Green Productivity Approach in Batik Industry

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Abstract. Nowadays, Industries compete one to each other on many factors. When industries improve productivity, they may ignore the environmental effect. Green Productivity is a concept that can improve both productivity and environmental performance. Thus, this research was conducted in the batik industry namely Batik Ayu Arimbi. The Batik industry is known as one of the most polluting industries since it creates both liquid and solid waste. Most of them release the waste directly into nature without disposing it in a proper way. After the EPI index has been calculated, it is known that the environmental performance of this industry is far below the government standards. To tackle the issue, this research uses the green productivity approach. This approach results in 2 (two) alternatives solutions for Batik production which increased the productivity as well as the EPI index.

1. Introduction
Nowadays, industries are facing tougher competition since many of them are improving their performances. There are some indicators being improved such as quality, innovation, and productivity. To stay in the competition, industries need to perform hard work. However, some are not aware about the environmental effect caused by the improvement actions. For example, when one is willing to improve productivity, the industry tends to use some liquid chemicals. By using these chemicals, this industry is able to increase productivity as well as increasing the environmental disruptions.

Green productivity is a strategy developed by Asian Productivity Organization that covers business improvement opportunities and demand from customers about good environmental management \cite{1}. Green productivity concept is “Better with Less”. It is believed that Green Productivity approach can reduce some environmental effects and improve productivity. It also answers global issues about sustainable development. Another advantages of applying Green productivity strategy are the way it generates the problem solver (solutions) and green productivity can be used by combining some tools that make it a flexible approach.

Batik industry, which belongs to the dye industry, is known as the most polluting industry. The environmental damage caused by batik industries can come from such as water pollution and soil contamination due to their waste disposal. This condition is not in line with the green productivity concept.

It is common for industry to dispose the liquid waste into the river since it is the easiest way to do it. However, it causes environmental disruptions. The coloring and washing process activities in Batik Ayu Arimbi are producing waste. By the time, the river can be contaminated and cause bigger problem to the environment

Indonesian Government is concerned about environmental issues. It is written in Local Government Regulation Number 7 Year 2016 about the liquid waste limitation for the batik industry. In addition, Indonesian Government issued a set of regulations related to waste disposal through the Government Ordinance Number 27 Year 1999 about the environment impact assessment, known as Analisis Mengenai Dampak Lingkungan (AMDAL).
In order to generate the green productivity approach, it uses the following tools. The approach uses material balance, fishbone diagram, and Environmental Performance Indicator (EPI) index. Material balance will be used for determining the gap from input and output on production that will be known as waste. Fishbone diagrams will be used for problem identification to generate the option for problem solving. Then EPI index will be used as an indicator to know the environmental performance of the batik industry.

By applying green productivity, industries are gaining some benefits such as the increase of environmental performance as well as their productivity. Thus, this paper tries to increase the productivity of Batik Ayu Arimbi, proposing an alternative planning stage for its production by applying the green productivity approach.

2. Literature Review

This paper uses seven previous studies to compare with. The indicators used in the comparison are tools, methods, and results of the research. As a result, authors are able to fill the gap between previous studies and improve it.

In research “Waste Reduction with Green Productivity Approach for Increasing Productivity (Case Study: PT. Indopherin Jaya)”, the scholars aimed to reduce the phenol waste in the motors industry to increase the productivity [2]. NPV, IRR, and Green productivity Index are used as tools to perform the study. This study mentioned EPI to measure the chemical substances released by the company, but it is done without any further explanation [2]. Shortfalls will be covered in this research.

Another scholar used Benefit Cost Ratio (BCR), EPI and Material balance to evaluate the implementation of green productivity in the manufacturing plan [3]. The result shows the industry is able to save up to 28 million rupiahs after applying the reuse concept. The study performed by [3], but there is no further explanation on problem identification. Thus, to fill in the gap, problem identification using Ishikawa diagram will be added. The purpose is to understand the root causes from each problem identified. As a result, alternative provided will be able to tackle the problem.

Another study applied the reuse concept as a solution to reduce the environmental effect of disposing the waste into nature [4]. The study shows that the green productivity index is significantly increased. Alternative solution was chosen using Analytic Hierarchy Process (AHP) using experts’ judgement but have not considered financial factors which will be carried out in this research.

The other scholars, [5] conducted a study to minimize liquid waste. The research focuses on steam boilers and liquid waste as the result of the production process. In this study, several tools are occupied such as fishbone diagram, Benefit Cost Ratio (BCR), and Environmental Performance Index (EPI). In order to achieve the objective of the study, they proposed a heat exchanger, adding more fuel, and installing Dissolved Air Flotation (DAF). As a result, after implementing the green productivity method the productivity and environmental performance are increased. Compared to the study by [5], in this study, finance analysis will be added in order to help the stakeholder choose an alternative solution.

Similar to other previous studies, [6] proposed an implementation of green productivity to minimize waste and increase the productivity and environmental performance. The object of research in this study is Batik Industry. She proposed the usage of Indigofera natural color to push the level of water pollution. Study by [6] proposed a coloring substitution from chemical to natural coloring. However this solution is not able to be applied in Batik Arimbi since it requires a longer coloring process and has many restrictions regarding fabric material used. To fill this gap, this study proposes a solution that is applicable for any batik industries that has similar characteristics to Batik Arimbi.

Another benefit derived from implementing green productivity is profit improvement. The study performed by [7] conducted a study in a chemical manufacturing plant to minimize waste by adding evaporator. As a result, the manufacturing plant is able to increase profit as well as increasing the sales. From the study by [7], green productivity is proven to increase profit and sales in a chemical industry. Thus, this study focuses on the batik industry to broaden the implementation of green manufacturing in other industries and attain the same success.

As the conclusion, this paper combined tools and methods used in the previous study such as EPI, investment analysis using uniform sequence method, fishbone diagram, and material balance. The tools and methods are proven to apply green productivity. Based on the literature review that has been done,
the research gap identified is that there is no study yet to conduct research about green productivity in the batik industry. Thus, the Batik Industry is chosen as an object in order to broaden the type of industries that can be assessed.

3. Research Methods
The stages of implementing green productivity on Batik Ayu Arimbi are (1) measuring the productivity index, (2) following the stages of green productivity introduced by Asian Productivity Organization, (3) managing the material inventory using material balance, (4) measuring the environmental performance, and (5) problem identification.

3.1. Productivity
According to [8], productivity is the comparison between input and output. Mathematically, productivity index can be formulated as total output divided by labor plus cost of capital, materials, tools and other factors from goods and services as presented in equation (1) below.

\[
\text{Productivity Index} = \frac{\text{Output}}{\text{Input}} \times 100\% \quad (1)
\]

3.2. Green Productivity
Green productivity (GP) is a concept introduced by Asian Productivity Organization (APO) in 1994. This concept allows big industries and SME’s to manage their environmental performance. According to [3], green productivity is an effort to increase the productivity of environmental performance and sustainability.

According to [9], the following steps are used to implement green productivity:

- Getting Started
  1. Form a team
  2. Conduct survey and data collection
- Planning
  1. Problem identification and perform root cause
  2. Set objectives
- Generation and Evaluation of GP option
  1. Generate options and alternatives of green productivity
  2. Monitoring and evaluation
- Implementation of GP option
  1. Designing the action plan
  2. Implementation of selected options
  3. Building awareness, training, and developing competence
- Monitoring and review
  1. Monitoring and evaluation of the results
  2. Management review
- Sustaining Green Productivity
  1. Incorporate changes into organizations system of management
  2. Sustaining the approach

3.3. Material Balance
Material balance is known as a tool to manage inventory based on the environment. This tool describes the process using flowchart diagram. Mathematically, material balance is formulated as input = finish product + waste. According to [9], steps to generate material balance are follows:

1. Determining inputs: raw material, water, and energy used in the process
2. Assessing the outputs: liquid waste, gas emission, solid waste, and waste from the usage of energy
3. Determining the material balance
4. Creating preliminary material balance
5. Evaluation and continuous improvement
3.4. Environmental Performance Indicator (EPI)
EPI or environmental performance indicator is a set of indicators that can be used by industries to assess their environmental performance. EPI can be formulated as presented in equation (2) below.

$$\sum_{i=1}^{k} W_i P_i = \frac{\text{Standard} - \text{Analyst}}{\text{Standard}}$$

$W_i =$ Weight of k variables attained from the questionnaire
$P_i =$ Percentage of deviation between standard and result

3.5. Problem Identification
Ishikawa diagram known as fishbone diagram were used to perform problem identification. According to [10] there are eight steps needed as follows:
1. Determine the problem
2. Create team to perform analysis, preferably through brainstorming
3. Draw the fishbone graph as guidance
4. Determine the cause category, such as man, material, method, and machine
5. Identify the root causes and categorize them
6. Create new category if needed
7. Prioritize the root causes by ranking the most significant
8. Take an action to improve

4. Discussion
4.1. Productivity
Table 1 shows the result of Batik Ayu Arimbi productivity. The time window chosen was 12 months in 2017.

| Period      | Output   | Input     | Productivity |
|-------------|----------|-----------|--------------|
| Jan 2017    | Rp 11,895,000 | Rp 18,703,562 | 63.60%       |
| Feb 2017    | Rp 5,910,000 | Rp 3,709,700  | 159.31%      |
| Mar 2017    | Rp 10,966,000 | Rp 13,388,499 | 81.91%       |
| April 2017  | Rp 20,245,000 | Rp 9,178,000  | 220.58%      |
| May 2017    | Rp 33,092,750 | Rp 36,018,368 | 91.88%       |
| June 2017   | Rp 17,121,000 | Rp 8,767,500  | 195.28%      |
| July 2017   | Rp 14,718,500 | Rp 11,179,749 | 131.65%      |
| Aug 2017    | Rp 15,910,500 | Rp 9,845,250  | 161.61%      |
| Sept 2017   | Rp 4,805,000  | Rp 5,878,500  | 81.74%       |
| Oct 2017    | Rp 26,349,000 | Rp 10,744,500 | 245.23%      |
| Nov 2017    | Rp 6,660,000  | Rp 4,389,000  | 151.74%      |
| Dec 2017    | Rp 14,171,000 | Rp 4,708,000  | 301.00%      |

Based on table 1, Batik Ayu Arimbi has four periods where the productivity percentages are below 100%.

4.2. Material Balance
As seen in Fig.1, there are activities that produce waste such as manual stamping, early coloring or known as pencoletan, color locking, washing, coating, soaking, coloring, decay or dispeling attached wax from the fabric, and final washing. Based on those activities, Batik Ayu Arimbi produces two types of waste, liquid and solid waste.
4.3. Environmental Performance Indicator (EPI)

The assessment of EPI has been done by having data collection through questionnaire. Before the questionnaire being used, it needs two types of tests as mentioned: validity test, and reliability test.

As seen in table 2, the questionnaire was made based on a standard set according to the government regulation. Questionnaire was developed by the authors, which is the parameter index used in the questionnaire referring to the standard from Government regulation, this is *Balai Besar Teknik Kesehatan Lingkungan dan Pengendalian Penyakit Yogyakarta* (BBTKLPP). The survey was done through a close ended questionnaire and used Likert scale. Questionnaires were filled by experts in the liquid waste who are working as a chemist expert from BBTKLPP.

Compared to the standard, the laboratory result as seen in table 3 shows significant difference. It then creates huge deviations. It causes the EPI score is very low, -250.509 as seen in table 4. In conclusion, EPI index is below the normal number where EPI categorized as normal when it scores more than 0. The result shows that Batik Ayu Arimbi is below government standards.

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![Material balance diagram](image-url)

*Figure 1. Material balance*
Table 2. Standard

| Parameter   | Most (mg/L) |
|-------------|-------------|
| BOD         | 85          |
| COD         | 250         |
| TDS         | 2000        |
| TSS         | 60          |
| Fenol       | 0,5         |
| Chromium (Cr) | 1         |
| Ammonia     | 3           |
| Sulfide     | 0,3         |
| Temperature | ± 3° room temperature |
| pH          | 6.0 - 9.0   |

Source: Government Regulation

Table 3. Result Laboratory Test By BBTKLPP

| No | Parameter        | Unit | Result | Max |
|----|------------------|------|--------|-----|
| 1  | BOD5             | mg/L | 1278   | 85  |
| 2  | COD              | mg/L | 6567.5 | 250 |
| 3  | TDS              | mg/L | 3320   | 2000|
| 4  | TSS              | mg/L | 1038   | 60  |
| 5  | Fenol            | mg/L | 0.717  | 0.5 |
| 6  | Cr               | mg/L | 0.0213 | 1   |
| 7  | Ammonia (NH₃ as N) | mg/L | 4.466 | 3   |
| 8  | Sulfide          | mg/L | 0.0043 | 0.3 |
| 9  | Degree           | °C   | 25.1   | Temperature ± 3 |
| 10 | pH               | -    | 10     | 9   |

Table 4. EPI Index

| Variable       | Weight | Standard | Result | Deviation (%) | EPI Index |
|----------------|--------|----------|--------|---------------|-----------|
| BOD5           | 4.4    | 85       | 1278   | -1403.53      | -61.755   |
| COD            | 4.6    | 250      | 6567.5 | -2527.00      | -116.242  |
| TDS            | 4.4    | 2000     | 3320   | -66.00        | -2.904    |
| TSS            | 4.6    | 60       | 1038   | -1630.00      | -74.980   |
| Phenol         | 5.4    | 0.5      | 0.717  | -43.40        | -2.344    |
| Total Cr       | 5.2    | 1        | 0.0213 | 97.87         | 5.089     |
| Total Ammoniac | 5.8    | 3        | 4.466  | -48.87        | -2.834    |
| Sulfide        | 5.8    | 0.3      | 0.0043 | 98.57         | 5.717     |
| Degree         | 5.2    | 27       | 25.1   | 7.04          | 0.366     |
| pH             | 5.6    | 9        | 10     | -11.11        | -0.622    |

Total EPI: -250.509
4.4. Problem Identification
Fishbone analysis was performed through brainstorming methods. The team consisted of the chief of Batik Ayu Arimbi, accounting staff, and five students who were working on their research in Batik Ayu Arimbi.

First category is material, as seen in Fig.2, it is shown that the root cause is the usage of chemical coloring agents. The usage of chemical coloring is in consequence of high demand and to get more varied color. Second problem that is identified is from the method. The industry tends to dispose of their liquid waste directly into the river. The effect of using the wrong procedure caused more damage to the environment. Batik Ayu Arimbi does not have any waste treatment system to support their waste management system. Thus, Batik Ayu Arimbi is not able to dispose of their liquid and solid waste properly.

4.5. Define Objective and Target
Based on problem identification, some root causes were found. The next step is to define objective and target as follows:
1. Objective: minimize the liquid waste disposal in order to improve the productivity and performance of the environment.
2. Target: as a result, from minimizing waste disposal, Batik Ayu Arimbi is eager to improve the productivity and performance of the environment.

4.6. Solution
This paper proposes two alternative solutions. The solutions must be able to improve the productivity and performance of the environment. The following are suggested alternatives:
1. Use natural coloring instead of chemical coloring. Natural dyes can be obtained from plants. The benefit derived from using natural dyes is that water disposal becomes environmentally friendly.
2. Create a washing basin from used drums and add coconut shells in the waste disposal pond. The benefit obtained from adding coconut shells is to filter the water disposal before being discarded to the river.

4.7. Choosing Alternative Solution
Alternative solutions are chosen based on three factors such as productivity, finance analysis, and the value from EPI. Values on each factor are generated based on assessments that have been done. Finance analysis for both alternatives were calculated from savings obtained if alternatives are implemented minus total cost. Productivity can be derived from average output divided by average input from each alternative. While the environmental performance indicator is achieved from the formula given.

In table 5 we can see the comparison between two alternative solutions. Based on table 5, alternative number two is leading by two factors, finance and productivity score. Meanwhile, alternative number one leads in terms of EPI. In conclusion, alternative number two was chosen.
Table 5. Alternative

| No | Factor                                      | 1st Alternative | 2nd Alternative |
|----|---------------------------------------------|-----------------|-----------------|
| 1  | Finance Analysis                            | Rp 34,590,000   | Rp 36,392,146   |
| 2  | Productivity                                | 168.11%         | 282.24%         |
| 3  | Environmental Performance Indicator (EPI)    | -115.48         | -173.883        |

4.8. Implementation

Implementation plan is the last step on green productivity and is created as the final result of this research. Implementation plan should be designed to achieve objective and target. As seen in table 6, stakeholders involved in the implementation are workers in Batik Ayu Arimbi under supervision from experts. The experts help Batik Ayu Arimbi to design and build the washing tool.

Table 6. Alternative Implementation Planning

| Goals                                      | Target                                      | Action                                      | Stakeholder               |
|--------------------------------------------|---------------------------------------------|---------------------------------------------|----------------------------|
| Minimize liquid waste on Ayu Arimbi          | Improving productivity and Environment Performance | Create tool for washing fabric              | Ayu arimbi and an expert to make tools |

5. Conclusion and Future Research

Explanations below are the conclusion point from this research:

1. Percentage of productivity in Batik Ayu Arimbi has varied in 2017. A third of the periods are below 100%.
2. Batik Ayu Arimbi has an EPI score below the government standards.
3. Washing activity is the most polluting activity in Batik Ayu Arimbi production. Not only due to chemical substance in their dyes but also the way they have consumed water to rinse the fabric.
4. Creating washing basins from used drums and adding coconut shells are proven to minimize budget around Rp 36,392,146 per year, improving productivity to 282.24% and increasing the EPI index.
5. The chosen alternative solution is expected to minimize waste disposal significantly.

This research mainly focuses on water disposal of liquid waste produced in the batik industry. Thus, for future studies, research focusing on other types of waste, such as solid waste can be conducted to expand the research.

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