methodology based on systems theory [13]. Dynamic system model judges object system's changing trend by simulating object system dynamically in order to study and plan future action and corresponding decision-making of the object system [7]. Stocks, flows, converters, and interrelations among them constitute a dynamic system computer simulation model. The interrelations are graphically represented as arrows and mathematically modeled as the finite difference equations [15]. [6] at MIT first introduced the concept of dynamics system as Urban Dynamics to model systems with complex feedback structures. Since then, the dynamics system methodology has majorly focused on modeling of management strategies and, personnel management and inventories in industrial fields. Furthermore, in order to make the scenario that is akin to a real-life problem, the system dynamics methodology can be used as a tool [21]. [16], applied the dynamic system methodology to the performance measurement.

In the tea agroindustrial context, the quality performance and tea rendemen is a working achievement of all employees of the plant, processing, and financial support and human resources. The tea agroindustry of working assessment system is a dynamic process that can be seen from a projection of performance measurement stated in the work planning and company budgets in the coming years to increase better company performance. An increase in efforts to see future performance trends can be done by identifying problems pattern of past performance measurement. The integration of model of the working assessment system with a dynamic system approach is used to increase the future performance. This integration output is a synergy to produce a better model of the working assessment system with the help of computer simulations. The use of this simulations is aimed to see the effectiveness of policy scenario formulas before they are tested. The dynamic system approach is a

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methodology to see the interrelationship among performance key variables becoming the reference of tea agroindustry success.

The data collected consist of primary and secondary data [19]. Primary data obtained from field observation, and interview with the employees of tea agroindustry. Secondary data is obtained from literature study in order to obtain the theoretical foundations and supporting data related to the research material.

2.1 Dynamic System Methodology

A dynamic system is a problem analysis method, in which time becomes a significant factor including an understanding of how a system can be maintained from interference outside the system, or made in accordance with the purpose of system modeling that will be created. It is built on three disciplinary backgrounds; traditional management, feedback theory or cybernetics and computer simulations. The principles and concepts of those disciplines are integrated into a methodology to solve problems holistically, eliminating the weaknesses of each discipline to form synergies [20]. To successfully use system dynamics as a learning tool we must understand the effects of feedback loops on dynamics system. Causal diagrams are crucial tool for structuring the feedback loops. In order to develop cause and effect relationship between main variables of system, causal loop diagrams or influence diagrams should be used as a tool [4].

2.2 Dynamic Model of the Tea Agroindustry Performance Assessment

The causal diagram of the performance assessment of tea plant agroindustry of Bantaran plantation area is shown in Figure 1. It consists of three sub-models, namely production process, financial, and growth and learning sub-model.

The tea production process sub-model is made by referring to [14] theory. It describes some of the most influential variables in determining the results of tea production rendemen. The tea production rendemen is the variable becoming the area of success in the production process sub-model, because the yield of this tea production will greatly affect the profit from the tea agroindustry. The tea production itself is divided into three types of quality, such as first quality, second quality, and local quality.

In this reasearch, the financial sub-model is adopted from the general model reviewed by several authors, includes Sterman [18] in his book Business dynamics: System thinking and modeling for a complex world and [22] in his book "Competitive strategy dynamics". The flowchart of financial sub-model is consisted of two SFD arrangement that is an accumulation of amount of income (rupiahs or IDR) and accumulation of total profit (IDR). The accumulated flowchart structure of amount is influenced by income inflows (IDR). The accumulated structure of profit amount is influenced by yearly income inflows (IDR) before taxes and total expenses.

The growth and learning sub-model adopt a general model structure derived from the reference model discussed by [22] in his book "Competitive strategy dynamics". The flowchart of growth and learning sub-model consists of two SFD arrangements, namely the accumulation of employees amount (people) and the accumulation of skill (ununited). The growth and learning sub-model of tea agroindustry are sourced from the employees working in the tea agroindustry, running information system, and rules applied in the tea agroindustry.

2.3 Model Assumptions

1. The average of employee skills has a positive influence on the achievement of the yield value. The employee skills will increase working performance in all areas of tea agroindustry that contribute directly or indirectly to the rendemen performance. Procurement of training refers to the needs for competency-based training.

2. The average of training hours amount has a positive influence on the increase in the employess skill of the tea agroindustry. The employee training hours is provided for all levels of tea agroindustry employee management.

3. Tea plant productivity variables, the amount of raw material purchases, production of yield rendemen, production costs, costs beyond production costs and the total needs of employees become parameter that can be defined as a priori by tea agroindustry management whose value is determined based on RKAP of tea agroindustry management. The assumptions covered in the RKAP has already included financial potension, social, regulatory and others.

4. The period of simulation analysis is limited to the period of 2017 to 2025.

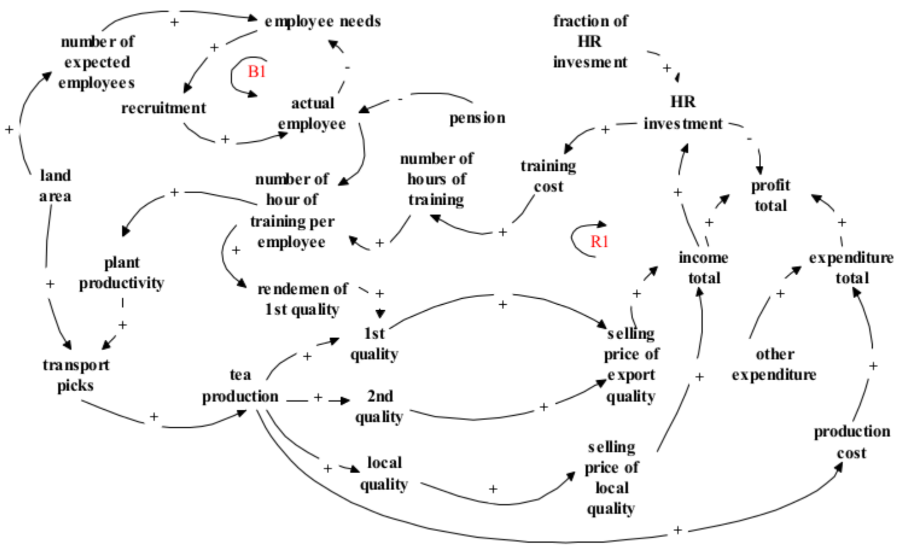

Figure 1. Causal diagram of working assesment at tea agroindustry

3. Results And Discussion

3.1 Model Validation

Validation as a proof that the computer model has been prepared in the previous stage is able to simulate the abstract model [5]. The consistency test of output result was by comparing simulation result data and actual data based on average percent error (APE) and mean value. The statistical test is done by checking the error value between the data and the actual data, the deviation limit conveyed not more 10% [11]. The output data result of Powersim simulation and actual data were compared by percentage value of several different variables, such as the amount of crop productivity, 1st quality, and profit growth (Table 1). The consistency test results showed that those three variables have a low MAPE. The test of profit variable had a quite low MAPE value that is 3.63%. While the MAPE value for other test variables were in the range of 9-8%. The higher the complexity of the tested variables, the greater the MAPE values.

Tabel 1. Model validation of variable in crop productivity, 1st quality, and profit growth.

Crop productivity				1st Quality				Profit			
Aktual (kg/ha)	Simulasi (kg/ha)	APE (%)	Valid-ation	Aktual (kg)	Simulasi (kg)	APE (%)	Valid-ation	Aktual (Rp in thousand)	Simulasi (Rp in thousand)	APE (%)	Valid-ation
5749	6322	9,97	Valid	295751	268605	9,18	Valid	-602693	-614354	1,93	Valid
5779	5982	3,51	Valid	235008	217244	7,56	Valid	819219	777538	5,09	Valid
6935	6129	11,62	Not	224373	208053	7,27	Valid	-695710	-674938	2,99	Valid
6855	6149	10,30	Valid	210171	196731	6,39	Valid	626384	604562	3,48	Valid
6633	5985	9,77	Valid	190062	163806	13,81	Not	-869853	-829317	4,66	Valid
MAPE		9,03	Valid	MAPE		8,84	Valid	MAPE		3,63	Valid

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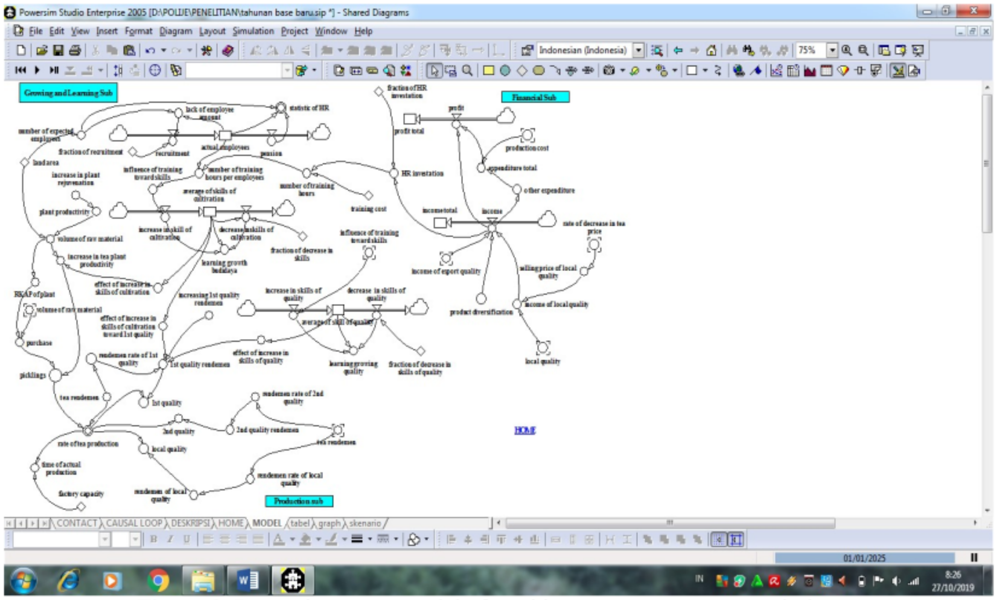


Figure 2. Dynamic system model of working assesment at tea agroindustry

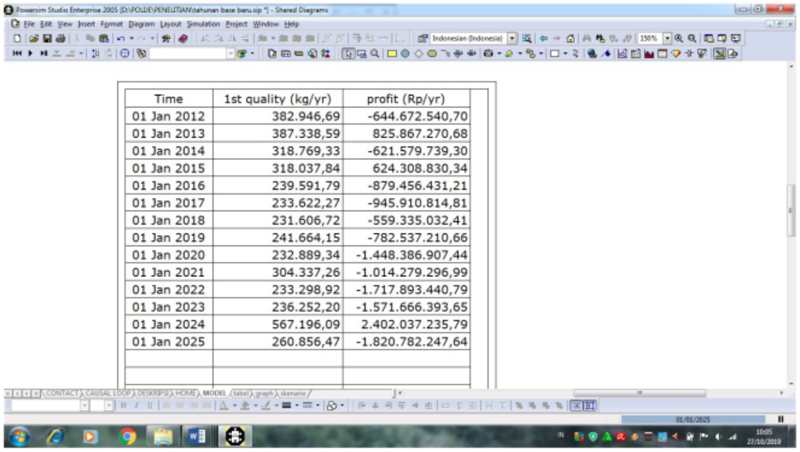
3.2 Model Simulation Results

The simulation analysis by changing some parameter values of tea agroindustry management policy refers to [10] consisted of four scenarios; without policy (scenario 1), pessimistic scenario (scenario 2), moderate scenario (scenario 3), and aggressive scenario (scenario 4). The policy analysis was the knowledge of strategic ways influencing the system to achieve the desired goals [12]. The model was first simulated in 2012. The policy scenario was implemented in 2017 and simulated until 2025. This aims to know the possibilities that will be occured in the future. Dynamic behavior analysis makes it possible for model users to change parameter values. Although the base case scenario run analysis is so important as a reflection of the actual conditions, in reality tea management agroindustry decision makers always plan performance measures in the next years which are reflected in the RKAP.

Scenarios that recommended are the implementation of increased plant rejuvenation, decreased of production costs, setting the minimum price of export quality tea sales above the production price, and increased human resources can to improve company performance. According to [9], raw materials conditions, especially the rejuvenate tea plants, and production costs are one of the factors that influence tea production. The developed scenarios were as follows:

3.2.1 First scenario: without policy implementation

In the simulation period from 2020 to 2025, there was a decrease in the variables studied. Profit variables would decrease continuously, even the tea agroindustry would suffer losses under 4 billion rupiah (Figure 3). The losses occur because the tea agroindustry was still implementing the same performance system as in previous years. The pattern of profit decrease under tea agroindustry was followed by other variables, such as crop productivity and tea production, for first quality, second quality, and local quality.



Time	1st quality (kg/yr)	profit (Rp/yr)
01 Jan 2012	382.946,69	-644.672.540,70
01 Jan 2013	387.338,59	825.867.270,68
01 Jan 2014	318.769,33	-621.579.739,30
01 Jan 2015	318.037,84	624.308.830,34
01 Jan 2016	239.591,79	-879.456.431,21
01 Jan 2017	233.622,27	-945.910.814,81
01 Jan 2018	231.606,72	-559.335.032,41
01 Jan 2019	241.664,15	-782.537.210,66
01 Jan 2020	232.889,34	-1.448.386.907,44
01 Jan 2021	304.337,26	-1.014.279.296,99
01 Jan 2022	233.298,92	-1.717.893.440,79
01 Jan 2023	236.252,20	-1.571.666.393,65
01 Jan 2024	567.196,09	2.402.037.235,79
01 Jan 2025	260.856,47	-1.820.782.247,64

Figure 3. Simulation results without scenarios

3.2.2 Second scenario (pessimistic scenario): increased plant rejuvenation as much as 5%, decreased production costs as much as 7%

The implementation of second scenario could increase the amount of first quality and profit. The results of policy scenario simulation could be seen in Figure 4. First quality increased from 136,647 kg to 152,822 kg in 2025 due to the rejuvenation of tea plants, so that the productivity of the plant increased. In line with first quality, the profit would increase from (Rp 3,401,702,849, -) to Rp. 1,578,510,965, -. That was due to increased tea production and also decreased production costs.

3.2.3 Third scenario (moderate scenario): increase in plant rejuvenation as much as 5%, decrease of production cost as much as 7%, minimum tea selling price determination on export quality

The result of third scenario implemented simulation showed that there was the increase in first quality and profit. First quality increased from 136,647 kg to 152,822 kg. In line with first quality, the profit would increase from (Rp 3,200,732,845, -) to Rp. 2,188,490,351, -. That was due to the increase in tea production and also the decrease in production cost, and the policy of minimum tea selling price determination on export quality.

3.2.4 Fourth scenario (aggressive scenario): 10% rejuvenation increase, 10% decrease in production cost, minimum tea selling price on export quality, increased investment cost of human resources

The use of fourth scenario could improve the first quality and profit. First quality increased from 147,006 kg to 326,949 kg, this was due to the increase in plant rejuvenation scenario, so that crop productivity increased compared with the previous scenario. In line with first quality, the profit would increase from (Rp 3,200,732,845, -) to Rp. 12,508,372,820, -. That was due to the increase in crop productivity up to 90%, and also the decrease in production cost by 10%.

Figure 4. Profit simulation result with scenario

The average value's recapitulation of the simulation results of various scenarios shows that there was an increase in profits. The aggressive scenario is the highest average profit which is an increase in profit of Rp. 6,740,437,921, -, because applied an increased human resource policy can improve tea agroindustry performance. Then in the third scenario there was an increase in profits due to price quality I influenced setting of 3 USD/gr and due to an increase in plant rejuvenation. In the second scenario, only a plant rejuvenation scenario can increase profits due to increased crop productivity. The application of dynamic system model design of tea agroindustry performance assessment (Figure 5) had succeeded in describing the dynamic behavior patterns of tea agroindustry performance assessment and formulate policy for tea agroindustry in the coming year according to company's RKAP.

Figure 5. Dynamic system for performance measurement of tea agroindustri application

4. Conclusion

Based on the results of simulated the policy scenario and the management strategy of the tea agro-industry, several priorities formulated that made as policy recommendations. The policy formulation relates to the parameters tested in the model that correlation to the main parameters significant, namely crop productivity per hectare and the number of quality production yields I. Policy formulation covers aspects of the production sub-model where there is a tea plant rejuvenation scenario, aspects of the financial sub-model which include a scenario of reducing production costs, as well as a scenario of increasing the price of export quality tea. Where is the formulate policies covering aspects of the growth and learning sub-model where there is a scenario of increasing investment in human resource. The best scenario is the aggresive scenario. The measures were 10% rejuvenation increase, 10% production cost decrease, minimum tea selling price on export quality, increase in HR investment cost as much as 20%.

5. References

[1] BPS (Badan Pusat Statistik). 2015. *Export of Tea According to Destination Country.* www.bps.go.id
[2] Brilliantina, A., Purnomo, B.H., Suryaningrat, I.B. 2016. Review: Pendekatan Penilaian Kinerja Agroindustri Teh Menggunakan Model Sistem Dinamik. *Jurnal Agroteknologi* Vol. 10 No. 02 (2016)

[3] Brilliantina, A., Purnomo, B.H., Suryaningrat, I.B. 2017. Sistem Penilaian Kinerja Agroindustri Teh Kebun Bantaran PT Perkebunan Nusantara XII. *Jurnal Ilmiah INOVASI*, Vol. 17 No. 1 Edisi Januari - April 2017
[4] Coyle, R. 1977. *Management System Dynamics*. John Wiley & Sons: Chichester.
[5] Eriyatno. 1999. *System Science: Improving Management Quality and Effectiveness*. IPB Press. Bogor
[6] Forrester, J.W. 1961. *Industrial Dynamics*. MIT Press, Cambridge, MA
[7] Feng, Yang. 2012. System Dynamics Modeling for Supply Chain Information Sharing. *Physics Procedia* 25 (2012), pp 1463 – 1469
[8] Gumbira-Sa'id E, Rachmayanti, Muttaqin MZ. 2004. *Agribusiness Technology Management is The Key To Global Competitiveness of Agribusiness Products*. Ghalia Indonesia. Jakarta.
[9] Indonesia Tea Board. 2015. *Tea Production Area*. www.indonesiateaboard.org
[10] Lyneis, James M. 1980. *System Dynamics for Market Forecasting and Structural Analysis*. Pugh-Roberts Associates, 41 William Linskey Way, Cambridge, MA 02142, USA.
[11] Makridakis, Wheelwright, McGee. 1999. *Metode dan Aplikasi Peramalan*. Suminto H, translator. Jakarta: Binarupa Aksara. Translation of : Forecasting: Methods and Application, Second Edition.
[12] Muhammadi, E Aminullah dan B Soesilo. 2001. *Dynamic Systems Analysis of Enviroment, Social, Economics, Management.* UMJ Press. .Jakarta
[13] Park, S., Kim, B,J., Jung, S,Y. 2014. Simulation methods of a system dynamics model for efficient operations and planning of capacity expansion of activated-sludge wastewater treatment plants. *Procedia Engineering* 70 (2014), pp1289 – 1295
[14] Rayati, D.J and Widayat, Wahyu. 2009. *More Than A Cup Of Tea*. Pusat Penelitian Teh dan Kina. Bandung
[15] Richardson, G.P., Pugh, A.L., 1981. *Introduction to System Dynamics Modeling with DYNAMO*. Cambridge, MA: The MIT Press.
[16] Rohmatulloh. 2011. Development of Dynamic System Model of Sugar Cane Performance. *2nd Workshop on System Modelling for Policy Development : Rehearsing Strategic Initiatives,* Jakarta, 26 November 2011
[17] Santoso, J. and Suprihatini R. 2007. Policy to Fight for Revitalization of National Tea Agribusiness. *Warta Pusat Penelitian Teh dan Kina.* Volume 18, pp 1-18.
[18] Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw Hill, Chicago.
[19] Suliyanto. 2006. *Methods of Business Research*. Andi, Yogyakarta
[20] Sushil. 1993. *System Dynamics : A Practical Approach for Managerial Problems.* Wiley Eastern Limited.
[21] Wankhade L. and Dabade B: M. 2006. TQM quality perception: a system dynamics approaches. *The TQM Magazine*. Vol. 18, No 1.
[22] Warren, Kim. 2002. '*Competitive Strategy Dynamics'*. John Willey & Sons, New York, USA

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