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Challenges on Water Footprint (WF) Accounting of Batik Production: A Reflection from the Study on Batik SMEs in Jarum Village, Klaten Regency, Indonesia

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Abstract: Indonesian batik has been a cultural product for a hundred years. Its recognition as an intangible heritage has led its production to bring benefits in economic terms. However, there are environmental problems indicated by its production, and one of which is the water use. It is common to find information regarding the pollution caused by batik production. However, studies on water footprint of batik could bring insight that batik problem in relation to water doesn't limit solely to pollution, but also to the huge volume of water consumed during batik production. In this understanding, the WF approach, both consumptive and degradative water use, is important. Although studies on batik WF have been conducted, it is still limited. This paper discusses the challenges faced in exploring batik WF based on field experience. An understanding of batik itself and batik SME characteristics are required because they are closely related to the WF of the process. Finally, this paper explains the conceptual and technical challenges that will be faced during the study of batik WF.

Key words: Batik, challenges, small and medium enterprises, water footprint accounting.

Introduction

Water scarcity is a global concern, particularly the severe impact it causes on the global economy (Hoekstra et al., 2017). The expanding studies on water resources in relation to consumption, production, and trade led to the emergence of the Water Footprint (WF) Assessment (Hoekstra, 2017). WF is a measurement of fresh water, both for direct and indirect use by producers or consumers (Hoekstra et al., 2015). The assessment involved four steps and one of them is WF accounting, which involves the Blue, Green, and Grey WFs (Hoekstra et al., 2011).

Since its concept was introduced, studies on WF have been conducted particularly on agricultural products, such as on cotton consumption (Chapagain et al., 2006), crop products (Bulsink et al., 2009), agricultural virtual water trade (Mubako & Lant, 2013), Gazpacho (Ibáñez et al., 2017), and white radish (Cha et al., 2017). There are also research on textile WF (Li et al., 2017; Hossain & Khan, 2020; Xu et al., 2018; Zhang et al., 2019), in biofuel (Gerbens-Leenes et al., 2014), and ceramic production (Kandananond, 2018).

Batik has been Indonesia's cultural product since 1516 (Elliott, 2004), which has become an important textile commodity, particularly after its recognition by UNESCO as an intangible cultural heritage in 2009. It is indicated by The Ministry of Industry and Trade of Indonesia (2021) that batik supports the economy of Indonesia as well as provides employment. However, the

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impact of batik Small and Medium Enterprises (SMEs) on pollution has been reported widely (Handayani et al., 2018a; Phang et al., 2022; Sutisna et al., 2017; Zuhria & Prasetyo, 2018). Since sustainable development consists of three pillars of economic, social, and environmental, the imbalance on one of them will bring an adverse impact to environmental and batik sustainability.

Some studies on batik WF have been conducted (Handayani et al., 2019; Handayani et al., 2020a; Nursanti et al., 2018; Widianarko et al., 2021). However, batik is usually produced by SMEs and hence the accounting or measurement of batik WF is not an easy task. This paper will evaluate the challenges of WF accounting conducted in batik SMEs based on the past fieldwork on batik SMEs in Jarum village, Klaten Regency, Indonesia from 2015 to 2020. Hence, this paper is structured into three parts, i.e. (1) the Indonesian batik; (2) the characteristics and the problematics of batik SMEs in Indonesia; and (3) a reflection on the challenges of accounting for the batik WF.

What is an Indonesian Batik?

Indonesian batik was recorded in 1516 when the word "*tulis*" which means "handwriting" was mentioned first (Elliott, 2004). According to Hamzuri (1981), it is a painting or drawing pattern on the surface of an object – usually a piece of cotton cloth – using a melted wax flown from a tool like a pen or stylus called "*canting*" (Figure 1a), in order to resist successive dyes from penetrating a specific pattern on the cloth (Elliott, 2004) that different patterns could be coloured by different dyes. The increase in population in Java during 1815-1860 promoted batik industries to bring batik to an emerging market (Elliott, 2004).

Based on its process, there are hand-drawn batik, stamped or block-printed batik, and their combinations. The hand-drawn batik is a highly precious one because it is fully handmade. The block-printed batik is a tool invented around 1840 made of a copper block (Figure 1b) to apply an entire design consisting of some motifs onto the cloth by a single imprint (Elliott, 2004). Using this tool, the drawing process becomes easier and faster. The combination often involves the use of a block print to create the grand design, and the tiny details to fill the design are hand-drawn using the *canting*.

Figure 1: A canting (a) and a block print tool (b) (*Source*: personal documentation, 2020)

Based on its colouration, there are two kinds of batik, i.e. natural dye batik (Figure 2) and synthetic dye batik. Previously, batik colouration took place using natural dyes (Elliott, 2004; Hamzuri, 1981; Raffless, 2019) although, since 1898, they have been replaced by synthetic dyes (Elliott, 2004). Current global issues on textile-based pollution have emerged the concern and preference for the use of natural sources in textile dyeing, with no exception to batik. Therefore, natural dyes, which were replaced by synthetic dyes long ago, find their way to revival.

Figure 2: Some natural dye batik produced by an SME in Jarum village (*Source*: personal documentation, 2020).

The Batik SMEs: Characteristics and Problematics

After being recognised by UNESCO in 2009, batik has been an important cultural and economic commodity in Indonesia, particularly in providing employment. Siswanto et al. (2022) indicated that batik could significantly contribute to an increase in Indonesia's foreign exchange through its exports. However, as the problems of environmental damages caused by batik production are arising to the surface, many studies are focussed on batik SMEs, the batik-producing home industry.

A study found that 69% of entrepreneurs of batik SMEs in East Java inherit their batik skills from parents or families (Murtianingsih et al., 2021), and 24% of batik entrepreneurs in Central Java obtain their batik skills from formal education (Kurniati & Rahayu, 2021). This is common in batik-producing regions, such as Surakarta, Yogyakarta, and Pekalongan. It is also found that batik entrepreneurs are dominated by middle formal education graduates as indicated by Murtianingsih et al. (2021). The batik workers consist of (1) batik artisans, who are usually dominated by females, and do batik craft to support the living of their household (Gunawan et al., 2022), and (2) the colouration workers who tend to be dominated by male.

The Batik SMEs face many challenges because of their weaknesses. Setiawan & Wirjodirdjo (2020) highlight some weaknesses of batik SMEs in Sidoarjo Regency – East Java, i.e. low level of product development, the tendency to manage the enterprise traditionally, a limited number of employees; lack of product standardisation and technologies as also reported by Kurniati & Rahayu (2021). Those challenges have been summarized by Gunawan et al (2022) who identify three barriers to batik SMEs, i.e. knowledge, socio-cultural, and regulatory barriers.

Knowledge barriers could be related to the lack of knowledge of batik entrepreneurs on sustainable batik and this may be caused by limited information of the entrepreneurs (Gunawan et al., 2022), and this might be related to low level of formal education and limited in assessing information. Therefore, the role of Batik Entrepreneurs' Association and the support of the government will bring an advantage in increasing Batik entrepreneurs' capabilities and expanding their network.

Figure 3: A batik craftwoman is hand-drawing batik (*Source*: personal documentation, 2020).

Accounting of Batik WF and the Challenges: A Reflection from the Field

Since long ago, batik has been a water-consuming product. It is reported that classical batik needs approximately 40 days to create, i.e. 15 days to pre-treat the cloth, and 25 days for natural dyeing the cloth (Hamzuri, 1981). Hamzuri (1981) also indicates the use of water to colour classical batik using indigo. It is written that indigo dyeing needs about 24 *pikul* of water and a *pikul* is equal to 40 litres, which means the water needed for indigo dyeing only is 960 litres. This volume of water is used to make 30 pieces of batik cloth in about 40 days (Hamzuri, 1981). This indicates that ever since the past, batik has been produced using a huge volume of water. However, as it becomes a commodity, it should be mass-produced quickly, and therefore water is consumed more.

Studies on batik in environmental aspects have been conducted. However, studies on batik water footprint are quite limited. Using the keyword "batik water footprint" there is only one article found in the Directory of Open Access Journals (DOAJ) written by Handayani et al (2020a). Using the same keyword, nine articles are found in Google Scholar. Table 1 summarises the articles found by using the corresponding keyword.

The WF assessment by Nursanti et al (2018) was conducted according to Le'vova & Hauschild (2011) and focused more on direct water use followed by their study in developing an approach to assess direct water use (Nursanti et al., 2023). In Phang et al. (2022), water footprint is put as the reason why the authors conducted the study. Our studies were conducted using the WF concept developed by Hoekstra et al. (2011) which involved both consumptive and degradative water use. The consumptive water use consists of the Blue WF and Green WF as they represent the volume of water representing the blue component (Hoekstra et al., 2011; Hoekstra, 2017), while the evapotranspiration (Hoekstra et al., 2011) represents the green component. The degradative water use is the so-called Grey WF indicating the volume of freshwater required to assimilate pollutants entering freshwater bodies (Hoekstra et al., 2011). The concept also explains the water footprint of a process as a building block for product WF or other WFs on a larger scale (Hoekstra et al., 2011). However, based on our previous field studies, some challenges need to be overcome when one wants to conduct a batik WF accounting. The challenges are mostly technical but need to be addressed properly as discussed below.

Table 1: Research on the batik WF as keyword

No.	*Title*	*Authors*
1.	Water Footprint assessment of Indonesian batik production	Nursanti et al. (2018)
2.	A water footprint case study in Jarum village, Klaten, Indonesia: The production of natural-colored batik	Handayani et al. (2019)
3.	Water Footprint of the Natural Coloured Batik-Making Process: A Study on a Batik Small Enterprise in Jarum Village, Klaten Regency, Indonesia	Handayani et al. (2020a)
4.	The Blue Water Footprint of Block-printed Batik Coloured by Natural Dye of Myrobalan (Terminalia bellirica Roxb.) Mordanted by Alum and Copperas	Handayani et al. (2020b)
5.	Blue Water Footprint and Grey Water Footprint Assessment of Block-Printed Batik-Making Process Coloured by Indigo (Indigofera sp.), Tingi (Ceriops sp.) and Mahogany (Swietenia sp.) Dyes	Widianarko et al. (2021)
6.	Environmental Awareness in Batik Making Process	Phang et al. (2022)
7.	An Approach for the Assessment of Water Use in Batik Production Processes	Nursanti et al. (2023)

WF of Batik or WF of Batik-Making Process?

The WF accounting may be conducted in many aspects, from the process to the nation (Hoekstra et al., 2011). Hence, one needs to ensure if they will conduct WF accounting on the batik – which indicates the product WF – or batik-making process which of course is focused on the process. If the WF accounting will be focused merely on the process, then the knowledge of the batik-making process will be adequate. This means one just needs to identify which of the whole process uses water and which does not use water. However, if the accounting is focused on the product, then ones need to identify the process of making the raw materials and supporting materials in addition to the batik-making process. In general, batik is made using a cloth of cotton or silk. Therefore, the WF of cotton or silkworm production to the WF of cotton or silk processing should be considered. The batik-making process also involves other materials such as wax, dyes and mordants, kerosene, natural gas, or firewood for fuels. Hence, one will also need to measure the WF of those materials prior to conducting the WF of batik.

Are the Data on WF of Raw and Supporting Materials Available?

Unfortunately, not all information on the WF of raw and supporting materials is available. Our study on batik WF (Handayani et al., 2019) incorporated the WF of cotton production and cotton processing to cotton cloth based on the data of Chapagain et al. (2006). Nevertheless, the WF of wax and dyes – particularly of plant-based natural dyes such as mahogany and myrobalan – have not been incorporated in the study and this is due to the data unavailability. Raluy et al (2022) indicated that olive, citrus, and oil palm are mostly studied. In Indonesia, oil palm is probably the most studied species, however, other species such as mahogany and myrobalan have not yet been reported to be studied by the water footprint approach, as well as indigo.

How to Deal with Variations Among Batik SMEs?

Batik SMEs are usually traditionally managed home industries, therefore standardised operating procedure is usually not found. The unavailability of standardised operating procedures (Handayani et al., 2021b; Kurniati & Rahayu, 2021) for batik production leads to huge variations among batik entrepreneurs. Although all entrepreneurs use a similar process, however, there are variations among them on what dyeing mode or what kind of chemicals will be used. For example, there are batik entrepreneurs who use starch to remove the wax. However, other entrepreneurs might prefer to use soda ash (Handayani et al., 2018a) because it removes the wax faster than starch. Variations are also related to the motifs and how many colours will be applied which consequently influence the water use. An entrepreneur prefers to boil a mix of tingi (*Ceriops* sp), tegeran (*Cudrania javanensis*), and soga jambal (*Peltophorum pterocarpum*) barks together for dyeing (Handayani et al., 2020); while another entrepreneur prefers to prepare the tingi dye in a single colour. However, considering that batik is also a craft, the latter variation could not be controlled because it is related to the creativity of the entrepreneurs. Therefore, a thorough observation will be important if one seeks to understand the WF of the batik-making process.

Measuring the Blue WF: How to Deal with Limitations to Technology?

It is unusual to find batik SMEs measuring their water use (Handayani et al., 2019) because they can access it easily or because it is free in terms they don't need to pay for the water (Handayani et al., 2021b). Although they have permanent cisterns, the batik entrepreneurs also tend to use water containers and dippers. They also use water containers made of stainless steel or aluminum for wax removal. However, the water containers they use may vary among batik SMEs. Furthermore, information in regard to the volume of each container cannot be expected as they usually do not measure those containers. Considering that in order to calculate the Blue WF, we need to measure the volume of the water, then measuring the dimensions of the containers will be helpful to determine the volume of the water (Handayani et al., 2018a) while measuring water evaporated from the cloth could be conducted by calculating the weight of the cloth after the washing process and after it is dried (Handayani et al., 2019). Sometimes, other calculations might need the measurement of the density, such as wax density (Handayani et al., 2020) if the use of wax or recycled wax will be measured.

Measuring the Grey WF: What parameters are to be used?

Another technical problem is related to the calculation of Grey WF. Many studies on WF are usually devoted to the agricultural sector. In the case of batik production, there are parameters that are usually determined by the government, such as BOD5, COD, and other parameters. Moreover, not all wastewater is discharged into water bodies that we can consider it as point source pollution. It is common to find that batik SMEs discharge their wastewater into the soil or into a channel that ends in the paddy field, which is related to diffuse pollution. These habits could cause a technical problem in measuring and calculating the Grey WF. Based on the personal communication with Mialyk & Wöhler (2022), inventory of the pollutants is an important task to do. The COD concentration could be used as an indicator representing grey WF, particularly because the COD concentration of batik wastewater is considerably high. The estimated water volume needed to assimilate pollutants could be determined using an experiment (Nursanti et al., 2018) or calculation (Handayani et al., 2019).

Conclusion

Studies on the water footprint of batik are still limited. Understanding the batik-making process and the characteristics of batik SMEs becomes important prior to conducting the study in order to decide if the study will be conducted for batik water footprint accounting or batik-making process water footprint accounting. Considering the characteristics of batik SMEs which mostly are traditionally managed with no standardised operating procedures can prepare the researchers to deal with variations among SMEs as well as technical issues.

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