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CIRCULAR ECONOMY FOR GLOBAL WATER SECURITY

Toward water friendliness in batik production: addressing the key factors on water use for batik production in Jarum village, Klaten Regency, Indonesia

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Abstract

The Indonesian batik is a cultural product recognized as Intangible World Heritage by UNESCO. However, its production by small and medium enterprises has been raising environmental problems, including water pollution. Since water is vital for humans and batik production, deterioration of its quality affects the people, ecosystem, and batik sustainability. The water scarcity and the emerging concept of circular economy show that a regenerative system that focuses on resource efficiency is essential to replace the current linear production system. A previous study was conducted to examine the role of water in batik production. However, a complete picture on the water use in batik production is required as it will imply to water sustainability, from the experts' perspectives. Therefore, this study identified the factors influencing water use for batik production based on perspective of the experts in combination to craftsmen's experience using a qualitative Delphi method with seven experts on batik and water technology. The result indicates identified challenges that influence the water use for batik production, and four aspects that need to be addressed in order to realize water friendly batik production. Finally, three key factors of actor, system, and technology were concluded if the circularity of water use in batik SMEs will be realized.

Keywords Batik production · small and medium enterprises · circular economy; · Water-friendly · water use

Introduction

The Indonesian batik is one of the ethnic products recognized as the Intangible World Heritage by UNESCO. Batik is a cultural product created by Indonesians for a long time. For instance, the term *Tulis* (handwriting) was first mentioned in 1518 (Elliott, 2004). Although it was previously worn mainly by the royal family, it became a common product from 1850, with best works produced between 1850 and 1939 (Elliott, 2004). With its massive production, batik has contributed to the economics of the Indonesians, particularly in the small and medium enterprises (SMEs).

According to Weerasiri and Zhengang (2012), SMEs are a leading group in global economic activities. Specifically, they play an essential role in supporting the economy in Asia Pacific countries. Apart from supporting economic growth, SMEs can absorb labor that cannot be accommodated by the formal sector (Tambunan, 2019). According to Capri (2019), 99.9% of businesses in Indonesia comprises micro and small-medium enterprises. In 2017, there were about 57 million micro and SMEs operating in Indonesia. Statistics show that about 60% of Indonesia's GDP is contributed by micro and small-medium enterprises (Capri, 2019; Tambunan, 2019). Despite their contribution to economic growth, SMEs have a significant negative impact on the environment (del Brio & Junquera, 2003; Hillary, 2004; Vasilenko & Arbačiauskas, 2012).

It is generally understood that natural resources are important for economics as production and consumption processes depend on natural resources in addition to energy, and the use of the materials in general usually ends up in generating waste. The use of natural resources will bring economical, environmental, and social consequences, and the intensity will depend on some factors, such as the amount of the natural resources

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used, the natural resources management, and the location from which the natural resources originate. Therefore, efforts are required to improve the efficiency and productivity of natural resources along their life cycle (OECD, 2020). Recently, in order to address the problem caused by the linear model of production, i.e., take-make-dispose which usually ends up in generating waste and resource inefficiency, a restorative or regenerative industrial system called circular economy has been proposed. The circular economy seeks to increase efficient use of resource by utilizing it in a circular cycle in order to avoid or minimizing waste generation, including the use of renewable energy, and promotes material reuse, less use of toxic chemicals, and less waste generation (Ellen MacArthur Foundation 2013). In addition, it seeks to maximize the value of material use in the process of economics, and reducing material consumption (OECD, 2020). A review conducted by Lieder and Rashid (2016) highlight three major aspects of circular economy, i.e., waste and environmental which focuses on minimizing the environmental impact, resource scarcity that motivates the regenerative use of resources, and economic benefits to maintain companies' sustainability and increasing profit. Korhonen et al. (2018) wrote two contributions of circular economy, i.e., high value and quality of material cycles in a new design, and provided possibilities in sharing economy along the sustainable production, while identifying six main challenges of circular economy implementation. In spite of its limitations and challenges, the previous studies indicated the potential of circular economy in order to conserve natural resources and, hence, maintain its sustainability.

In recent years, water resource has been a big challenge in the world's economics (Hoekstra, 2014). In 2007, the UN highlighted the need to address water scarcity urgently. It is predicted that in 2025, about two-thirds of the world population will be living under water stress. Statistics also show that around 1.8 billion of the world's population will live in regions with absolute water scarcity (UN Water, 2007). In terms of economics, water scarcity hurts a broad spectrum, including bilateral international trade, businesses, food production, and the tourism industry (Guarino, 2017). Therefore, there is a need for an urgent move to sustainable water use (Hoekstra, 2014). According to UN Water (2007), the amount of water used for industries, agriculture, and domestic activities will increase by 60–90% in 2050, unless water productivity increases.

Challenge on water resources are also reported in batik SMEs across Indonesian regions, including Klaten (Kristijanto et al., 2011; Mukimin et al., 2018; Handayani et al., 2018). These challenges include water inefficiency, the absence of 3 Rs (reduce, reuse, and recycle) implementation, and lack of waste water treatment. Since batik industry is heavily dependent on water resource, inefficient use of water and water quality deterioration could affect its sustainability. Recent batik studies related to water resource are focused on creating a technical model for green batik industry (Yaacob & Zain, 2016), improving and optimizing the batik wastewater treatment process (Sutisna et al., 2017; Mukimin et al., 2018), calculating batik water footprint (Handayani et al., 2019), and proposing strategies to manage batik wastewater based on environmental, economics, and social aspects (Sulthonuddin & Herdiansyah, 2021). It is clear that studies on batik are still focused on the end of pipe approach, especially in order to solve the problem of wastewater. In the context of circular economy, in order to put in the circular cycle,, the water should be processed to be reusable, instead of being processed to meet certain quality criteria followed by its disposal to environment. The circular economy indicates that in order to achieve efficiency, it is also important to focus on how the water should be managed since the beginning of the process or since the opening of pipe. This understanding highlights the importance of identifying the factors that influence water use for batik production.

Previously, a Focus Group Discussion (FGD) involving batik craftsmen identified four factors that influence the use of water, including the production scale or ratio of water use and the quantity of batik produced, the type of materials used, the habit of batik workers, and the availability of water technology (Handayani et al., 2021). However, in order to get the complete picture of the water use in batik production and its implication on water resource sustainability, a complementary survey involving the experts of batik production needs to be conducted. Therefore, this study explored water use by batik SMEs based on experienced experts and discussed their experience to gain more comprehensive information. The objective of the paper is identifying the factors that influence water use for batik production based on expert's perspective, and combining the craftsmen's daily experience to experts' technical judgment in order to formulate a recommendation to realize circularity of water use in batik production.

Method

This study was conducted using qualitative Delphi method. According to Linstone and Turoff (2002), the Delphi method is characterized by a structured group communication process effectively allowing group of individuals to deal with a complex problem. It is indicated by Skulmoski et al. (2007) that Delphi method was conducted by distributing questionnaires to experts by email, followed by collecting the experts' responses, repeating this process to some rounds. The data collection could be finished when answer for research question is found or a specific consensus is reached or certain stability on panelists' responses is achieved (Rowe & Wright, 1999; Skulmoski et al. 2007), and finally followed by data analysis, including quantitative analysis (Skulmoski et al. 2007).

Since statistical aggregation and quantitative analysis are considered to be necessary for a Delphi procedure (Rowe & Wright, 1999; Skulmoski et al., 2007); it seems that Delphi tends to be quantitatively performed. In fact, although quantitative Delphi method has been conducted, such as in the studies on meat consumption (Chamorro et al., 2012) and food safety management (Ilic et al., 2017), the Delphi has also been performed along with qualitative method for community-engaged research (Brady, 2015), Participatory Action Research in health leadership (Fletcher & Marchildon, 2014), and batik study (Pujotomo et al., 2018). However, both methods show similarity in using experts as panelist for collecting information (Skulmoski et al., 2007; Fletcher & Marchildon, 2014; Brady, 2015; Ilic et al., 2017; Conchin & Carey, 2018).

In addition to Delphi, qualitative method was used for this study. The qualitative method is selected because of its characteristics which could find deeper understanding on human behavior, perspectives, and experiences of people. According to Mohajan (2018), it is the qualitative method that could systematically describe and interpret an issue or phenomenon based on the perspective of the individual or population, which finally, by its inductive inquiry, could generate new concepts and theories. Since water use for batik is related to human activities, and "how the batik craftsmen use water," as well as "why do they use the water that way," might be influenced by their perspectives and experiences with water, the qualitative method becomes relevant to be used for this study. Furthermore, as in this study Delphi method which involves the participation of expert is used, it is an advantage to grasp deeper information on water use for batik production based on the knowledge and experience of experts, as they could provide deeper understanding on the phenomenon, as indicated by Brady (2015).

The first step involved developing a research question similar to the one in the previous study (Handayani et al., 2021). Specifically, the question was on *the key factors that influence water use by batik SMEs*. However, it was broken into eleven questions to examine five topics, i.e., (1) the importance of water for batik production, (2) the required water quality, (3) the required water quantity of water and whether the production use water excessively, (4) the key factors which influence the water use by batik SMEs, and (5) possible efforts to raising awareness of batik craftsmen on using the water with special concern.

The second step involved looking for experts in batik. The criteria for the experts were explained by Skulmoski et al. (2007). Specifically, (1) the panelists should have knowledge and experience on batik, (2) the panelists should be available and willing to participate in the research, (3) the panelists should have sufficient timeframe, and (4) the panelists should have effective communication. Considering that Delphi method involves the expert, the samples for the study are usually determined purposively, which is very similar to the qualitative methods. As indicated by Brady (2015) instead of having a number of samples for generalization purpose, purposive sample of individuals on specific expertise is preferred in Delphi method.

In regard to recruitment, we make a list that consists of the name of researchers on batik based on their published researches in journals. In terms of expertise, we prefer to list researchers who have published two or more articles on batik and environmental context or have been conducting research on batik for years, which indicates the long experience they have on batik and environmental issue. Based on the selection, we decided six candidates to contact, which consists of two researchers from Balai Batik Yogyakarta, and the rest were academicians from universities in Indonesia. Among those six candidates, three candidates agreed to participate in the research, two other researchers could not be contacted using their email indicated in their articles, while the rest confirmed that she could not participate the research. Using the snowball technique, we get five more candidates to follow-up. One of them did not response to our invitation, and four of the candidates agreed to participate. Therefore, in this research, seven batik experts were involved. They were (1) two senior female university researchers of doctoral degree and a female university researcher of master degree who have been conducting researches on batik and mentoring their students on batik research; (2) a female university researcher of master degree who is also an expert on batik art and activist for women batik artisan's empowerment; (3) a male practitioner on water and wastewater treatment for textile industries by more than 5 years experience; (4) and two male and female senior researchers from Balai Batik Yogyakarta. Essentially, the Balai Batik Yogyakarta is the Government's Agency for Batik Research and Development, and therefore, their involvement is relevant. In order to keep anonymity of experts, the identity of participants was not shared among them.

The third step is collecting the data. As this research was conducted using a qualitative approach, instead of distributing the questionnaires as suggested by Skulmoski et al. (2007), a modified Delphi technique was conducted in the format of Focus Group Discussion (FGD), without sacrificing the structured communication principles of Delphi method, i.e., feedback of individual contributions of information and knowledge; assessment of the group judgment or view; and opportunity for individuals to revise their views. By seven participants, the FGD is suitable to conduct. As it is indicated by Nyumba et al. (2018), the participants for FGD could be in the range from six participants to fifteen participants, although more than twelve participants will consequently lead to difficulties in managing the group. Therefore, seven participants is appropriate for this study, particularly because of the limited number of experts on batik and environmental context as well as their willingness to participate in the study. Furthermore,

the FGD format enables an open and comfortable discussion among the participants with the role of researcher as moderator for the discussion (Nyumba et al., 2018). Therefore, through an FGD, the structured communication principles required for Delphi can be met. The FGD was conducted online by the Google Meet platform for about 150 min to obtain panelist's input and opinions using prepared questions. Afterward, they examined the previous result based on the opinion of batik craftsmen presented by the moderator of the group. This step was conducted to reconcile the understanding of experts and the experience of batik craftsmen and workers. This FGD was run until no new information was produced from the discussion (Nyumba et al., 2018), which is in line with the Delphi; i.e., when research question is answered, specific consensus or panelists responses' stability is achieved (Rowe & Wright, 1999; Skulmoski et al. 2007). As no information was exchanged after the 150-min FGD, therefore, it could be expected that data collection using this one round FGD is sufficient. During FGD, the meeting is recorded. The data collected was transcribed and analyzed descriptively by qualitative data analysis technique, and the results are narratively presented.

Results and discussion

This section describes the results obtained from FGD with the experts, which reflects the experts' experience with batik craftsmen. The comparison on the experts' perspectives on the key factors of water use for batik production to the batik craftsmen perspectives which has been previously published will also be conducted in this section. In addition, the results obtained from this study will also be compared to other relevant studies on batik. Finally, the results found from this study will be discussed with results from other studies in textile, because batik is quite specific, and in the context of circular economy.

Results

The importance of water for batik production

The experts highlighted the importance of water for batik production. Water is considered to be the main resource for batik-making process. This means production might be disturbed in case water is unavailable. Table 1 shows the opinions of experts reflected from their own experience with batik craftsmen and workers.

According to Table 1, the batik craftsmen prefer to use water obtained abundantly and immeasurably. It is indicated by Susanty et al. (2015) that water use for batik production is diverse as there was batik SME who uses 350,000 L of water per month while another SME uses 3,000 L per month, by a different production scale. Nevertheless, they showed difference in terms of water use efficiency, as there was a SME in Pekalongan who uses 10,000 L/month of water to produce 200 pcs/month batik which equal to 50 L/pc, while another SME in Solo uses 4,000 L/month of water to produce 600 pcs/month of batik or equal to 6.67 L/pc (Susanty et al., 2015). Harren (2019) also found this phenomenon in Ciwaringin batik, West Java, and indicates that there are outside and unknown qualitative variables which might influence the water use by batik craftsmen. It is the phenomenon highlighted by the experts in how the batik craftsmen are usually using water abundantly or immeasurably, not only in Central Java, but also in West Java. However, the experts also indicated this pattern of behavior relates to their access to water and their need to pay for the water. When water is available for free or at no cost, they will use it abundantly. It is common to find in SMEs that they do not incorporate the cost for water in the product's price, or even they do not calculate the cost for water which in reality they pay in the form of electricity to pump the water from their boreholes. This situation might influence the batik craftsmen's behavior on using water. In addition, they are always reluctant to pay for wastewater treatment. This case might be related to their understanding that wastewater treatment needs a specified technology, while the craftsmen are usually limited in terms of educational level. Based on our observation and experience, most of the craftsmen in Klaten graduated from primary or secondary school, and only a few graduated from higher education level. Furthermore, their understanding on wastewater technology usually relates to its high cost, which could be another barrier for them to invest for wastewater treatment technologies.

Based on experts' experience, the best water source often used by the batik craftsmen was from the well, dug and deep. In case the well is not available, they use water from Perusahaan Daerah Air Minum (the government's agency for drinking water provision). In Jarum village, the batik craftsmen usually use water from wells and not from PDAM. This is because PDAM was not operating in the village. According to the experts, the well's water is the best choice mainly because its hardness is usually low, affecting quality, particularly for the natural batik dyeing process. In natural dyeing, mordants are required to fix the color onto the cloth due to the instability of natural dyes to light exposure and washing (Christie, 2015). Some mordants frequently used for natural batik dyeing include alum, lime, and copperas (Handayani et al., 2020). Since hard water often contains calcium or magnesium ions, water quality may negatively affect the batik's color quality. However, the well of Jarum people often contains calcium, which may negatively affect the quality of the product. According to Patil et al. (2019), hard water showed a detrimental effect on textile dyeing when the coloration involves reactive dyes. This is because the depth of shade decreases with the increase in hardness, indicating the

Table 1 The importance of water for batik production

No.	Facts about the importance of water based on the opinion of experts
1a	Water is the main resource for batik production.
1b	Water is used throughout the process, from cloth mordanting until final washing.
1c	The unavailability of water could affect batik production continuity.
1d	The batik craftsmen are interested in using water for free or at no cost.
1e	If water available at no cost, the batik craftsmen and batik workers tend to use it abundantly.
1f	The batik craftsmen are interested in free cost regarding (waste)water disposal.
1g	The batik craftsmen and batik workers tend to use water immeasurably.

need for a water softener or sequestering agent. Since hardness is strongly related to water quality, one cannot expect a "standard" quality of batik. This is because the quality might vary over time, and using a water softener or sequestering agent means spending more money.

According to the experts, neutral pH and low metal levels affect color quality during the dyeing process. A low level of pH or acidic water tends to form a yellowish color. In comparison, alkaline water often produces a red color. Furthermore, a higher level of iron in the water produces darker colors, which is in line with the report of Ali et al. (2010) that the use of ferrous sulfate or copperas as mordant for natural dyeing result in dark color of the fabric.

Although the expert confirms that rainwater is not appropriate for batik production, the craftsmen from Jarum have been harvesting it, both for daily needs and for production (Handayani et al., 2021). This habit is attributed to the fact that they suffered from water scarcity before 2006. They tried to obtain water from whatever source, including their wells, neighborhoods, and rainwater (Handayani et al., 2021).

How do the batik craftsmen use water for production?

All experts agreed that most batik craftsmen often used water excessively or immeasurably. This is particularly the case with craftsmen who have not yet practiced cleaner or green batik production. Table 3 shows the opinion of experts regarding the water use behavior of batik craftsmen.

According to the experts, the behavior of the craftsmen in using water is influenced by several factors. For instance, free water leads to facilitation of excessive use because of thinking it is found easily. For this reason, they fill the water tank, particularly for washing. Furthermore, the lack of technical knowledge, such as removing hydrochloric acid as a fixing agent with much water instead of an alkaline solution, affects them. The craftsmen also prefer collecting the clothes for certain amounts before wax removal. This is in line with Handayani et al. (2020), who established that the owner often collects up to 70 or 80 sheets to be processed for wax removal once. The water used for wax removal, followed by the washing process to produce 50 sheets of batik per day by a large-scale batik SME, was 575 L/day (Handayani et al., 2018). However, there was also a different pattern indicated by batik SMEs that focus on wax removal anytime regardless of the quantity produced. These habits indicate a different use of water. It can be more efficient suppose the batik clothes are collected and finished once, instead of conducting wax removal every day.

According to an expert, the huge water consumption is attributed to a lack of set standards. However, another expert stated that the government represented by the Ministry of Industry and Trade of Indonesia (2019) has been publishing a regulation on a standard for green batik production, specifically 50 L/m^2/color and 10 L/m^2 for synthetic and natural dyeing, respectively. The water needed for batik produced by synthetic dyeing was 10 L/sheet calculated from dyeing

Table 2 The water source for batik production

No.	Facts about the water source and water quality for batik production
2a	Freshwater from the well is of the best quality for batik production.
2b	Rainwater is not very good for batik.
2c	If freshwater from the well is unavailable, the batik craftsmen can use water from the Perusahaan Daerah Air Minum (The government's agency for drinking water provision).
2d	Although it is quite rare, there are craftsmen from some batik centers who use surface water from the river to wash the batik cloth.
2e	The used water from certain process might be reused for other processes that do not require clean water.
2f	Despite the quality, batik craftsmen will consider the cost of getting water to consider the water they will use.

Table 3 The water use behavior of batik craftsmen

No.	Water use behavior of batik craftsmen
3a	The batik craftsmen often use water resources excessively or immeasurably, mainly if they have not practiced yet cleaner production or green production of batik.
3b	There is no standard in using water for production among batik craftsmen.
3c	Lack of technical knowledge contributes to the excessive use of water.
3d	The craftsmen prefer to fill the water tank in full, particularly for washing.
3e	The craftsmen prefer to collect the batik clothes in a certain quantity before wax removal.
3f	The behavior seems to be related to satisfaction, i.e., the craftsmen are satisfied if they could use water in huge quantities.
3g	The behavior of batik craftsmen in using water also relates to the free cost of getting water.

to the wax removal process. This might be suitable suppose the calculation was conducted with a direct water use approach. From the 16 SMEs spread in Yogyakarta, Solo, and Pekalongan, one of them consumes 350,000 L/month of water to produce 2,624 pieces of batik per month, while another one used 3,000 L/month of water to produce 90 pcs per month (Susanty et al., 2015). This means water consumption by the first SME was 133.38 L/pc, while the second SME was 33.33 L/pc. The information provided by the expert contravened Susanty et al. (2015). However, 10 L/sheet was only from dyeing to wax removal processes, while Susanty et al. (2015) indicate the water consumed in the entire batik making process. This comparison implies variations in water consumption for batik production among SMEs, often calculated based on the direct water use approach. Nevertheless, in relation to the former debate on batik production standard, it is possible the batik craftsmen in Jarum have not been informed by the regulation of Ministry of Industry and Trade of Indonesia (2019). If this situation occurs, a meeting to provide information to the craftsmen regarding the implementation of Green Batik Industry indicated by the government would be necessary.

Table 4 shows the key factors that influence water consumption for batik production. According to the experts, one of the key factors is the batik design, which relates to the complexity of the batik, for example, where the batik is of the full motif (Fig 1a) or not-so-full motif (Fig 1b). The design also relates to the number of colors applied to the cloth. The more the colors applied, the more water required to prepare the dyes, both natural and synthetic. This also depends on the dyeing frequency, which can be more frequent in line with dye application.

Compared to the arguments of batik craftsmen, the key factors that determine water use was different from the experts. The previous FGD with the craftsmen identified four key factors that affect the water uses for batik production, i.e., (1) the ratio of water use to the number of batiks produced, (2) the materials used, (3) the water uses habit of the craftsmen, and (4) water technology (Handayani et al., 2021). The materials used in batik production, such as the type of dyes and water use habit, are similar factors identified by craftsmen and experts. However, the batik design that includes dyeing frequency and the number of dyes for the batik-making process was not identified by the craftsmen. Similarly, the water consumed per sheet of batik produced and technology was not identified by the experts.

Table 5 shows some of the efforts to reduce water use in batik production. The first effort is raising the awareness of the craftsmen regarding the vitality of water for batik. This may lead to the conservation of water resources to maintain their sustainability. Furthermore, it is important to ensure cleaner production to improve batik quality and preserve it as Indonesia's cultural heritage. The government has been promoting green product certification to draw the craftsmen's attention to adopt cleaner batik production. In this regard, water should always be measured to monitor its use during production. This can help the craftsmen calculate their monthly expenditure for water resources and how much money they

Table 4 Key factors on water consumption for batik production

No.	Key factors that influence water consumption for batik production
4a	Batik design
4b	The number of dyes used for the batik-making process
4c	Dyeing frequency
4d	The habit of batik craftsmen in using water
4e	Type of dyes used, i.e., natural dyes or synthetic dyes

(a) (b)

Fig. 1 Samples of batik design of full motif (**a**) and not-so-full motif (**b**). (Source: personal documentation)

could save, suppose they use it more efficiently. Educating the craftsmen to incorporate water resource cost in product pricing is vital because they often ignore the cost for water in product pricing due to the "water is free" mindset.

The experts also highlight the importance of creating a standardized operating procedure (SOP) for batik production. This SOP is required to guide the batik craftsmen to use resources efficiently during production. To increase efficiency, the disposal of dye solutions and neutralizing the fixing agent by water are not suggested. Instead, the dye solutions should be used completely, and the acidic fixing agent neutralized using an alkaline solution instead of water. Finally, technology is important to improve water quality in the demineralization and dyeing process improvement.

Reconciling the experts and batik craftsmen's opinion in water use for batik production

This study shows that water consumption for batik production is influenced by factors related to the batik itself and the craftsmen. For instance, design (Table 4) affects the number of colors used and dyeing frequency. The second factor may relate to the habit of batik workers in using water (Table 4). According to Table 5, there are other factors apart from those mentioned in Table 4. The four key factors highlighted in the previous study include water use habits, the materials used which may consume less water, production scale, and water technology (Handayani et al., 2021). Table 6 shows the combination of factors reflected by both the experts based on this study and the craftsmen based on the previous study (Handayani et al., 2021).

According to Table 6, the first issue that needs to be addressed relates to the batik craftsmen. Although the craftsmen understand the importance of water in production, they are not very likely to conserve water. This is due to a lack of understanding in conserving water because the craftsmen think they could quite easily and for free. Training is vital to help them measure the water used and the cost incurred to change this mindset. Moreover, they can understand how much water is used to produce a sheet of batik and the money spent and know that expenditure has not been incorporated into their product. Shiva (2002) highlighted water as common goods, emphasizing that no one could privatize or sell it. However, this understanding leads to excessive use of water by the

Table 5 Possible efforts to reduce water use in batik production

No.	Possible efforts to save water for batik production
5a	Increasing awareness of the craftsmen that water is vital for batik; hence, its sustainability is essential to support batik sustainability.
5b	Increasing awareness of batik craftsmen that batik as cultural heritage should be directed to eco-friendly production.
5c	Promoting green product certification and the advantages or incentives the craftsmen will receive suppose their products are certified.
5d	Promoting water measurement as a different activity from batik production.
5e	Calculating the water use cost, incorporating the cost for product pricing, and explaining the economic benefit obtained if the batik craftsmen could save water or use less water.
5f	Creating a Standardized Operating Procedure for batik production
5g	Avoiding the disposal of "unused" dye solution
5h	Using the alkaline solution to neutralize acidic fixing agents instead of using a large amount of water.
5i	Improving water quality, particularly reducing the hardness or minerals contained in the water.
5j	Improving dyeing technology.

Table 6 The key factors that influence water use for batik production (based on expert and batik craftsmen)

No.	Key factors	Interpretation
1.	• Lack of understanding of water conservation to sustain batik (experts) • Lack of understanding that cleaner production is required to realize eco-friendly batik (experts) • of understanding that water resources should be considered to incorporate into product pricing, instead of free public goods. (experts) • Using water in neutralizing fixing-agents (experts) • Disposing dye solutions (experts) • Using water excessively (experts) • The use of a huge quantity of water to produce a small amount of batik (craftsmen)	Lack of understanding and excessive water behavior reflects the lack of knowledge and technical skills of batik workers regarding water importance. Therefore, education in the form of training and workshops is needed to address the situation and raise the craftsmen's awareness.
2	• The need of standardized operating procedure (SOP) for batik production (experts) • The need of water measurement for batik production (experts)	The SOP is a "guidebook" for batik craftsmen in using production resources, including measurement to monitor water use during production.
3	• The need of green industry implementation for batik SMEs (experts) • The need of green product certification for batik SMEs (experts) • The need of incentives for batik SMEs that certified as green batik SMEs (experts)	Green batik certification is important to control the batik quality by examining whether the production meets certain indicators of green batik assessment or not; included whether the production process meets the green industry criteria or not.
4	• Improving water quality by reducing hardness or demineralizing the water before its use for production (experts) • Improving the dyeing technology (experts) • Providing water technology, particularly to recycle the wastewater (craftsmen; experts) • Using less consuming-water materials (craftsmen; experts)	Appropriate technology is important to improve water quality, dyeing technology, and recycling the wastewater.

craftsmen. Although water is a public good, this term possibly relates to its domestic roles but not production.

Discussion

In economics, natural resources is capital which is required as production of goods. In times when the natural resources diminishes gradually, even to scarcity, the use of those resources should be led to a more efficient way. Although efforts have been put to improve resource efficiency, the linear production pattern of take-make-dispose still implies an inefficient resource use disposal (Ellen MacArthur Foundation, 2013). Furthermore, there is still less concern in designing material leakage and disposal (Ellen MacArthur Foundation, 2013). The concern on circular economy has been emerging, mainly because the regenerative system is involved in design to replace the linear or end of life concepts through restoration and elimination of waste and toxic chemicals (Ellen MacArthur Foundation, 2013). In the loom of global water crisis issue, the circular economy paradigm becomes relevant and should be achievable because it involves slowing, closing, and narrowing the loop of materials and energy to minimize resource input and waste emission, and energy leakage (Geissdoerfer et al., 2017). In the context of batik production, the common end of pipe approach that focuses on managing the wastewater as well as its treatment and its disposal after the process is irrelevant to circular economy, because the water should be recycled and reusable for the production. In regard to efficiency, concern on water should not be focused based on the end of pipe approach, but since the openings of the pipe.

In general, the results show how the experts reflected their own experience with batik craftsmen regarding the water use. They agreed that water is the main and important resource for batik production, which could affect the sustainability of batik. When water is unavailable, batik would not be produced continuously. Furthermore, the water use of batik craftsmen was explored deeper by the experts by identifying the craftsmen's habit or behavior. The experts explained the water quality preferred by batik craftsmen for production, how the craftsmen usually use the water, and why they use the water in their manner. Based on their personal experience with batik SMEs across Indonesia, they could provide information that batik craftsmen usually use water immeasurably, and relate their habit to the low cost or even free cost of water.

This study shows that a lack of understanding of batik and environmental issues and knowledge could affect batik

craftsmen's habit. According to Yaacob et al. (2015), batik entrepreneurs in Kelantan, Malaysia, had some awareness on environmental issues, though it depended on respective individuals. This is in line with the previous finding in the batik industry in Jarum, where some craftsmen practiced eco-friendly attitudes in various aspects, such as reusing the wax and harvesting rainwater (Handayani et al., 2020; Handayani et al., 2021). Therefore, providing education through training and workshops continuously improves batik craftsmen's habit of using water because the cognitive aspect is reported to influence environmental awareness (Fraj & Martinez, 2007; Ham et al. 2016; Mei et al., 2016). Guarino (2017) stated that education help raises the awareness of businessman, households, farmers, entrepreneurs, and policymakers, particularly when the water scarcity issue is involved. In this case, education is needed to increase the knowledge of batik craftsmen and help them understand when to use freshwater and other materials.

Apart from increasing awareness of batik craftsmen, creating SOP implemented in Indonesia is also essential. Although the Ministry of Industry and Trade (2019) has regulated the use of green batik production resources, the regulation still focuses on the dyeing process. The water used for wax removal and washing is left unexplained. In general, the water for wax removal and washing is used in the highest portion. According to the previous study, 575 L/day was consumed for washing (Handayani et al., 2018), while Hossain and Khan (2017) reported the water footprint from the wet process (fabric dyeing, washing, and finishing) contributes 62.85% of the total water footprint of textile production in Bangladesh.

It is common to find water use studies based on direct water use (Susanty et al., 2015). However, the direct water use approach could not reflect the water used to dilute the wastewater. This means the water consumption reflected by the water footprint approach can be higher than the direct water use. Xu et al. (2018) established that the Blue Water Footprint (BWF) of 25 industrial sectors in Dalian contributes 65.42% of the total water footprint, while 34.58% was contributed by the Grey Water Footprint (GWF), indicating the volume of freshwater required to assimilate pollutants. Hossain and Khan (2017) reported that in the textile industry, BWF for knit and woven products were 102 and 130 million m^3, respectively, while the GWF was 600 and 858 million m^3. From 2001 to 2010, the highest BWF of China's textile production was 1.09 Gm^3/year in 2007, while the highest GWF was 62 Gm^3/year (Wang et al., 2013). The previous study also showed a higher portion of GWF in batik production (65,207 L/day) than the BWF, which was 234 L/day (Handayani et al., 2019). These imply that in textile production, the GWF tends to be higher than the BWF. This is attributed to the fact that textile production uses much water for most processes (Kant, 2012). Apart from water, chemicals are used in its processing, and the dyeing contributes 15–20% of wastewater flow (Kant, 2012).

The certification of green batik and its incentives provided by the government for the green batik SMEs may encourage the batik craftsmen to move into cleaner production. In this respect, the product quality and its production could be monitored and evaluated by a government agency. Hoekstra (2014) highlighted the importance of water use sustainability throughout the supply chain, formulated its consumption, targeted pollution reduction, and implemented the plan to achieve water stewardship targets. The green industry for batik is a policy implemented by the government in order to push batik SMEs to move forward to green production, including water-friendly production which focus on water use efficiency and minimized water pollution. In a more technical level, SOP becomes an important part to monitor and evaluate the process of batik production in order to ensure that production meets the indicators of green batik.

This study showed that technology is required to increase water use efficiency. Innovation for efficient use of resources, including water, is important in circular economy-based textile production (Ellen MacArthur Foundation, 2017). However, Tonda and Susan (2015) established that new technology requires specific knowledge and skills. This is challenging in developing countries with low education levels in science, engineering, and technology. In general, not all technology is suitable for batik SMEs, especially those categorized as advanced. Appropriate water technology in terms of simplicity, ease of usage and maintenance, and cheap cost are suitable for batik craftsmen.

Figure 2 shows four aspects which influence the water use for batik production. It is clear that in order to realize water-friendly batik production, the role of batik craftsmen is essential, particularly because they are the main actor in the process

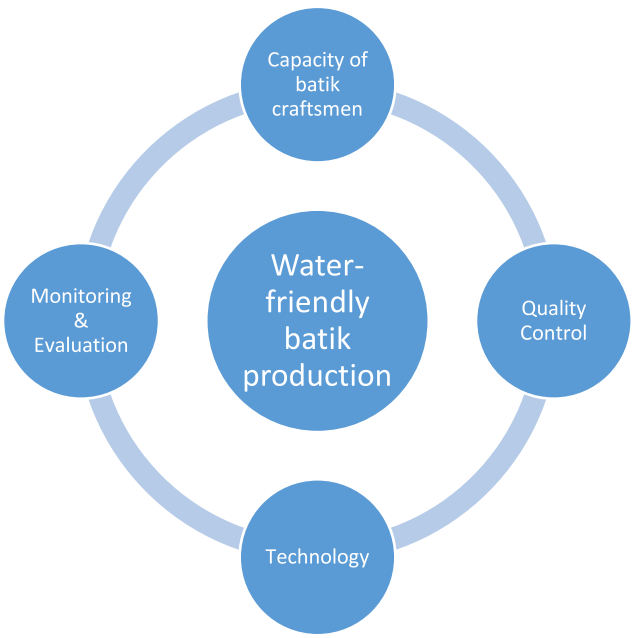

Figure 2 Aspects that influence the water-friendly batik production

and they are the decision-maker in the process that takes place. Therefore, education for building the capacity of the craftsmen is either important. It is the role of higher education in collaboration with the government to increase the capacity of batik craftsmen. The capacity building of craftsmen should be accompanied by providing a suitable work system which functions as quality controller in order to realize the water-friendly batik production. This is the essential part of the government by the implementation of green batik industry policy. Next, the role of technology as innovation to help human beings solve their problem cannot be separated from the system and actor. Appropriate technologies in wastewater treatment and dyeing process will be necessary to be involved in realizing the water friendly batik production, and this will be the responsibility of scientists in Indonesia, both of government institutions and of higher education. Finally, we conclude three key factors, i.e., actor-system-technology, that influence the water use for batik production. Building the capacity of batik craftsmen, ensuring the green batik working system, and providing appropriate water technology are core to the realization of water-friendly batik production. Future research will be focused on examining the environmental awareness of the batik craftsmen and building their capacity, as well as introducing the green batik policy to the batik SMEs.

Conclusion

Four aspects need to be addressed in order to realize water-friendly batik production have been identified, i.e., educating batik craftsmen to increase environmental awareness collectively, ensuring water use monitoring and evaluation, controlling product quality through green batik certification, and introducing appropriate water technologies to the craftsmen. Those four aspects could be summarized into three key factors, i.e., the actor that is represented by batik craftsmen, while monitoring, evaluation, and product quality control are represented by the system, and the last is the role of water technology. Well-educated and skilled craftsmen along with good system and appropriate technology would be important to the realization of circularity of water for batik production. This study contributes an insight on how water is utilized in the traditional batik-making process in Indonesia which is still understudied so far. Detailed accounts on factors determining the water use in the industry provide a new understanding on the interaction among factors as well as the importance of each factor. On the empirical side, these new understandings can be used as a guideline for the stakeholders to use the water resources in a more sustainable way. Due to the fact that most of traditional batik industries are small-scale and located in a cluster with a limited stock of water, a communal water management model will be a suitable option. The implementation of communal water management model along with monitoring system by the decision-makers will support the industry in coping with the increasing water needs due to the ever-increased market demand of the product and realizing a greener batik industry.

Author contribution All authors contribute to the manuscript with specified contribution of AP in analyzing and interpreting the importance of water for batik production, BW performed the analysis and interpretation for water source and water use behavior, while WH analyzed and interpreted the key factors that influence water use, efforts to reduce water use, arranged the model, and also the major contributor for the writing. All authors have read and approved the manuscript prior to submission.

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Data availability The authors declare that all data included in this published article are in the form of analyzed data, while the datasets in the form of Focus Group Discussion recording and transcript are not included in this study. The datasets analyzed during this current study (in Indonesian language) are available from the corresponding author upon a reasonable request.

Declarations

Ethics approval and consent to participate The authors declare that the participants in this study agreed to participate in this study. Prior to data collection, a letter (in Indonesian) signed by Prof. Dr. Budi Widianarko from Soegijapranata Catholic University—as the person in charge for this research—was sent to each participant in order to ensure their willingness to participate in this study. The letters are well documented and will be provided in case the journal needs the corresponding letters.

Consent to publish Not applicable, as the identity of all participants for this study was not mentioned specifically in this manuscript. The profession as experts in batik or wastewater was mentioned without specifically mentioning their identity, e.g., their name.

Competing interest The authors declare no competing interests.

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