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IMPROVING THE PRODUCTIVITY AND ENVIRONMENTAL PERFORMANCE ON SMALL INDUSTRY OF COFFEE PRODUCTION

***ERINA RAHMADYANTI, ELIZABETH TITIEK WINANTI, DEWIE TRI WIJAYATI AND DIAH WULANDARI**

[1,2,4]Faculty of Engineering, Universitas Negeri Surabaya, Kampus Unesa Ketintang, Surabaya 60231, East Java, Indonesia
[3]Faculty of Economic, Universitas Negeri Surabaya, Kampus Unesa Ketintang, Surabaya 60231, East Java, Indonesia

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Abstract– Waste and pollution are two important issues in the small industry of coffee production despite of the equipment and capital constraints. The green productivity method is able to reduce the waste generated through the efficient use of resources, low operating costs, environmental management, and productivity improvement. This study is aimed to formulate an alternative environmental management as well as to improve the productivity of small industry of coffee production. The results showed that the Environmental Performance Indicator (EPI) index was negative at -621.229 which means that environmental performance was below the standard. The alternative green productivity generated was: 1) by operating pulper machine with capacity of 125 kg/hour and power 2.2 kW; 2) by designing water immersion tub for coffee sized 2.4 x 1.2 x 0.85 m with capacity of 2.45 m^3. Based on NPV analysis, it obtained that the alternative 1 showed financial analysis as 28.130, 271.61 IDR with productivity increase estimation as 171% and wastewater reduction efficiency as 0%. While the alternative 2 showed the NPV analysis as 40.224.591,11 IDR with productivity increase estimation as 163% and wastewater reduction efficiency as 30%.

INTRODUCTION

Coffee is one of the most important agricultural products in the world (Padmapriya *et al.*, 2013). In Indonesia, coffee is popular as one of local vegetations that have been planted since colonial era. Coffee cultivation originally located in the western region of Java has spread to eastern Java and throughout Indonesia and the tropical climate supports its cultivation. Therefore, becoming one of the largest coffee productions after Brazil, Vietnam, and Columbia is not a surprising for Indonesia (Neumann, 2012). The overflow of coffee production encourages small industries throughout Indonesia starting to emerge.

Small industry including coffee processing industry is actually the backbone of Indonesian economy. Small industries have an important role in the production, innovation and employment. On the other hand, most of small industries have limitation in capital, equipment and knowledge affecting on productivity. In addition, those small industries unaware on the environment pollution generated from their production activities (Rahmadyanti and Andre, 2016). Waste and pollution are two of the most important issues in coffee processing industry as both lead to generating waste resources, increasing costs, and reducing product quality, in which those adversely affect the environment and company reputation (Cong and Hien, 2016).

In today's global challenges, small industries face the challenge not only in increasing productivity, but also in improving product quality and environmental performance (Yusup *et al.*, 2014; Masoumik *et al.*, 2015). Therefore, increasing productivity by integrating environmental protection remains as challenge up to present. This increase is intended as internal change of small industries which continuously could participate in the sustainable development.

Until the present time, many researchers have conducted researches in order to maximize the sustainability of the coffee industry through the cost and risk reduction as well as opportunity creation

Corresponding author's email: erinarahmadyanti@unesa.ac.id

(Giannetti *et al.*, 2011). Green productivity is one of methods which are potentially implemented in sustainable small industry. The term "Green productivity" was first introduced by the Asian Productivity Organization (APO) in 1994 referring to the tools, methods, technologies and management systems applied to produce eco-friendly products or services (Hang and Hong, 2001). This concept helps small industries to participate in environmental protection without sacrificing their economic performance through utilizing resource efficiently to prevent pollution (Findiastuti *et al.*, 2011). Implementing green productivity in small processed coffee industries is focused on post-harvest processing which plays 40% role in determining the quality of coffee. Processing post-harvest is the process of processing the coffee fruit into green been (Musebe *et al.*, 2014). There are two processing ways, dry and wet processes (Subedi, 2011).

In most cases, wet process is able to produce better quality product, though, in some areas, dry process remains done as It is able to produce a thicker flavor (Padmapriya *et al.*, 2013; Hang and Hong, 2001). In small industries coffee processing, dry process produces both solid and liquid waste. Solid waste consists of fractions of coffee beans and coffee skin while the liquid waste contains organic material and high acid (von Enden *et al.*, 2002). Up to these present days, those wastes have not undergone any processing. Unprocessed effluent surpasses the ability of self-purification by natural waterways which become the cause of environmental pollution. Planning wastewater treatment units for small industries is very difficult due to the limitations of capital, knowledge and technology. Therefore, to sustain the formulated strategy, the target of green productivity is to reduce the amount of both solid and liquid wastes. This study aimed to formulate the strategy implemented in green productivity of small industry coffee processing which uses dry process method.

MATERIALS AND METHODS

This research applied observation method and the object of the research was small industry coffee processing named *Puspa Tani Makmur*. Green productivity used productivity measurement devices and environmental management performance separately to measure its index (Findiastuti *et al.*, 2011). Measuring green productivity started by preparing the mass balance of coffee production. Thus, sampling of liquid waste of coffee production process was taken and analyzed according to the standard method. The parameters used were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) and Power of Hydrogen (pH). Furthermore, these parameters are compared to the standards set by the East Java regional government (Gubernur Jawa Timur, 2002).

Adopting green productivity ratio (Gandhi *et al.*, 2006) is done by formulating the environmental impact through providing quality on the environmental indicators of the effluent produced by the coffee processing. It was obtained through questionnaires about the level of danger of each chemical contained in the liquid waste.

The danger was divided into 2, 1) based on the environmental equilibrium parameters of both flora and fauna and 2) based on the human health parameters. The questionnaires were distributed to 12 respondents who had competence in the field of Environmental Chemistry and Environmental Engineering to ensure the validity.

Few studies have used the green productivity index as an integrated environmental performance which means measuring green productivity and environmental performance separately were better (Findiastuti *et al.*, 2011). The positive index measurement indicated that environmental performance was good. However, if the index was negative, it indicated that environmental performance was not good or did not meet the standard set by the government.

The data was analyzed to calculate the productivity level of small industry coffee processing (*Puspa Tani Makmur*), to measure Environmental Performance Indicator (EPI) index, to determine objectives and targets, to prepare the series of alternative solutions and to arrange the alternative plan by implementing 3R (Reduce, Reuse, Recycle).

RESULTS AND DISCUSSION

EPI Index Calculation

EPI can be used as an indicator to understand the environmental performance achieved by *Puspa Tani Makmur* related to the waste generated on the surrounding environment. Before calculating (EPI), questionnaires are first distributed to know the

danger level from chemical content of each parameter of liquid wastes. Assessment numbers range from 1 to 5 where the bigger the number is, the higher the danger level becomes (Gubernur Jawa Timur, 2002).

Most of developed countries provide databases on the danger level of chemical substance, but it is different in developing countries, where most of those data are not available. Therefore, the rating quality is possibly to be done by related experts [1]. Table 1 shows the quality values derived from questionnaires by 12 respondents who are experts in Environmental Chemistry and Environmental Engineering. How to calculate the quality rate of the questionnaire can be done by using equation 1.

$$\text{Quality (Wi)} = (\Sigma Xi.Si)/n \quad \text{.....Equation 1.}$$

This equation is applied when the respondents are no more than minimum number of questionnaires assessment (30 respondents), due to the difficulty in validating the questionnaire.

Table 1 shows that the biggest quality was in BOD_5, meaning that BOD_5 is the most dangerous parameter according to those 12 respondents. The rating quality obtained by distributing questionnaires was used to measure EPI index by applying equation 2.

$$\text{EPI index} = \Sigma Wi.\ Pi \quad \text{.....Equation 2.}$$

Wi is quality rate obtained from questionnaires in Table 1. Pi is percentage of deficiency between standard set and analysis result. Pi is obtained from equation 3.

$$P = \frac{\text{Standard} - \text{Analysis}}{\text{Standard}} \times 100\% \quad \text{.... Equation 3.}$$

The results show that the value of EPI index was -621.92 meaning that there was no environmental management effort. Previous research mentioned, aside of acid, industrial wastewater of coffee processing contains high organic material which becomes very dangerous for body water, human health and aquatic life when directly discharged (Padmapriya *et al.*, 2013).

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Determining Objectives and Target

Based on the problems emerging in *Puspa Tani Makmur*, objectives and targets were determined by implementing green productivity (GP). The targets were 1) to maximize the process of peeling coffee beans and drying process; 2) to minimize the use of water in the production process. Both targets refer to the eco-efficiency by minimizing the waste generated and preventing detrimental effect to the environment (van Berkel, 2007; Salem *et al.*, 2011).

Designing Alternative Solution

Referring to the targets in green productivity, minimizing the use of water in production process and the use of lease labor was formulated as:

1. Utilizing coffee pealing machine with capacity of 125 kg/hour and power of 2.2 kW to simplify been peeling process. This machine uses diesel due to evade the electricity problems. Introducing this machine helped to reduce production cost as 40% by not renting the *huller* machine;
2. Creating water immersion tub sized 2.4 × 1.2 × 0.85 m with capacity of 2.45 m^3 to wash the coffee bean. This tub saved 30% water used in washing process as well as simplified the waste treatment.

Based on the alternatives arranged, one of them was selected as the alternative implemented in improvement effort. There are three bases considered in selecting alternative solution, namely:

1. Financial analysis of each alternative using *net present value* (NPV);
2. Contribution estimation of each alternative to level of productivity; and

Table 1. Result of EPI Calculation

Var.	Qual. (Wi)	Stand. of waste water	Rslt	Dev.(Pi)	EPI Index (Wi* Pi)
BOD_5	23.4	150	2235	-13.9	-325.26
COD	23.2	300	3473	-10.57	-245.37
TSS	23	100	323	-2.23	-51.29
pH	23.2	6-9	5		
Total EPI index	-621.92				

3. Contribution estimation of each alternative to EPI index.

Net Present Value (NPV) Analysis

Financial analysis of each alternative was calculated for the period of 10 years within assumption: a) interest rate on bank loan is 11.83 % (source: Bank Indonesia); b) inflation rate is 3.82 % (August 2017) (source: Bank Indonesia); c) tax is 30% (source: Law No. 36 Year 2008); d) alternative expenses before inflation was IDR 20,000,000; e) capital alternative 2 before inflation was IDR 6,955,000.

Estimating contribution of each alternative to level of productivity

Productivity was obtained by measuring input-output. Input was obtained by accumulating raw material cost, labor cost, energy cost, and maintenance cost during production process of one year. Level of productivity of Puspa Tani Makmur in the period of 2016-2017 can be seen on Table 2.

Table 2 shows an adequate level of productivity between 1.203 and 2.013. High level of productivity had started from July to August, due to the increasing raw material cost caused by coffee harvesting time. Harvest started decreasing in September and October, although in December level of productivity slightly increased even input of raw material cost decreased due to selling and increasing output.

By implementing alternative 1 of green productivity performed by *Paguyuban Puspa Tani Makmur* increased the average productivity from 157% to 171%. However alternative 2 was able to increase 163% of productivity as seen in Table 2. According to the analysis, there was an increase of level of productivity as 14% by implementing alternative 1 and as 6% by implementing alternative 2.

The NPV analyses for each Estimating Contribution on Productivity Improvement. Based on alternative 1 and alternative 2 calculations, estimation calculation of productivity was done. Implementing both alternatives did not increase either input or output, but it reduced the both solid and liquid wastes generated. Table 3 shows the detail productivity increase.

Estimating Contribution of each alternative on EPI

Table 2. Productivity index at Puspa *Tani Makmur*

Month	Total Input (IDR. in thousand)	Total Output (IDR. in thousand 000)	Productivity (O/I)
March	47,222	63,000	1.334
April	47,240	75,000	1.588
May	47,290	72,000	1.523
June	49,679	75,000	1.510
July	54,445	105,000	1.929
August	57,369	115,500	2.013
September	56,860	102,300	1.799
October	56,326	82,500	1.465
November	51,272	75,000	1.463
December	47,294,	75,000	1.586
January	47,362	60,000	1.267
February	47,380	57,000	1.203

Table 3. Estimating Productivity Improvement

	Alternative 1	Alternative 2
Output (IDR per month)	79.775.000	79.775.000
Input of raw material (IDR per month)	42.550.000	42.550.000
Input of supporting material (IDR per month)	1.742.833	1.742.833
Input of manpower(IDR per month)	3.356.250	3.356.250
Input of Energy (IDR per month)	1,335.567	1,335.567
Input Maintenance (IDR per month)	750.000	824.999,67
Input Estimation (IDR per month)	49.734.650	48.850.426,9
Early Production	157%	157%
Estimation of Productivity	171%	163 %

Table 4. Selecting alternative green productivity

Reasoning	Alternative 1	Alternative 2
Financial analysis based on NPV	28,130,271.61 IDR	40,224,591.22 IDR
Productivity Estimation	171 %	163%
Amount of Wastewater reduction	0 %	30%

level

Based on both alternatives, contribution estimation of EPI level was done. Of both alternatives, there was no effect on the chemical concentration in liquid waste. It made both alternatives have no contribution in increasing EPI level. However, it did not mean that both alternatives do not provide any improvement in environmental performance.

Based on the concept of waste reduction in this research, the improvement of environmental performance or quality was not only by reducing the concentration of waste but also by reducing the amount of waste. In implementing alternative 1, there was no reduction in the liquid waste volume, but it reduced the amount of solid waste. While on alternative 2, there was 30% of waste reduction.

Determining Alternative of Green Productivity

Selecting alternative of green productivity strategy is seen in Table 4. In Table 4, although alternative 1 shows no reduction to the amount of wastewater but it is necessary to improve the efficiency of the production process. This efficiency is in the reduction of the amount of solid waste from the spills of coffee bean and the labor costs. Alternative 1 is part of technological innovation which has an important role in improving production efficiency and accommodating environmental issues.

Efficiency through technology utilization will reduce the use of labor and meet environmental requirements as found in traditional management models. In addition, it provides an opportunity to improve the ability to detect early causes of environmental problems from various aspects in the early stages (Masoumik *et al.*, 2015). Other researches mentioned that minimizing waste was proved to be more effective than clean production strategy or product control to create environmentally friendly industries (Yusup *et al.*, 2014).

CONCLUSION

Based on the EPI index calculation, the value obtained was -621.229 meaning that the environmental performance in Puspa Tani Makmur did not meet standard. Negative value indicates that there are many chemical substances in the waste that exceed the maximum limit of standard set by Bapedalda of East Java (East Java Decree No. 45 Year 2002 on raw material quality of liquid waste for industry).

Referring to the problems and objectives in green productivity, minimizing the use of water in the production process and the use of labor, the alternative was formulated by: 1) utilizing coffee machine with capacity 125 kg/hour and power 2.2 kW to peel the coffee bean, 2) creating water immersion tub sized 2.4 x 1.2 x 0.85 m with a capacity of 2.45 m3 to wash coffee bean. Based on NPV analysis obtained alternative 1 showed financial analysis as 28,130,271.61 IDR, productivity increase as 171%, and 0% waste water reduction. While in alternative 2, it showed the financial analysis as 40,224,591.11 IDR, productivity increase as 163%, and 30% waste water reduction.

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