



# Sustainability of Batik wastewater quality management strategies: analytical hierarchy process

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## Abstract

Batik industries have some positive impact on economic growth and socio-cultural development. However, they also produce wastewater in large quantities with high pH, containing biochemical oxygen demand, containing chemical oxygen demand and also have a substance of total suspended solid that do not meet quality standards and also could have negative impacts on the environment. Paoman village, Indramayu regency, is one of the batik small industries supporting economic and socio-cultural development in local communities, although there is an installations system of wastewater treatment plant (WWTP). The study aimed to identify priorities in wastewater management on batik industrial center based on environmental studies, economic studies and social factors in the local community and institutional aspects using analytical hierarchy process. The priorities were identified as follows: (1) application of WWTP systems and technologies for environmental aspect, (2) understanding the perceptions of batik small and medium enterprises (SMEs) for the social aspect, and (3) the cost of installation, operation and maintenance of WWTP for economic aspect.

**Keywords** Strategy management · Wastewater treatment plant · Batik industry · AHP

## Introduction

From UNESCO (United Nations Educational Scientific and Cultural Organization) in 2009, Batik has already recognized be one of the most valuable national and cultural treasures in Indonesia (Ismail et al. 2012; Mafira et al. 2017; Sutisna et al. 2017; Arifan et al. 2018; Kridarso 2018). In addition, it represents an oral and intangible cultural heritage (Malik et al. 2018). Therefore, ensuring the sustainability of batik production is the responsibility of all levels of Indonesian society. In Indonesia, batik represents a local culture of patterned fabric (Sutisna et al. 2017; Arifan et al. 2018), which has an impact on national development (Rahmadyanti et al. 2017) and is currently developing into the batik industry (Pratiwi et al. 2017). Batik industry has already become one of the biggest textile industries in Southeast Asia scope (Rashidi et al. 2015). In Indonesia, there some cities could be classified as craftsmen areas, including Yogyakarta,

Surakarta, Cirebon, Indramayu, Semarang, Pekalongan and Lasem (Borshalina 2015; Rukayah et al. 2015; Kridarso et al. 2018). Indonesian batik industry in small and medium scope has contributed to economic growth and socio-cultural development in Indonesia (Anna et al. 2018; Sirait 2018).

Although the batik industry in Indonesia has had some positive impact on the growth of the national economy, it has also had some negative environmental impact, largely due to the resulting water scarcity associated with inefficient water use and pollution from batik waste. Batik small and medium enterprises (SMEs) not only generate wastewater in large quantities, but also high quantities of chromium used in the coloring process, which pollute aquatic environments (Sutisna et al. 2017; Arifan et al. 2018; Mukimin et al. 2018; Tambunan et al. 2018), degrade ecological environment (Sirait 2018) and pose public health risks (Soni and Mishra 2017; Mukimin et al. 2018). Overall, the batik industries could affect the environment due to production processes such as coloring, wax coating and immersion, which generated a lot of wastewater (Rahmadyanti et al. 2017).

Batik industrial wastewater usually contains a lot of organic compounds, suspended solids, ammonia, or other pollutants at high concentrations (Vymazal 2014). In addition, wastewater that produced from batik industries

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activities contains some synthetic compounds and it is not easy to degrade, for example, are heavy metals material, suspended solids material, and some kind of organic compounds (Sutisna et al. 2017; Arifan et al. 2018). The chemicals used in the dyeing process and in manufacturing motifs (dye, wax, alum sulfate and starch) could also negatively affect the chemical characteristics of wastewater produced by the batik industry (Mukimin et al. 2018). During the coloring process, only 5% of water can be reused, while 95% is released as wastewater into the environment (Sirait 2018). Waste is disposed of directly into the environment without being processed, entering waters around human settlements and raises chemical oxygen demand (COD) levels and decreases the quality of water resources in the neighboring communities. In addition, chemical dyes are not easily degraded nature as they are fairly stable (Reddy et al. 2014), while high concentrations of pollutants can be hazardous for environmental because from the hazardous of pollutants can increase the containing of COD and biological oxygen demand (BOD) levels in water (Dasgupta et al. 2015). Batik industry generates wastewater which 95% coming from dyes processing (Sirait 2018).

Paoman village, Indramayu district, is a batik industry center that does not have an installation called wastewater treatment plant (WWTP). For reducing the pollutant from an industrial activity like wastewater, wastewater treatment plant (WWTP) can be used for processing the pollutants by any combination treatment program like physical, biological and chemical (Anjum et al. 2016). Therefore, the wastewater and runoff from batik production are discharged directly into the sewerage system without any processing. Similarly, SMEs of batik Semarang, batik Trusmi from Cirebon, batik Pekalongan, Simbang Kulon Pekalongan, batik Yogyakarta, batik Madura, batik Malang do not have a proper WWTP (Yuliasni et al. 2017; Arizal 2017; Riyanto and Hidayah 2017; Anna et al. 2018; Sirait 2018). The absence of a WWTP in such batik industrial centers is large because of the high cost of setting up a WWTP and that batik production is still performed using traditional methods, in addition to a lack of awareness in local communities on the need to stop polluting water resources and to protect the environment. Such activities result in the pollution of rivers and raise environmental sustainability concerns.

Batik SME wastewater is cloudy and dark and contains non-biodegradable and carcinogenic organic compounds (Babu et al. 2007) that require proper management. Considering the chemical properties of the waste that the batik industry produces, effective and economical strategies for the management of batik wastewater containing high silicon (Si) and COD concentrations, in addition to toxic heavy metals, are required (Birgani et al. 2016). In addition, the batik wastewater could be recycled using chemical, physical and biological processes (Pratiwi et al. 2017).

Batik wastewater treatment and water resource management could facilitate the preservation of batik being a cultural heritage, the benefit for reducing the wastewater from batik production and save the quality of water that could support human needs and ecosystem services, while promoting a sustainable batik culture and environment.

The application of titanium dioxide ( $\text{TiO}_2$ ) nanoparticles could decrease COD, BOD and (total suspended solids) TSS concentrations in wastewater via photodegradation (Arifan et al. 2018). Chemical oxygen demand (COD) is usually used to determinate the number of organic load in the wastewater sample. For the next in processing, it is done by completed of oxidation process from organic load in wastewater sample being water ( $\text{H}_2\text{O}$ ) and carbon dioxide ( $\text{CO}_2$ ) substance. (Kolb et al. 2017). Biochemical oxygen demand or BOD in generally used for the detected amount of the oxygen consumed by microorganisms in aerobic metabolism processing. Total suspended solids or TSS are described by particle or material that drowning into based of wastewater after dried at 103–105 °C and could be shaped being ash after getting burned process (Zhang et al. 2017).

In addition, utilization of lead dioxide/lead electrodes in e of lead-acid batteries could considerably degrade wastewater as a form of batik wastewater treatment using electrochemical methods (Riyanto and Hidayah 2017). Revitalization of sustainable batik from Paoman village is one of the cultural heritage of villages could be achieved through (1) ensuring the physical quality land and buildings by looking the environment aspect, green open spaces, parks, roads, drainage networks, a network of WWTPs and waste disposal process (2) promotion some of non-physical aspects from environment such as economic activities, socio-cultural heritage and stakeholder engagement (Musyawaroh et al. 2018). Kind of the economic activities from batik SME's is corporate social responsibility or CSR program. From Howard Bowen in 1953, CSR was described as an obligation process in businessman scope to making other values for some society scope (Hamidu et al. 2015).

Waste management and waste handling in Pekalongan batik can be achieved using several strategies, including using preventive, remedial and sustainable strategies. Preventive measures are carried out by educating communities about batik industrial waste management, motivational programs, provision of industrial waste management facilities for batik and carrying out of monitoring activities for environmental quality, river water, groundwater and air quality, in addition to education on eco-friendly strategies, for example, by using natural dyes that are environmentally friendly. Remedial measures would include waste management using WWTP both at communal and household scales. In addition, law enforcement could restore damaged environments through the imposition of sanctions for batik entrepreneurs who dispose of the waste in undesignated sites (Jerliu and

Bajcinovci 2018). After the adoption of corrective measures, the next step would be to adopt strategies that ensure sustainability, including raising awareness among the public.

Batik wastewater management strategies include the licensing of waste management facilities, batik waste disposal and the provision of WWTPs. Some obstacles to waste management included a limited number of WWTPs (Zaenuri and Dwidayati 2020) and low public awareness on batik waste management, particularly among batik industry entrepreneurs. Therefore, greater efforts to increase the number of WWTP and education about the importance of proper batik waste management, particularly among by the community, are requires batik industry entrepreneurs who will care with the impact to the environment. In addition, more local or national government officers are required to monitor and prescribe actions against entrepreneurs who violate the regulations of batik waste management in the form of administrative sanctions and criminal penalties in addition to the need for local or national government officers with third parties in batik waste management.

Considering the problems caused by the Paoman SME's batik industry to river water pollution and the environment, it is necessary to investigate the industrial wastewater management strategies in the Paoman batik industry based on environmental aspects, social aspects and economic aspects.

## Materials and methods

The study location is Paoman village, Indramayu district, West Java Province. Paoman village, Indramayu district, is a batik industry center and has the potential to support the local economy and empower local communities. Sampling points were located in the sewerage outlet centers for batik waste in Paoman with the following coordinates: S 06 19 '21.0 'and E 108 19' 12.6'. Geographically, Paoman village is located in the northern region in Indramayu district, located in 107°51'–108°36' east longitude and 6°15'–6°40' south latitude (Fig. 1). Paoman village has a population of 8295 residents. The total area is 2048 km<sup>2</sup> Paoman village with a population density of 4050 individuals/km<sup>2</sup>. The working population in the processing industry sectors in the village of Paoman is as many as 207 people, including many who work within the batik industry in Paoman.

The study was conducted on 2018. The tested parameters included pH, BOD, COD and TSS. The tested water quality parameters and the methods used are listed shown in Table 1.

Prioritization of strategies used the analytical hierarchy process (AHP), which includes environmental aspects, social aspects, economic aspects and institutional aspects. (AHP includes institutional aspect, but there are no the variable bellow & not provide in discussion 3.6

Institutional Aspects after 3.5 Economic Aspects). The use of AHP is based on research that has been carried out by Muhrom et al. (2017) and Pusparini et al. (2017). Study variables include environmental aspects, such as (a) economic environment (b) wastewater pollution loads (c) the WWTP system and technologies and (d) the application of cleaner production principles. Variable social aspects of the study include (a) understanding the perceptions of batik SMEs, (b) understanding the active attitudes of batik SMEs and (c) increase batik SME's effects. Variable economic aspects of the study include (a) the economic environment, (b) the efficiency cost of installing a WWTP and its operation and maintenance, (c) the availability of economic incentives and disincentives and (d) the presence of private sector CSR programs. No variable of Institutional Aspects.

Respondents were doing by two academics, lecturers selected from the School of Environmental Sciences, University of Indonesia. The government represents are represented by the Head of the Pollution Control Department of the Environment (DLH), West Java Province and Chairman of the Environmental Pollution Control Agency (DLH), Indramayu district. Residents were represented by public figures in the village, including the village chief in Paoman, chairperson of the Institute for Community Empowerment, (LPM) and chairperson of a non-governmental organization in the environmental field. Responses of the respondents were then processed using Expert Choice v.11 (Expert Choice Inc., Pittsburgh, PA) with outputs in the form of graphs and strategic priority scores.

AHP was used to determine the priority levels of housing area development in alternative locations by determining the weights of each criterion and sub-criteria (Saaty 1980). The value from the priority scale used in the present study is already based on the collection of primary data in forms. The forms were mean to the questionnaire and interview process from some respondents who are expert to the environmental scope, social scope, economic fields and institutions. AHP is a multicriteria analysis technique that provides appropriate tools that take into account the conflicting views of different stakeholder groups. AHP models consist of four levels: objectives, criteria, sub-criteria and alternatives (Komariah and Matsumoto 2017). There are several steps involved in the processing of data. Step one, directly to obtain priority values that would be applied in the pairwise comparison matrices, and then to the criteria and sub-criteria priorities, geometric means are calculated to align the results in pairs because the assessment involves more than one individual.

Geometric means values were calculated using an equation:

$$G = \sqrt[n]{(X_1 \cdot X_2 \cdot X_3 \dots \dots X_n)}$$

where





Fig. 1 Location of Paoman village, Indramayu district, West Java Province, Indonesia

Table 1 Method for wastewater quality testing

No	Parameter	Unit	Reference-based method
1	pH	–	SNI 06–6989.11–2004
2	BOD	mg/L	SNI 6989.72: 2009
3	COD	mg/L	ISO 6989.2: 2009
4	TSS	mg/L	SNI 06–6989.29–2005

SNI, Indonesian National Standard, ISO, International Organization for Standardization (BSN 2017; ISO 2020)

$G$  = Average values of Geometric.

$X_1, X_2, \dots, X_n$  = Assessment to-1, 2, ....., n

$n$  = Number rating coefficient.

Subsequently, final results from priority scale are applied as pairwise comparison matrices for criteria and sub-criteria, and

then from normalized condition to standardize condition the eigenvectors from each element. Therefore, we could obtain the priority weighting of each criterion and sub-criteria. Before the normalization of the pairwise comparison matrix, the columns of each criterion/sub-criteria are summed for us in the calculation in the next step using the following equation:

$$S_j = \sum_{i=1}^n a_{ij}$$

where

$S_j$  = The total value of each column.

$a_{ij}$  = Matrix i to j.

$n$  = Number of criteria.

Normalization values in the comparison matrix were calculated using an equation:

$$V_{ij} = \frac{a_{ij}}{s_j}$$

where

- $V_{ij}$  = Normalization value i to j.
- $S_j$  = The total value of each column.
- $a_{ij}$  = Matrix i to j (Riyanto and Hidayah 2017).
- Normalization values in the comparison matrix were calculated using an equation:

$$W_i = \frac{\sum_{j=1}^n V_{ij}}{n}$$

where

- $W_{ij}$  = Weight priority.
- $V_{ij}$  = The normalization matrix i to j.
- $n$  = Number of criteria (Cabala 2010).
- Maximum of eigenvalues ( $\lambda_{max}$ ) were calculated by using the equation:

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{[AW]_i}{W_i}$$

where

- $\lambda_{max}$  = Rated maximum eigen.
- $A$  = Value eigen.
- $W_i$  = Weight priority.
- $n$  = Number of criteria (Cabala 2010).

Consistency index or CI aiming to give a piece of information about the values of logical consistency comparisons that being pairwise. When the values of CI are 0.0, there is an inconsistency logical from pairwise comparisons, or considered to be 100% consistent ratings. After a maximum eigenvalue ( $\lambda_{max}$ ) is obtained, the CI value is calculated using the following equation:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where

- CI = Values of Index consistent.
- $\lambda_{max}$  = Maximum of eigenvalues.
- $n$  = The criteria number (Alonso and Lamata 2011).

The consistency ratio or CR measures of consistent ratings are relative for the ratings of larges sample purely at random. Once the value of CI is obtained, and the next CR values are calculated using the following equation:

$$CR = \frac{CI}{RI}$$

where

- CI = Consistency Index values.
- CR = Ratio of consistency.
- RI = Random index values.

## Results and discussion

### Batik SMEs wastewater quality

The results in Fig. 2 show that the batik industrial wastewater has pH, BOD, COD and TSS levels that are much higher than the thresholds of wastewater quality standards set by the government.

Information:

- a. Quality standards: Based on the regulation of the Minister of Environment from the Republic of Indonesia Number 5 the Year 2014 Appendix XLVII on Standard Quality for Class 1 Wastewater for Business and/or activities not Have Wastewater Quality Standard Set (a).
- b. World Bank (b).
- c. Does not meet the Quality Standard (^).

Figure 2 shows that the pH, BOD, COD and TSS levels do not meet the wastewater quality standards stipulated by the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 Annex XLVII Group 1 on Wastewater Quality Standard for Enterprises or activities do not have a standard number for wastewater. As well as wastewater quality standards according to the World Bank. Batik wastewater is hazardous and toxic (Riyanto and Hidayah 2017). Wastewater discharges of batik dyes are concentrated and have a acid degree (pH), BOD, COD and TSS, which do not meet quality standards (Subki et al. 2011; Yuliasni et al. 2017; Mukimin et al. 2017; Mukimin et al. 2018; Sirait 2018) due to the use of chemicals during the processing of batik dyes (Sirait 2018). The characteristics of the wastewater in the batik industry are potentially due to the organic matter used as raw materials. The organic material is broken down by microorganisms that cause COD and BOD levels in wastewater to increase. In addition to raw materials, chemicals applied in dyeing processes could increase COD and BOD levels in the water. Traditional batik industries, such as the Paoman batik industry uses chemical dyes in the dyeing process. Consequently, the process produces wastewater

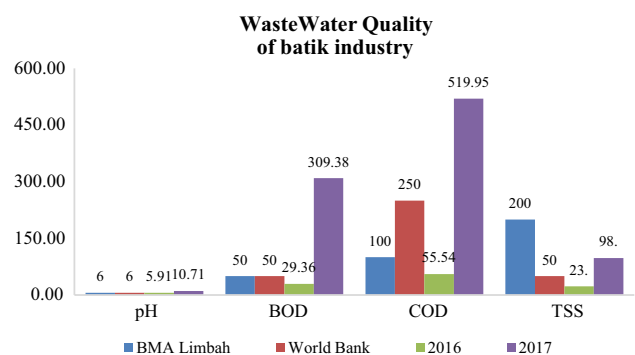


Fig. 2 Values of waste water quality from batik industry

with high pH, BOD, COD and TSS values. The application of TiO<sub>2</sub> nanoparticles could decrease COD, BOD and TSS levels in batik wastewater via the process of photodegradation (Arifan et al. 2018). Therefore, it is a technology that could be applied to the treatment and management of batik wastewater. Some considerations in the selection of appropriate water treatment technologies for include quality and quantity of wastewater to be treated, ease of operation and the availability of human resources qualified to operate the type of WWTP selected, the accumulated amount of mud, land requirements and availability, operational costs, the expected quality results of the waste processing activity and energy requirements.

### Priority industrial wastewater management strategy for batik

From Table 2, total number each of the criteria from the environmental aspect were 1.87; social aspects totaled 4.67; economic aspects totaled 7.33, and institutional aspects amounted to 12.00. Normalization pairwise comparison matrix is presented in Table 3 below. To get a priority weighting of each criterion, the normalization condition is calculated by using Eq. 4. Priority weight aims to determine the value of each criterion be the priority. The greater the criterion weight value, the greater prioritized (best choice). And conversely, the smaller the criterion weight value, the smaller priorities (a poor choice). Priority weighting for each criterion is presented in Table 4 below.

Based on the results in Table 4 for each criterion, we obtained the priority order of the criteria as follows:

- (1) Environmental aspects (score: 0.50).
- (2) Social Aspects (score: 0.26).
- (3) Economics (score: 0.16).
- (4) Institutional Aspects (score: 0.08).

Priority strategy of the criteria used in wastewater processing of batik industry center was dominated by the highest environmental criteria numbering 0.50. Weights obtained should be determined CI the views of the respondents for measure quality of priority. When CI values less than 0.1, consistent opinions from the subject that are respondents considered acceptable. While the value of the CI of more than 0.1, the opinions of respondents who considered

**Table 2** Matrix pairwise comparison of criteria

Criteria	Environment	Social	Economy	Institutional
Environment	1.00	3.00	3.00	5.00
Social	0.33	1.00	3.00	3.00
Economy	0.33	0.33	1.00	3.00
Institutional	0.20	0.33	0.33	1.00
Amount	1.87	4.67	7.33	12.00

inconsistent unacceptable and must be done by getting the data from questionnaire again to describe the weight so that the appropriate CI values. Based on Table 4 that the strategic priorities criteria established are (a) the environmental aspects with weight amounts to 0.50. 4.2514 total  $\lambda$  max value criteria. CI amounted to 0.0838 criteria. The index rate totaled 0.0931 criteria.

### Environmental aspects

Variable sub-criteria assessment of environmental aspects included (a) the economic environment, (b) the pollution load in wastewater, (c) the determination of WWTP systems and (d) the application of cleaner production principles (Table 5). Normalization pairwise comparison of the matrix can be seen in Table 6 below.

Based on calculations using Eq. 4, the priority weight from each sub-criteria is presented in Table 7 below.

Based on the results in Table 7, we then obtained the priority order of the following criteria in each sub-criterion:

- (1) Environmental condition (score: 0.12).
- (2) Cost of polluting wastewater (score: 0.26).
- (3) The quality of the WWTP system (Score: 0.56).
- (4) Application cleaner production principles (score: 0.06).

Based on Table 7, the priority strategies in environmental aspects sub-criteria are (a) the determination of the WWTP system, whose weight amounted to 0.56. In addition, the  $\lambda$  max value for environmental aspects in total 4.1767. Environmental aspects CI amounted to 0.0589, while the index rate totaled 0.0654 for environmental aspects. The batik

**Table 3** Normalization pairwise comparison matrix

Criteria	Environment	Social	Economy	Institutional
Environment	0.54	0.64	0.41	0.42
Social	0.18	0.21	0.41	0.25
Economy	0.18	0.07	0.14	0.25
Institutional	0.11	0.07	0.05	0.08
Amount	1	1	1	1

**Table 4** Criteria weighting priority

Criteria	Amount	Weight	Priority
Environment	2.00	0.50	1
Social	1.05	0.26	2
Economy	0.64	0.16	3
Institutional	0.31	0.08	4
Amount	4	1	

\*The amount is indicated the total of the normalization matrix  $i$  to  $j$  for each criteria in Table 3

**Table 5** Matrix comparison of sub-criteria

Sub-criteria	Environmental condition	Pollution load in wastewater	Determination of WWTP system	Application of cleaner production principles
Environmental condition	1.00	0.33	0.20	3.00
Pollution load in wastewater	3.00	1.00	0.33	5.00
Determination of WWTP system	5.00	3.00	1.00	7.00
Application of cleaner production principles	0.33	0.20	0.14	1.00
Total	9.33	4.53	1.68	16.00

**Table 6** Normalization sub-criteria pairwise comparison matrix

Sub-criteria	Environmental condition	Pollution load in wastewater	Determination of the WWTP system	Application of cleaner production principles
Environmental condition	0.11	0.07	0.12	0.19
Pollution load in wastewater	0.32	0.22	0.20	0.31
Determination of the WWTP system	0.54	0.66	0.60	0.44
Application of cleaner production principles	0.04	0.04	0.09	0.06
Total	1	1	1	1

**Table 7** Sub-priority weighting criteria

Sub-criteria	Amount	Weight values	Priority
Environmental condition	0.49	0.12	3
Pollution load in wastewater	1.05	0.26	2
Determination of the WWTP system	2.23	0.56	1
Application of cleaner production principles	0.23	0.06	4
Total	4	1	

\*The amount is indicated the total of the normalization matrix i to j for each sub-criteria in Table 6

industry requires innovative methods to prevent excessive wastewater production. Currently, net production is going to produce waste by prevention methods and has been applied widely globally to minimize industrial waste (Sirait 2018). The high concentration and an acid degree in wastewater discharges from batik dyes make the wastewater not easy to treat. The wastewater treatment system should reduce the chemical concentration to meet the standard effluent (Subki et al. 2011; Yuliasni et al. 2017; Mukimin et al. 2017, 2018; Sirait 2018). However, the results effluent from the WWTP system in some of batik SME not yet meet with the requirement (Susanty et al.2013). Furthermore, some of the SME not yet have a WWTP, they used the system that provides by local government, yet the capacity not enough to support the whole wastewater quantity that discharges to that WWTP (Zaenuri and Dwidayati 2020). Many types of treatment that can provide to make a better a WWTP system. However, the system design should be provided based on the wastewater composition and generation rates (Oteng-Peprah et al 2018). Because of that the management should evaluate they are wastewater treatment based on the water effluent

quality daily or monthly report to be able to innovate their system. As well as local government can provide support to increased the capacity of communal WWTP together with the SME that used the WWTP.

**Social aspects**

Study variables for social aspects included (a) understanding the perception of batik SMEs, (b) the active attitudes of batik SMEs and (c) increased participation of batik SMEs.

Based on Table 8, the total numbers for each sub-criterion in the understanding of the perceptions of batik SMEs amounted to 1.67; active attitudes of batik SMEs amounted to 7.00, and increased participation of SMEs batik 4.33 sequentially numbered. Normalization pairwise comparison matrix results are presented in Table 9 below.

Based on calculations using Eqs. 4, the priority weights of each sub-criterion of social aspects are presented in Table 10 below. Based on Table 10, for each criterion, then obtained the priority order of the following criteria:



(1) Understanding the perceptions of batik SMEs Batik (score: 0.57).

(2) The active attitudes of batik SMEs (score: 0.14).

(3) Increasing the participation of batik SMEs (score: 0.29).

Based on Table 10, the priority of social aspect strategies was (a) understanding the perception of batik SMEs, which amounted to 0.57. Value  $\lambda$  max social aspects in 3.1768. Social aspects CI amounted to 0.0884. The index rate totaled 0.1524 for social aspects. From social aspects like understanding of perception, industry active attitude and increasing of participation, it gives some effect for sustainable in wastewater from batik SMEs. The perception was meaning be a sensation of expression to describe for the subject or an object (Pageaux 2016). The perception concept could be like social perfection that means to interventions solution with political interest concept (Turrén-Cruz et al. 2019). From three sub-criteria, it already had some effect on increase or decrease the impact of SMEs from batik wastewater. Understanding the perception of the batik SMEs can be as some of the effort to increase the practice toward this sustainable in wastewater treatment (Mardhiah et al. 2018). Social perception is one of the factors that can affect the success or failure

of development of wastewater scheme (Saad 2017). Because of that understanding the perception of the batik SMEs is one of driven to increase the awareness the importance of wastewater treatment in they are industry system, as well as to reduce the practice of throwing the wastewater directly to the river (Zaenuri and Dwidayati 2020).

## Economic aspects

Table 11 study variables for economic aspects included (a) economic conditions, (b) the cost of installation of WWTP systems, their operation and maintenance, (c) the availability of economic incentives and disincentives and (d) availability of private sector CSR programs. From Table 11, amounts all for each sub-criterion in the economic aspect were as follows: economic conditions amounted to 5.20; the cost of installation of WWTP systems, their operation and maintenance amounted to 2.00; availability of economic incentives and disincentives 5.33; and availability of private sector CSR programmes amounted to 12.00. The results of the normalization pairwise comparison matrix are presented in Table 12 below.

**Table 8** Matrix comparison of sub-criteria

Sub-criteria	Understanding the perception of batik SMEs	Active attitudes batik	Increased participation of batik SMEs
Understanding the perception of SMEs batik	1.00	3.00	3.00
Small and medium industry active attitude batik	0.33	1.00	0.33
Increasing the participation of SMEs batik	0.33	3.00	1.00
Amount	1.67	7.00	4.33

**Table 9** Sub-criteria comparison matrix normalization

Sub-criteria	Understanding the perception of SMEs batik	Small and medium industry active attitude batik	Increasing the participation of SMEs batik
Understanding the perception of SMEs batik	0.60	0.43	0.69
Small and medium industry active attitude batik	0.20	0.14	0.08
Increasing the participation of SMEs batik	0.20	0.43	0.23
Amount	1	1	1

**Table 10** Sub-priority weighting criteria

Sub-criteria	Amount	Weight	Priority
Understanding the perception of SMEs batik	1.72	0.57	1
Small and medium industry active attitude batik	0.42	0.14	3
Increasing the participation of SMEs batik	0.86	0.29	2
Amount	3	1	

\*The amount is indicated the total of the normalization matrix  $i$  to  $j$  for each sub-criteria in Table 9



**Table 11** Matrix comparison of sub-criteria

Sub-criteria	Condition economic regions	The investment costs, operation and maintenance of WWTP	The application of economic incentives and disincentives	CSR programs private parties
Condition economic regions	1.00	0.33	1.00	5.00
The investment costs, operation and maintenance of WWTP	3.00	1.00	3.00	3.00
The application of incentives and disincentives economic	1.00	0.33	1.00	3.00
CSR programmes private parties	0.20	0.33	0.33	1.00
Amount	5.20	2.00	5.33	12.00

**Table 12** Normalization sub-criteria comparison matrix

Sub-criteria	Condition economic regions	The investment costs, operation and maintenance of WWTP	The application of economic incentives and disincentives	CSR programs private parties
Condition economic regions	0.19	0.17	0.19	0.42
The investment costs, operation and maintenance of WWTP	0.58	0.50	0.56	0.25
The application of economic incentives and disincentives	0.19	0.17	0.19	0.25
CSR programs private parties	0.04	0.17	0.06	0.08
Amount	1	1	1	1

Based on Table 12, the investment costs, operation and maintenance of WWTP give the best values. The investment costs were meaning to a studied of economics with using an assume but without loss of generality. In basically, investment costs had given some effect on sustainability from the impact of batik SMEs. It has to keep in best portion for the stability values in evaluating from economics factor in the sustainability process.

Based on calculations using Eqs. 4, the priority weights of each sub-criteria in the economic aspects are presented in Table 13 below.

Based on Table 13, for each criterion, we obtained the order of priority for each criterion as follows:

- (1) Economic conditions (score: 0.24).
- (2) The cost of installation of WWTP systems, their operation and maintenance (score: 0.47).
- (3) The availability of economic incentives and disincentives (score: 0.20).
- (4) Availability of private sector CSR Programs (score: 0.09).

Based on the results in Table 14, the strategic priority economic aspect is (a) the cost of installation of WWTP systems, their operation and maintenance, based on the weighing results. The  $\lambda$  max value for economic aspects was in 4.3116. Economic aspects of the CI amounted to 0.1039. The index rate is the economic aspect amounted to 0.1154. To install the WWTP with capacity 150m<sup>3</sup> systems, the batik SME needs investment cost around \$ 70.4

**Table 13** Sub-priority criteria weighting

Sub-criteria	Amount	Weight	Priority
Condition economic regions	0.96	0.24	2
The investment costs, operation and maintenance of WWTP	1.89	0.47	1
The application of economic incentives and disincentives	0.80	0.20	3
CSR programs private parties	0.35	0.09	4
Amount	4	1	

\*The amount is indicated the total of the normalization matrix i to j for each sub-criteria in Table 12

thousand with operation cost around \$6.34 thousand each year (Kurniati and Prajanti 2018). That cost investment can be a burden for them with the SMEs that have revenue of around \$23.44 thousand each year (Kurniati and Prajanti 2018). One of the solutions is to make columnal wastewater treatment among the group SMEs within the same area, so the investment and operational cost can be shared among them. However, this system can be more successful if the process of build the WWTP they have government support not only financial support but also guiding support during process build of WWTP.

## Economic aspects

The study of institutional aspect variables includes (a) compliance with laws and regulations on environmental management and protection (PPLH), (b) application of the strategic environmental assessment (KLHS), (c) collaboration of stakeholders (between ministries/government agencies, private, academics and the public) in environmental pollution control (PPL) programs and (d) environmental law enforcement and supervision (PPHL).

Based on Table 14, the total number of each sub-criteria for institutional aspects is compliance with PPLH laws and regulations totaling 10.00; implementation of KLHS totaling 10.00; collaboration between stakeholders in the PPL program amounted to 1.73; and PPHL environmental surveillance and enforcement number 4.60, respectively. Pairwise comparison matrix normalization can be seen in Table 15 below.

Based on the results of calculations using equation formula 4, the priority weights of each sub-criteria for institutional aspects can be seen in Table 16 below.

Based on Table 16, for each criterion, the priority order of the criteria is obtained, including:

(1) Compliance with laws and regulations on environmental management and protection (score: 0.095).

(2) Application of strategic environmental assessment (score: 0.095).

(3) Collaboration of stakeholders (between ministries/government agencies, the private sector, academia and the public) in the environmental pollution control program (score: 0.56).

(4) Monitoring and enforcement of environmental laws (score: 0.25).

Based on Table 16, the strategic priority in the institutional aspect is (a) Collaboration of stakeholders (between government ministries/agencies, private sector, academics and the community) in environmental pollution control programs with a weight of 0.56. The  $\lambda_{max}$  value of the

**Table 14** Matrix comparison of sub-criteria

Sub-criteria	Obedience to PPLH laws and regulations	Application of KLHS	Collaboration of stakeholders in the PPL program	Supervision and enforcement of environmental law PPHL
Obedience to PPLH laws and regulations	1.00	1.00	0.20	0.33
Application of KLHS	1.00	1.00	0.20	0.33
Collaboration of stakeholders in the PPL program	5.00	5.00	1.00	3.00
Supervision and enforcement of environmental law PPHL	3.00	3.00	0.33	1.00
Amount	10.00	10.00	1.73	4.60

**Table 15** Normalization sub-criteria comparison matrix

Sub-criteria	Obedience to PPLH laws and regulations	Application of KLHS	Collaboration of stakeholders in the PPL program	Supervision and enforcement of environmental law PPHL
Obedience to PPLH laws and regulations	0.10	0.10	0.11	0.07
Application of KLHS	0.10	0.10	0.11	0.07
Collaboration of stakeholders in the PPL program	0.50	0.50	0.58	0.65
Supervision and enforcement of environmental law PPHL	0.30	0.30	0.20	0.21
Amount	1	1	1	1

**Table 16** Sub-priority criteria weighting

Sub-criteria	Amount	Weight	Priority
Obedience to PPLH laws and regulations	0.38	0.095	4
Application of KLHS	0.38	0.095	3
Collaboration of stakeholders in the PPL program	2.23	0.56	1
Supervision and enforcement of environmental law PPHL	1.01	0.25	2
Amount	4	1	

institutional aspect is 4.23. The consistency index for the institutional aspects was 0.05. The index ratio for institutional aspects was 0.07. Collaboration and involvement of stakeholders in the management and control of pollution are top priorities (Pohan et al. 2016; Tabrani et al., 2017). Furthermore, environmental law enforcement efforts are needed accompanied by supervision and guidance to the community (Rosiana et al. 2016).

## Conclusions

Based on the final results, the quality of wastewater generated by the batik industry did not meet quality standards based on parameters such as pH, BOD, COD and TSS, as stipulated by the regulation of the Minister of Environment from Republic of Indonesia Number 5 Year 2014 Annex XLVII Group 1 on Wastewater Quality Standard for Enterprises and/or activity yet Having Wastewater Quality Standard Defined, in addition to the wastewater quality standards of wastewater according to the rules the World Bank. Priority industrial wastewater management strategies of batik Paoman are as follows: (1) the environmental aspect, which is the application of WWTP systems and technologies. (2) The social aspect in the form of understanding the perceptions of batik SMEs, (3) the economic aspect in the form of the cost of installing, operating and maintaining a WWTP and (4) the institutional aspect is the collaboration of stakeholders (between ministries/government agencies, the private sector, academics and the community) in environmental pollution control programs.

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**Informed consent** Informed consent was obtained from all individual participants included in the study.

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