Sustainable production of natural textile dyes industry

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Abstract. Natural dye raw material is obtained from potential plants grown around the industry and then extracted by the industry itself. The uncertainty of the supply of natural dyes in the textile industry causes delayed fulfillment of consumer needs. The principle of sustainable production consists of economic, social and environmental aspects. The purpose of this paper is to examine the economic, social and environmental aspects of the production of natural textile dye industry. This study is conducted to determine consumer preferences for the natural dye textile products and the added value of the natural textile dye industry. Consumer preferences is acquired using cross-tab and value-added analysis using the Hayami method. Consumer preferences indicators were dye selection, willingness to pay, awareness, and market access. The natural textile dye industry has the potential to be developed because it can provide added value to agricultural materials that have not been used optimally and support sustainable development.

Keywords: added value, consumer preference, natural dyes industry, sustainable production

1. Introduction

The textile industry in Indonesia is an industry that has high prospects. Export grew 6% every year from 2016 and in 2017 the growth of textile exports was worth USD 12.4 billion [1] and USD 13.5 billion in 2018 [2]. Indonesian textile products that have the potential to be developed include batik and weaving. In 2012, Indonesia's local batik industry experienced a decline in competitiveness because there were imported patterned-batik fabrics from China amounting to 1,037 tons or valued at IDR 285 billion [3]. This batik from China was very cheap so it was very competitive in the Indonesian market even with low quality. The import procurement was also feared to change people’s perspective on batik that has been built so far. Thus, the Ministry of Trade issued Minister of Trade Regulation (Permendag) No. 53 / M-DAG / PER / 7/2015 concerning Provisions on the Import of Textile and Textile Products (TPT) Batik and TPT Batik Motifs.

The exported value of batik and weaving in 2016 exceeded USD 151 million and the growth of national production and export of batik reached USD 58.46 million in 2017 [2]. The exported value of batik and weaving in 2018 was USD 53.3 million [4]. Therefore, to maintain the export value of the textile product, government increases the competitiveness of batik by ensuring the availability of batik raw materials by importing 50% of several raw materials, including dyes [2]. Uncertainty in the supply of dyes in the textile industry will result in delayed meeting the needs of consumers. Especially for the process of making one sheet of natural dye batik cloth takes minimal in 10 days. Therefore, it was
necessary to study about sustainability of natural textile dye production by focusing on consumer preference and added value of natural textile dye product.

The need for natural dyes will increase along with technological developments and awareness of the impact of the use of synthetic dyes on textiles. Increasing consumer needs must be accompanied by effective and efficient supply chain management and production. The supply chain will describe the business activities carried out, consisting of the flow of material, information, and money [5]. Success in the supply chain is able to increase competitiveness in the industry [6]. Thus, an increase in added value is needed to make sure the sustainability of all business activities [7].

The purpose of this study is to examine the economic, social and environmental aspects to achieve the sustainable production of the natural textile dye industry. Based on that, the specific objective are as follow: 1) analyse social aspects by measuring consumer preference of textile product (batik) as well as its influence on the purchase decision 2) analyse economic aspect by measuring the added value of natural textile dye industry, and 3) analyse the environmental impact and utilization of waste generated from natural textile dye industry.

2. Methodology

2.1. Data collection procedure
Data was collected from natural textile dye industry that produced natural dye from *Indigofera tinctoria* (blue dye), sappan wood (red dye), and *Cudrania javanensis* wood (yellow dye). The study was conducted to determine consumer preferences for the natural dye textile product (batik) (social aspect), the added value of the natural textile dye industry (economic aspect), and utilization of waste generated (environmental aspect). The basic method used in consumer preference research was a quantitative descriptive method with implementation techniques using case studies. The type of data used was primary data which was carried out through online questionnaires. Value added analysis and utilization waste generated data collection used interviews and direct observation to the natural textile dye industry in Sukoharjo, Central Java.

2.2. Data analysis
The data processing method used cross-tab analysis (cross tabulation) to get a complete picture of the potential demand for natural dye textile products which are seen based on dye selection, awareness willingness to pay, and market access). The principle of cross-tab analysis is to calculate the frequency and percentage of two or more variables at once so that conclusions can be drawn conclusively between the two variables. The data entered consists of nominal data and ordinal data [8]. Value added was analyzed using the Hayami method with case study in the natural textile dye industry in Sukoharjo, Central Java. Added value describes the rewards for capital, management, and labour that can be expressed systematically as follows:

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\text{Added-value: } f \{ \text{capacity, raw materials, labours, pay of labours, output price, cost of raw material and production, and other input value} \}
\]

3. Result and discussion
Sustainable production and sustainable consumption cannot be separated. The problem of sustainable development requires a comprehensive process in responding the local challenges, in this case the natural textile dye industry [9]. Sustainable consumption and production are to create consumers and producers who care about the issue of environmental sustainability. Business processes in the industry can continue to run when selling with quantity and quality that increase continuously. Marketing systems that help industry sales need to be involved in turning old goals into new sustainable goals. The purpose of conventional marketing systems was to maximize consumption and customer satisfaction. Consumptive nature is very contrary to the principle of sustainable consumption.
Producers are assisted by marketing systems whose purpose needs to be changed to maximize quality of life cycle of product [10].

Consumer behaviour strongly determines the impact of consumption patterns on environmental problems. High-income people have the potential to have consumption patterns that damage the environment. Therefore, this study examines consumer preferences based on income per month. Sustainable consumption emphasizes consumers to become green consumers by paying attention to environmental sustainability through proper consumption patterns, patterns of handling goods/services that are not consumed properly, and giving support to companies that pay attention to environmental sustainability issues by only buying goods/services produced by companies observing environmental issues [10].

Consumer behaviour can be seen from their preferences for a product. Consumer preferences were needed to determine consumer selection factors in natural dye textile products and their effects on purchasing decisions [9]. This purchasing decision will show the potential demand for certain product characteristics and how the consumer view the product. There are four indicators to see the potential demand for natural dye textile products, including dye selection, awareness, willingness to pay, and market access. The number of respondents in this study was 188 respondents, as many as 135 women and 54 men with data collection methods using online questionnaires. The income of dominant respondents ranges from IDR 0-5 million as many as 158 respondents, IDR 6-10 million as many as 19 respondents, earning IDR 11-15 million as many as 10 respondents, and income above IDR 15 million as many as 2 respondents. Characteristics of respondents based on age are dominated by ages ranging from 21-30 years as many as 80 respondents, aged 15-20 years as many as 19 respondents, 31-40 years as many as 27 respondents, 41-50 years as many as 32 respondents and over 50 years as many as 30 respondents. Result of consumer preference based on income per month can be seen in Table 1. From these results, it can be concluded in the form of a pie chart shown in Figure 1-4.

Based on the survey, percentage of consumer preference based on dye selection in Figure 1 there were 75% of respondents who chose soft / calm dye compared to bright / sharp dye. Soft or calm dye was characteristic of the dye that will be produced by natural dyes on textile products. Factors that influence the impact of sustainable consumption were external factors, financial factors, cognitive and individual factors, and social impacts [9] [10]. External factors are where to buy textile products and the popularity of an eco-product. Based on a survey conducted, there were 59% of respondents who liked the characteristics of natural dye experiencing difficulties (Figure 4) in getting natural dye textile products. Natural dye textile products in Indonesia are classified as expensive products, so they can only be purchased by the upper classes. This was also caused by the absence of labeling on batik, making it difficult to identify the type of dye used if consumers do not understand the characteristics of natural color batik. Based on these characteristics, expanding the market of natural color batik to get easy access from consumers is needed. Market expansion also requires an increase in the capacity of natural dye production and its supporting industries. This will be an opportunity for the development of agro-industry and an opportunity for the growth of new SMEs.

Eco-products are experiencing popularity, seen from the emergence of awareness by 54% of respondents (Figure 3) about the dangers of synthetic textile dyes for humans and the environment. It certainly will affect consumer preference factors to be looking for products that are environmentally friendly. The selection of a product by consumers can be grouped in three dimensions, namely product selection (selection based on consumer needs), brand selection (preference on a brand during the consumption process), and store selection (selection of certain stores to buy a product) [7]. Based on Figure 2, 75% of respondents were willing to pay more for environmentally friendly textile products. Consumer acceptance of natural dye textile products is high because of characteristics of consumer preferences.
Table 1. Result of consumer preference based on income.

| Willingness to pay more | Salary/month | Grand Total |  |
|-------------------------|--------------|-------------|---|
|                         | > IDR 15 M   | IDR 0-5 M   | IDR 10-15 M | IDR 6-10 M | Total | %  |
| No                      | 1            | 37          | 3           | 6          | 47    | 25 |
| Yes                     | 1            | 120         | 7           | 13         | 141   | 75 |
| Grand Total             | 2            | 157         | 10          | 19         | 188   | 100|

| Characteristic of Dye Selection | Salary/month | Grand Total |  |
|---------------------------------|--------------|-------------|---|
|                                 | > IDR 15 M   | IDR 0-5 M   | IDR 10-15 M | IDR 6-10 M | Total | %  |
| Soft/ Calm                      | 2            | 117         | 8           | 14         | 141   | 75 |
| Bright/ Sharp                   | 40           | 2           | 5           |            | 47    | 25 |
| Grand Total                     | 2            | 157         | 10          | 19         | 188   | 100|

| Ease of market access           | Salary/month | Grand Total |  |
|---------------------------------|--------------|-------------|---|
|                                 | > IDR 15 M   | IDR 0-5 M   | IDR 10-15 M | IDR 6-10 M | Total | %  |
| No                              | 1            | 36          | 3           | 6          | 45    | 23.9362 |
| Yes                             | 1            | 121         | 7           | 13         | 143   | 76.0638 |
| Grand Total                     | 2            | 157         | 10          | 19         | 188   | 100|

| Awareness of environmental effect of synthetic dyes | Salary/month | Grand Total |  |
|-----------------------------------------------------|--------------|-------------|---|
| Not aware                                           | > IDR 15 M   | IDR 0-5 M   | IDR 10-15 M | IDR 6-10 M | Total | %  |
|                                                    | 2            | 70          | 2           | 12         | 86    | 45.7447 |
| Aware                                               | 87           | 8           | 7           | 102        | 54.2553 |
| Grand Total                                        | 2            | 157         | 10          | 19         | 188   | 100|

Figure 1. Percentage of consumer preference based on dye selection.

Figure 2. Percentage of willingness to pay more for protecting environment.
Sustainable development in the environmental aspects consists of the stages of the process that is the emergence of awareness from the community of environmental impacts, the government issued laws and regulations related to production practices, and the final stage where producers receive a great responsibility not to damage the environment in producing products. The concept of green marketing is used here where companies demand suppliers to deliver environmentally friendly products and involve consumers to preserve nature in the use of products. Producers can give rewards to consumers who contribute to the company's commitment to protect the environment. This will attract the attention of consumers to jointly eliminate and minimize environmental impact. In other words, the traditional supply chain will change to become a sustainable supply chain (green supply chain) [10]. The structure of the natural textile dye supply chain can be seen in Figure 5.

Based on the supply chain illustration in Figure 5, the processing industry of natural textile dyes gets the supply of biomass raw materials from suppliers. Procurement of raw material for dyeing can be done by contracting with cultivation farmers or through certain suppliers. In this process, the natural dye industry does not check the quality and accept all supplies from farmers and suppliers. Thus, the risk of poor quality of raw materials is borne by the natural dye industry. This is because the supply of raw materials is only taken from one source and the lack of knowledge and skills of farmers. Farmers provide raw materials in unpredictable time and quantity.
Table 2. Added value of natural dye products.

| Variables | Unit     | Values     |
|-----------|----------|------------|
| **Supply-Chain Interaction** |           |            |
| Material purchase price (Indigo) | IDR/Kg    | 2 000      |
| Blue dye price | IDR/Kg    | 68 000     |
| Material purchase price (Sappan) | IDR/Kg    | 15 000     |
| Red dye price | IDR/Kg    | 17 500     |
| Material purchase price (Cudrania javanensis) | IDR/Kg    | 35 000     |
| Yellow dye price | IDR/Kg    | 25 000     |
| **Output and Income** |           |            |
| Output blue dye (Sale volume) | Kg        | 500        |
| Output Indigo dye (Sale value) | IDR       | 34 000 000 |
| Output red dye (Sale volume) | Kg        | 160.8      |
| Output red dye (Sale value) | IDR       | 2 814 000  |
| Output yellow dye (Sale volume) | Kg        | 53.6       |
| Output yellow dye (Sale value) | IDR       | 1 876 000  |
| **Cost** |           |            |
| The amount of blue dye raw material | Kg        | 5 000      |
| The amount of red dye material | Kg        | 150        |
| The amount of yellow dye material | Kg        | 50         |
| Raw material cost (Indigo) | IDR       | 10 000 000 |
| Raw material cost (Sappan) | IDR       | 2 225 000  |
| Raw material cost (Cudrania javanensis) | IDR       | 42 440     |
| Additional cost to produce blue dye | IDR       | 7 500 000  |
| Additional cost to produce red and yellow dye | IDR       |            |
| **Added value** |           |            |
| Added value | IDR       | 14 647 560 |
| Added value ratio | %         | 37.86      |

Basis: 500 kg/month for blue dye, 150 kg/month for red dye and 50 kg/month for yellow dye

The business plan for achieving sustainable production consist of production aspect, price aspect, distribution aspect, and promotion aspect [11]. The production aspect where producers have to design products that do not contain hazardous and toxic materials and have adverse effects both long and short term to consumers. In addition, the need for labels to the product as education to consumers. The price aspect is the need to increase production efficiency so that environmentally friendly products are not expensive and have competitive price. In this case, it is necessary to know the added value of the natural textile dye industry in producing dyes. Aspect distribution is a multicellular strategy so that consumers can get goods in a short time. Aspects of promotion must be accompanied by information and education to consumers to participate in maintaining environmental sustainability.

Added value can be calculated based on both qualitative and quantitative way. Quantitatively added value can be calculated by increasing productivity, while qualitative added value is an increase in employment opportunities and human resource knowledge and skills. Added value to the industry involves the processing of agricultural commodities that are perishable and bulk so that it becomes a
A product that is ready for use or to consume by consumers. Added value is a reward from labour, management, and capital that has been spent to produce a product [12]. The results of value added analysis can be seen in Table 2 that the added value of natural textile dye products in 2019 packaged per kg was 37.86%.

The extraction process by *Indigofera tinctoria* plants is done by fermentation process (Figure 7) while sappan wood and *Cudrania javanensis* wood are done by aqueous extraction process (Figure 6). *Indigofera tinctoria* is an indigo dye that produces a blue dye which is a tropical plant from India. Meanwhile, sappan wood produces red dye and *Cudrania javanensis* wood produces yellow dye. The first thing to do for aqueous extraction is cutting the raw material biomass to expand the surface contact of the material and water solvent with an ingredient and water content of 1: 8 (w/v). Then boiled until it reaches half of the initial volume. In the simple extraction process, the fuel used is wood fuel, so the boiling time cannot be measured. The dye liquid is then filtered to separate the biomass waste and the dye solution. Based on Merdan et al. (2017) [13], the disadvantage of this process is that it consumes a lot of water, required high temperatures, and has a long extraction time. The dye solution is still in liquid form, so it is difficult in distribution to the textile industry. The process of drying into powder needs to be developed for practical distribution and packaging and also increase the shelf life of natural textile dye products. This production process will produce wood biomass waste that can be reused as fuel in the dye extraction process.

![Figure 6. Production and biomass waste utilization in aqueous extraction.](image)

The extraction process of *Indigofera tinctoria* is by soaking for 24 hours with water at room temperature. This fermentation produces a yellow solution caused by the activation of indimusl enzymes producing indoxyl content found in indigo leaves. Then the content of indoxyl turns into blue indigotina (blue dye solution) with aeration process for 2 hours. Then a precipitation process is carried out to separate the dye paste and the liquid waste. The yield of the production process can reach 10-17% depending on the quality of raw materials affected by the climate. However, the disadvantages of this process are the bad odour arising from the fermentation process, the long extraction time and the process must be done directly after harvesting [13]. Waste generated is liquid waste and solid waste that can be reused to produce biogas, briquettes, and fertilizers.
The production of natural textile dyes in collaboration with farmers while at the same time conserving biodiversity will ensure the availability of raw material sources for natural textile dyes. Emissions and wastes produced by natural textile industry dyes greatly influence the sustainability system. Biomass waste and wastewater from the production of natural dyes can be reused into derivative products such as compost, biogas, and animal feed to support the 3R principle (Reduce, Reuse, Recycle) and allow for the creation of the zero emission industry concept if the industrial institution has been formed. The development of the natural textile dye industry will form new industries, increase land productivity, farmers and local wisdom, maintain cultural heritage, competitiveness, guarantee consumer health and safety and also guarantee the security of industrial workers. The potential for increasing awareness and collaboration of stakeholders is also needed to build a sustainable natural textile dye industry.

Figure 7. Production and biomass waste utilization in fermentation extraction.

- : waste and emission flow
- : reuse flow
4. Conclusions
Economic, environmental and social aspects to support the sustainability of natural textile dyes can be done with the revenue of the cost of natural dyes while increasing the production capacity of natural textile dyes. The natural textile dye industry has the potential to be developed because it can provide added value to agricultural materials that have not been used optimally.

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