Application of Circular Economy to SME Batik Dyeing and Finishing

Sustainability Vetting of Ciwaringin Batik

MAJA HARREN
Application of Circular Economy to SME Batik Dyeing and Finishing

Sustainability Vetting of Ciwaringin Batik

Maja Harren
Supervisor / Examiner
Prosun Bhattacharya
Supervisor at su-re.co

Takeshi Takama

TRITA-ABE-MBT-19138

Degree Project in Environmental Engineering and Sustainable Infrastructure
KTH Royal Institute of Technology
School of Architecture and Built Environment
Department of Sustainable Development, Environmental Science and Engineering
SE-100 44 Stockholm, Sweden
Abstract
This study is part of a feasibility study conducted by the Sustainability and Resilience Company (su-re.co) and is identified within this report as the sustainability vetting. This study aims to evaluate the sustainability of the natural indigo-dyeing process at a small and medium enterprise (SME) batik dying community, Ciwaringin Batik, located in Cirebon, West Java, Indonesia. Following this, sustainable development strategies (SDSs) based on the Circular Economy (CE) RESOLVE Framework will be created for Ciwaringin Batik to further empower the community and provide sustainable business growth initiatives. An iterative qualitative and quantitative data methodology is used when collecting and analyzing production data from Ciwaringin Batik. Data is collected from 9 Ciwaringin Batik craftsmen, who use natural indigo dye during batik production, in Life Cycle Inventory (LCI) format, questionnaires, and through a site visit to Ciwaringin Batik. Water and indigo consumption data were thoroughly analyzed because it is directly related to a feasibility study conducted by su-re.co and is relevant to their future involvement with Ciwaringin. Current sustainable and “unsustainable” production practices were identified, 10 SDSs were created following the RESOLVE framework structure, 6 SDSs were explained and then prioritized regarding implementation feasibility.

Keywords: Batik, Circular Economy, SME, Indonesia
Acknowledgements

Firstly, I offer sincere thanks to my KTH supervisor, Prosun Bhattacharya, for agreeing to this endeavor and sticking with me until the end. I am deeply grateful for your support and guidance throughout the process.

Similarly, I express my gratitude to my supervisor at su-re.co, Dr. Takeshi Takama. Takeshi, you challenged me to be a thorough researcher and helped me create a solid foundation for my thesis writing, without which my thesis would be incomplete.

I am also very grateful to the su-re.co staff members, Rumi Takama and Kadek, for always having the answers to my many questions. Thank you for your generosity and kindness.

Thank you also to Marielle, Matt and Ivan, who conducted the feasibility study mentioned in this study. Working with you made writing this thesis more bearable.

I would be remiss if I did not make special mention of my many colleagues at su-re.co – the French, the Dutch Boys, the Germans, the Americans, and the Dane – who made my time in Bali an unforgettable experience. Bali became a home away from home because of your hospitality and kindness.

Finally, this work is dedicated to my mom and dad. No matter where life takes me – Sweden for my masters or Bali for my thesis – you have always supported and encouraged me to live my best life. For this, I am forever grateful.

Maja Harren
Abbreviations

ASEAN – The Association of Southeast Asian Nations
BIRU – Biogas Rumah (Indonesia Domestic Biogas Programme)
CBI – Clean Batik Initiative
CE – Circular Economy
EU – European Union
IDR – Indonesian Rupiah
ISO – International Organization for Standardization
Kg – Kilogram
LCA – Life Cycle Analysis
LCI – Life Cycle Inventory
LPG – Liquid Petroleum Gas
NGO – Non-Governmental Organizations
ODA – Overseas development assistance
PM – Production Materials and/or Methods
PPU – pay-per-use
POC – Potential Opportunity for Change
PUPUK – Perkumpulan Untuk Peningkatan Usah Kecil (Association for Advancement of Small Business)
RESOLVE – Regenerate, Share, Optimize, Loop, Virtualize, and Exchange (Ellen MacArthur Foundation)
SDS – Sustainable Development Strategy
SME – Small and Medium Enterprise
su-re.co – Sustainability and Resilience Company
ToL – Threads of Life
UGM – Gadjah Mada University
WWTP – Wastewater Treatment Plant
WTIS – World Integrated Trade Solution
YRE – Yayasan Rumah Energi
WTIS – World Integrated Trade Solution
YRE – Yayasan Rumah Energi
# Table of Contents

Abstract ............................................................................................................................................... iii
Acknowledgements .............................................................................................................................. iv
Abbreviations ....................................................................................................................................... v
Table of Contents ................................................................................................................................. vi
List of Figures ......................................................................................................................................... vii
List of Tables ......................................................................................................................................... viii
Introduction .......................................................................................................................................... 1
  Aim and Objectives ............................................................................................................................. 3
  Scope and Limitations of the Research ............................................................................................... 3
    Scope – Ciwaringin Batik Collective ................................................................................................. 3
    Limitations and Challenges .............................................................................................................. 3
  Theoretical Framework ....................................................................................................................... 4
    CE Principles and Characteristics .................................................................................................. 4
  The RESOLVE Framework ................................................................................................................ 6
Methodological Framework .................................................................................................................. 7
History of Batik ..................................................................................................................................... 7
Dyeing with Natural Indigo .................................................................................................................. 9
Sustainable Circular Businesses .......................................................................................................... 12
  Life Cycle Analysis and Circular Economy ....................................................................................... 12
  Ciwaringin Batik Production ............................................................................................................ 13
  su-re.co Involvement ......................................................................................................................... 14
Methodology ....................................................................................................................................... 15
  Life Cycle Inventory Data Collection ............................................................................................... 16
  Sustainable Development and Circular Economy ............................................................................ 17
Assumptions ....................................................................................................................................... 17
  Data Collection ................................................................................................................................. 18
  Data Interpretation ............................................................................................................................. 18
Results and Data Analysis .................................................................................................................. 18
  Ciwaringin Batik – Qualitative Approach ......................................................................................... 19
  su-re.co Site Characterization .......................................................................................................... 19
Life Cycle Inventory – Quantitative Approach ................................................................. 20
System Inputs ......................................................................................................................... 24
System Outputs ....................................................................................................................... 26
Questionnaire and Survey Responses ................................................................................... 26
Indigo Production Costs and Batik Revenue ........................................................................... 26
Water and Indigo Consumption Data .................................................................................... 28
Existing CE within Ciwaringin .............................................................................................. 31
Summary of Results .............................................................................................................. 33
Discussion ............................................................................................................................... 34
Challenges and Sustainable Solutions .................................................................................. 34
Sustainable Development Strategies ..................................................................................... 35
Regenerate ............................................................................................................................... 36
Share ...................................................................................................................................... 36
Optimize ................................................................................................................................. 37
Loop ....................................................................................................................................... 39
Virtualize ................................................................................................................................. 39
Exchange ................................................................................................................................. 40
Prioritized SDS ....................................................................................................................... 41
Honorable Mention ................................................................................................................ 41
Conclusion ............................................................................................................................... 41
Future Work ........................................................................................................................... 42
Life Cycle Assessment ........................................................................................................... 42
Japan International Cooperation Agency (JICA) ................................................................. 42
Biogas ..................................................................................................................................... 42
References ............................................................................................................................. 43
Appendices .............................................................................................................................. 45
Appendix A: Ciwaringin Project Stakeholders ...................................................................... 45
Appendix B: su-re.co Gap Analysis ....................................................................................... 46
Appendix C: LCI Instructions ............................................................................................... 48
Appendix D: LCI Input/Output Template ............................................................................. 51
Appendix E: LCI and Questionnaire Result Data ................................................................. 53
Appendix F: LCI Clarification Email Message ..................................................................... 71
Appendix G: Potential Stakeholders ..................................................................................... 74
List of Figures

Figure 1: Hand-dyed batik from Ciwaringin Batik being hung up to dry...................................................................................... 2
Figure 2: Circular economy within the biological cycle and technical cycle ..................................................................................5
Figure 3: RESOLVE Framework – Ellen MacArthur Foundation..................................................................................6
Figure 4: Indigofera tinctoria leaf held by Ivan Bobashev............................................................................................9
Figure 5: Natural indigo paste after fermentation process ..................................................................................................10
Figure 6: Heated dye vat using natural indigo paste .............................................................................................................11
Figure 7: Group of Ciwaringin Batik craftsmen canting batik motifs ......................................................................................13
Figure 8A: A Ciwaringin craftsman hand-paints a motif design with tegeran bark dye .........................................................14
Figure 8B: Batik being dyed in an indigo dye vat ................................................................................................................14
Figure 9: Linear economy model created by the Ellen MacArthur Foundation ..................................................................................16
Figure 10A: Ibu Lina holding processed natural indigo powder from UGM ..............................................................................20
Figure 10B: A Ciwaringin craftsman hanging a naturally dyed batik sheet ..................................................................................20
Figure 11: Batik production flow diagram ..................................................................................................................21
Figure 12: Production flow diagram stage – batik motif design ..........................................................................................22
Figure 13: Production flow diagram stage – batik dyeing ........................................................................................................23
Figure 14: Production flow diagram stage – pelorodan ........................................................................................................24
Figure 15: Comparison of water consumption by Ciwaringin craftsmen ..................................................................................29
Figure 16: Indigo consumption comparison by Ciwaringin craftsmen .....................................................................................30
Figure 17: Categorized CE production methods within Ciwaringin Batik – RESOLVE Framework ........................................32
Figure 18A: Mahogany bark being used as a natural dye color .................................................................................................33
Figure 18B: Ibu Lina of YRE holding a naturally dyed batik .................................................................................................33
Figure 19: Simple water filtration system ....................................................................................................................38

List of Tables

Table 1: Organic dyes used in Ciwaringin Batik ....................................................................................................................8
Table 2: LCI input data for one naturally indigo-dyed batik sheet ..................................................................................25
Table 3: Calculation for monthly indigo cost ..................................................................................................................27
Table 4: Calculation for average monthly sales ..................................................................................................................28
Table 5: Calculation of monthly indigo consumption with and without reduction rate ....................................................30
Table 6: Calculation of monthly indigo consumption data error percentage ..................................................................31
Introduction

Water is one of the most significant natural resources in the world today. Shaping landscapes, creating life, and supporting global economies, water contributes to every facet of life. Yet its quality, availability, and accessibility continue to diminish due to various human impacts and climate change. Climate change research has identified water scarcity and water pollution as the top two environmental concerns across both the northern and southern hemispheres (Greenpeace International, 2013). As industries continue to develop, waterways become increasingly polluted, damaging vital ecosystems and threatening global water quality. Many industries release hazardous wastewater into the environment without proper treatment methods, especially those in the southern hemisphere, where the cost of industrial chemical additives remains low and regulations on industry production are lax (Greenpeace International, 2013). Industry in high-income countries has been able to tackle industrial pollution, whereas lower-income regions in the southern hemisphere continue to see an increase in water pollution (Greenpeace International, 2013). Much of the economic development being experienced in these regions is due to an influx of global consumerism, specifically clothing and textiles, with textile manufacturing being a primary culprit in water quality degradation.

Indonesia is a major contributor to the global textile and clothing industry. As the largest economy in South East Asia, Indonesia sits among the top 10 largest clothing and textile exporters in the world (Greenpeace International, 2013). According to data from 2016 from the World Integrated Trade Solution (WITS), textiles and clothing are 8.19 percent of Indonesia's global exports, an estimated 11.8 billion USD (World Bank Group, 2018). Trading roles between the Association of Southeast Asian Nations (ASEAN) provide an increased opportunity for Indonesian textile trade as the number of trade barriers is greatly reduced, increasing exports and GDP. The traditional Indonesian textile manufacturing style, known as batik, remains a major contributor to the global textile demand and is manufactured at various production scales of textile production. However, as Indonesia’s textile industry grows, its waterways continue to suffer. Hazardous industrial chemicals are being discharged directly into waterways with little to no wastewater treatment practices in place. With 60 percent of Indonesia’s textile industry sitting in the Citarum River watershed in Bandung, West Java, water quality in the region has severely suffered (Greenpeace International, 2013). The rapidly diminishing water quality of the Citarum River degrades the surrounding environment, affects the local finishing industry, and significantly reduces water availability.

The Citarum River supplies the Bandung metropolitan area and the greater Jakarta region, where a combined 35 million people reside (Asian Development Bank, 2013). Several factors influencing water quality contribute to the pollution of the Citarum River. Agricultural runoff and sewage lead to addition of nitrate and other nutrients into the waterways, leading to eutrophication and anaerobic water conditions (Greenpeace International, 2013). Hazardous chemicals from industries also contribute to the polluted waterways as chemicals build up in rivers and oceans and enter the food chain, adversely affecting human and ecological health. Concentrated within the Upper Citarum area, textile manufacturing dominates industry, representing “68% of all industrial factories in the region, with a total of 446 textile manufacturing facilities” (Greenpeace International, 2013). Of the estimated 1,500 industry facilities in the Bandung Basin, only 300 have registered wastewater treatment plants revealing that many facilities in the Bandung region remain unregistered (Van Ginkel, 2015). These textile manufacturers produce batik at both the industry and small and medium enterprises (SME) levels.

For many textile manufacturers operating at micro and small enterprises these regulations do not apply; only licensed medium to large enterprises are required to obtain a wastewater treatment plant. Herein, regulations remain obsolete and wastewater treatment non-existent, and many SME batik manufacturers dump hazardous water into surrounding waterways and fields. SME batik manufacturers in the Bandung region focus on the dyeing and finishing phases of textile production, showing their traditional patterns, which vary region to region. Experts in climate change and textiles have identified the dyeing and finishing processes in textile manufacturing as the most polluting production methods. However, the traditional Indonesian batik originally used natural dyes made of indigo and tree bark. This traditional manufacturing technique has been preserved
in many rural SMEs around Indonesia and is changing the way local and global consumers and big industry view textile manufacturing.

![Hand-dyed batik from Ciwaringin Batik being hung up to dry.](image)

Figure 1: Hand-dyed batik from Ciwaringin Batik being hung up to dry.

Producing sustainably dyed and finished batik still faces many challenges. Depending on an SME’s location and land availability, dye color and ingredients are imported or purchased from a third party. Few SME batik manufacturers can cultivate indigo within their region due to a lack of indigo farming knowledge, adequate arable land, and harvest-time availability, leaving the remaining craftsmen dependent on outside resources for dye color. Additionally, deteriorating water quality in the region affects water supply and availability, leading to many rural SMEs drilling their own water wells. Ciwaringin Batik collective is one SME batik manufacturer, located in West Java, that continues to change its production processes to alleviate environmental impact and produce environmentally friendly batik. Many of the craftsmen within this collective continue to practice traditional natural batik dyeing techniques and show interest in sustainable textile production.

Sustainable development in the textile industry has influenced innovation in textile manufacturing. Consumers are becoming more environmentally conscious as media exposes the dark side of the textile industry, further supporting the transition back to more natural, more environmentally friendly production methods. The demand for naturally dyed batik has dramatically increased over the last decade, alleviating economic pressures within Ciwaringin Batik. Due to this shift in consumer attitude environmentally friendly textiles have greater value to the consumer. Former batik craftsmen are returning home from migrant work outside of Ciwaringin to learn the traditional batik techniques once again. As SME batik manufacturers in rural Indonesia compete for consumer demand, those who produce more sustainably can sell their products at a higher price point. Yet Ciwaringin Batik operates at small production margins, limited by land and time constraints, the ability to market and sell their products at the price that reflects its superior quality and cultural significance, and evidence that proves traditional production methods are environmentally conscious.

The textile industry is constantly faced with numerous environmental challenges, and until the late 19th century, few tools existed to assess the sustainability of industrial production. Now, a common method for assessing environmental impact is Life Cycle Analysis (LCA). LCA has been identified as “the best framework for assessing the potential environmental impacts of products currently available” (European Commission, 2003). The importance of LCA as a tool for sustainability vetting continues to grow as both consumers and
government bodies demand production transparency. Additionally, LCA is used by textile manufacturers who target niche markets of sustainability-conscious consumers as proof of their environmentally friendly production.

SMEs are viewed as the “cornerstones of sustainable development” (Van Hoof et al., 2013). With the help of the Sustainability and Resilience Co (su-re.co), Yayasan Rumah Energi (YRE) and PUPUK, Ciwaringin Batik has the potential to set the standard for sustainable SME batik manufacturing. This study intends to further empower those working within the Ciwaringin Batik collective through sustainability vetting (to assess the batik production process), conducting a feasibility study (to determine the feasibility of su-re.co assistance, and the su-re.co and YRE partnership), and providing sustainable development strategies (to offer environmentally friendly alternatives and production practices to Ciwaringin Batik).

**Aim and Objectives**

The aim of this study is to assess the sustainability of the production processes of batik dyeing and finishing at Ciwaringin Batik. This sustainability vetting will determine the environmental sustainability of batik production at Ciwaringin Batik and make recommendations for sustainable development and growth strategies to further empower the Ciwaringin Batik collective in the natural indigo-dyeing batik community. Furthermore, this research intends to serve as primary supporting evidence for su-re.co to move forward in a collaboration with Ciwaringin Batik and YRE.

The specific objectives were set to:

- Evaluate the sustainability of the natural indigo-dyeing process at Ciwaringin Batik based on data obtained through site visits and surveying.
- Provide the Ciwaringin Batik collective with sustainable development strategies.

**Scope and Limitations of the Research**

The Ciwaringin Batik manufacturing process has countless potential research focus points within it. Due to time constraints this study has been limited to the inputs and outputs of producing one sheet of naturally indigo-dyed batik, based on the current batik dyeing and finishing techniques.

**Scope – Ciwaringin Batik Collective**

Ciwaringin Batik is an organized collective of traditional Indonesian batik craftsmen located in Ciwaringin, a small district in Cirebon, West Java. This batik collective consists of roughly 180 batik painters and dyers who have lived and naturally dyed batik as their community has since the end of the 19th century. Although Ciwaringin craftsmen produce batik as a collective, craftsmen primarily practice their craft individually. Nine (9) batik craftsmen were selected from the 60 operating craftsmen who dye and finish batik, with respect to existing diversity (delineated subsequently in this report), to assess sustainability and production methods within Ciwaringin Batik. These 9 craftsmen responded to a questionnaire and Life Cycle Inventory (LCI) survey to collect batik production data and information on business operations. The justification behind the data collection methods is further explained and supported in the section of this thesis titled "Methodology". This scope is limited to assessing the sustainability of the ongoing natural indigo dyeing and finishing production methods of the selected 9 Ciwaringin Batik craftsmen, providing sustainable development suggestions based on the Circular Economy RESOLVE Framework and prioritizing these suggestions based on su-re.co and YRE implementation feasibility.

**Limitations and Challenges**

It was su-re.co’s intention to conduct a Life Cycle Analysis to provide thorough environmental sustainability vetting of the production process at Ciwaringin Batik. However, numerous limitations arose throughout the various stages of research, hindering the performance of a full LCA. Limited funds also restricted the su-re.co
team to a single visit to Ciwaringin Batik, making it necessary to rely on PUPUK and its on-site team to distribute and collect the questionnaire responses and LCI results. Time constraints limited the surveying capacity to just 9 of the estimated 60 artisans who actively dye and finish batik. Furthermore, lack of data from the craftsmen and LCA database limited the development of an accurate production model. Nearly all collected quantitative data relied heavily on qualitative variables, making several assumptions, rendering it implausible to perform LCA at this time.

Challenges were primarily experienced during data collection and data interpretation. Coordination with on-site surveyors generally provided a speedy data turnover, yet data inconsistencies, clarifications, and lack of knowledge of Ciwaringin production methods resulted in a lagged dataset completion. To perform sustainability vetting with an LCA or circular economy approach, comprehensive knowledge of the production methods, resource purchasing, batik collective culture, and business operations is required, at a minimum. The entirety of this data was not obtained due to the craftsmen's reluctance to share information about batik production methods, especially those that were environmentally damaging (i.e., wastewater and wastewater filtration methods).

As data was collected, it became apparent that questions about production methods had to be direct and fundamental to ensure that no information was misconstrued. This alone provided varied challenges and required much clarification and coordination with PUPUK to understand the various cultural, social, and economic complexities that exist within Ciwaringin Batik. Many craftsmen within Ciwaringin Batik live in a low-tech economy, making several of the action plans within the RESOLVE Framework used in this study inapplicable. Much dialogue with Pak Cecep, Executive Director of PUPUK, was necessary to confirm that the sustainable development suggestions were achievable, and if not achievable now, then perhaps in the future, given more time and additional funding.

Theoretical Framework

The theoretical framework used in this study is the Circular Economy (CE) RESOLVE Framework developed by the Ellen MacArthur Foundation. The RESOLVE Framework is derived from the CE Principles and Characteristics and is a circular framework designed as a guide for businesses to transition from existing processes to circular operational practices and to develop circular strategies and growth initiatives (TCE MC). CE Principles describe the intended goals and action plans for developing circular economy strategies while CE Characteristics describe what a circular economy is.

CE Principles and Characteristics

To understand the RESOLVE Framework, it is necessary to further elaborate on what a circular economy is and what it aims to achieve. A circular economy is restorative and regenerative and always aims to keep products and materials at their highest utility and value (Ellen MacArthur Foundation et al., 2015). In present-day society, which functions in a linear economy (from cradle to grave), CE provides a foundation for businesses to operate sustainably from start to finish, and then start again (cradle to cradle). Designing with end-of-life in mind enhances the consumer's ability to choose sustainable products that reduce their ecological footprint and the producer's production costs and environmental impact, as well as drive sustainable innovation. The Ellen MacArthur Foundation has been a pioneer in CE and works with industry experts and government organizations to gain clear insight into how a circular economy can be achieved. When researching CE, the Ellen MacArthur Foundation and collaborators thoroughly studied the impacts of creating a circular economy in the EU and delineated the necessary steps for transition toward it.
A circular economy aims to connect the end of a product's life cycle to the beginning through recycling, reusing/remanufacturing and lengthening a product's lifespan. Figure 2, created by the Ellen MacArthur Foundation, illustrates the characterization of materials, energy, and resource flows within a circular economy.

The circular economy’s foundation is set in its three principles, and each CE principle is based on sustainable consumption and production ideals.

“Principle 1: Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows” (Ellen MacArthur Foundation et al., 2015). This principle focuses on using available technology to dematerialize and provide virtual utility (Ellen MacArthur Foundation et al., 2015). This is done by wisely selecting resources and technologies that use renewable resources or resources that improve the current system.

“Principle 2: Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles” (Ellen MacArthur Foundation et al., 2015). The technical cycle encompasses finite resource management, replacing use with consumption, and restoring and recovering technical materials. The biological cycle includes flows of renewable materials, where consumption occurs, and renewable nutrients are regenerated (Ellen MacArthur Foundation et al., 2015).

“Principle 3: Foster system effectiveness by revealing and designing out negative externalities” (Ellen MacArthur Foundation et al., 2015). This principle is further described as reducing damage to systems such as food, education, and health, and then managing externalities such as land use, water, and pollution.

These circular economy principles are designed for action, whereas the five fundamental characteristics describe a circular economy (Ellen MacArthur Foundation et al., 2015).

1. Waste is “designed out”
2. Diversity builds strength
3. Renewable energy sources power the economy
4. Think in systems
5. Prices or other feedback mechanisms should reflect real costs

The CE principles and characteristics provide general guidelines and action plans when transitioning to circular production and consumption. A more specified set of actions was created by the Ellen MacArthur Foundation through conducting case studies and expert interviews, which can be recognized as the RESOLVE Framework.

The RESOLVE Framework

The Ellen MacArthur Foundation identified six actions that businesses can take to shift toward a circular economy: Regenerate, Share, Optimize, Loop, Virtualize, and Exchange, creating the RESOLVE Framework. The RESOLVE Framework provides businesses with a strategy for moving to sustainable growth and circular business designs. This framework was built on the notion that it could be implemented in a technologically advanced economy, such as the European Union (EU), at any business scale. The opportunities provided within the RESOLVE Framework are general ideas that encourage those who subscribe to them to further elaborate on and implement them within businesses to guide the transition to a circular economy. Each action within the framework represents opportunities for businesses to use available technological developments to create circular growth. Figure 3 shows the RESOLVE Framework in detail.

![RESOLVE Framework](image)

**Figure 3: RESOLVE Framework – Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015).**

Because the RESOLVE Framework is a guideline for making a transition to circular business practices, it was used in this study as a brainstorming tool and theoretical methodology to develop circular growth strategies for Ciwaringin Batik. Although the RESOLVE Framework was developed with the EU in mind, one could argue
that a circular economy can be implemented at any scale in any geographic location. The Ellen MacArthur Foundation was created to aid the transition to a circular economy, with their research focusing on the EU. Yet, if the scope of study is shifted to a location with a different socio-economic status, the circular economy principles remain the same. As sustainable development strategies are developed for Ciwaringin Batik, these CE principles and characteristics and the RESOLVE Framework’s actions will be used as the foundation for the transition to a more circular production than Ciwaringin Batik has been traditionally using.

CE generally applies to both the production and consumption of goods and services. For the purposes of this study, CE will only be integrated into Ciwaringin Batik collective’s batik production practices and not on the consumption aspects. This application is limited to Ciwaringin Batik production due to the lack of consumer data from Ciwaringin craftsmen.

Using this framework, sustainable development strategies were created and tailored to Ciwaringin Batik based on recorded LCI data and questionnaire responses, coordination with Ciwaringin Batik and PUPUK, and data collected throughout this study period. These strategies factor in implementation feasibility regarding socio-economic standings, as well as the craftsmen’s desire to change certain production methods. Based on this information, the strategies are then ranked based on implementation feasibility.

**Methodological Framework**

Generally, in Indonesia, industrial textile production methods are highly automated, well-documented, and monitored by government and industry, providing consistent and accurate data ideal for a quantitative analysis (e.g., LCA). However, the scope of this study focuses on rural Indonesian SME batik production, for which the same standards of data consistency, accuracy, and availability cannot be expected, due to the many socio-economic variables affecting textile production, available technology, and production scale. Using quantitative analysis alone would be impractical and inconclusive because all data collected relies heavily on qualitative factors. Therefore, an iterative qualitative and quantitative framework was chosen as the methodological framework for this study.

Both quantitative and qualitative approaches reflect their respective advantages (Robertson et al., 2017). Quantitative scenarios provide a technical depth and can relate production methods within the SME to empirical real-world data (Robertson et al., 2017). An example of this are the material quantities used during batik production. Qualitative narratives can incorporate the various socio-economic characteristics experienced, providing a wider view of the research scenario. Many times, qualitative approaches are criticized for introducing research bias to a study and for reflecting a lack of technical depth (Robertson et al., 2017). However, quantitative models may also contain bias within their design, collecting specific data to produce a desired conclusion or data that lacks accurate system representation. By combining the two approaches of data collection and interpretation, information bias is reduced that could otherwise appear when one is researching a single method. Due to the nature and scope of this study, it is necessary to implement this iterative approach to ensure there is no misrepresentation of data and a fair conclusion is reached.

**History of Batik**

Although “batik” is a Javanese word, batik-dyeing is thought to have originated in India, and then circulated through trade routes that crisscrossed China, India, and Europe in the 16th and 17th centuries (Stephenson, 1993). Batik is the method of textile dyeing that uses wax as a dye resistant, creating elaborate patterns in fabrics. Under Dutch colonialism, Indonesia experienced many outside influences. The Dutch East India Company (DEIC) dominated commercial trade in the Indonesian archipelago and used dyed Indian textiles as currency for Malaysian spices and goods (Stephenson, 1993). Indonesia’s location along the DEIC’s trade route played a significant role in the development of Indonesian textiles. Indonesian textile incorporated this complex trade history in its designs, combining local motifs, and Indian and Dutch influences (Stephenson, 1993). Throughout Dutch colonial involvement, Dutch artists and scholars collaborated with Indonesia batik artisans,
introducing new design motifs and applications for their textiles (Stephenson, 1993). Local adaptations of Dutch designs became integrated into Indonesian batik, transforming local batik motifs and Indonesian culture, especially in Java, where Indian patola fabrics are still worn for weddings and other Indonesian ceremony (Stephenson, 1993).

The textile industry in Indonesia has substantially contributed to Indonesian tradition and culture. Batik motif designs used vary throughout Indonesia and represent a craftsman’s locale. Motifs on traditional garments can display one’s social status. Patterns are carefully hand-drawn with an apparatus made of copper and bamboo containing hot wax onto the motif design (canting), or wooden blocks with hand-carved patterns are dipped into hot wax and then pressed onto the fabric to create detailed repetitive designs along the entire sheet (blocking), the former of the two methods rendering a higher retail value. Furthermore, batik motifs are traditionally designed on cotton yet can be seen on silk worn by Indonesian aristocrats and government officials. Just as in most cultures, Indonesians have “every-day” and occasion wear. Traditional Indonesian garments worn are dependent on region and occasion and can include: kain pandjang (which translates to "long cloth") – a rectangular sheet worn around the hips by both men and women decorated with motifs traditionally made with blocking; sarong – a cloth sewn to fit around the hips; and kain kapala (specific to Javanese culture) – a headcloth designed with a blocking pattern that is bordered by a more elaborate and detailed design made by canting (Mijer, 1919). Indonesian history, art and society are all represented in the batik of one’s region. Javanese batik is predominantly recognized as traditional Indonesian batik and is worn all over South-East Asia.

Historically, Indonesia has used natural dyes when making batik for centuries. Dyes used when creating batik are unique to the craftsman’s location, creating a region-specific motif and color scheme (Rinawati, et al., 2017). Indonesian craftsmen have produced dyes from local species of trees, flowers, roots, wood, leaves, and other plants from their local environment. For example, blue can be made from fermented indigofera (indigo) leaves and is seen in batik all around Indonesia. However, yellow is only traditionally seen in batik from Java, where craftsmen extract the color from tegeran trees (Rinawati, et al., 2017). Batik not only represents the culture of Indonesia, it represents its people and their relationship with the environment.

In Ciwaringin Batik, the traditional practice of batik dates back to the same era but became more popular in the late 19th century. Batik tulis, are the finest of batik created in Java, made with canting wax in between dyeing (Stephenson, 1993). Over five generations of batik craftsmen in Ciwaringin have used natural dye colors from indigo, tree bark, and local plants to dye their textiles. Members within Ciwaringin Batik show pride in their tradition and resilience in creating traditional batik but remain wary of what the future of natural batik holds. In the last century, Ciwaringin Batik faced numerous setbacks threatening the survival of traditional batik production in the region. The widespread use of synthetic dyes in Indonesian textiles and the evolution of the batik printing press have continually lowered the price of naturally-dyed batik, thus reducing production margins within the community.

Despite these challenges the traditional natural dyeing technique in Ciwaringin survived. The continual use of natural dyes within Ciwaringin Batik illustrates the dedication to tradition and to the environment that many of the craftsmen still exhibit. Craftsmen in the collective who use natural dyes primarily use indigo. Table 1 shows the distribution of organic dyes used in Ciwaringin.

*Table 1: Organic dyes used in Ciwaringin Batik.*

<table>
<thead>
<tr>
<th>Dyes</th>
<th>Indigofera</th>
<th>Mahogany bark</th>
<th>Mango skin</th>
<th>Jengkol skin</th>
<th>Tegeran bark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color produced</strong></td>
<td>Blue</td>
<td>Dark brown</td>
<td>Yellow</td>
<td>Soft brown</td>
<td>Yellow</td>
</tr>
<tr>
<td><strong>Proportion</strong></td>
<td>70%</td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As illustrated in Table 1, indigofera (the local strain of indigo paste) accounts for 70 percent of the organic dyes used, while the remaining 30 percent are dyes made from mango skin and tegeran bark (yellow), and jengkol skin and mahogany bark (soft and dark brown). Other dye colors are being explored within the community as natural dyeing continues to gain popularity. However, dyeing with natural indigo still faces some challenges. Although the craftsmen do not process and extract indigo themselves, they still possess the knowledge required to extract the indigo dye color from the indigofera leaf just as their community have done in the past and passed down from generation to generation. This extraction process is crucial if Ciwaringin Batik were ever to produce its own indigo paste.

Dyeing with Natural Indigo

Three indigofera strains are native to the Bandung Java region, indigofera *tinctoria*, indigofera *arrecta* and indigofera *strobilanthes cusia*. Each of these varieties has been identified as containing significant levels of the precursor indican necessary for indigo dye extraction. Indonesia’s wild abundance of indigofera *tinctoria*, also known as true indigo, and other natural dye colors, presents the potential for SMEs to adopt natural dyeing techniques. Using natural indigo dyes promotes environmental sustainability and presents a unique opportunity to reintroduce natural dyes into batik production. However, to use this opportunity the extraction process of indigo dye from the indigofera plant must be understood.

![Indigofera tinctoria leaf held by Ivan Bobashev; the blue indigo color can be seen in the indigofera leaf.](image)

Extracting indigo dye color from the indigofera leaf is a simple yet time-consuming process. The most common method of extraction is water immersion. This is done when indigofera leaves are soaked in water overnight, creating a hydrolysis reaction that produces indoxyl (a white indigo oily liquid) and glucose (Purnama et al., 2017). Traditionally this method uses lime or other oxidizing agent to catalyze the fermentation of the indigo. These oxidizing agents change the indoxyl from white to blue. By oxidizing the indoxyl from the indigofera leaf in an alkaline solution made with lime, indigofera paste can be made. After fermenting, indigofera biomass is removed and excess water is poured off, leaving a mixture of the indigo dye and sediments. This mixture is sieved and dried, creating an indigo paste that is ready to use by a textile dyer.
It is important that the indigofera plants being used for extraction are fresh. Lower yields of indigo color will be produced from semi-dry-to-dried plant materials (Purnama et al., 2017). This is because the β-glucosidase enzyme found in indigo is more active when the indigofera leaves are fresh (Purnama et al., 2017). In a study performed by H. Purnama to identify conditions in which the highest yields of indigo are produced during fermentation, it was found that fresh indigo leaves soaked for 48 hours in cold water (room temperature around 30 degrees Celsius) produced the highest yield of indigo per indigofera leaf of 24+% (Purnama et al., 2017). The inclusion of lime in the water solution was subsequently analyzed to determine the effect on the indigo yield. Results from this experiment showed that the quantity of lime does have an impact on the yield, with a higher lime content generating a higher indigo dye concentration during fermentation (Purnama et al., 2017). The chemical reaction of lime with water can be expressed as follows:

$$\text{CaO(s) + H}_2\text{O(l)} \leftrightarrow \text{Ca(OH)}_2\text{(aq)} \quad (\Delta H_r = -63.7 \text{ kJ/mol of CaO}) \quad \text{……………………………………………………………(Eqn. 1)}$$

Further detail in the chemical reaction of indigofera, lime and water can be found in the study (Purnama et al., 2017).

Once the indigo dye paste is prepared, the dyeing phase begins. First, fabric that is to be dyed is soaked in water mixed with a mordant to clean the cloths of any previous bleaching or processing and prepare the fabric to be dyed. Mordants are metallic compounds used to “fix” dye colors onto textiles (Cunningham et al., 2011). Using mordants in the dyeing process is essential so dyes can create lasting chemical bonds to the textiles, increasing the quantity of dye absorbed in the textile threads (Cunningham et al., 2011). This step is important to increase color fastness, ensuring dye colors last through washing. This step can also be performed in the dyeing process by adding the mordant to the dye vat. However, to increase dye penetration and lower surface tension, fabric should be wetted. If the cloths are soaked, excess water is wrung out of the fabric, leaving the cloths slightly damp and ready to dye.

Following this, craftsmen can dye batik with vat dyeing or by hand-painting the indigo paste onto the desired area. For vat dyeing, a vat is filled with water and indigo paste (containing indigo color and lime) and heated to 60 to 70°C. This temperature is maintained from 30 minutes to an hour depending on dye-vat size and is stirred.
to aid in indigo oxidation. A small quantity of lime is in the indigo paste. However, many craftsmen add more lime and other mordants, such as hydrogen sulfate (referenced in the document as hydrosulfate) or palm sugar, to ensure color fastness. Through hydrolysis, hydrosulfate, an ester of sulfuric acid (H₂SO₄), is broken down to alcohol and sulfuric acid (McGraw-Hill Dictionary of Scientific & Technical Terms, 2003). Figure 6 shows a ready indigo dye vat.

![Figure 6: Heated dye vat using natural indigo paste.](image)

Batik in Indonesia is predominantly made on white knitted cotton sheets, requiring a dye bath of 10 to 15 minutes, fully submerged in the solution to guarantee even color distribution. After the allotted time, the fabric is squeezed of excess dye and hung to dry/laid out to further oxidize the indigo color. When the fabric is removed from the dye bath, it first appears green-blue. As time passes, the fabric changes to a bright solid-blue hue. This color change is a result of the oxidation process. Depending on the desired shade of indigo the dyeing process is repeated. Fabric that contains wax-resistant from blocking or canting is generally dipped multiple times as the wax is removed between dye baths. Once the batik cloth is finished being dyed, all wax is removed in a process called pelorodan. All batik made in a week of dyeing is placed into a boiling hot vat of water. The pelorodan vat melts the wax off the dyed cotton fabric and washes any remaining excess dye out of the fabric. The used wax floats to the top, is collected, and can be reused at a certain reduction rate, or it is thrown out. Pelorodan is the final finishing process of batik production. This is the traditional batik dyeing process when using natural indigo dye, from dye extraction to a finished batik cloth.

Throughout these stages, significant amounts of water are being used. Because most SME batik craftsmen do not ferment their own indigo dyes, wastewater is generated only in the dyeing and finishing stages. In all textile production, both SME and industrial, these two stages have the most environmental impact because dye vat ingredients become effluents, polluting waterways (Chequer et al., 2013). Many Indonesian SME textile manufacturers use excessive quantities of dyes and mordants, water, energy, and wax due to lax regulations and inexpensive material costs. In the textile industry, inefficient dyeing and finishing continues to produce hundreds of thousands of tons of hazardous wastewater, contaminating environments with heavy metals, detergents, and dyes (Chequer et al., 2013). Due to the volume and composition of wastewater produced from textile manufacturing, it is classified as the most polluting of all industries (Chequer et al., 2013). Industrial and
SME textile manufacturers are beginning to feel pressure from governments and consumers to produce environmentally friendly textiles. SME batik producers, such as Ciwaringin Batik, are reigniting traditional batik production methods and promoting the use of natural dyes. Industrial and SME textile manufacturers alike are starting to consider what a fully sustainable textile production may look like and what steps are necessary to become one.

**Sustainable Circular Businesses**

Sustainability in industry presents itself in many ways and is integrated into every industry. Businesses now include sustainable innovation and development in overhead expenses as they compete for niche markets and challenge industry norms. This sustainable phenomenon can be identified as the development of a circular economy. Although CE concepts and research have existed since the early 19th century, the transition to CE is only now becoming relevant. The Ellen MacArthur Foundation tirelessly researches various economies and industries to identify areas where circular economy strategies can be applied and provide information for government leaders to change regulations. Circular economy continues to gain traction in Europe and around the world as businesses and individuals become more aware of climate change and sustainability. The Ellen MacArthur Foundation argues that transitioning toward a circular economy can reduce dependency on resources and waste generation, and increase resource efficiency, employment and business growth (Ellen MacArthur Foundation et al., 2015). Supporters of circular economy suggest that business that applies circular economy principles can enter untapped markets, increasing their profitability and sustainability. Naysayers, on the other hand, argue that transitioning to circular systems presents unaffordable strategies, and energy should be focused on mitigating current resource consumption and waste management.

To transition to a circular economy, a thorough analysis of business production and consumption of goods/services must be performed. Evaluating these business processes provides operations, consumer trend and market information. Such data can assist manufacturers, consumers, and government in sustainable innovation and business development strategies. As CE stands to create a zero-waste economy, necessary sustainability analysis is required and can be performed through a *Life Cycle Assessment (LCA)*.

**Life Cycle Analysis and Circular Economy**

A Life Cycle Assessment (LCA) is a structured, comprehensive, and internationally standardized method for quantifying all relevant emissions, resources consumed, the related environmental and health impacts and resource depletion issues associated with any goods or services (European Commission et al., 2010). LCA can be used to assess a product's entire life cycle, including resource extraction, product manufacturing, usage, waste disposal and recycling (European Commission et al., 2010). Often, solutions for an environmental problem associated with a product's life cycle unintentionally create an additional problem within the studied system. LCA is a tool that helps to avoid this "shifting of burdens" and aids in creating more sustainable production and consumption of materials (European Commission et al., 2010).

LCA was initially chosen as a method of analysis in support of the aims and objectives of this thesis, which furthermore aligns with su-re.co’s proposed sustainability vetting of the Ciwaringin Batik production process. LCAs have been widely used when identifying methods and materials in the textile industry that negatively affect the environment. Extensive research into textile manufacturing regarding environmental impact and mitigation strategies has provided vast insight into the various facets of the industry, exposing inefficient production methods and demanding sustainable innovation. Using LCA as the method for environmental impact analysis can pinpoint problem areas for which circular economy can be the solution. In the rapidly changing textile industry, combining LCA and CE can give textile manufacturers the upper hand, shifting the discussion from solely creating mitigation techniques to producing sustainable textiles as a whole and providing consumers and governments with radically transparent production data.

Prior to performing an LCA, inventory data of all system inputs and outputs must be gathered that are relevant to the system regarding data collection and interpretation (Rinawati et al., 2017). PUPUK’s field team
selected 9 dyeing and finishing craftsmen within Ciwaringin Batik to participate in the LCI data collection and questionnaire. Interview participants were selected with respect to existing diversity within the collective community to assess Ciwaringin Batik’s aggregate production methods accurately. Gender, economic well-being, age, and experience were all given consideration.

Ciwaringin Batik Production

Current batik production practices in Ciwaringin Batik are similar to those in the rest of Indonesia, regarding wax application (canting and blocking) and dyeing methods. Ciwaringin Batik craftsmen dye batik with both natural and synthetic dyes. Synthetic dyes are used by craftsmen who cannot afford natural indigo powder. Craftsmen in the community who use synthetic dyes strive to transition to natural dyeing. As more craftsmen increase their efficiency and productivity, their economic capacity is raised, providing economic stability and opportunity to produce naturally-dyed batik.

At Ciwaringin Batik, the craftsmen do not pre-soak the fabric in water mixed with mordant. Instead, mordant is added directly into the hot dye vat or added to the dye paste provided by a third party. Batik is produced two ways in the community, hand painted batik or vat dyed batik.

First, the batik motif is drawn onto a blank white cotton sheet using pencil. As previously stated, the process is split; designs are then covered in hot wax through canting or blocking. Areas covered in wax prevent dye color from being absorbed into the cloth, leaving blank spaces to be painted in/dyed afterwards. Canting and blocking are many times combined to create new unique designs, or motifs are custom ordered by customers.

![Figure 7: Group of Ciwaringin Batik craftsmen canting batik motifs.](image)

Following this, the dye process begins in two ways: The fabric is dipped repetitively into the dye vat, creating a solid background color across the sheet, or it is hand-painted with a dye paste. This process depends on the desired color pattern; layering/mixing dyes creates new colors. Dye vat ingredients consist of the desired dye color, vinegar, water, and lime or chalk powder (sodium carbonate). If the sheet is soaked in a dye vat, excess dye is squeezed out of the fabric back into the dye vat. Both vat-dyed and hand-painted cloths are then dipped into boiling water, removing all wax from the fabric (pelorodan). Then the cloths are hung to air-dry, oxidizing the colors to ensure the dye penetrates fully into the fabric.
Generally, the canting process is then repeated to create more intricate designs between dye baths, the cloth sheet is carefully hand-painted in small areas to add/change the color of the motifs, or both methods are combined. When darker colors are desired, more wax is used up front and then gradually removed after each round of dyeing. These motifs range from basic detailing along edges to extremely intricate full-sheet designs and can take anywhere from one day to one week to create, depending on customer requests and demands. A diversity of community-specific motifs, techniques, and quality of workmanship have been passed down across generations of Ciwaringin Batik families and community-wide. Four motifs are currently patented by Ciwaringin Batik and are among the most commonly produced there.

Currently, Ciwaringin Batik operates in the shadow of other regional SME batik production communities within the Cirebon district. One such batik producer is Batik Trusmi. This centrally located community benefits from greater financial capital and economies of scale than does Ciwaringin Batik. Batik Trusmi can sell its products cheaply, often as a result of using inexpensive synthetic dyes and less environmentally friendly production practices. As a result, Ciwaringin Batik continues to brand itself as an environmentally friendly batik SME (ECO Batik) and was awarded the title of Center of Organic Batik by the Indonesian government. With this branding, Ciwaringin Batik hopes to access the niche natural batik dyeing market. Ciwaringin Batik also welcomes the support of local government and non-governmental organizations (NGOs), especially to aid in expanding their access to markets. Perkumpulan Untuk Peningkatan Usah Kecil (in English, the Association for Advancement of Small Business) (PUPUK) is a Bandung-based NGO currently assisting the 9 batik craftsmen who were affected by development of the Cipali Toll Road in Bandung. PUPUK supports these craftsmen in business and with institutional development, financial management and networking.

su-re.co Involvement

Initially, su-re.co was introduced to the natural indigo-dyeing batik produced at Ciwaringin Batik through Lina Moeis (Ibu Lina), the Executive Director of Yayasan Rumah Energi (YRE), the operating arm of the Indonesia Domestic Biogas Programme (BIRU). Conversations between su-re.co’s CEO, Takeshi Takama, and Ibu Lina led her to request su-re.co support in evaluating the potential for creating value-added opportunities within Ciwaringin Batik’s business through the integration of biogas and bioslurry. su-re.co was asked to assist in this business development due to its experience in creating value-added businesses for farmers using biogas in rural Indonesia. The integration of biogas into the Ciwaringin Batik collective would contribute to a sustainable agricultural project in which indigo would be grown and processed.
into natural dye, creating a sustainable natural indigo supply for the Ciwaringin textile craftsmen. Additional information on potential stakeholders can be found in Appendix A.

A thorough feasibility study was performed to identify areas in which su-re.co could contribute to the empowerment of Ciwaringin Batik. This feasibility study lays some initial groundwork in the research within this report, providing background information, a market analysis, business development plan, stakeholder analysis and partnership-building strategies, and securing donor support. The research in this study will provide the sustainability vetting required by su-re.co and contribute to the Ciwaringin Batik feasibility study. Within the feasibility study, a gap analysis was performed to identify how su-re.co’s proposed scope of contribution aligns with the needs of Ciwaringin Batik and its vision for future operations. Furthermore, the gap analysis delineated the barriers to entry, complete with specific activities aimed at mitigating each barrier and identifying which partner would be best suited to conduct the activity. (The gap analysis table and description can be found in Appendix B.) This gap analysis further clarified the efficacy of su-re.co’s intervention with Ciwaringin to ensure the proposed contributions were relevant.

Ciwaringin Batik’s desire to produce more sustainably and enter more competitive markets directly correlates with the goals of su-re.co involvement. A niche market for naturally-dyed Indonesian batik and fabric exists within the community where su-re.co is based. The intended partnership involving Ciwaringin Batik, PUPUK, YRE, and su-re.co will potentially extend far beyond the sustainability vetting performed in this study.

Methodology

The iterative qualitative and quantitative methodological framework used in this study increases the consistency between the two storylines. Qualitative methods used within this research are site visit observations and individual interviews. Quantitative data collection methods used are surveying for the LCI and the distribution of a questionnaire. Following data collection, many assumptions were made due to the nature of the information received from the craftsmen. These assumptions can be found in a later section.

An initial literature review of the Indonesian textile industry and circular economy was preformed to further understand the many complexities of the textile industry and circular economy applications. Following this, a su-re.co team visited Ciwaringin Batik collective to observe the ongoing batik dyeing and finishing practices and gather necessary data for the required sustainability vetting of Ciwaringin Batik and related su-re.co feasibility study. Subsequently, a sustainability assessment of Ciwaringin Batik’s naturally indigo-dyed batik was conducted. Data for this assessment was collected in the form of a Life Cycle Inventory and questionnaire. The results of this assessment prompted the development of sustainable production alternatives for Ciwaringin Batik based on the Circular Economy RESOLVE Framework. This study was conducted over a six-month period, with three months of literature review and defining the research parameters, and three months of data collection, data interpretation, and writing.

- Literature review of the Indonesian textile industry water pollution, water resource management, naturally indigo-dyed batik, and the principles and characteristics of a circular economy
- An initial site visit to Cirebon, West Java, in cooperation with Yayasan Rumah Energi (YRE) and PUPUK to identify and document indigo dyeing and finishing practices at Ciwaringin Batik
- Input and output production data collected in LCI format, along with a questionnaire, the answers to which further clarify production methods and business data
- Development of workable alternatives and sustainable development practices for Ciwaringin Batik, based on the Circular Economy RESOLVE Framework

Next is a sub-section containing the further elaborated LCI data collection method and the development of sustainable batik production suggestions for the craftsmen at Ciwaringin Batik.
Life Cycle Inventory Data Collection

Life Cycle Inventory is the data collection methodology used in a Life Cycle Assessment. This method for data collection was used because it is the standard data collection process when conducting an LCA. Because it was the initial intention of su-re.co to perform an LCA, and it was unknown that conducting an LCA was not feasible until data collection began, the LCI format is still used as the primary data collection method.

Today, society operates in the traditional linear economy model of “take, make, and dispose” (Ellen MacArthur Foundation et al., 2015). Using LCA as the sustainability vetting method for the linear economy model is common in the textile industry because LCA tracks environmental impact from the initial extraction of resources to the final disposal of the product made using those resources. It is due to this linear model that many of the finite natural resources are becoming depleted today. The Linear Economy Model shown in Figure 9 was created by the Ellen MacArthur Foundation.

![Linear Economy Model](image)

Figure 9: Linear economy model created by the Ellen MacArthur Foundation (Ellen MacArthur Foundation et al., 2015).

For sustainability vetting and empirical assessment of Ciwaringin Batik, it was necessary for the qualitative batik production model to be quantified. Quantifying the production methods used in the Ciwaringin Batik collective was accomplished through an LCI.

LCI is a precursory method of data collection used for LCA. All data related to the measurement of the environmental impact of the natural indigo dyeing at Ciwaringin Batik is collected and interpreted based on both quantitative and qualitative standards. LCIs identify the various inputs and outputs within a system necessary for analysis. For example, within the batik dyeing system the water used in dyeing batiks could be categorized as an input. The water, in turn, becomes an output of the system and is further tracked to identify what happens to it after its use in the dyeing process is done (e.g., reused, recycled, treated).

An LCI survey based on International Organization for Standardization (ISO) 14040 and ISO 14041 standards was created to gather system input and output data for Ciwaringin Batik’s production process. ISO 14040 provides general information on the LCA Framework, principles and requirements when one is performing an LCA. ISO 14041 states the necessary requirements when conducting and defining the LCA scope and goals and provides information for performing an LCI and interpreting the data collected. Locally operating partner PUPUK agreed to disseminate the survey on behalf of su-re.co. To ensure an accurate collection of data,
supplementary instructions were provided to PUPUK. Survey materials were written with attention to clarity and comprehensiveness to improve their usefulness and limit the amount of follow-up required to verify the survey results. In total, three documents were provided to PUPUK: LCI Instructions, an LCI spreadsheet and a questionnaire, each translated from English into Indonesian. The English form of the LCI Instructions and LCI Template can be found in Appendix C and D. Primary data collected from Ciwaringin Batik covered the material, energy, and resource (water) being used to produce one sheet of batik. Secondary data was gathered from scientific literature, interview transcriptions, and phone calls with coordinating partners.

PUPUK’s field team selected 9 craftsmen within the community to participate in the LCI data collection and questionnaire. Interview participants were selected with respect to existing diversity within the collective community to accurately assess Ciwaringin Batik’s aggregate production methods. Gender, economic well-being, age, and experience were all given consideration. Due to the nature of the information collected and the willingness to provide accurate information, quantitative data was not entirely reliable. Therefore, additional qualitative data was collected from site visits and phone and in-person interviews, email threads, and surveying. The LCI data set combined with the qualitative data provided sufficient information for a circular economy analysis and provision of sustainable development alternatives. Yet, data was severely lacking, preventing the completion of a full LCA.

**Sustainable Development and Circular Economy**

For the purpose of empirical sustainability vetting, the RESOLVE Framework was used to identify circular economy production methods existing within Ciwaringin Batik collective and used as a guideline when recommending sustainable development strategies for Ciwaringin Batik. If the Ciwaringin Batik collective currently practiced circular business methods, these production stages would be assessed against the RESOLVE framework.

Research conducted within the areas of natural dyeing, circular economy, the Indonesian SME textile industry, and Ciwaringin Batik provided the groundwork for the development of sustainable batik dyeing and finishing production suggestions, as well as operational business improvements. These recommendations are designed to be achievable by the Ciwaringin Batik craftsmen and are built on the RESOLVE Framework. This framework promotes the ideals rooted in a circular economy that are geared to sustainable circular production and consumption, and ultimately a completely circular society. Each set of recommendations was divided into the identified six actions within the RESOLVE Framework (Regenerate, Share, Optimize, Loop, Virtualize, and Exchange) and then prioritized based on the feasibility of adoption and environmental importance.

Communication with Pak Cecep was essential while developing the sustainable development strategies, to ensure the suggestions were, in fact, achievable and in line with goals PUPUK has previously coordinated with Ciwaringin Batik. It was important to consider the cost and implementation time of each suggestion due to the varying economic standings of the craftsmen. Seeing as the 9 craftsmen selected by PUPUK are assumed to be a representation of Ciwaringin Batik, it was also necessary to create recommendations that coordinated with the collective as a whole.

**Assumptions**

Throughout this research and analysis, it became clear that, to perform any quantitative or qualitative analysis, many assumptions would be necessary. Because the LCI spreadsheet and questionnaire were distributed by PUPUK and not a su-re.co team member, data received from the Ciwaringin Batik craftsmen was collected in multiple formats. This is due to the complexity of the LCI instructions, template, and questionnaire. Furthermore, questions concerning material quantities and batik production data are not specific enough, allowing craftsmen the opportunity not to answer any one question fully. Assumptions for LCI data collection and data interpretation are described below.
Data Collection

Several assumptions were made prior to and during the data collection and surveying of the 9 Ciwaringin craftsmen. Because PUPUK surveyors are not trained in LCA, creating a comprehensive and straightforward set of instructions for the LCI data collection process was required. Therefore, it is assumed that the PUPUK team fully understood the instructions and conducted the data collection per the requirements of the documents provided. Owing to the close proximity within which the Ciwaringin Batik craftsmen operate, it is assumed that results from the survey are mostly similar. Existing relationships between the craftsmen and PUPUK are also expected to influence study group participants.

Furthermore, the 9 surveyed Ciwaringin craftsmen provided no written record of their individual material and resource purchases for batik production and specific resource input and output amounts, and all LCI data and questionnaire answers were received orally and then transcribed by a PUPUK team member, making it difficult to go back and verify accuracy. Therefore, it is assumed that the data collected from the craftsmen is precise and honest with respect to the analysis of the collected results.

Data Interpretation

Data collected from the Ciwaringin craftsmen is reported in the provided LCI format, alongside the completed questionnaire. The unit measurements of the recorded data varied among the craftsmen (e.g., input amount used per dye vat versus per batik sheet produced, output amount per vat versus per batik sheet) and much discussion with Pak Cecep from PUPUK was needed to clarify the accuracy of the input and output data derived during the production of one naturally indigo-dyed batik sheet. Therefore, during data interpretation the following assumptions are made.

Unless otherwise stated:

- The amount of hydrosulfate used is per sheet of knitted cotton batik.
- The amount of sodium carbonate is per sheet of knitted cotton batik.
- The standard dye vat contains 20 liters of water.
- Vat-dye-stuff ingredients are used at a reduction rate of 20 percent per vat, with 80 percent of vat-dye-stuff ingredients being new for each sheet of batik.
- Vat water is reused 3 times in water consumption calculations.
- Wax is reused at a reduction rate of 30 percent, with 70 percent being new wax for each new sheet of batik.
- Each batik sheet is a blank canvas, with no previous motif design or dye color.
- Average monthly Ciwaringin Batik motifs produced are made with only natural indigo dye.
- An average month is 30 days.
- Traditional gender roles are ignored, and both genders perform the same tasks throughout production.

These assumptions aid in the data interpretation and help provide consistent quantitative results and a basis for the sustainability development strategies created for Ciwaringin Batik.

Results and Data Analysis

Results and data from the su-re.co site visit to Ciwaringin Batik, LCI data and questionnaire responses, and RESOLVE analysis are provided below. The results and data are divided among the respective iterative
qualitative and quantitative methods used in this research, to illustrate the various steps taken in data collection and analysis. All data collected will be presented in this section, yet only data pertinent to the su-re.co feasibility study regarding business opportunities and sustainability vetting will be thoroughly discussed and analyzed. su-re.co identified relevant production data to be production data related to batik sales and monthly indigo cost, and water and indigo consumption. Therefore, data throughout this section will be centered around these focal points in the following qualitative and quantitative sections. Full LCI data spreadsheets and questionnaire responses from the 9 participating craftsmen are provided in Appendix E.

Each of the following sections analyzes the data relevant to said section (e.g., LCI spreadsheet data reflects only data recorded in the LCI spreadsheets or questionnaire data referencing the data collected from questionnaire results, with exceptions for water and indigo consumption data because the amount of water and indigo used per batik sheet is only recorded in the LCI spreadsheet). Different assumptions apply to each section and have been stated in the Assumptions sub-section in Section 3. Methodology.

Data collected from the LCI spreadsheets, questionnaire, email messages and phone conversations with PUPUK identified existing circular economy inspired methods within Ciwaringin Batik. The RESOLVE Framework was used to categorize and analyze these production methods.

**Ciwaringin Batik – Qualitative Approach**

Although the data collection methods were designed for quantitative purposes, much of the data received relied heavily on qualitative factors, such as age, experience, gender, and socio-economic status. Furthermore, the lack of a complete LCA database rendered it infeasible to rely solely on the quantitative data collected in the LCI spreadsheets and questionnaires. These various qualitative variables hindered the completion of a full quantitative analysis, therefore prompting an iterative quantitative and qualitative data collection and analysis.

**su-re.co Site Characterization**

On June 19 and 20, 2018, the su-re.co indigo team met with project stakeholders (Ibu Lina of YRE and Pak Cecep of PUPUK) in Cirebon, West Java, to attend a scheduled site visit at the Ciwaringin Batik collective. This site visit was deemed necessary to identify the roles of the involved stakeholders accurately, observe the production of batik at Ciwaringin Batik, interface with the project’s potential beneficiaries, and further understand the difficulties that they encounter. Qualitative results from the semi-structured interviews with Ciwaringin craftsmen provided su-re.co with further understanding of the batik production in the Ciwaringin community. The results relevant to this research have been simplified and are stated in the following paragraphs.

Ciwaringin Batik collective receives its primary sales from showrooms within the community, supplemented by online sales and travel. Middlemen generally purchase the batik produced and then resell the products across Indonesia. The varying social and economic status of the individual craftsmen limits production capacity and production sustainability. Craftsmen within Ciwaringin Batik have the desire to produce 100 percent naturally dyed batik, yet the cost of the synthetic indigo powder remains more affordable, and thus it is still being used by craftsmen who cannot afford the natural indigo powder. Those on the lower end of the economic scale remain unable to afford natural dye due to a lack of production capacity, resulting in lower monthly income and consequently less sustainable batik production.

It was noted that hydrosulfate is the mordant used by the craftsmen in the dyeing process. In the past, brown cane sugar was used as the mordant agent in the preliminary dyeing stages. However, over time, this technique was lost as hydrosulfate was introduced into the community by “outsiders”. Now, it is unclear who provided the Ciwaringin craftsmen with hydrosulfate: a neighboring limestone quarry or Gadjah Mada University (UGM) in Yogyakarta, Java. Hydrosulfate continues to be used by all craftsmen due to its lower cost and ease of purchase. It was noted that the sodium carbonate is provided by the local limestone quarry and that the quarry supports a local youth group through organized batik-training events. Currently the craftsmen in Ciwaringin
Batik purchase ready-to-use indigofera paste directly from UGM, and other dyes are collected from their surrounding environment.

Figure 10A (Left): Ibu Lina holding processed natural indigo powder from UGM; Figure 10B (Right): A Ciwaringin craftsman hanging a naturally dyed batik sheet.

Pak H. Fatoni is one of Ciwaringin Batik’s leaders and is the primary contact through which PUPUK communicates with the collective. During the site visit, Pak Fatoni provided much of the insight into Ciwaringin Batik operations and expressed the community’s desire to remove middlemen from the batik production and selling phases. To do this, Ciwaringin Batik collective need to become independent in its material purchasing and batik selling.

Life Cycle Inventory – Quantitative Approach

The purpose of conducting an LCI was to gather information on the material, energy, and resources used in the Ciwaringin Batik natural indigo dyeing and finishing batik production. Information collected provided the inputs and outputs of the system and aided in the sustainability vetting of the naturally indigo-dyed batik produced. Pak Cecep and the on-site PUPUK team distributed the Life Cycle Inventory spreadsheet to the 9 participating craftsmen. Information from the su-re.co site visit, a batik production assessment from PUPUK, and a production input-output scheme developed by the ILCD Handbook are used as the guidelines for creating the production flow diagrams. The purpose of creating production flow diagrams is to provide a visual aid for the reader to understand the production process of the naturally indigo-dyed batik. Production flow of the naturally indigo-dyed batik produced by the 9 craftsmen and their most common practices are illustrated below in Figure 11.
Figure 11: Batik production flow diagram.

Knitted cotton is listed as a separate input, for purposes of clarity, to illustrate that the fabric used is purchased as processed knitted cotton and not manufactured at the batik collective, and therefore it is not included as a material input. Remaining inputs are dye color, energy, water, and materials. Materials used in the production flow are identified by the craftsmen as entirely soluble and therefore only included in the wastewater output. These materials will be detailed in the subsequent production flow diagrams. During the pelorodan process, solid waste includes wax that is not being reused and ash from firewood, and if used, burned mahogany bark. Emissions and excess heat are produced throughout all stages of production.

The Batik Production Flow Diagram shows the dyeing and finishing processes that the interviewed craftsmen use. Please see the section of this thesis titled “Ciwaringin Batik Production" for a review of the steps of the various Ciwaringin batik-dyeing processes.

Each stage of production is broken down into separate diagrams to illustrate the specific inputs and outputs in the system. The production flow diagram illustrates the batik production methods as recorded by PUPUK, not the assumed batik production methods used in the data interpretation, meaning wax is applied to the batik cloth through canting and is hand-painted before going into the dye vat. Batik in the production flow diagrams are not blank sheets of knitted cotton and contain no dye.
As previously stated, designing the batik motif begins with a blank sheet of knitted cotton on which the motif is drawn with pencil. Candle wax is then heated and poured into an apparatus used for canting, using a small electrical heating plate or fire to heat up the wax. The small apparatus used is usually copper and shaped into a narrow spout connected to a bamboo handle. The tool can be seen being used by the craftsmen in Figure 7. After the motif has been drawn on with wax, it is then hand-painted with dye. Emissions and excess heat are produced from the wax heating. Ready-to-dye batik is then placed in the dye vat as shown above in Figure 12.
Batik sheets are now ready to be placed in a dye vat containing water, vinegar, dye color, hydrosulfate and sodium carbonate. The dye vat is heated, and the prepared batik sheets are dipped into the liquid. These ingredients penetrate the cotton fabric threads not covered in wax and dye the batik cloth. All craftsmen identified liquid petroleum gas (LPG) as the energy source used in heating their dye vats. Batik dyeing produces excess heat and emissions from the dye vat and small amounts of dye wastewater when batik sheets are hung for oxidization, producing richer and brighter colors in the batik motifs. This production flow is illustrated above in Figure 13. Dye water is shown as an output because it is assumed that it is reused 3 times before being discarded. Yet, for simplicity this “reuse” is not reflected in the production flow diagram. However, additional information stated that some craftsmen use stationary dye vats, dumping no dye water, and only replenishing the dye-vat materials at the reduction rate provided previously. The use of a stationary dye vat will not be reflected in the resulting data or data interpretation.
Dyed batik is then placed in a separate bath of boiling water that is used for the pelorodan stage, or the stripping of the wax from the batik. Energy used in this process varies from craftsman to craftsman; many craftsmen use firewood mixed with other scraps from the dyeing process or LPG for pelorodan. Therefore, the outputs include both emissions and excess heat from energy. Wastewater produced is a result of the pelorodan wash, and solid waste is produced by the wax removed and ash from the burnt wood and scraps. Figure 14 illustrates the final stage of batik production, during which washed batik is hung for a final dry.

The production flow diagrams illustrate a summary of the dyeing and finishing processes commonly performed in Ciwaringin Batik. The production processes can be repeated depending on the detail of the design, number of colors used, desired color shade, and client motif request. However, to produce consistent data from design to finishing, all craftsmen were assumed to have reported data for dyeing a blank knitted cotton sheet containing a motif design drawn on through canting and vat dyeing, with no repetition of the dyeing and finishing processes.

The 9 craftsmen who participated in the LCI and questionnaire are as follows: H. Fathoni, Solifah, Farhan, Ida, Iim Rohimah, Umar, Toifah, Nuraliah, and Sanuri. Each craftsman interviewed provided production data for creating one sheet of naturally indigo-dyed batik. This data has been separated into system inputs and outputs to identify the processes and materials used that have the most environmental impact. This data presentation is standard when performing an LCA. These results will further contribute su-re.co business modeling and intervention strategy outside this report. For the purpose of this research, water and indigo consumption per craftsman was analyzed and compared. This analysis can be found in Appendix E: LCI and Questionnaire Result Data.

System Inputs

As assumed, all craftsmen interviewed provided similar system production data regarding input quantity used, where the input was purchased, and input cost per unit. The various inputs are cotton, hydrosulfate, sodium carbonate, candle wax, dyes – indigo powder, mahogany bark, or tegaran (yellow) bark, vinegar, water, and energy – liquified petroleum gas (LPG), mahogany bark, or firewood. Not all craftsmen use mahogany bark or
tegaran as dye colors, nor mahogany bark and firewood, as a source of energy; therefore, these dye colors were removed from the summary table below. Those craftsmen who do use mahogany bark as dyestuff tend to use these scraps plus firewood as fuel for the pelorodan process. The remaining craftsmen use only LPG, or a combination of the two, for pelorodan, and all craftsmen use LPG when heating the indigo dye vats. Due to these variations in production, a simplified table was created, focusing on the inputs common to the 9 craftsmen. Table 2 shows the simplified input data used to produce one naturally indigo-dyed batik sheet.

Table 2: LCI input data for one naturally indigo-dyed batik sheet.

<table>
<thead>
<tr>
<th>Craftsmen</th>
<th>Cotton</th>
<th>Hydrosulphate</th>
<th>Sodium Carbonate</th>
<th>Candle Wax</th>
<th>Vinegar</th>
<th>Water</th>
<th>Dye</th>
<th>Batik Dyeing</th>
<th>Pelorodan</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. Fathoni</td>
<td>330 g</td>
<td>0.16 g</td>
<td>300 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3 kg</td>
<td>3 kg</td>
<td>17 g</td>
<td>0.6 kg</td>
</tr>
<tr>
<td>Solifah</td>
<td>330 g</td>
<td>10 g</td>
<td>167 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3 kg</td>
<td>8 g</td>
<td>6 g</td>
<td>0.6 kg</td>
</tr>
<tr>
<td>Farhan</td>
<td>330 g</td>
<td>0.16 g</td>
<td>813 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3 kg</td>
<td>25 g</td>
<td>6.6 kg</td>
<td>10 kg</td>
</tr>
<tr>
<td>Ida</td>
<td>330 g</td>
<td>15 g</td>
<td>400 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>8 g</td>
<td>0.75 kg</td>
<td>0.75 kg</td>
</tr>
<tr>
<td>Iim Rohim</td>
<td>330 g</td>
<td>33 g</td>
<td>600 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>9 g</td>
<td>0.5 kg</td>
<td>0.5 kg</td>
</tr>
<tr>
<td>Umar</td>
<td>330 g</td>
<td>25 g</td>
<td>500 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>8 g</td>
<td>0.5 kg</td>
<td>0.6 kg</td>
</tr>
<tr>
<td>Toifah</td>
<td>330 g</td>
<td>33 g</td>
<td>600 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>8 g</td>
<td>0.5 kg</td>
<td>0.5 kg</td>
</tr>
<tr>
<td>Nuralifah</td>
<td>330 g</td>
<td>33 g</td>
<td>600 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>5 g</td>
<td>0.5 kg</td>
<td>0.5 kg</td>
</tr>
<tr>
<td>Sanuri</td>
<td>330 g</td>
<td>33 g</td>
<td>800 g</td>
<td>100 g</td>
<td>15 ml</td>
<td>3.33 kg</td>
<td>8 g</td>
<td>0.5 kg</td>
<td>0.5 kg</td>
</tr>
</tbody>
</table>

Data presented in Table 2 displays the inputs chosen for preliminary analysis and data provided in the LCI spreadsheet. Much of the data received is identical and as a result is omitted during data analysis. This is because all similar data (cotton, candle wax, and vinegar) have fixed parameters. The size of each batik sheet that is dyed remains constant with each sheet produced, as well as the amount of vinegar used in each dye vat. How much candle wax used varies per craftsman, depending on the batik motif created, but it is assumed to be constant due to the difficulty involved in estimating quantity.

Water consumption data recorded in the LCI spreadsheet shows little variance. Per the LCI spreadsheets 20 liters of water are used in the dye vats of Ida, Iim Rohimah, Umar, Toifah, Nuralifah, and Sanuri, and, on average, 6 batik sheets are dyed per 20-liter vat, resulting in 3.33 liters of water per batik sheet. H. Fathoni, Solifah, and Farhan reported 3 liters of water per batik sheet and also, on average, produced 6 batik sheets per 20-liter dye vat. The variance in water consumption shown in Table 2 illustrates how the input data value changes, depending on whether quantities were recorded per dye vat or per batik sheet produced.

Inputs that showed significant variation were hydrosulfate, sodium carbonate, indigo powder, and energy used – LPG or wood. These inputs are reportedly varied due to batik motif designs, dyeing and finishing experience, gender and socio-economic standings of the craftsmen participating in the survey. Hydrosulfate and sodium carbonate values depend on the motif design used by the individual craftsman. Generally, more hydrosulfate and sodium carbonate are used when there is a more detailed motif because a brighter “truer” color is desired.

Additional qualitative factors, such as gender and experience, need to be considered in these stages due to the motif design variation. Women in the community generally design more detailed motifs, hand-painting much of the intricate batik patterns, requiring more time to complete one sheet of batik and therefore having to repeat the production stages multiple times before a finished batik product is made. Repeating the canting, dyeing and pelorodan stages uses more materials and energy and creates additional wastewater, atmospheric emissions, solid waste, and excess heat loss, making the women’s process, on average, less sustainable than the men’s. Men design batik motifs as well, but they primarily dye the fabric. This is because it is considered a more laborious and hazardous task because the dye vats contain hot water and chemicals (hydrosulfate and sodium carbonate). Consequently, these traditional differences in the production based on the gender of the craftsman greatly affect the overall sustainability of batik produced in Cwaringin Batik. However, it is assumed these gender differences in production do not significantly alter the resulting data collected, and all craftsmen produce similarly.
System Outputs

Batik production system outputs are wastewater, solid waste, and atmospheric waste. As stated in the assumptions, dye water is recycled at a 20 percent reduction rate and is assumed to be used 3 times. Per this assumption, the wastewater of every third dye vat is discarded in nearby fields or streams. (These streams allegedly lead to SPAL, the local wastewater treatment plants (WWTP).) Small-scale wastewater filters consisting of large and small stones, charcoal, palm fiber, and shredded coconut husks are used by a few craftsmen, who filter the wastewater before dumping it. Wastewater is poured through the coconut husk filtration system, and clear water is said to flow out the opposite end. The wastewater filtration and disposal process is repeated for the pelorodan process as well.

Almost all solid waste and nearly all atmospheric emissions occur during the pelorodan process. Generally, all batik produced in a week is gathered and then put into one large pelorodan vat. Pelorodan is a non-stop process that takes an estimated 5 to 7 hours to complete and requires constant energy to maintain heat for the removal of wax and excess dye. Most of the craftsmen use firewood for pelorodan, making it the most atmospherically polluting stage of batik production. Because wax is used at a 30 percent reduction rate, 70 percent of wax used for canting batik is collected during pelorodan and thrown away in communal waste, likely ending in a local landfill. This process is performed, on average, once a week, depending on the craftsman’s weekly production rates.

Additional clarification was needed for much of the LCI spreadsheet and questionnaire results. Documentation of the relevant clarifications by PUPUK through email is provided in Appendix F. This clarification was used to edit responses and values originally provided by the craftsmen.

Questionnaire and Survey Responses

Results from the questionnaire provided monthly production details, estimated monthly batik sales, and information on water consumption and wastewater filtration. This data was collected to further aid the su-re.co feasibility study regarding business opportunities, as well as contribute to the Ciwaringin sustainability vetting. Following the theoretical methodology, this section contains both the quantitative and qualitative results from the questionnaire and survey responses. Qualitative data provided is organized into two sub-sections, batik production costs and revenue, and batik production water and indigo consumption data. The first sub-section includes batik production quantities, indigo costs, and estimated revenue of the naturally indigo-dyed Ciwaringin Batik motif produced per month. Water and indigo consumption data from the craftsmen is graphically compared in the following sub-section. Qualitative data is primarily gathered from the surveying done via phone and email with PUPUK and is documented throughout the sections below.

Indigo Production Costs and Batik Revenue

Ciwaringin Batik craftsmen do not currently cultivate and ferment their own indigo powder and therefore purchase natural indigofera paste from the local cooperative in Cirebon or UGM. Natural indigo provided by UGM costs 1.15 million IDR per kilogram (kg) and produces a high-quality indigo color. The local cooperative provides 1 kilo of indigo for 800,000 IDR and is identified by the craftsmen as a lower quality indigo powder. Factors that affect production costs include indigo dye source and quantity of indigo used per sheet of batik. Each craftsman provided the estimated number of days 1 kilogram of natural indigo powder lasts. This value varies from craftsman to craftsman because it is dependent on the same assumptions listed for the LCI – gender, economic well-being, and experience.

In the table below, the monthly natural indigo dye cost was calculated based on LCI and questionnaire data. The price in each indigo source column reflects the price per kilogram of natural indigo powder. If a craftsman purchases indigo from both UGM and the cooperative, the cost of indigo was averaged, resulting in a cost of 957,500 IDR per kg. Each craftsman produces varying quantities of batik and uses different amounts of indigo per batik sheet. The questionnaire asked craftsmen approximately how long 1 kg of indigo dye lasts; the
responses are recorded in the “1 kg = X days” column. Monthly indigo dye cost was then calculated by dividing the cost per kg by the number of days the indigo lasts each craftsman, providing the daily cost of indigo. The daily cost is then multiplied by 30 days to calculate the monthly indigo dye cost.

\[
(\text{Price of Indigo per kg}/(X \text{ # of days})) \times 30 \text{ days} = \text{Monthly Indigo Dye Cost} \quad \text{.........................}(\text{Eqn. 2})
\]

The data and results for this calculation are shown below in Table 3.

<table>
<thead>
<tr>
<th>Craftsman</th>
<th>Indigo Source - Price per Kilogram</th>
<th>Average Batik per Dye Vat</th>
<th>1 kg Indigo = X Days</th>
<th>Monthly Indigo Dye Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UGM</td>
<td>Cooperative</td>
<td>Both</td>
<td></td>
</tr>
<tr>
<td>H. Fathoni</td>
<td>Rp 1,115,000.00</td>
<td></td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>Solifah</td>
<td>Rp 800,000.00</td>
<td></td>
<td>20</td>
<td>180</td>
</tr>
<tr>
<td>Farhan</td>
<td>Rp 800,000.00</td>
<td></td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Ida</td>
<td>Rp 800,000.00</td>
<td></td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>Imam Rohim</td>
<td>Rp 957,500.00</td>
<td></td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Umar</td>
<td>Rp 1,115,000.00</td>
<td></td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Toifah</td>
<td>Rp 957,500.00</td>
<td></td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Nuralifah</td>
<td>Rp 957,500.00</td>
<td></td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>Sanuri</td>
<td>Rp 957,500.00</td>
<td></td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>

The results from the calculations illustrate how dramatically batik motif design and monthly batik produced affect the monthly cost of natural indigo dye. For example, Solifah purchases her indigo from the cooperative and can use 1 kg of natural indigo powder over 180 days. However, Solifah produces, on average, 13 batik per month and dyes close to 20 batik sheets at a time, potentially justifying her estimated 133,333 IDR indigo monthly cost. Per this data, it is possible for Solifah to dye batik less often because her monthly output is less than her estimated quantity per dye vat.

Another example is Umar, who spends the most on natural indigo of the 9 craftsmen because he purchases 1 kg of indigo dye from UGM every month. Depending on the month, Umar produces, on average, 30 batik per month and dyes close to 15 batik sheets at once. His monthly output is twice as much as his estimated quantity per dye vat, resulting in a higher number of dyestuffs needed and total dye vats made per month, supporting the data received.

Toifah spends about 638,333 IDR per month, using 1 kg in 45 days and purchasing her indigo from both UGM and the cooperative. However, per the questionnaire, Toifah produces anywhere from 75 to 100 batik each month and uses, on average, 12 batik sheets per indigo dye vat. Hers is the highest production of batik of the 9 craftsmen even though she dyes only 12 batik at a time. It should be stated that the batik production quantities in this section reflect the values in the questionnaire responses and are rough estimations provided by the participating craftsmen.

Revenue data for the naturally dyed batik produced by the interviewed craftsmen is shown in Table 4 below. Ciwaringin craftsmen produce batik for both the Ciwaringin Batik collective and for individual commerce. However, Ciwaringin Batik motifs must be naturally dyed. The quantities for naturally dyed batik are recorded by each craftsman in the questionnaire, yet it was not specified in the question if the natural dye was solely indigo or a combination of multiple natural dyes used in Ciwaringin. Therefore, the values in the figure are assumed to reflect only naturally indigo-dyed batik. Additionally, many of the craftsmen did not specify how many batik they produce individually each month. It was stated that, in general, if the monthly demand was higher than the estimated supply for that month, craftsmen would seek to purchase batik from other smaller producers within the community to meet the required demand. Some craftsmen provided an exact value when asked their average monthly batik quantity sold per month while others provided an estimated range (e.g., 10 to 15). Those who provided a range of batiks sold had their range averaged, as reflected in the figure. When calculating the average monthly sales, the average quantity of batik sold per month was multiplied by the average selling price. The results of this calculation are shown in Table 4.
(Average Batik Sold per Month) * (Average Selling Price) = Average Monthly Sales

Table 4: Calculation for average monthly sales.

<table>
<thead>
<tr>
<th>Craftsmen</th>
<th>Average Batik per Dye Vat</th>
<th>Avg. Ciwaringin Batik Motif (monthly)</th>
<th>Average Batik Sold per Month</th>
<th>Average Selling Price (IDR)</th>
<th>Average Monthly Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. Fathoni</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>Rp 350,000</td>
<td>Rp 9,450,000</td>
</tr>
<tr>
<td>Solifah</td>
<td>20</td>
<td>13</td>
<td>15</td>
<td>Rp 350,000</td>
<td>Rp 5,250,000</td>
</tr>
<tr>
<td>Farhan</td>
<td>15</td>
<td>30</td>
<td>35</td>
<td>Rp 400,000</td>
<td>Rp 14,000,000</td>
</tr>
<tr>
<td>Ida</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>Rp 250,000</td>
<td>Rp 3,750,000</td>
</tr>
<tr>
<td>Iim Rohim</td>
<td>12</td>
<td>30</td>
<td>30</td>
<td>Rp 300,000</td>
<td>Rp 9,000,000</td>
</tr>
<tr>
<td>Umar</td>
<td>15</td>
<td>24</td>
<td>30</td>
<td>Rp 350,000</td>
<td>Rp 10,500,000</td>
</tr>
<tr>
<td>Toifah</td>
<td>12</td>
<td>75</td>
<td>88</td>
<td>Rp 300,000</td>
<td>Rp 26,400,000</td>
</tr>
<tr>
<td>Nuralifah</td>
<td>12</td>
<td>25</td>
<td>27</td>
<td>Rp 300,000</td>
<td>Rp 8,100,000</td>
</tr>
<tr>
<td>Sanuri</td>
<td>12</td>
<td>45</td>
<td>42</td>
<td>Rp 350,000</td>
<td>Rp 14,700,000</td>
</tr>
</tbody>
</table>

Average monthly sales are reliant on two quantitative variables, average batik sold per month and average selling price. The average selling price is dependent on the craftsman’s experience, the detail of the batik motif, and customer demand. As expected, Toifah has the highest monthly sales of 26.4 million IDR, producing, on average, 88 batik per month at 300,000 IDR each. Earning the least, Ida produces 15 batik per month at 250,000 IDR each, making 3.75 million IDR. These values reflect the estimated revenue based on the data provided in the questionnaire. It is unclear if the entire value of the average monthly sales is received by the craftsmen, or if the Ciwaringin Batik collective receives a percentage. This data provided insight for su-re.co when considering intervention strategies and supports future calculations on craftsmen’s willingness to pay regarding dyestuff and indigofera cultivation.

Further explanation of the category, average batik per dye vat, is needed to fully justify the values used later in water consumption calculations. Each craftsman provided the estimated total number of batik dyed per vat when dye vat water is being recycled. On average, craftsmen recycle vat water 3 times, and generally dye 6 batik at once. (These values depend on current demand and motif design.) Therefore, the provided data per craftsman varies if they recycle vat water 3 times and if they do indeed dye 6 batik at once. As stated in the assumptions, the data received from the craftsmen is assumed to be honest and accurate and is therefore not adjusted in the figure.

Although the figures above provided quantitative data, qualitative factors greatly affect the accuracy of the results. When analyzing the results, low production values could be due to a lack of experience, low economic capacity, or designing of very detailed motifs. High production values and costs would reflect the opposite – greater experience, higher economic capacity, or lower detailed motifs. These qualitative factors make it difficult to analyze the data accurately and as a result are inconclusive. Average monthly indigo cost in Table 3 is considered the more accurate of the two tables because craftsmen are considerably more conscious of their spending compared to their revenue. These figures reflect the estimated spending on natural indigo powder and the estimated average monthly revenue on batik sold (this could potentially include the use of synthetic dyes).

Water and Indigo Consumption Data

When analyzing batik production data, it was deemed necessary to analyze current water consumption. As previously stated, craftsmen provided consumption data in two formats: liters used per batik sheet and liters used per dye vat. Those who provided water data per dye vat (20 liters) also stated that, on average, 6 batik sheets were dyed at once, accounting for the slight difference in water consumption per batik sheet. The value for average batik sold per month is taken from the figures above.
Consumption data was calculated as follows:

\[
(Water \ \text{Consumption per Batik Sheet}) \times (Average \ \text{Batik Sold per Month}) / 3 = Monthly \ \text{Water Consumption} \quad \text{(Eqn. 4)}
\]

Water consumption per batik sheet is first multiplied by the average quantity of batik sold per month, then divided by 3. As stated in the assumptions, dye vat water is assumed to be recycled 3 times before it is discarded, minimizing total wastewater released. Monthly water consumption data illustrates consumption for the average monthly batik sold. Again, this data cannot be limited to naturally indigo-dyed batik because it was not specified during data collection. These calculations were graphically represented to show the differences in consumption rates among the craftsmen.

![Water Consumption (Litres) Chart]

*Figure 15: Comparison of water consumption by Ciwaringin craftsmen.*

The water consumption figure above illustrates the consumption rates per batik sheet and per monthly production. As previously explained, average monthly batik production quantities are used from Tables 3 and 4. Seeing as Toifah produces a considerably higher monthly average of batik, it is reasonable that her monthly water consumption is almost 3 times that of the rest of the craftsmen. In contrast, Solifah consumes 15 liters of water each month, more than 6 times less than Toifah. However, a fair comparison cannot be made due to the various outside qualitative variables and unknowns. With the vat water reduction, each craftsman uses considerably less water, releasing less effluents into nearby waterways and fields. The consumption data relies heavily on the qualitative factors previously listed.

Indigo consumption required much more calculation, being significantly more complex. Each craftsman provided a quantity of indigo used per batik sheet and the monthly average quantity of batik produced with the Ciwaringin Batik motif. As stated above, all batik produced with the Ciwaringin Batik motif must be naturally dyed and assumed to be naturally indigo-dyed. However, at least 4 motifs are specific to Ciwaringin Batik, each with varying quantities of dye. This difference is not reflected in the calculations but is discussed afterwards.

A monthly average quantity of dye vats used was calculated based off the average batik dyed per dye vat – H. Fathoni, Solifah, and Farhan, Ida, lim Rohimah, Umar, Toifah, Nuralifah, and Sanuri stated 6 batik per dye vat – where the average monthly total batik produced was divided by the average batik dyed per vat, then
rounded to the nearest whole number. This was done to estimate the total number of vats used per month. Total indigo used per dye vat was then calculated by multiplying the quantity of indigo used per batik sheet by the provided number of batik used per dye vat (6 batik). Monthly indigo consumption is then calculated as follows:

\[
\text{Indigo used per dye vat (g) + (Indigo used per dye vat (g) \times 0.08 \times (Monthly \# \text{ of dye vats} - 1) = Monthly Indigo Consumption} \quad \text{(Eqn. 5)}
\]

Per the assumptions, all craftsmen use a 20 percent reduction rate of dyestuff when creating a new dye vat, resulting in 80 percent of the initial amount used in subsequent dye vats. Therefore, the initial dye vat contains the full quantity per batik sheet, plus the dye quantity per batik sheet multiplied by the reduction amount. This is then multiplied by the calculated number of vats per average monthly production minus 1 to reflect the initial dye vat indigo quantity. Monthly indigo consumption with no reduction rate was calculated by multiplying the monthly number of dye vats by the quantity of indigo used per dye vat. Table 5 reflects the monthly indigo consumption quantities calculated per craftsman.

Table 5: Calculation of monthly indigo consumption with and without reduction rate.

<table>
<thead>
<tr>
<th>Craftsmen</th>
<th>Avg. # of Ciwaringin Batik Motif (monthly)</th>
<th>Monthly # of Dye Vats</th>
<th>Indigo Per Batik Sheet (g)</th>
<th>Indigo Used per Dye Vat</th>
<th>Monthly Indigo Consumption (g)</th>
<th>Monthly Indigo Consumption No Reduction (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. Fathoni</td>
<td>20</td>
<td>3.3</td>
<td>17</td>
<td>102</td>
<td>292</td>
<td>340</td>
</tr>
<tr>
<td>Solifah</td>
<td>13</td>
<td>2.2</td>
<td>8</td>
<td>48</td>
<td>93</td>
<td>104</td>
</tr>
<tr>
<td>Farhan</td>
<td>30</td>
<td>5.0</td>
<td>25</td>
<td>150</td>
<td>630</td>
<td>750</td>
</tr>
<tr>
<td>Ida</td>
<td>15</td>
<td>2.5</td>
<td>8</td>
<td>48</td>
<td>106</td>
<td>120</td>
</tr>
<tr>
<td>Iim Rohim</td>
<td>30</td>
<td>5.0</td>
<td>9</td>
<td>54</td>
<td>227</td>
<td>270</td>
</tr>
<tr>
<td>Umar</td>
<td>24</td>
<td>4.0</td>
<td>8</td>
<td>48</td>
<td>163</td>
<td>192</td>
</tr>
<tr>
<td>Toifah</td>
<td>75</td>
<td>12.5</td>
<td>8</td>
<td>48</td>
<td>490</td>
<td>600</td>
</tr>
<tr>
<td>Nuralifah</td>
<td>25</td>
<td>4.2</td>
<td>5</td>
<td>30</td>
<td>106</td>
<td>125</td>
</tr>
<tr>
<td>Sanuri</td>
<td>45</td>
<td>7.5</td>
<td>8</td>
<td>48</td>
<td>298</td>
<td>360</td>
</tr>
</tbody>
</table>

Monthly indigo consumption rates were calculated both with the reduction rates and without to illustrate the differences in indigo consumption. All craftsmen interviewed operate with the reduction rate and therefore save money on indigo costs over time. The indigo consumption rates are graphically represented below.

Figure 16: Indigo consumption comparison by Ciwaringin craftsmen.
Table 6 identifies Farhan as the highest indigo consumer of the 9 craftsmen and Solifah the lowest. Farhan produces 30 naturally indigo-dyed Ciwaringin Batik motif batik each month, using 25 grams of indigo per sheet and 6 batik sheets per dye vat. Toifah produces far more batik sheets per month; yet she uses just 8 grams of indigo per sheet. These differences illustrate the significant impact of dyeing experience and motif design. These calculations contain as many known variables as unknown. Known variables in the calculation are as follows: natural indigo dye used when dyeing Ciwaringin Batik motifs, monthly average Ciwaringin Batik motifs produced, number of batik sheets dyed per dye vat and quantity of indigo used per sheet. Unknown variables include which Ciwaringin Batik motif is being used, how much indigo is used per Ciwaringin Batik motif, how experienced each craftsman is, and how much experience affects the craftsman’s dyeing capabilities. All data received from the craftsmen is assumed to be precise and honest. However, after calculating monthly indigo consumption, it became apparent that there were inconsistencies within the data set.

When asked how many days 1 kg of indigo lasts, craftsmen provide “x” number of days in the questionnaire response. As a consumption rate check, monthly indigo consumption (in kg) is multiplied by the number of days 1 kg of indigo lasts, and then divided by 30 days. The data error percentage is calculated by \(1 - \text{Indigo Consumption Rate Data Check} \times 100\). Data error percentages for the craftsmen’s monthly indigo consumption are shown in Table 6.

Table 6: Calculation of monthly indigo consumption data error percentage.

<table>
<thead>
<tr>
<th>Craftsmen</th>
<th>Avg. # of Ciwaringin Batik Motif (monthly)</th>
<th>Monthly Indigo Consumption (g)</th>
<th>Monthly Indigo Consumption (kg)</th>
<th>1 kg Indigo = X Days</th>
<th>Indigo Consumption Rate Data Check</th>
<th>Data Error Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. Fathoni</td>
<td>20</td>
<td>292</td>
<td>0.29</td>
<td>60</td>
<td>0.58</td>
<td>42%</td>
</tr>
<tr>
<td>Solifah</td>
<td>13</td>
<td>93</td>
<td>0.09</td>
<td>180</td>
<td>0.56</td>
<td>44%</td>
</tr>
<tr>
<td>Farhan</td>
<td>30</td>
<td>630</td>
<td>0.63</td>
<td>45</td>
<td>0.95</td>
<td>5%</td>
</tr>
<tr>
<td>Ida</td>
<td>15</td>
<td>106</td>
<td>0.11</td>
<td>45</td>
<td>0.32</td>
<td>68%</td>
</tr>
<tr>
<td>Iim Rohim</td>
<td>30</td>
<td>227</td>
<td>0.23</td>
<td>45</td>
<td>0.34</td>
<td>66%</td>
</tr>
<tr>
<td>Umar</td>
<td>24</td>
<td>163</td>
<td>0.16</td>
<td>45</td>
<td>0.16</td>
<td>84%</td>
</tr>
<tr>
<td>Toifah</td>
<td>75</td>
<td>490</td>
<td>0.49</td>
<td>45</td>
<td>0.73</td>
<td>27%</td>
</tr>
<tr>
<td>Nuralifah</td>
<td>25</td>
<td>106</td>
<td>0.11</td>
<td>60</td>
<td>0.21</td>
<td>79%</td>
</tr>
<tr>
<td>Sanuri</td>
<td>45</td>
<td>298</td>
<td>0.30</td>
<td>60</td>
<td>0.60</td>
<td>40%</td>
</tr>
</tbody>
</table>

Data inconsistencies may be due to inaccuracies when estimating total indigo used per dye vat, inaccuracies during data collection, or incorrect data for number of days 1 kg of indigo lasts per craftsman, resulting in imprecise monthly indigo consumption data. The error percentage identifies indigo consumption data from Farhan as the most accurate, with just a 5 percent error percentage, and Umar, with an 84 percent data error percentage. These percentages in Table 6 demonstrate how, in indigo consumption alone, questionnaire responses and LCI spreadsheet data can be extremely inconsistent, rendering much of the monthly indigo consumption calculations unreliable.

Existing CE within Ciwaringin

When accumulating data throughout the su-re.co site visit, the LCI spreadsheet and questionnaire responses, and various clarification phone calls and email messages with PUPUK, several production methods that use circular economy principles are identified within Ciwaringin Batik. These circular production strategies are listed below and categorized within the RESOLVE Framework. These production techniques are not practiced by all craftsmen interviewed but provide general insight into the current sustainability of the batik dyeing and finishing process at Ciwaringin Batik. All CE data collected from Ciwaringin Batik is assessed against the RESOLVE Framework and corroborated by PUPUK and the su-re.co indigo team members who participated in the site visit. The CE production methods identified and categorized are relevant to water and indigo consumption, as well as the natural indigo dyeing and finishing processes.
Existing CE production techniques within Ciwaringin are as follows: the use of basic water filtration systems, reusing dye water and indigo dye at a 20 percent reduction rate, reusing wax from batik designing at a 30 percent reduction rate, and providing online shopping to customers. Below are each of these production techniques categorized in their relevant sections and corresponding definitions within the RESOLVE Framework.

![Figure 17: Categorized CE production methods within Ciwaringin Batik – RESOLVE Framework.](image)

**REGENERATE** – “Return recovered biological resources to the biosphere”: using basic water filtration systems. Basic water filtration systems for dyeing and pelorodan wastewater produce clear dye and solid-waste-free water. This reduces the environmental impact of wastewater dye effluents and solid waste seeping into waterways. It should be noted that it is unknown whether the filtration systems used filter out the sodium carbonate and the hydrosulfate, and these effluents are assumed to remain in the water. Due to the rudimentary nature of the filtration systems, it is assumed that the hazardous chemicals remain in the water.

**LOOP** – “Recycle materials”: reusing dye water and indigo dye at a 20 percent reduction rate, reusing wax from batik designing at a 30 percent reduction rate. By integrating this reduction rate into water and wax usage, less wax and water is being used per batik sheet. Wax can only be reduced at a 30 percent rate because its structural integrity and malleability are affected when the reduction rate is increased.
VIRTUALIZE – “Dematerialize indirectly”: providing online shopping opportunities to customers. Several craftsmen interviewed have the ability to provide online sales through their own Facebook and Instagram pages, reaching higher volumes of customers and creating a larger client base.

One could argue that the reuse of materials, dye water, and wax could be included in the category, “Optimize – remove waste in production and supply chain”. However, this implies that the wax performance/quality is improved so that less will be used during production. In fact, this is not the case. Regarding water usage, the production method is altered, resulting in overall less water consumption. Similar conclusions can be reached with respect to wax usage. With the provided reduction rate, portions of water and wax cycle back into production, yet eventually wax and water still produce waste at the end of their life cycle. Therefore, the “Loop” category more accurately defines the process of reducing wax and water consumption because a percentage of the wax and water used is circled back into production.

For the purposes of this report, natural indigo dye is the only dye type considered in analysis. However, it is worth noting that several craftsmen use mahogany bark to create a brown dye. After it is used, the mahogany bark is then dried out and burned with firewood as fuel during the pelorodan process. Ash and charcoal left over from the bark, and firewood is then used as an abrasive material for cleaning household items (e.g., a dirty frying pan). At the end of the life cycle, the ash is then discarded in nature. This would also be considered a circular production method and could be categorized in “Optimize – remove waste in production and supply chain” or “Regenerate – Return recovered biological resources to the biosphere”.

Summary of Results

Although several circular production practices exist within Ciwaringin, many of the ongoing production practices are unsustainable and environmentally degrading. These production methods are listed here because they are significant as they relate to the sustainability vetting of Ciwaringin Batik, and the creation of sustainable development strategies for Ciwaringin Batik. “Unsustainable” is a rather arbitrary term, yet in this
report it is interpreted as not functioning within the principles of a circular economy and creating negative environmental impacts.

Unsustainable production methods of the craftsmen interviewed are identified as high volumes of untreated wastewater released into the environment with each dye vat being emptied, excess heat lost during the pelorodan process, and lack of renewable energy used during production. Environmentally degrading production methods are the use of hazardous chemicals when dyeing batik, high volumes of water used during dyeing and finishing stages (water is pumped individually by each craftsman from a personal well, and effluents are released into local waterways post-production), and large quantities of firewood used during the pelorodan process, producing significant volumes of atmospheric emissions.

During data collection it was noted that select craftsmen within the collective share expertise on batik production, showroom space, and technology for marketing batik online. However, the 9 craftsmen who partook in the surveying and inventory did not clarify whether they participate in these activities. Therefore, a lack of batik production expertise and technology and showroom space sharing are recorded. Furthermore, no information on the purchasing of batik production materials, origin of production materials purchased, or record of batik sales is documented by the craftsmen. This information was recorded orally by PUPUK, making it difficult to be verified further in the sustainability vetting.

Production methods that are identified as being unsustainable or having a significant impact on the environment occur due to a lack of willingness or capacity to change and the lack of awareness of sustainable alternatives. Creating sustainable development strategies for Ciwaringin Batik is done with the intention of raising awareness of environmental impacts of production and sustainable batik production methods to further empower Ciwaringin Batik.

**Discussion**

Due to the significant results listed above and all relevant data, sustainable development strategies supported by the circular economy RESOLVE Framework were created. Here, the production stages and materials will be analyzed and workable sustainable production alternatives for Ciwaringin Batik will be provided and then prioritized as they relate to implementation feasibility. Significant results will be further elaborated on in the subsequent sections. The sustainable development strategies based on the RESOLVE Framework have been designed to alleviate environmental impact and increase production sustainability. Much quantitative and qualitative data interpretation was performed in the previous section. However, further analysis of the data is necessary to determine the efficacy of the sustainable development strategies. (Qualitative data and factors are experience, gender, and economic capacity.) This section will primarily discuss the RESOLVE sustainable development strategies, which will then be ranked with respect to implementation feasibility.

**Challenges and Sustainable Solutions**

To create environmentally friendly batik and encourage sustainable development at Ciwaringin Batik, significant material, energy and resource inputs and outputs must be identified prior to strategy development. Several production methods and materials were previously identified as unsustainable and as having a negative impact on the environment. Each of the production materials and methods were analyzed, and sustainable development strategies were created based on the presented challenges. Listed below are the identified production materials and/or methods (PM) with their corresponding sustainable development strategy (SDS).

1. **PM** – High volumes of untreated wastewater are released into the environment with each dye vat being emptied. As presented in the results, dye water is disposed of after 2 to 3 cycles of dyeing. This wastewater primarily remains unfiltered and is disposed of in nearby streams and fields. Streams are said to lead to local WWTP.
   **SDS** – Install a basic water filtration system (as described in previous sections).
2. PM – Excess heat is lost during the pelorodan process; PM – The pelorodan process uses high quantities of firewood, producing significant volumes of atmospheric emissions.
SDS – Build an oven-like structure around the pelorodan vat or design a basic furnace to contain vat heat.

3. PM – There is a lack of renewable energy used during production.
SDS – Install biodigesters in the community and use community dye waste and compost for anaerobic digestion to produce biogas as fuel for the dyeing process.

4. PM – (a) Knowledge, (b) technology and (c) showroom spaces are not shared.
SDS – (a) Organize community events during which experienced craftsmen and community partners can educate less experienced craftsmen on non-hazardous dyeing materials, efficient batik production methods and environmental awareness. (b) Create a community sharing program whereby relevant technology can be shared with or rented out by craftsmen with lower economic capacities. (c) Develop a showroom rental and sharing program whereby craftsmen can rent showroom space from one another or share responsibility for showroom rent.

5. PM – No hardcopy of material purchases for batik production or sales batik exist.
SDS – Integrate bookkeeping into community business practices through workshops.

6. PM – Ciwaringin Batik uses hazardous chemicals (hydrosulfate) as a mordant for batik dyeing.
SDS – Reintegrate brown sugar as mordant in dyeing batik, eliminating the use of hazardous chemicals.

7. PM – High volumes of water are used during the dyeing and finishing stages of batik production.
SDS – Incorporate stationary dye vats into the dyeing process and basic water filters into wastewater disposal.

Additional SDSs, in addition to those listed above, are also listed in this section. These, too, are strategies to supplement the transition toward a circular economy in Ciwaringin's batik production. They are listed here because they are not a direct result of unsustainable batik production methods and materials; rather they are facets of everyday life experienced within the entire community. They are identified as potential opportunities for change (POC) and listed with a corresponding SDS.

8. POC– Solid waste from natural dye (with the exception of mahogany bark), food scraps, and other biomass waste are put into the same waste bins as traditional garbage earmarked for a landfill.
SDS – Create a community composting program.

9. POC – Craftsmen lack funds to rent showroom space monthly.
SDS – Sell batik online.

10. POC – Craftsmen use firewood indoors for cooking and other household activities.
SDS – Transition to using LPG for household activities.

All assumptions previously stated are also assumed for SDSs created. Due to time constraints, 6 of the 10 developed SDSs have been elaborated upon and analyzed below.

**Sustainable Development Strategies**

The sustainable development strategies presented above are solutions to unsustainable and environmentally degrading production methods observed in Ciwaringin Batik. At a minimum, one strategy per RESOLVE Framework subsection is listed, providing a total of 6 SDS options for Ciwaringin craftsmen to implement potentially. The goal of each SDS is implementation and adoption by Ciwaringin Batik craftsmen. However,
there are benefits and downsides for each strategy. Due to the nature of Ciwaringin Batik socio-economic structure and intracommunity relations, certain SDSs face fewer implementation obstacles than others. These challenges are expressed for each SDS and are the basis for the prioritization of SDSs for Ciwaringin Batik. Each SDS is categorized in its corresponding section of the RESOLVE Framework to further illustrate the relation to a circular economy.

Regenerate

1. Create a community composting program.

Currently 160 craftsmen are living in the Ciwaringin Batik community, with 60 actively participating in batik dyeing and finishing. Factoring in daily food consumption in addition to dyeing materials and other organic waste produced in Ciwaringin, community composting is achievable. As stated in the results, solid waste from the natural indigo dyeing process is solely wax because craftsmen do not ferment indigofera leaves. The wax used by the craftsmen is candle wax and not compostable. However, craftsmen do ferment tegeran bark, mango skin, jengkol skin, and mahogany bark to extract dye color. This process produces solid waste that can be used in a community composting program. Additionally, food scraps and other vegetation waste collected can also contribute to a compost. To develop this program, craftsmen need to be educated on what composting is and its significance as it relates to the environment and waste separation. Composting structures made of netted wire used in gardening can be placed around the community to ensure the entire collective has access to composting. The number of composting stations would be determined based on community layout, and volume of organic waste produced.

The benefits of creating a community compost program could be twofold: 1) increasing community awareness of environmental issues (e.g., recycling, composting) and the issues Indonesian landfills face and 2) subsequently removing organic waste from local landfills. It is important for the craftsmen to become/remain educated on environmental matters existing within their community and Indonesia as the environment slowly deteriorates around them. Instilling environmental values within the Ciwaringin craftsmen can provide benefits related to other activities performed by the craftsmen. Waste separation occurs globally, and depending on future endeavors, can be a beneficial habit for the community as a whole to adopt (regarding recycling and potential biogas integration).

Although a community composting program presents upsides for Ciwaringin craftsmen, in terms of raising environmental awareness and removing organic waste from landfills, craftsmen may be hesitant to adopt it. Separating organic waste requires additional effort, as well as maintaining a compost station that requires maintenance and is complex because of the fermentation process. Creating additional labor for the craftsmen is risky because many already struggle to find free time outside of batik production, making labor-intensive strategies difficult to adopt. Furthermore, craftsmen do not experience the upsides of removing organic waste from landfills, only the labor required to do so. Without incentives or the ability to illustrate the added benefits of alleviating organic waste volumes from landfills and raising environmental awareness, changing craftsmen’s behavior remains challenging.

Share

2. Organize community events during which experienced craftsmen and community partners can educate less experienced craftsmen on non-hazardous dyeing materials, efficient batik production methods, and environmental awareness.

Expertise on batik dyeing and finishing within the community varies among craftsmen. This can be due to the influx of community members returning from migrant labor over the previous decades or perhaps the failure of craftsmen to share knowledge on the many intricacies of batik production. Family members and community leaders often share batik production techniques with one another. However, many craftsmen in the community lack the equivalent skills and remain at the lower end of the economic scale. This, in turn, affects the sustainability of a craftsman’s production seeing as inexperienced craftsmen produce inefficiently, increasing
their individual environmental impact. The circulation and sharing of knowledge are “at the core of the maintenance and reproduction of a community practice” (Iraba et al., 2011). As community members become educated on environmental awareness and sustainable production methods, community events/workshops can be organized to disseminate this new knowledge to all craftsmen in the collective. Integrating knowledge sharing programs into Ciwaringin Batik further aligns with the values of a circular economy, creating transparency within the community and an environment for sustainable innovation. Environmental awareness will be raised and surrounding environments will be protected from negative environmental impacts. In addition, batik production can become more efficient, preserving resources and increasing overall economic status, eventually leading to an entire community producing environmentally friendly batik.

This increase in community knowledge could, over time, place craftsmen on a similar production level. With the entire community producing sustainable batik, competition within the community itself would rise. Rather than competing with adjacent communities for consumer demand, craftsmen would experience pressure from their peers creating similar batik. This realization has the potential to impact the willingness of craftsmen to share production knowledge because increased intra-community competition would negatively affect community relationships, which are often a combination of “business” and “family”. However, if there is no desire to produce environmentally sustainable batik and economic capacity is raised, craftsmen may also continue to produce batik with synthetic dyes and hazardous chemicals and use excessive amounts of water and fuel. Therefore, it would be necessary for the events within the community to be organized by a community leader, such as Pak H. Fatoni, or through a familiar organization, such as PUPUK, which stresses the moral importance of environmental batik to the craftsmen and to Ciwaringin Batik’s reputation. This solidifies the craftsmen’s knowledge awareness – “awareness in terms of where to find relevant information and knowledge as well as knowing whether such information or knowledge actually exists” (Beylier et al., 2009). Many collaboration-centered knowledge-sharing approaches, in various industries, are effective in SMEs because knowledge and experience are shared through socializing (Beylier et al., 2009).

Watching leaders and experts performing a skill facilitates the learning experience, helping inexpert craftsmen in the community engage in hands-on learning (Iraba et al., 2011). In the past, PUPUK has facilitated these types of events with the Clean Batik Initiative (CBI). Although PUPUK did not organize the movement, they facilitated discussion between participating craftsmen and representatives from CBI. Organizing events such as these could be done but would require much preparatory work by both the community leaders and participating organizations and facilitators. Events such as these are currently being organized by the local limestone quarry in Ciwaringin, which hosts workshops on traditional batik production.

Optimize

3. Install a basic water filtration system (as described in previous sections).

Some craftsmen in Ciwaringin use a small-scale wastewater filter to clean the water used during the pelorodan process. The filter is basic, using large and small stones, charcoal collected from pelorodan heating, palm fiber, and shredded coconut husks. Craftsmen and Pak Cecep of PUPUK have stated that, when using the filter, clean clear water is produced. This would allow for the filtered wastewater to be collected and reused, significantly reducing wastewater production volumes. This filtration process can similarly be used if dye water is being disposed of. When asked to see the filtration system, craftsmen redirected the conversation to other topics, and photographs of the mentioned water filtration systems were not obtained. A similar filtration system is used as an example of a simple water filtration system. It is designed for easy assembly and uses small grain material at the bottom with coarser material at the top (Anuar et al., 2017). This water filtration system is shown below in Figure 19.
Figure 19: Simple water filtration system (Anuar et al., 2017).

Water is filtered through coarse and fine gravel, coarse and fine sand, and finally through a cheesecloth (a coffee filter is also acceptable) (Anuar et al., 2017). This example filtration system is designed for a 2-liter bottle and a small beaker used for collection. This system appears too small for the expected volumes of water produced during pelorodan. A larger scale system using a standard 5-gallon (18.9 liters) bottle is proposed if this simple water filtration system were to be used. Many countries in Southeast Asia face both surface and groundwater pollution issues. As a result, basic filtration systems have been designed to alleviate water scarcity issues and can successfully filter microbial contaminated surface water and arsenic-contaminated groundwater into drinking water (Nitzsche et al., 2015). In this report, water filtration is suggested solely for recycling purposes, not for purposes of consumption of filtered water.

As craftsmen in the community use water from their individual wells, water usage and collection are not monitored, and is free, leading to overconsumption. Basic water filters used in the community have been introduced by PUPUK. However, the dissemination of this information is irregular, and many craftsmen do not use the filtration systems. Pak Cecep stated the reasoning for this as a lack of environmental awareness and understanding of the filtration system recommended. Furthermore, craftsmen who use the prementioned water filtration systems do not frequently maintain them. Filtration materials, such as palm and coconut husks, are often not changed for months and left saturated with water. Another difficulty faced is water collection. Large quantities of water are used during the pelorodan process, and filtering this volume would require extra labor. Water collection requires additional materials (e.g., a collection container), which craftsmen may not have, this being the reason that this SDS is in the Optimize category and not in Loop. However, materials used in the water filtration systems are found within the community and easy to obtain. The information on water
filtration construction, maintenance, and environmental importance must be shared, further reiterating the significance of SDS 2 (Share).

Loop

4. Install biodigesters in the community, and use community dye waste and compost for anaerobic digestion to produce biogas as fuel for the dyeing process.

In Indonesia bioenergy is a widely researched topic. The Biogas Rumah (BIRU) program (which, translated to English, means household biogas) began in 2009 and aimed to install 10,000 biodigesters in Indonesia by 2013 (FAO, 2014). Electrifying rural Indonesia and providing clean energy to Indonesians is a priority for the Indonesian government. As Indonesians gradually adopt bioenergy and biodigesters, they can begin to move away from using LPG and firewood as main sources of energy.

YRE and su-re.co have expressed interest in pursuing this venture with Ciwaringin Batik. Some craftsmen have the livestock necessary to produce enough biomass for the anaerobic digestion in a biodigester. However, were the Ciwaringin craftsmen to create a community composting program from household food and dye waste, this too could be used as “fuel” for a community biodigester. A communal bioenergy system would provide all craftsmen with clean energy for both dyeing and pelorodan processes. In Yogyakarta, Java, a study was performed to identify the impacts of adopting household biogas (Ahmad Romadhoﬁ Surya Putra et al., 2017). Benefits of biogas adoption in the study showed reduced firewood consumption, further reducing atmospheric emissions and improving air quality (Ahmad Romadhoﬁ Surya Putra et al., 2017).

Installing biodigesters in the community presents several challenges as well. In this study, biogas produced from biodigesters cannot fulﬁl the energy requirements needed for cooking and are difﬁcult to install (Ahmad Romadhoﬁ Surya Putra et al., 2017). The farmers in that study community showed a lower likelihood of biogas adoption due to these challenges. This would likely occur in Ciwaringin should they have biodigesters because their daily energy consumption for dyeing and pelorodan is greater than it is for cooking. Furthermore, materials for creating biodigesters are expensive. Unless materials are donated, Ciwaringin Batik craftsmen cannot afford the biogas technology.

Biogas and biodigesters have the potential to provide Ciwaringin Batik with sufﬁcient energy for batik production. A constant source of biomass, a full understanding of the technology, a sufﬁcient supply of energy for the community and funding for the biodigesters are needed in order to move forward.

Virtualize

5. Sell batik online.

The availability of technology in urban areas continues to rise, yet still remains unaffordable to rural communities (Oreglia, 2013). Sharing technology can increase the economic capacity of craftsmen who do not currently have an online presence. In most cases, Instagram and Facebook accounts for batik sales are created and maintained using basic smartphones. The ﬁrst principle of circular economy focuses on using technology that is available to dematerialize and provide virtual utility (Ellen MacArthur Foundation et al., 2015). Rather than renting or creating a showroom space for oneself, using existing technology within the community to sell batik provides craftsmen with the opportunity to allocate funds for other facets of production or personal investment. Additionally, craftsmen with these technologies can potentially organize a technology rental program, renting their mobile devices out to others in the collective who cannot explore these purchasing opportunities, resulting in additional income outside online batik sales.

It is necessary to gather additional data on technology available and the economic impact of introducing technology to the craftsmen for purposes of increasing overall proﬁts to prove to Ciwaringin Batik that technology is a worthwhile investment. In the past, YRE and PUPUK members have helped those with access to the internet create Instagram and Facebook accounts. These craftsmen have seen an increase in their overall batik sales, and, in turn, experienced individual economic growth. With internet access and online presence, several craftsmen have created an international customer base, whereby customers and collectors are able to
browse and purchase merchandise online, connecting Ciwaringin Batik craftsmen to prime markets for naturally dyed batik. Should other craftsmen in the community experience these benefits, overall economic prosperity would rise.

If craftsmen were to adopt a rental program as well, data on the current economic standing of technology renters is needed before suggesting a fair rental price. A pay-per-use (PPU) rental program is suggested as the business strategy for craftsmen supplying technology. PPU services are common in the software industry and generally apply to product companies (Gebauer et al., 2017). This allows a customer to pay only when they use a product, further encouraging sustainable consumption.

Similar to challenges faced in SDS 2, selling batik online may eventually create additional competition among craftsmen within the collective. As craftsmen in Ciwaringin Batik produce batik unique to the world of batik (e.g., batik created with natural dyes and the 4 patented Ciwaringin motifs), intracommunity competition is raised. By increasing their individual sales and productivity, craftsmen producing similar batik and selling it to a niche customer base may feel threatened by community members’ businesses. Furthermore, not all craftsmen in the community have access to technology or know how to maintain a social media presence. If online profiles were created, craftsmen might become overwhelmed by the technology, the increase in customer demand, and/or the additional competition within the community.

Furthermore, sharing technology through a rental program would also depend on the existing interpersonal relationships in the community, craftsmen’s ability to use that technology and potential maintenance costs, affecting initial willingness to share and the longevity of sharing (Gebauer et al., 2017). However, due to the economic incentive that comes with a technology renting program, craftsmen who adopt this program and reap its benefits will continue to achieve a higher economic status through the additional income received, negating intracommunity competition. Overall, those who choose to rent and share technology will successfully increase their market reach, individual profits, and business brand.

Exchange

6. Adopt standard bookkeeping practices (to be verified for further sustainability vetting).

Bookkeeping is the process of collecting and recording financial data of a company or organization (Gusti Ayu Purnamawati et al., 2018). It is used to identify necessary and inefficient costs to create a more profitable, productive, and efficient business. Furthermore, it provides transparency for business investors, when paying taxes, and for producers and customers to ensure a fair price is being paid for goods or services. Bookkeeping can also aid in sustainability vetting, such as an LCA as inputs and outputs of a business (system) are identified and recorded.

Threads of Life (ToL) is a fair-trade business that uses culture and conservation to alleviate poverty in rural Indonesia. One of its primary strategies in doing so is through introducing a bookkeeping system into the communities where they conduct business. The heirloom-quality textiles and baskets they commission are made with local materials and natural dyes, and to ensure both craftsmen and distributors receive a fair price for goods produced, it is pertinent for craftsmen to use a standardized bookkeeping system. Proceeds from ToL gallery sales help weavers form independent cooperatives to manage their resources sustainably, which can further aid in future sustainability vetting. PUPUK can work with craftsmen to adopt a bookkeeping system similar to that used by ToL, which would further encourage ToL business investment and support. This transparency further aids NGO participation when assessing potential intervention strategies.

Potential challenges faced with bookkeeping in Ciwaringin are the literacy levels of craftsmen, willingness to adopt bookkeeping, and PUPUK’s ability to communicate benefits of the system and team proper bookkeeping methods. However, bookkeeping has proven to be successful in all current ToL projects in Indonesia, as well as another study performed in the Sidemen District, Karangasem Regency, Bali, Indonesia, on a traditional weaving business. A business training and mentoring program with traditional Balinese weavers showed promise as craftsmen successfully adopted the bookkeeping system, more accurately tracking costs and profits.
and providing overall improvements in business efficiency and product pricing (Gusti Ayu Purnamawati et al., 2018). Over time, increasing numbers of Ciwaringin craftsmen can adopt bookkeeping, ideally becoming self-sufficient, teaching one another and selling batik at higher justified price points.

**Prioritized SDS**

The list below shows the ranking of the SDSs based on feasibility of implementation.

1. SDS 3 (Install a basic water filtration system.)
2. SDS 6 (Adopt standard bookkeeping practices.)
3. SDS 2 (Organize community events during which experienced craftsmen and community partners can educate less experienced craftsmen on non-hazardous dyeing materials, efficient batik production methods and environmental awareness.)
4. SDS 1 (Create a community composting program.)
5. SDS 5 (Sell batik online.)
6. SDS 4 (Install biodigesters in the community and use community dye waste and compost for anaerobic digestion to produce biogas as fuel for the dyeing process.)

**Honorable Mention**

7. SDS 7 (Incorporate stationary dye vats into the dyeing process and basic water filters into wastewater disposal. Stationary dye vats remove all wastewater from the dyeing stage of production.)

SDS 7 is mentioned because of its ease of implementation and adoption by craftsmen. Stationary dye vats have proven to be successful in many textile dyeing practices. It is unclear if the 9 interviewed Ciwaringin craftsmen do, in fact, dispose of dye water every 3 dyeing cycles (this is assumed), but it was noted that other craftsmen in the community use stationary dye vats. Should SDS 2 be implemented, information about how to use stationary dye vats effectively should be included in the information disseminated to the craftsmen.

**Conclusion**

Ciwaringin Batik continues to strive toward 100 percent environmentally friendly batik production. After analyzing Ciwaringin Batik production through an LCI, questionnaire, site visits using the CE RESOLVE Framework, SDSs were created to provide Ciwaringin Batik with strategies for circular business growth. Production data provided insight into current business operations, the existing socioeconomic status of craftsmen, and ongoing sustainable practices. Data collected from this study presented inconsistent results regarding indigo consumption but provided general consumption values for both water and natural indigo dye. The SDSs created aim to further empower Ciwaringin Batik in its production, providing them with sustainable alternatives to alleviate environmental impacts and improve business operations. These SDSs have been ranked based on implementation feasibility, with SDS 3 (Install a basic water filtration system.) ranking as number 1. This is due to the ease of creating a water filtration system. A water filtration system can be installed and be successful, and filtered water could be collected and reused for the dyeing and pelorodan processes.

Overall, more data and analysis are needed to perform an LCA to vet the precise quantitative sustainability of Ciwaringin Batik production thoroughly. A longer, more in-depth research period would also provide more accurate information on social structure in the community, as well as the willingness to adopt the SDS created. su-re.co, YRE and PUPUK are currently seeking funding from JICA and hope to move forward with a land acquisition to provide the Ciwaringin Batik craftsmen with land to cultivate indigo. Should the land acquisition be approved, indigo cultivation and fermentation could provide a sufficient amount of biomass necessary for biodigesters, further supporting biodigester installation in the community.
Future Work

Moving forward, Ciwaringin Batik and the stakeholders involved (su-re.co, YRE and PUPUK) have expressed interest in acquiring government land, Pehutani, where indigofera strains can be planted for cultivation. Ciwaringin Batik community members would be responsible for the farming of the indigo and could then ferment it and use it for natural dyeing rather than purchasing indigo powder from UGM and the collective. This project works concurrently with a biogas project that YRE and su-re.co would lead, creating value-added business to indigo farming. In the future, it is recommended that an LCA is performed to accurately identify the input and output quantities for the batik produced at Ciwaringin. Potential stakeholders for this future work are listed in Appendix G.

Life Cycle Assessment

It is predicted that with more time, clear and precise inventory data sheets, and access to a relevant database in an LCA program, a comprehensive LCA could be performed. Ability to acquire a program, database and relevant data information to perform a sufficient LCA is necessary because it significantly reduces time spent on input/output data collection, interpretation, calculation and modeling. If Ciwaringin were to adopt standardized book-keeping, records from each craftsman would provide exact information on production costs, resource consumption, production methods, purchasing methods, number of sales, sales revenue, material transportation type, and other factors influencing the production and distribution process. Where the data from book-keeping is lacking, an LCA database could provide answers that would fill gaps in information, resulting in fewer assumptions made.

Japan International Cooperation Agency (JICA)

JICA is a government agency that coordinates the official overseas development assistance (ODA) provided by the government of Japan. The proposed project would involve the Pehutani land acquisition and indigofera cultivation being accomplished through the provision of Pehutani government land access for indigofera agriculture. Biodigesters and biogas would then be introduced where appropriate in the value chain (starting at indigo cultivation and finishing at batik finishing). Agricultural waste from the process would be repurposed as biogas feedstock, and the bioslurry would be used as fertilizer for the indigo plant. YRE, PUPUK, and su-re.co have already proposed this project to JICA and await the potential funding results.

Biogas

A project proposed by su-re.co and YRE would create and spread climate change adaptation and mitigation using clean bio-energy integrated into the Indonesian indigo textile industry in Ciwaringin Batik, Cirebon, West Java, Indonesia. Through the synergy of biogas and natural indigo-dyed textiles, farmers and textile producers will generate additional income through the production of natural indigofera, reduce their energy costs, and potentially use bioslurry created during biogas generation as natural fertilizer for the indigofera crops. Making use of biogas production and naturally dyed textiles, incentivizes craftsmen to use these renewable bioenergy systems and sustainable textiles in their production process. Additionally, this project is based on the EC Horizon 2020 Green-Win project in which agricultural vulnerabilities in Bali were evaluated in relation to climate change.
References


Mijer, P. 1919. *Batiks and how to make them.* Dodd, Mead.


### Appendices

#### Appendix A: Ciwaringin Project Stakeholders

<table>
<thead>
<tr>
<th>Organization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yayasan Rumah Energi (YRE)</strong></td>
<td>A state-owned enterprise working toward the alleviation of energy poverty within Indonesia. Currently executing the BIRU initiative in partnership with the Indonesian government, promoting the use of biogas digesters as a local energy source for job creation and improvement of the business sector. Executive Director, Lina Moeis, came to learn of the Ciwaringin Batik through existing work with PUPUK. Ibu Lina is interested in supporting the livelihoods of Ciwaringin Batik artisans and the long-term prospect of introducing biogas and bioderivatives into their production.</td>
</tr>
<tr>
<td><strong>PUPUK</strong></td>
<td>The Association for Advancement of Small Business is an independent nonprofit working to strengthen small businesses and empower resilient entrepreneurs within Indonesia. PUPUK works closely with the Ciwaringin Batik community as part of an ongoing project related to livelihood support for peoples affected by the building of a new toll road through West Java. PUPUK is works closely with Ibu Lina (YRE)</td>
</tr>
<tr>
<td><strong>Pehutani</strong></td>
<td>This state-owned enterprise in Indonesia has the duty and authority to organize planning, management, exploitation and protection of forests in its working area.</td>
</tr>
<tr>
<td><strong>Ciwaringin Batik</strong></td>
<td>Ciwaringin Batik is an organized collective of traditional batik artisans living in Kebun Gedang, a hamlet of Ciwaringin, a small village located in the district of Cirebon, West Java. The collective consists of ~180 batik painters and dyers whose families have lived and worked in the Kebun Gedang hamlet since the end of the 19th century. Pak Fatoni is one of Ciwaringin Batik’s leaders. He is the primary contact through which PUPUK communicates with the collective.</td>
</tr>
<tr>
<td><strong>Karung Taruna (TARKA)</strong></td>
<td>This non-partisan independent locally-based youth organization serves to empower the livelihoods of members aged 17 – 35. Dadang Supriatna (Pehutani) is a primary organizer for the group, closely involved in the creation of a group-run “activities park” located adjacent to the proposed grow site.</td>
</tr>
</tbody>
</table>
## Appendix B: su-re.co Gap Analysis

<table>
<thead>
<tr>
<th>Barriers to entry</th>
<th>Market</th>
<th>Intervention</th>
<th>Who is best suited?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local</td>
<td>Intra- and Inter-Island</td>
<td></td>
</tr>
<tr>
<td>Resource base needs</td>
<td>\textit{Indigofera tinctoria} for small-scale production can be gathered from the wild</td>
<td>Strobilanthes cusia and \textit{I. tinctoria} for mid-scale production can be cultivated on marginal land</td>
<td>Land grant for indigo cultivation</td>
</tr>
<tr>
<td>Capital needs</td>
<td>Little capital is required to buy buckets for temporary soaking vats</td>
<td>Some capital required to buy tarpaulin for temporary soaking vats</td>
<td>Setup of processing facility (Lab)</td>
</tr>
<tr>
<td>Scale and price needs</td>
<td>1 – 10 kg of production for local market demand at IDR 120,000 – IDR 150,000 per oz.</td>
<td>10-100kg of production for intra- and inter-island market demand at IDR 120,000 – IDR 150,000 per oz.</td>
<td>Negotiation of price between dye makers and batik painters, facilitated by PUPUK</td>
</tr>
<tr>
<td>Quality needs</td>
<td>Local dyers will tolerate variation in dye quality as long as price reflects quality</td>
<td>Commercial-scale natural dyers will take top and second grade indigo paste</td>
<td>Feedback on quality from batik producers; quality assurance with centrifuge</td>
</tr>
<tr>
<td>Market knowledge needs</td>
<td>Local indigo dye traditions and dyers will be known within producer’s community</td>
<td>There are few commercial-scale natural dyers and they will be hard to meet</td>
<td>Bringing together the youth group and Ciwaringin Batik</td>
</tr>
<tr>
<td>Trade network needs</td>
<td>Extensive family and clan relationships connect farmer and dyer</td>
<td>Commercial natural dyers buy directly from producers or producer agents</td>
<td>Introducing Ciwaringin Batik and ToL</td>
</tr>
<tr>
<td><strong>Inventory turnover needs</strong></td>
<td>Seasonal product made during season of textile production can be sold when needed by dyers</td>
<td>Seasonal product for year-round market with 30- to 60-day lead times</td>
<td>Maintaining inventory, addressing seasonality and dyeing demand</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Policy and regulation needs</strong></td>
<td>Trade functions entirely within the &quot;hidden economy&quot; outside of regulation</td>
<td>Formal inter-regency shipment requires forestry department documentation</td>
<td>Establish trade rules and relationship between Youth group and local gov't</td>
</tr>
<tr>
<td><strong>Marketing partner needs</strong></td>
<td>Marketers need to understand local social networks and textile traditions</td>
<td>Marketers need relationships within commercial natural dye sector</td>
<td>Market analysis to identify willingness to pay, field visits to maintain relationships among partners</td>
</tr>
<tr>
<td><strong>Producer support needs</strong></td>
<td>Producers need training in making paste and dyers need training in using paste</td>
<td>Need training in making paste at scale, oversight of quality, and support in managing orders</td>
<td>Organizing training and workshops at the extraction lab once it is established</td>
</tr>
</tbody>
</table>
Appendix C: LCI Instructions
Below are the LCI Instructions created for PUPUK.

Materials Inventory for PUPUK
Inventory Introduction

Because all the materials inventory information was not obtained on the site visit to Ciwaringin, Pak Cecep from PUPUK has agreed to assist in life-cycle analysis (LCA) inventory data collection. A translated inventory sheet will be reviewed with a group of selected craftsmen from Ciwaringin to obtain a more comprehensive understanding of the materials used in production, the amount of material used, and their origin. The data collected from this inventory will be used to evaluate the approximate life cycle of batik produced within the Ciwaringin collective. From this LCA, stages in the production process with high pollutants will be identified, and workable alternatives will be suggested to ensure sustainable business development. Additional information about wastewater quality and management techniques will further benefit impending research determining environmental impact and identifying potential circular economy entry points.

This document is intended for PUPUK surveyors to better understand the data collection process and provided inventory sheets.

Pre-Inventory Assessment

This section contains a series of questions and assumptions to consider when selecting craftsmen to review the LCA inventory sheet. The reasoning behind collecting this amount of data is to ensure the LCA can be performed even if some of the columns are left blank.

Assumptions and Variables

Seeing as Ciwaringin Batik is a collective of 115 craftsmen, it is assumed all members will not/cannot be surveyed or contribute to the data collection. Therefore, it is advised that a group of craftsmen be selected that encompasses the varying socio-economic disparities and dyeing practices within the Ciwaringin collective. The selected craftsmen should be well experienced in batik dyeing and willfully participate in the surveying.

Questions

Standard LCA Inventory data collection is divided into inputs and outputs. Inputs will be divided into subsections: raw or intermediate materials, water, and energy. Outputs are defined as environmental releases and products of the system, such as atmospheric emissions, waterborne wastes, solid wastes, and products.

To simplify the data collection process, a series of questions associated with the LCA Module are listed below. The more information, the better! After data collection, the data will be sorted, and relevant data will be used for the LCA.

1. What materials are used in the batik dyeing process?
2. How much material/input is used in the batik dyeing?
3. Where does the input come from?
4. Where is the input produced?
5. Are there waste byproducts? If yes, what are they?
6. Are inputs reused? If yes, what inputs are reused?
7. What wastewater management methods are in place?
Below is an example of what some inventory input and output results could look like, with corresponding numbers for each section heading for further explanation. The information provided in the table is just for reference purposes for data collection based on notes from the site visit but not actual information obtained from Ciwaringin Batik. Please do not use the data from these examples in the actual data collection.

Module Inputs

<table>
<thead>
<tr>
<th>Inputs (1)</th>
<th>Amount (2)</th>
<th>Units (3)</th>
<th>Source (4)</th>
<th>Location (5)</th>
<th>Raw/Processed (6)</th>
<th>Additional Info (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile – cotton</td>
<td>One sheet of batik</td>
<td>300 grams</td>
<td>&quot;Company X&quot;</td>
<td>Central Java</td>
<td>Processed</td>
<td>Harvested, and spun into thread, and woven at &quot;Company X&quot;</td>
</tr>
<tr>
<td>Hydrosulfate</td>
<td>one teaspoon</td>
<td>10 grams</td>
<td>University</td>
<td>Java</td>
<td>Processed</td>
<td>Shipped to university from &quot;Z&quot;</td>
</tr>
<tr>
<td>Wax</td>
<td>-</td>
<td>20 grams</td>
<td>Cirebon</td>
<td>Raw</td>
<td></td>
<td>Raw wax</td>
</tr>
<tr>
<td>Water</td>
<td>One vat – 10 liters</td>
<td>10 kg</td>
<td>Collection point – &quot;River Y&quot;</td>
<td>Cirebon</td>
<td></td>
<td>River used as drinking water; wastewater from manufacturing not returned here</td>
</tr>
<tr>
<td>Energy</td>
<td>LPG</td>
<td>5 min. on high</td>
<td>LPG plant</td>
<td>Jakarta</td>
<td></td>
<td>Transported by truck from LPG plant to Cirebon, then to Ciwaringin</td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td>-</td>
<td>500g</td>
<td>Local tree</td>
<td>Ciwaringin</td>
<td></td>
<td>Used bark from batik dyeing</td>
</tr>
</tbody>
</table>

Corresponding Numbers:

(1) Inputs – all sourced materials known to be used in the batik-dyeing process.

(2) Amount – quantity used to make one sheet of batik.

(3) Units – amount in grams or kilograms. If the exact number of grams is not known, it can be calculated based on whether the amount (2) used for one batik is recorded.

(4) Source – where material was produced or collected from.

(5) Location – source location relative to batik center. This is important to collect, so transportation emissions can be considered in the LCA module.

(6) Raw/Processed – (Only applies to materials, not water and energy) whether the materials are processed beforehand (such as the textiles/hydrosulfate) or used raw (such as firewood, wax). Data on materials processed is important because there are inputs and outputs for the processing of these materials.

(7) Additional Information – any information about the input worth noting. Ideally, information about the input source, transportation of input to Ciwaringin, and specific use of input in dyeing process.
Module Outputs

<table>
<thead>
<tr>
<th>Outputs (1)</th>
<th>Amount (2)</th>
<th>Units (3)</th>
<th>Location (4)</th>
<th>Additional Info (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric emissions</td>
<td>wood burning</td>
<td>10 minutes</td>
<td>1 kilo wood</td>
<td>Garbage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wood comes from mahogany dye color, produced ash solid waste</td>
</tr>
<tr>
<td>Waterborne waste</td>
<td>1 dye vat – 10 liters</td>
<td>10 kg</td>
<td>River</td>
<td>Water filtration system used – coconut bark, filters</td>
</tr>
<tr>
<td>Solid waste</td>
<td>Dye by-products</td>
<td>300g</td>
<td>garbage</td>
<td>Landfill</td>
</tr>
</tbody>
</table>

Corresponding Numbers:

(1) Outputs – atmosphere pollutants (smoke, gas from LPG), waterborne waste (dye wastewater), solid waste (dye by-products). Solid waste also included anything that was not used during the dyeing process or otherwise thrown away.

(2) Amount – quantity of output produced from making one sheet of batik.

(3) Units – amount in grams or kilograms. If the exact number of grams is not known, it can be calculated based on whether the amount (2) used for one batik is recorded.

(4) Location – where the outputs are disposed of or where their end-point will be.

(5) Additional Information – any information about the disposal process (for example, are there recycling systems and/or wastewater treatment methods in place)

Final Thoughts

This data collection may seem very repetitive, but all the information collected is relevant to the LCA research. There needs to be a sufficient amount of information collected from the Ciwaringin Batik craftsmen for the LCA to be successful, precise, and fairly representative of the collective’s batik production methods. As previously stated, the more data collected on the system inputs and outputs, the better. It is especially important to include all waste from the production, specifically wastewater and filtration techniques.
# Appendix D: LCI Input/Output Template

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Amount</th>
<th>Units (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Info</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile – Cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrosulfate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Carbonate (Lime)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wax</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigo Powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outputs</td>
<td>Amount</td>
<td>Units (g)</td>
<td>Location</td>
<td>Additional Info</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
<td>-----------</td>
<td>----------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric Emissions</td>
<td>LPG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wood Burning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterborne Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Appendix E: LCI and Questionnaire Result Data

## Results and Responses from H. Fathoni, Batik Quu

<table>
<thead>
<tr>
<th>Name</th>
<th>H. Fathoni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Ciwaringin</td>
</tr>
<tr>
<td>Batik Brand Name</td>
<td>Batik Quu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Pekalongan</td>
<td>Rp 31,000</td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>0.16 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Chemical Shop in Cirebon</td>
<td>Rp 35</td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>300 gram</td>
<td>Chalk Factory</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount</td>
<td>Rp 6,600</td>
</tr>
<tr>
<td>Candle</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store</td>
<td>Rp 30,000</td>
</tr>
<tr>
<td>Dye</td>
<td>Mahogany Bark</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>3 liter</td>
<td>From own farm</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Rp 2,500</td>
</tr>
<tr>
<td></td>
<td>Indigo Powder</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>17 gram</td>
<td>Univ. UGM</td>
<td>Jogjakarta</td>
<td>Processed (powder form)</td>
<td>Rp 19,000</td>
</tr>
<tr>
<td></td>
<td>Vinegar</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed (powder form)</td>
<td>Rp 800</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>3 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Rp</td>
</tr>
<tr>
<td>Energy</td>
<td>Gas LPG 3 kg</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>0.6 kg</td>
<td>Grocery Store</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Rp 4,600</td>
</tr>
<tr>
<td></td>
<td>Mahogany Bark</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>10 kg</td>
<td>Furniture Factory</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Rp 3,400</td>
</tr>
<tr>
<td></td>
<td>Firewood</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>0.1 M³</td>
<td>Firewood Seller</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Rp 10,000</td>
</tr>
<tr>
<td></td>
<td>Tegeran - dye color (yellow)</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>1 kg</td>
<td>Univ. UGM</td>
<td>Jogjakarta</td>
<td>Processed (powder form)</td>
<td>Rp 75,000</td>
</tr>
<tr>
<td>Output</td>
<td>Amount</td>
<td>Unit</td>
<td>Location</td>
<td>Additional Information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>------</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>84</td>
<td>3 kg</td>
<td>Workshop of Batik Quu</td>
<td>1 container of 3 kg LPG gas used for 1 week and to produce 5 pieces of batik cloth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Burning</td>
<td>7</td>
<td>1 M³</td>
<td>Batik Quu kitchen</td>
<td>For the production needs of 10 batik fabrics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid Waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   **Answer:**
   - From UGM University in Jogjakarta
   - Amount purchased 1 kg at a price of Rp1115,000
   - 1 kg Indigo for stock for 2 months.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   **Answer:**
   - Specific to Ciwaringin motives, we use 20 sheets of natural dye per month
   - 25-30 pieces; with 20 pieces of natural batik dye and the rest is customised for demand

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   **Answer:**
   - Average price per sheet Rp350.000
   - The most expensive price is Rp2.000.000 for the silk soft fabric, while the cheapest is Rp350.000

4. To how many people did you sell batik cloth?
   **Answer:**
   - Between 5 to 8 people

5. What is the mode of transportation of your batik sale? Where have you been?
   **Answer:**
   - Mode of transportation using motorcycles, on the bikes and public transport
   - Batik is sold to all over Indonesia online through e-commerce and social media, to hotel, exhibition, resseller, and guest who come

6. Do you have a limestone or limestone source (calcium carbonate)?
   **Answer:**
   - No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
   **Answer:**
   - 20 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   **Answer:**
   - Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   **Answer:**
   - Yes
   - About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    **Answer:**
    - IPAL (Wastewater Treatment Plant)
    - Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk.

Ciwaringin, 09 Juli 2018
Respondent's Signature
Results and Responses from Solifah, Batik Novi

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Pekalongan</td>
<td>Rp 31,000</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>1 Fabric sheet</td>
<td>10 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Chemical Shop in Cirebon</td>
<td>Rp 500</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>1 Fabric sheet</td>
<td>167 gram</td>
<td>Chalk Factory</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount</td>
<td>Rp 4,000</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candle</td>
<td>1 Fabric sheet</td>
<td>400 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store</td>
<td>Rp 10,400</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td>1 Fabric sheet</td>
<td>4 liter</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>If processed themselves, it would be cheaper</td>
<td>Rp 6,500</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dye</td>
<td>1 Fabric sheet</td>
<td>8 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The color produced from indigo purchased in the cooperative is darker. The price is Rp700.000 per kg for the cheapest and Rp800.000 for the most expensive.</td>
<td>Rp 7,200</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinegar</td>
<td>1 Fabric sheet</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1 Fabric sheet</td>
<td>3 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td></td>
<td></td>
<td>Rp -</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>1 Fabric sheet</td>
<td>0.6 kg</td>
<td>Grocery Store</td>
<td>Ciwaringin</td>
<td></td>
<td>Subsidized LPG gas is often empty</td>
<td>Rp 4,600</td>
</tr>
<tr>
<td>Gas LPG 3 kg (for batik)</td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark (wax removal)</td>
<td>1 Fabric sheet</td>
<td>10 kg</td>
<td>Furniture Factory</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Bark is a waste from a furniture factory and is usually sold per sack for Rp10,000</td>
<td>Rp 3,400</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewood</td>
<td>1 Fabric sheet</td>
<td>0.1 M³</td>
<td>Wood Seller</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Purchased from a carpenter for Rp100,000 / M³</td>
<td>Rp 10,000</td>
</tr>
<tr>
<td></td>
<td>(size 1.00 x 2.50 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Output | Amount | Unit | Location | Additional Information
--- | --- | --- | --- | ---
LPG | 84 hours | 3 kg | Workshop Batik Novi | 1 container of 3 kg LPG gas used for 1 week and to produce 5 pieces of batik cloth
Wood Burning | 7 hours | 1 M³ | Batik Novi Kitchen | For the production needs 13 batik cloth
Solid Waste | - | - | - | -

1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   Answer: From the cooperative (quality under UGM)
   - Amount purchased 1 kg at a price of Rp800,000
   - 1 kg Indigo for stock for 6 months.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   Answer: - Special motif Ciwaringin using natural dye as much as 13 pieces per month
   - 10 s.d 15 sheets, depending on order

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   Answer: Average price per sheet of Rp300,000
   The most expensive price is Rp400,000 and the cheapest is Rp250,000

4. To how many people did you sell batik cloth?
   Answer: - 5 people

5. What is the mode of transportation of your batik sale? Where have you been?
   Answer: Mode of transportation using motorbike, onthel bike and public transportation
   - Batik is sold throughout Indonesia online via

6. Do you have a limestone or limestone source (calcium carbonate)?
   Answer: No. We bought it From a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
   Answer: - 20 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   Answer: - Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   Answer: Yes, there is
   - About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    Answer: Because the Amount of production is still small, the waste is directly flowed to the ground

Ciwaringin, 09 Juli 2018
Respondent’s Signature
Results and Responses from Farhan, Naya Batik

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Pekalongan</td>
<td>Rp 31,000</td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>0.16 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Chemical Shop in Cirebon</td>
<td>Rp 35</td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>1.6 liter</td>
<td>Chalk Factory</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount</td>
<td>Rp 6,600</td>
</tr>
<tr>
<td>Candle</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store</td>
<td>Rp 30,000</td>
</tr>
<tr>
<td>Dye</td>
<td>Mahogany Bark (size 1.15 x 2.50 m)</td>
<td>3 liter</td>
<td>From own garden</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Uses from his own tree in his garden</td>
<td>Rp 2,500</td>
</tr>
<tr>
<td>Indigo Powder</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>25 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed (powder form)</td>
<td>UGM has a special Research Institute of Indigo dyes</td>
<td>Rp 27,000</td>
</tr>
<tr>
<td>Vinegar</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td>Water</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>3 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
</tr>
<tr>
<td>Energy</td>
<td>Gas LPG 3 kg (for batik)</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>0.6 kg</td>
<td>Grocery Store</td>
<td>-</td>
<td>Subsidized LPG gas is often empty</td>
<td>Rp 4,600</td>
</tr>
<tr>
<td>Mahogany Bark (wax removal)</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>10 kg</td>
<td>Furniture Factory</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Bark is a waste from a furniture factory and is usually sold per sack for Rp10,000</td>
<td>Rp 3,400</td>
</tr>
<tr>
<td>Firewood</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>0.1 M³</td>
<td>Wood Seller</td>
<td>Jamblang - Wiyong - Budur</td>
<td>Raw</td>
<td>Direct Purchase - Wholesale price of Rp500,000 to make 70 batik cloths</td>
<td>Rp 8,500</td>
</tr>
<tr>
<td>Tegeran - dye color (yellow)</td>
<td>1 Fabric sheet (size 1.15 x 2.50 m)</td>
<td>1 kg</td>
<td>Univ. UGM</td>
<td>Jogjakarta</td>
<td>Processed (powder form)</td>
<td>UGM has a special Research Institute of Tegup dyes</td>
<td>Rp 75,000</td>
</tr>
</tbody>
</table>
1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   **Answer:** From the cooperative; lower quality than UGM's
   1 kg Indigo for stock for 45 days

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   **Answer:** Special motif Ciwaringin using natural dye as much as 30 sheets per month
   30-40 pieces; 30 pieces for natural batik dye and the rest are customised following the demand

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   **Answer:** Average price per sheet of Rp400,000
   The most expensive price Rp1,200,000 for cloth with soft design and the cheapest Rp350,000

4. To how many people did you sell batik cloth?
   **Answer:** 20 people per month and only sold by retail

5. What is the mode of transportation of your batik sale? Where have you been?
   **Answer:** Mode of transportation using motorcycles, on the bikes and public transport
   Batik is sold to all over Indonesia online through e-commerce and social media, to hotel, exhibition, resseler, and guest who come

6. Do you have a limestone or limestone source (calcium carbonate)?
   **Answer:** No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
   **Answer:** 15 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   **Answer:** Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   **Answer:** Yes
   About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    **Answer:** Directly discharged to SPAL (Wastewater Disposal) / comberan

Ciwaringin, 09 Juli 2018
Respondent's Signature
### Results and Responses from Ida Makhmuda, Mimi Ida Batik

<table>
<thead>
<tr>
<th>Name</th>
<th>Ida Makhmuda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Ciwaringin</td>
</tr>
<tr>
<td>Batik Brand Name</td>
<td>Mimi Ida Batik</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from Pekalongan</td>
<td>Rp 31,000</td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>2 teaspoons</td>
<td>15 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulphate for 1 oz of Indigo dye</td>
<td>Rp 750</td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>400 gram</td>
<td>Chalk Factory (CV. Kapur Berkat Nusantara)</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount</td>
<td>Rp 6,600</td>
</tr>
<tr>
<td>Candle</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store</td>
<td>Rp 26,000</td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td>0.2 jerrycan</td>
<td>5 liter</td>
<td>From waste furniture owned by Pa Jij (Adik Pak Fathoni)</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Purchased in the form of waste wood for Rp50,000 per sack, then self-processed and used as dye for approximately 60 liters</td>
<td>Rp 850</td>
</tr>
<tr>
<td>Indigo Powder</td>
<td>1 teaspoon</td>
<td>8 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed (powder form)</td>
<td>The color produced purchased in the cooperative is darker. The price is Rp800,000 per kg</td>
<td>Rp 4,500</td>
</tr>
<tr>
<td>Vinegar</td>
<td>1/4 bottle</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td>Water</td>
<td>1 tub (pool)</td>
<td>20 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>1 tub can be used for 6 fabrics</td>
<td>Rp -</td>
</tr>
<tr>
<td>Gas LPG 3 kg (for batik and pelorodan)</td>
<td>1 LPG container (used for 4 fabrics)</td>
<td>3 kg</td>
<td>Toko Kelontong</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Price per 3 kg gas container is Rp23,000: 1 container of 3 kg LPG used for batik and at the same time pelorodan for 4 cloth, with total a usage amount of 8 days batik and pelorodan 1 day.</td>
<td>Rp 5,750</td>
</tr>
<tr>
<td>Mahogany Bark (wax removal)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood. Only uses 3 kg LPG gas</td>
<td>Rp -</td>
</tr>
<tr>
<td>Firewood</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood. Only uses 3 kg LPG gas</td>
<td>Rp -</td>
</tr>
<tr>
<td>Tegeran - dye color (yellow)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
</tr>
</tbody>
</table>
1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   **Answer:** From cooperatives (quality under UGM). The resulting color is darker.
   *Amount purchased 1 kg at a price of Rp800,000
   *1 kg Indigo for stock for 90 days

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   **Answer:** Special motif Ciwaringin using natural dye as much as 15 pieces per month
   *15 sheets, and only make Ciwaringin motif with natural dyes

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   **Answer:** Average price per sheet Rp2500.000
   *The most expensive price Rp350.000 for and the cheapest Rp225.000

4. To how many people did you sell batik cloth?
   **Answer:** Only sold to consignment to batik gallery in Ciwaringin

5. What is the mode of transportation of your batik sale? Where have you been?
   **Answer:** Mode of transportation using onthel bikes
   *Batik only ditiip sell (consignment) to Batik Gallery owned by other craftsmen in Ciwaringin.

6. Do you have a limestone or limestone source (calcium carbonate)?
   **Answer:** No. We bought it from a chalk factory in Gempol Village, Paliman - Cirebon

7. How many pieces of batik are produced from a single dye barrel?
   **Answer:** 10 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   **Answer:** Until the water runs out. About 4 times staining.

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   **Answer:** There is about 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    **Answer:** Discharged directly by way of streamed to SPAL / Comberan.

Ciwaringin, 11 Juli 2018
Respondent’s Signature
## Results and Responses from Iim Rohimah, Griya Batik Sapu Jagat

**Name:** Iim Rohimah  
**Address:** Ciwaringin  
**Batik Brand Name:** Griya Batik Sapu Jagat

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Price per package (total 12 pieces) Rp400.000</td>
<td>Rp 33,000</td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>2 tablespoons</td>
<td>33 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulfate for 1 oz of Indigo dye</td>
<td>Rp 1,700</td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>0.6 bucket</td>
<td>600 grams per cloth</td>
<td>Chalk Factory (CV. Kapur Berkat Nusantara)</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount. Price per packaging is Rp12.000 for 25kg</td>
<td>Rp 5,500</td>
</tr>
<tr>
<td>Candle</td>
<td>1 Fabric sheet (size 1.00 x 2.50 m)</td>
<td>600 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store. Candles can be recycled for subsequent use</td>
<td>Rp 16,200</td>
</tr>
<tr>
<td>Dye</td>
<td>Mahogany Bark</td>
<td>0.2 jerrycan</td>
<td>5 liter</td>
<td>From Pa Joli’s furniture waste</td>
<td>Raw</td>
<td>Purchased in the form of waste wood for Rp50.000 per sack, then self-processed and used as dye for approximately 60 liters</td>
<td>Rp 850</td>
</tr>
<tr>
<td></td>
<td>Indigo Powder</td>
<td>2 teaspoons</td>
<td>9 gram</td>
<td>Pak Widodo, Pak Jamroni - Jogjakarta</td>
<td>Processed</td>
<td>Shopping Indigo via online</td>
<td>Rp 10,035</td>
</tr>
<tr>
<td></td>
<td>Vinegar</td>
<td>1/4 bottle</td>
<td>15 ml</td>
<td>Shop</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>1 tub (pool)</td>
<td>20 liter</td>
<td>From own well</td>
<td>-</td>
<td>1 tub can be used for 6 batik fabrics</td>
<td>Rp -</td>
</tr>
<tr>
<td>Energy</td>
<td>Gas LPG 3 kg</td>
<td>1 container (for 60 liters of dye)</td>
<td>0.5 kg</td>
<td>Grocery Store</td>
<td>-</td>
<td>Subsidized LPG gas is often empty. Price per 3 kg gas tube Rp23.000. 1 tube 3 kg used to make batik and also pelorodan.</td>
<td>Rp 11,500</td>
</tr>
<tr>
<td></td>
<td>Mahogany Bark (wax removal)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood</td>
<td>Rp -</td>
</tr>
<tr>
<td></td>
<td>Firewood</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood</td>
<td>Rp -</td>
</tr>
<tr>
<td></td>
<td>Tegeran - dye color (yellow)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
</tr>
<tr>
<td>Output</td>
<td>Amount</td>
<td>Unit</td>
<td>Location</td>
<td>Additional Information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>------</td>
<td>----------</td>
<td>----------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric Emissions</td>
<td></td>
<td></td>
<td></td>
<td>1 container of 3 kg LPG gas used for 6 days batik.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>50 hours</td>
<td>3 kg</td>
<td>Workshop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Burning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastewater Pollution</td>
<td>1 dye vat</td>
<td>20 Liter</td>
<td>Soil</td>
<td>Discharged waste is pelorodan residual waste. So the possibility when discarded is less than 20 liters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?

   **Answer:** From Universitas UGM in Jogjakarta and Cooperative
   - Amount purchased 1 kg at a price of Rp1115,000 (for UGM) and Rp800,000 for Cooperatives
   - 1 kg indigo for stock for 45 days

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?

   **Answer:** Special motif Ciwaringin using natural dye as much as 30 sheets per month
   - 30 sheets. When there is an additional demand while stock is not available, pick up from a small craftsman in Ciwaringin

3. What is the average selling price of each batik? What is the most expensive and cheapest price?

   **Answer:**
   - Average price per sheet Rp300,000
   - The most expensive price Rp1,500,000 for primisima cloth with motifs of halusan and the cheapest Rp250,000

4. How many people did you sell batik cloth?

   **Answer:** 3 - 4 people per month. Retail and wholesale

5. What is the mode of transportation of your batik sale? Where have you been?

   **Answer:** Mode of transportation using motorbike, onthel bike and public transportation
   - Batik is sold throughout Indonesia online through e-commerce and social media, to hotel, exhibition, resseler, and guest who come
   - Most consumers come from Jakarta, Bandung, and Bali, Semarang

6. Do you have a limestone or limestone source (calcium carbonate)?

   **Answer:** No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?

   **Answer:** 10 - 15 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?

   **Answer:** Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?

   **Answer:** There is
   - About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?

    **Answer:** Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk.
    - Shared IPAL

Ciwaringin, 11 Juli 2018
Respondent’s Signature
## Results and Response from Umar, Batik Astina

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Batik Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umar</td>
<td>Ciwaringin</td>
<td>Batik Astina</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Textile - Cotton</strong></td>
<td>1 Fabric sheet</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Price per package (total 12 pieces) Rp400.000</td>
</tr>
<tr>
<td><strong>Hydrosulphate</strong></td>
<td>4 teaspoons</td>
<td>25 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulfate for 1 oz of Indigo dye</td>
</tr>
<tr>
<td><strong>Sodium Carbonate (chalk)</strong></td>
<td>0.5 bucket (for 6 pieces of cloth)</td>
<td>500 gram</td>
<td>Chalk Factory</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount. Price per packaging is Rp12,000 for 25g</td>
</tr>
<tr>
<td><strong>Candle</strong></td>
<td>1 Fabric sheet</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store. Candles can be recycled for subsequent use</td>
</tr>
<tr>
<td><strong>Mahogany Bark</strong></td>
<td>0.2 jerrycan</td>
<td>5 liter</td>
<td>From Pa Jizi’s furniture waste</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Purchased in the form of waste wood for Rp50,000 per sack, then self-processed and used as dye for approximately 60 liters</td>
</tr>
<tr>
<td><strong>Indigo Powder</strong></td>
<td>1.5 teaspoons</td>
<td>8 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>(powder form) The color produced from Indigo purchased in the cooperative is darker. The price is Rp8,000 per kg</td>
</tr>
<tr>
<td><strong>Vinegar</strong></td>
<td>1/4 bottle</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>1 tub (pool)</td>
<td>20 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>1 tub can be used for 6 batik fabrics</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>Gas LPG 3 kg (for batik and pelorodan dye)</td>
<td>0.5 kg</td>
<td>Toko Kelontong</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Subsidized LPG gas is often empty. Price per 3 kg gas tube Rp23,000. 1 tube 3 kg used to make batik and also pelorodan.</td>
</tr>
<tr>
<td><strong>Mahogany Bark</strong> (wax removal)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood. Only uses 3 kg LPG gas</td>
</tr>
<tr>
<td><strong>Firewood</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood. Only uses 3 kg LPG gas</td>
</tr>
<tr>
<td><strong>Tegeran - dye color (yellow)</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp</td>
</tr>
</tbody>
</table>
1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
Answer: From UGM University in Jogjakarta. Amount purchased 1 kg at a price of Rp1,115,000. 1 kg indigo for stock for 1 month.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
Answer: Special motif Ciwaringin using natural dye as much as 24 pieces per month. 24 s.d. 35 pieces. When there is an additional demand while stock is not available, pick up from a small craftsman in Ciwaringin.

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
Answer: Average price per sheet Rp350,000. The most expensive price is Rp2,000,000 for the silk fabric with the cheapest motif and the cheapest Rp350,000.

4. To how many people did you sell batik cloth?
Answer: 20 people per month. Retail and wholesale.

5. What is the mode of transportation of your batik sale? Where have you been?
Answer: Mode of transportation using motorbike, onthel bike and public transportation. Batik is sold throughout Indonesia online through e-commerce and social media, to hotel, exhibition, resseler, and guest who come.

6. Do you have a limestone or limestone source (calcium carbonate)?
Answer: No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
Answer: 15 pieces of batik cloth.

8. How many times is the color water in the barrel being reused or recycled?
Answer: Until the water runs out.

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
Answer: There is about 20% of the initial amount.

10. What wastewater management is used? How is the filtering system (if any)?
Answer: Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk. Shared IPAL.

Ciwaringin, 11 Juli 2018
Respondent’s Signature
## Results and Responses from Toifah, Silfi Batik

**Name**: Toifah  
**Address**: Ciwaringin  
**Batik Brand Name**: Silfi Batik

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Textile - Cotton</strong></td>
<td>1 Fabric sheet</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Price per package (total 12 pieces) Rp400,000</td>
<td>Rp 33,000</td>
</tr>
<tr>
<td><strong>Hydrosulphate</strong></td>
<td>2 tablespoons</td>
<td>33 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulphate for 1 oz of Indigo dye</td>
<td>Rp 1,700</td>
</tr>
<tr>
<td><strong>Sodium Carbonate (chalk)</strong></td>
<td>0.5 bucket (for 6 pieces of cloth)</td>
<td>500 gram per cloth</td>
<td>Chalk Factory (CV. Kapur Berkat Nusantara)</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependent on fabric amount. Price per packaging is Rp12,000/for 25kg</td>
<td>Rp 6,600</td>
</tr>
<tr>
<td><strong>Candle</strong></td>
<td>1 Fabric sheet</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store. Candles can be recycled for subsequent use</td>
<td>Rp 27,000</td>
</tr>
<tr>
<td><strong>Dye</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mahogany Bark</strong></td>
<td>0.2 jerrycan</td>
<td>5 liter</td>
<td>From Pa Jizi's Furniture waste</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td></td>
<td>Rp 850</td>
</tr>
<tr>
<td><strong>Indigo Powder</strong></td>
<td>1.5 teaspoons</td>
<td>8 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed (powder form)</td>
<td>The color produced from Indigo purchased in the cooperative is darker. The price is Rp800.000 per kg</td>
<td>Rp 7,200</td>
</tr>
<tr>
<td><strong>Vinegar</strong></td>
<td>1/4 bottle</td>
<td>15 ml</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>1 tub (pool)</td>
<td>20 liter</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>1 tub can be used for 6 batik fabrics</td>
<td>Rp -</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gas LPG 3 kg</strong></td>
<td>1 container (for 60 liters dye)</td>
<td>0.5 kg</td>
<td>Grocery Store</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Subsidized LPG gas is often empty. Price per 3 kg gas tube Rp33,000. 1 tube 3 kg used to make batik and also pelorodan.</td>
<td>Rp 11,500</td>
</tr>
<tr>
<td><strong>Mahogany Bark (wax removal)</strong></td>
<td>1 Fabric sheet (size 1.15x 2.50 m)</td>
<td>10 kg</td>
<td>Furniture factory</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Bark is a waste from a furniture factory and is usually sold per sack for Rp10,000</td>
<td>Rp 3,400</td>
</tr>
<tr>
<td><strong>Firewood</strong></td>
<td>1 Fabric sheet</td>
<td>0.1 M³</td>
<td>Wood Seller</td>
<td>Jamblang - Wiyong - Budur</td>
<td>Raw</td>
<td>Direct Purchase - Wholesale price of Rp500,000 to make 70 batik cloths</td>
<td>Rp 8,500</td>
</tr>
<tr>
<td><strong>Tegeran - dye color (yellow)</strong></td>
<td>1 Fabric sheet (size 1.15x 2.50 m)</td>
<td>5 liter</td>
<td>-</td>
<td>Pekalongan</td>
<td>Processed</td>
<td>Purchased online</td>
<td>Rp 45,000</td>
</tr>
</tbody>
</table>
1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
Answer: From Universitas UGM in Jogjakarta and Cooperative
Amount purchased 1 kg at a price of Rp1115,000 (for UGM) and Rp800.000 for Cooperatives
1 kg Indigo for stock for 45 days.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
Answer: Special motif Ciwaringin using natural dye as much as 75 pieces per month
75 s.d 100 sheets. When there is an additional demand while stock is not available, pick up from a small craftsman in Ciwaringin

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
Answer: Average price per sheet Rp300.000
The most expensive price Rp2.200.000 for silk fabric with motifs of halusan and the cheapest Rp250.000

4. To how many people did you sell batik cloth?
Answer: 10 people per month. Retail and wholesale

5. What is the mode of transportation of your batik sale? Where have you been?
Answer: Mode of transportation using motorbike, onthel bike and public transportation
Batik is sold throughout Indonesia online through e-commerce and social media, to hotel, exhibition, resseller, and guest who come

6. Do you have a limestone or limestone source (calcium carbonate)?
Answer: No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
Answer: 10 - 15 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
Answer: Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
Answer: There is
About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
Answer: Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk.
Shared IPAL.

Ciwaringin, 11 Juli 2018
Respondent’s Signature
### Results and Responses from Nuralifah, Rumah Batik Tulis Risma

<table>
<thead>
<tr>
<th>Name</th>
<th>Nuralifah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Ciwaringin</td>
</tr>
<tr>
<td>Batik Brand Name</td>
<td>RBTR (Rumah Batik Tulis Risma)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabric sheet</td>
<td>1</td>
<td>330</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Price per package (total 12 pieces) Rp400,000</td>
<td>Rp 33,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>2</td>
<td>33</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulfate for 1 oz of Indigo dye</td>
<td>Rp 1,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium Carbonate</td>
<td>0.6</td>
<td>600</td>
<td>Chalk Factory</td>
<td>Geempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount. Price per packaging is Rp12,000 for 25kg</td>
<td>Rp 5,500</td>
</tr>
<tr>
<td>(chalk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candle</td>
<td>1</td>
<td>1250</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store. Candles can be recycled for subsequent use</td>
<td>Rp 33,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dye</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td>0.2</td>
<td>5</td>
<td>From Pa Jali’s furniture waste</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Purchased in the form of waste wood for Rp50,000 per sack, then self-processed and used as dye for approximately 60 liters</td>
<td>Rp 850</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigo Powder</td>
<td>1.5</td>
<td>5</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The color produced from indigo purchased in the cooperative is darker. The price is Rp800,000 per kg</td>
<td>Rp 5,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinegar</td>
<td>1/4</td>
<td>15</td>
<td>Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1 tub</td>
<td>20</td>
<td>From own well</td>
<td>Ciwaringin</td>
<td></td>
<td>1 tub can be used for 6 batik fabrics</td>
<td>Rp -</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas LPG 3 kg</td>
<td>1</td>
<td>0.5</td>
<td>Grocery Store</td>
<td>Ciwaringin</td>
<td></td>
<td>Subsidized LPG gas is often empty. Price per 3 kg gas tube Rp33,000. 1 tube 3 kg used to make batik and also pelorodan.</td>
<td>Rp 11,500</td>
</tr>
<tr>
<td>(for batik and pelorodan)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany Bark (wax</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not using firewood</td>
<td></td>
<td>Rp -</td>
</tr>
<tr>
<td>removal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewood</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
<td></td>
</tr>
<tr>
<td>Tegeran - dye color (yellow)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
<td></td>
</tr>
</tbody>
</table>
### Atmospheric Emissions

<table>
<thead>
<tr>
<th>Output</th>
<th>Amount</th>
<th>Unit</th>
<th>Location</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>120 hours</td>
<td>3 kg</td>
<td>Workshop</td>
<td>1 container of 3 kg LPG gas used for 5 days batik.</td>
</tr>
<tr>
<td>Wood Burning</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Wastewater Pollution

<table>
<thead>
<tr>
<th>Output</th>
<th>Amount</th>
<th>Unit</th>
<th>Location</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 vat</td>
<td>20 Liter</td>
<td>Soil</td>
<td>-</td>
<td>Disposable waste is waste of pelorodan waste. So the possibility when discharged amounts less than 20 liters</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   **Answer:**
   - From Universitas UGM in Jogjakarta and Cooperative
   - Amount purchased: 1 kg at a price of Rp1115,000 (for UGM) and Rp800,000 for Cooperatives
   - 1 kg indigo for stock for 60 days.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   **Answer:**
   - Special motif Ciwaringin using natural dye as much as 25 pieces per month
   - 25 - 30 sheets. When there is an additional demand while stock is not available, pick up from a small craftsman in Ciwaringin

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   **Answer:**
   - Average price per sheet Rp300,000
   - The most expensive price Rp1,500,000 for primisima cloth with motifs of halusan and the cheapest Rp250,000

4. To how many people did you sell batik cloth?
   **Answer:**
   - 10 people per month. Retail and wholesale

5. What is the mode of transfortation of your batik sale? Where have you been?
   **Answer:**
   - Mode of transportation using motorbike, onthel bike and public transportation
   - Batik is sold throughout Indonesia online through e-commerce and social media, to hotel, exhibition, resseller, and guest who come
   - Most consumers come from Jakarta, Bandung, and Bali

6. Do you have a limestone or limestone source (calcium carbonate)?
   **Answer:**
   - No. We bought it from a chalk factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
   **Answer:**
   - 10 - 15 pieces of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   **Answer:**
   - Until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   **Answer:**
   - There is
   - About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    **Answer:**
    - Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk.
    - Shared IPAL.

Ciwaringin, 11 Juli 2018

Respondent’s Signature
Results and Responses from Sanuri, Centra Batik Ciwaringin

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Unit (g)</th>
<th>Source</th>
<th>Location</th>
<th>Raw/Processed</th>
<th>Additional Information</th>
<th>Cost (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile - Cotton</td>
<td>1 Fabric sheet (size 1 x 2.50 m)</td>
<td>330 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Price per package (total 12 pieces) Rp400,000</td>
<td>Rp 33,000</td>
</tr>
<tr>
<td>Hydrosulphate</td>
<td>2 tablespoons</td>
<td>33 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>1 oz Hydrosulphate for 1 oz of Indigo dye</td>
<td>Rp 1,700</td>
</tr>
<tr>
<td>Sodium Carbonate (chalk)</td>
<td>0.8 bucket</td>
<td>800 gram per cloth</td>
<td>&quot;Chalk Factory (CV. Kapur Berkat Nusantara)&quot;</td>
<td>Gempol, Cirebon</td>
<td>Processed</td>
<td>Amount of chalk used is fixed and not dependant on fabric amount. Price per packaging is Rp12,000 for 25kg</td>
<td>Rp 7,336</td>
</tr>
<tr>
<td>Candle</td>
<td>&quot;1 Fabric sheet (size 1.15x 2.50 m)&quot;</td>
<td>1000 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>The cooperative bought it from the Drug Store. Candles can be recycled for subsequent use</td>
<td>Rp 30,000</td>
</tr>
<tr>
<td>Mahogany Bark</td>
<td>0.2 jerrycan</td>
<td>5 liter</td>
<td>From Pak Jizi’s furniture factory waste</td>
<td>Ciwaringin</td>
<td>Unprocessed</td>
<td>Purchased in the form of waste wood for Rp50,000 per sack, then self-processed and used as dye for approximately 60 liters</td>
<td>Rp 850</td>
</tr>
<tr>
<td>Indigo Powder</td>
<td>1.5 teaspoons</td>
<td>8 gram</td>
<td>Cooperative</td>
<td>Ciwaringin</td>
<td>Processed (powder)</td>
<td>The color produced from indigo purchased in the cooperative is darker. The price is Rp800,000 per kg</td>
<td>Rp 7,200</td>
</tr>
<tr>
<td>Vinegar</td>
<td>1/4 bottle</td>
<td>15 ml</td>
<td>Local Shop</td>
<td>Ciwaringin</td>
<td>Processed</td>
<td>Same vinegar used for food</td>
<td>Rp 800</td>
</tr>
<tr>
<td>Water</td>
<td>1 pool</td>
<td>20 liter</td>
<td>Personal water well</td>
<td>Ciwaringin</td>
<td>-</td>
<td>1 tub can be used for 6 batik fabrics</td>
<td>Rp -</td>
</tr>
<tr>
<td>Gas LPG 3 kg (for batik and pelorodan)</td>
<td>1 Fabric sheet (size 1.15x 2.50 m)</td>
<td>0.6 kg</td>
<td>Grocery store</td>
<td>Ciwaringin</td>
<td>-</td>
<td>Subsidized LPG gas is often empty. Price per 3 kg gas tube Rp23,000. 1 tube 3 kg used to make batik and also pelorodan.</td>
<td>Rp 4,600</td>
</tr>
<tr>
<td>Mahogany Bark (wax removal)</td>
<td>1 Fabric sheet (size 1.15x 2.50 m)</td>
<td>10 kg</td>
<td>Furniture Factory</td>
<td>Ciwaringin</td>
<td>Raw</td>
<td>Purchased in the form of waste wood for Rp10,000 per sack</td>
<td>Rp 3,400</td>
</tr>
<tr>
<td>Firewood</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
<td>-</td>
</tr>
<tr>
<td>Tegeran - dye color (yellow)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Rp -</td>
<td>-</td>
</tr>
</tbody>
</table>
### Output

<table>
<thead>
<tr>
<th>Output</th>
<th>Amount</th>
<th>Unit</th>
<th>Location</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Emissions</td>
<td>LPG</td>
<td>120 hours</td>
<td>3 kg</td>
<td>Workshop</td>
</tr>
<tr>
<td>Wood Burning</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wastewater Pollution</td>
<td>1 vat</td>
<td>20 Liter</td>
<td>Soil</td>
<td>-</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. Where did your indigo powder come from? What amount do you buy and at what price? How often do you prepare your purchase stock?
   **Answer:**
   - From Universitas UGM in Jogjakarta and Cooperative
   - Amount purchased 1 kg at a price of Rp1115,000 (for UGM) and Rp800,000 for Cooperatives
   - 1 kg indigo for stock for 60 days.

2. How much batik do you make for Batik Ciwaringin every month? How many batik do you make for your own sales each month?
   **Answer:**
   - Specifically the Ciwaringin motif uses natural dyes as much as 45 pieces per month (collectively with several craftsmen)
   - 40 to 45 sheets. When there is an additional request while stock is not available, pick up from small craftsmen in Ciwaringin

3. What is the average selling price of each batik? What is the most expensive and cheapest price?
   **Answer:**
   - Average price per sheet of IDR 350,000
   - The most expensive price is Rp2,200,000 for primisima cloth with halusan motif and the cheapest is Rp250,000

4. To how many people did you sell batik cloth?
   **Answer:**
   - 12-15 people per month. Retail and wholesale for sale

5. What is the mode of transportation of your batik sale? Where have you been?
   **Answer:**
   - Mode of transportation using motorbike, bicycle and public transportation
   - Batik is sold throughout Indonesia online through e-commerce and social media, to hotels, exhibitions, apartments, and guests who come
   - Most consumers' hometowns come from Jakarta, Bandung, Bali and Semarang

6. Do you have a limestone or limestone source (calcium carbonate)?
   **Answer:**
   - No. We bought it from a limestone factory in Gempol Village, Palimanan - Cirebon.

7. How many pieces of batik are produced from a single dye barrel?
   **Answer:**
   - 10-15 sheets of batik cloth

8. How many times is the color water in the barrel being reused or recycled?
   **Answer:**
   - until the water runs out

9. Is there a reduction in the number of inputs or materials into the barrel when the water is reused? How many?
   **Answer:**
   - There is
   - About 20% of the initial amount

10. What wastewater management is used? How is the filtering system (if any)?
    **Answer:**
    - Water is filtered to WWTP consisting of large stones, small stones, charcoal, palm fiber, and husk.
    - Shared IPAL.

Ciwaringin, 11 Juli 2018
Tanda Tangan Responden
Appendix F: LCI Clarification Email Message
(Formatted for report)
Re: Recap Batik Questionnaire
Matt Mayes
Thu 7/19/2018 7:49 AM
To: cecep jaelani <cecep_kj@pupuk.or.id>
Cc: Ivan Bobashev <ivan.bobashev@su-re.co>; Anjar Indraguna <anjar.indraguna@pupuk.or.id>; Caswadi <balin.cell@gmail.com>; Nuryana Lc <nuryana.lc@gmail.com>; Admin su-re.co <sureco@sustainabilityresilience.onmicrosoft.com>; Maja Harren <maja.harren@su-re.co>
Dear Cecep,
Thanks to you and your staff for clarifying our questions. We appreciate your help in finding more detailed/specific answers where available.
Warmly, Matt
From: cecep jaelani <cecep_kj@pupuk.or.id>
Sent: Monday, July 16, 2018 12:21:46 PM
To: Matt Mayes
Cc: Ivan Bobashev; Anjar Indraguna; Caswadi; Nuryana Lc; Admin su-re.co; Maja Harren
Subject: Re: Recap Batik Questionnaire
Dear Matt,
Our answer on blue.
Hello Cecep,
We reviewed the results of the 3 interviews. Overall everything looks great! We appreciate the diligence of your staff in administering the survey. Please thank them for us.
They are also here, and they said regards to you.
Some questions:
1.) Are the respondents being interviewed privately from one another? The photos you sent (thank you for those) make this a bit unclear. Please ask your staff to interview the respondents separately from one another if they aren't already.

They interviewed the respondents individually in their workshops. Why is there a photo of Fathoni, that is because Pa Fathoni is delivering and asking permission from the craftsmen for our interview, but they were ensuring me that Pa Fathoni did not intervene any answers from the respondents they interviewed. If it is necessary, we can also send the sound recording of the interview.

2.) The purpose of the "Source-Sumber" is to collect data on the origin of the particular "Input-Masuka." For example, in the case of "Tekstil," the entry should read "Pekalongan," given that the textiles were purchased externally and not at the "Koperasi." The further back in time the input can be traced the better.
We understand that detailed information on the ultimate origin of some of the inputs may be limited, and we appreciate as much specificity as possible.

It is rather unique. Every time my staff asked where they (SMEs) get the material to make batik, they tend to answer the name of the area and not the name of the person or the name of the business. Their reason is always "Forget it, we buy it online. Husband/wife who care about the purchase." And when I asked more details, the concerned would not tell us. The plausible reason is that they probably hide it since we're not part of them, so the tendency to specify the name of the supplier specifically seems to be inadvertently avoided.

3.) There were no recorded responses for "Waste water pollutants - Limbah pencemar air." We apologize as our original translation may have been unclear. "Limbah pencemar air" should read "Limbah air." We would like an estimation for the volume of water that is a bi-product of the production process before passing through the waste water treatment procedure.

I think they misunderstood on the question. They thought it's about handling waste. They promised me to find out today. They were recording 6 other interview results. Or they will sampling the respondent via phone. Perhaps the answers of one and the other will be almost the same considering the process of pelorodan batik of each craftsman is relatively the same.

4.) Similarly, there were no recorded responses for "Limbah padat - Solid waste." Can you confirm that no solid waste is produced through the production process?

In the process of making environmentally friendly batik, the presence of solid waste is almost non-existent. The resulting solid waste is a candle, and it can still be used in the next process. In the dyeing process, dye materials in the form of wood / bark after dry can be used as fuel. If the ash from combustion includes solid waste then that is the only solid waste left. It upun still can be reused as abrasive (to wash household items that have a crust such as frying pan, pan, etc.)

5.) For the question, "Ke berapa orang Anda menjual kain batiknya?" We want to clarify that we are looking for individual customers per month.

They also asked the same question to the respondent. And their answers always be the same ie 5 to 10 people. In terms of batik sales they have an average of its own customers from some circles such as resseler, boutique owners, collectors, and the rest sold retail. So, for one same person periodically shop batik for resale. So their customers are few, because each of the craftsmen have their own fixed customers.

6.) Related to the "Emisi ke Udara / Atmosfer - Energy inputs" we are a bit confused by the amounts listed. Fahtoni and Solifah both said that they used one 3 kg tank of LPG (84 hours over 1 week) in order to produce 5 sheets of batik. However, they also listed that it only takes 7 hours burning 1 M^3 of wood in order to produce 10 and 13 batik sheets, respectively. This seems like a lot of LPG used to produce only a small amount of batik. Perhaps your staff can collect additional information on how the two energy sources are used differently, confirm the numbers collected and provide a bit more description. Is the LPG used for the wax heating specifically?

Batik craftsmen use both fuel, LPG gas and firewood. LPG gas is used only for batik process (put wax on cloth), while firewood is used for the process of removing wax (pelorodan). In this pelorodan process, the craftsmen usually collect the batik cloths for the wax to be removed simultaneously, and done all day non-stop. So this process is certainly not done every day. While the batik process is done every day. So, the estimate is for 1 tube of LPG used for batik for 1 week, with working hours per day between 5 to 7 hours.

7.) Both Fathoni and Farhan answered that they use "0,16g" of Hidrosulfat, while Solifah answered "10g." Can this difference be accounted for? Are the artisans able to accurately measure the added Hidrosulfat to the
1/10ths of a gram? Any additional information on the Hidrosulfat purchased from the chemical shop would be helpful. It’s concentration, pictures of the packaging etc.

The function of the hydrosulfate is as a lock. Of course the amount of hydrosulfate used is depend on the detail of batik produced. So, when the detail of batik produced more complicated and detailed then the hydrosulfate used will also be more. And the tendency is batik women have detail motif that is more complicated than batik for men.

Once again, thank you very much for your help in coordinating the survey. Best,

Matt

If there are still un-clear answers, do not hesitate to contact me again.

Best Regards,

Cecep Kodir Jaelani Direktur Ekseku
# Appendix G: Potential Stakeholders

<table>
<thead>
<tr>
<th>Organization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan International Cooperation Agency (JICA)</td>
<td>A government agency which coordinates the official overseas development assistance (ODA) provided by the government of Japan.</td>
</tr>
<tr>
<td>Threads of Life</td>
<td><em>Threads of Life</em> is a fair-trade business that uses culture and conservation to alleviate poverty in rural Indonesia. The heirloom-quality textiles and baskets they commission are made with local materials and natural dyes. Proceeds from the Threads of Life gallery help weavers to form independent cooperatives to manage their resources sustainably.</td>
</tr>
</tbody>
</table>