



Empowering The Kemang Bogor Batik Association Through A Batik Waste Processing Installation, Cooperatives, And Digital Marketing

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Abstract

The Kemang Batik Association in Bogor Regency is a community-based creative industry with significant cultural and economic potential, however, its sustainability is constrained by untreated batik wastewater, weak financial management, and limited marketing capacity. Batik production activities generate colored liquid waste that is often discharged directly into the environment, posing pollution risks. In addition, the absence of formal cooperative institutions and reliance on conventional marketing methods hinder business growth and income stability among artisans. This community service program aimed to empower the Kemang Batik Association through an integrated approach encompassing environmentally friendly technology, institutional strengthening, and digital marketing. A portable electrocoagulation-based wastewater treatment installation (IPAL) namely Hydrobex, with a capacity of 100 liters per day was implemented to reduce pollutant loads in batik effluent. Furthermore, a Batik Cooperative was established to improve financial governance, collective management, and access to capital. Digital marketing platforms utilizing social media, online marketplaces and batik game based marketing (GARLaTik) were developed to expand market reach and enhance product visibility. The program was conducted through participatory training, technology transfer, mentoring, and continuous evaluation involving academics, students, and community members. The results indicate improved environmental awareness, strengthened organizational capacity, and increased adoption of digital marketing practices. This integrated empowerment model supports sustainable community development, promotes a green economy, and contributes to the achievement of relevant Sustainable Development Goals.

Keywords: Batik wastewater; Community empowerment; Cooperative; Digital marketing; Green economy.

1. Introduction

The Kemang Batik Association in Bogor Regency is a community-based creative industry with significant cultural and economic potential; however, its sustainability is constrained by untreated batik wastewater, weak financial management, and limited marketing capacity. Batik production activities generate colored liquid waste that is often discharged directly into the environment, posing pollution risks. In addition, the absence of formal cooperative institutions and reliance on conventional marketing methods hinder business growth and income stability among artisans. Batik production represents an important component of Indonesia's creative economy and local cultural heritage. In Bogor Regency, West Java, the Kemang Batik Association has emerged as a community-based micro-enterprise cluster producing hand-drawn batik with distinctive local motifs. Despite its cultural and economic potential, the sustainability of batik micro-enterprises is frequently constrained by environmental, managerial, and market-related challenges. Previous studies have emphasized that community-based creative industries require integrated technological and institutional support to strengthen their competitiveness and long-term viability (Tosida et al., 2023; Jayawinangun et al., 2024).

One of the most critical issues faced by batik producers is the management of liquid waste generated during dyeing and washing processes. Batik wastewater typically contains high concentrations of chemical oxygen demand (COD), total suspended solids (TSS), and synthetic dyes, which can cause serious environmental pollution if discharged untreated (Sutanto et al., 2012; Sutanto et al., 2018). Electrocoagulation has been widely reported as an effective and

environmentally friendly method for treating textile wastewater, demonstrating significant reductions in COD, TSS, and color intensity (Sutanto et al., 2021). However, the adoption of such technologies among small-scale batik artisans remains limited due to technical and financial constraints. Beyond environmental concerns, weak financial governance and the absence of formal cooperative institutions further hinder business sustainability. Studies on batik and tourism-based micro-enterprises indicate that strengthening cooperatives and accounting practices plays a crucial role in improving access to capital and organizational resilience (Andria et al., 2022a; Andria et al., 2022b). Moreover, the limited use of digital marketing restricts market reach, whereas digital platforms have been shown to enhance competitiveness and visibility of local products (Tosida et al., 2020; Ardiansyah et al., 2020).

Therefore, this study addresses the need for an integrated community empowerment model that combines environmentally friendly wastewater treatment technology, cooperative development, and digital marketing. Such an approach aligns with the smart village and green economy frameworks, which emphasize sustainable local development, environmental protection, and inclusive economic growth (Tosida et al., 2023; Tosida et al., 2024).

2. Literature Review

2.1 Batik Industry, Creative Economy, and Community-Based Development

The batik industry plays a strategic role in Indonesia's creative economy, particularly within community-based micro and small enterprises. Previous studies highlight that batik villages not only preserve cultural heritage but also contribute to local economic growth when supported by appropriate institutional and technological frameworks (Jayawinangun et al., 2024; Tosida et al., 2023). Community empowerment models emphasizing local wisdom, participatory governance, and collaborative networks have been shown to enhance resilience and competitiveness of batik-based micro-enterprises (Andria et al., 2022a).

2.2 Batik Wastewater and Electrocoagulation Technology

One of the major environmental challenges in batik production is the discharge of untreated liquid waste containing dyes, salts, and organic pollutants. Several studies report that batik and textile wastewater typically exhibit high COD, TSS, and color intensity, posing serious risks to water ecosystems (Sutanto et al., 2012; Sutanto et al., 2018). Electrocoagulation has been extensively studied as an effective wastewater treatment method due to its simplicity, low chemical usage, and high pollutant removal efficiency. Research demonstrates that continuous electrocoagulation systems can significantly reduce COD, TSS, and color levels in textile wastewater, making them suitable for small-scale industries (Sutanto et al., 2021). Validation studies on water quality analysis further support the reliability of electrocoagulation-based treatment systems for environmental applications (Mulyati & Sutanto, 2016).

2.3 Cooperative Development and Financial Governance

Weak financial management and limited access to capital remain persistent constraints for batik micro-enterprises. Prior research emphasizes the importance of cooperative institutions in improving accounting practices, production management, and collective bargaining power among artisans (Andria et al., 2022a). Cooperatives also facilitate business sustainability by separating household and business finances, improving transparency, and strengthening internal governance structures (Andria et al., 2022b).

2.4 Digital Marketing and Smart Village Framework

Digital transformation has become a critical factor in enhancing the competitiveness of micro-enterprises. Studies show that digital marketing, e-commerce platforms, and digital tourism education significantly improve market access and visibility for local products (Tosida et al., 2020; Ardiansyah et al., 2020). Within the smart village framework, the integration of digital platforms, community participation, and environmental sustainability supports the development of smart economies in rural areas (Tosida et al., 2023; Tosida et al., 2024). These findings underline the need for an integrated approach that combines environmental technology, institutional strengthening, and digital marketing to support sustainable batik communities.

3. Materials and Methods

3.1. Materials

This community-based study was conducted at the Kemang Batik Association, located in Kemang District, Bogor Regency, West Java, Indonesia. The research objects included batik artisans, batik production activities, liquid waste generated from dyeing and washing processes, and community-based institutional structures. The primary materials consisted of batik wastewater samples collected during the coloring and rinsing stages, aluminum electrodes used in the

electrocoagulation process, activated carbon as an adsorbent medium, and electrical components for the wastewater treatment system. Supporting materials included digital marketing platforms (social media and online marketplaces), cooperative management documents, and training modules. The tools and instruments used in this study comprised a portable electrocoagulation reactor with a treatment capacity of 100 liters per day, a direct current (DC) power supply, filtration units, and monitoring devices. Basic water quality parameters such as pH, turbidity, and visual color intensity were observed during system operation. In addition, information and communication technology tools were used to develop and manage digital marketing platforms.

3.2. Methods

The study employed a participatory action research approach combined with technology transfer and community empowerment methods. The implementation was carried out through five sequential stages.

Stage 1: Problem Identification and Community Engagement

Initial activities involved field observations, focus group discussions, and coordination meetings with batik artisans and local stakeholders to identify environmental, managerial, and marketing challenges. Documentation of existing conditions and baseline production practices was conducted see Figure 1.



Figure 1: Coordination meeting with the village head and members of the Kemang Batik Association

Stage 2: Design and Installation of Batik Wastewater Treatment System

A portable electrocoagulation-based wastewater treatment installation (IPAL), hereafter referred to as Hydrobec was designed and constructed. The system utilized aluminum electrode pairs operated under direct current conditions. The design and schematic of the electrocoagulation system are presented in Figure 2, while the electrical configuration is shown in Figure 3.

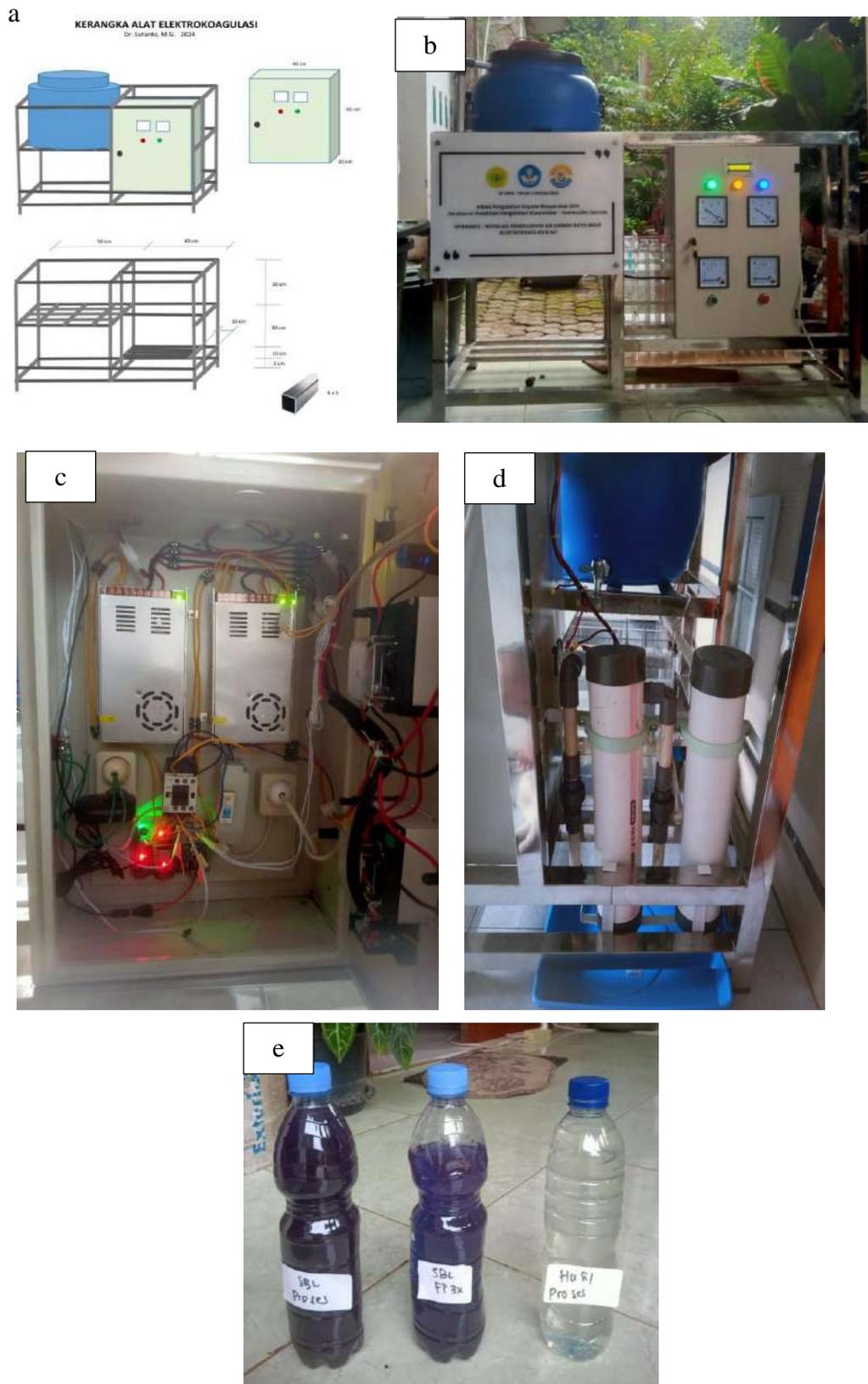


Figure 2: Meeting with batik artisans at the Kemang Batik Association village and site visit to batik production locations



Figure 3: Sample of batik wastewater from the Kemang Batik Association

Stage 3: Training and Technology Transfer

Artisans received hands-on training on the operation, maintenance, and troubleshooting of the IPAL (Hydrobec 2.0) systems, including basic understanding of electrocoagulation principles and IoT-based monitoring features. Training activities also included cooperative management and digital marketing practices. Documentation of the training and mentoring sessions is presented in Figure 4.



Figure 4: Documentation of cooperative management, digital marketing training, and Hydrobec 2.0 system for batik wastewater treatment.

Stage 4: Cooperative Formation and Digital Marketing Development

A Batik Cooperative was established to strengthen financial governance and collective management among artisans. Simultaneously, digital marketing platforms using social media and online marketplaces were developed to expand market access. In addition, the GARLaTik (Game Augmented Reality Batik) platform was introduced as an interactive digital marketing and cultural education tool, enabling users to explore batik motifs, production processes, and local cultural narratives through augmented reality-based gameplay. The digital marketing interfaces, online store layouts, and promotional media are shown in Figure 5.

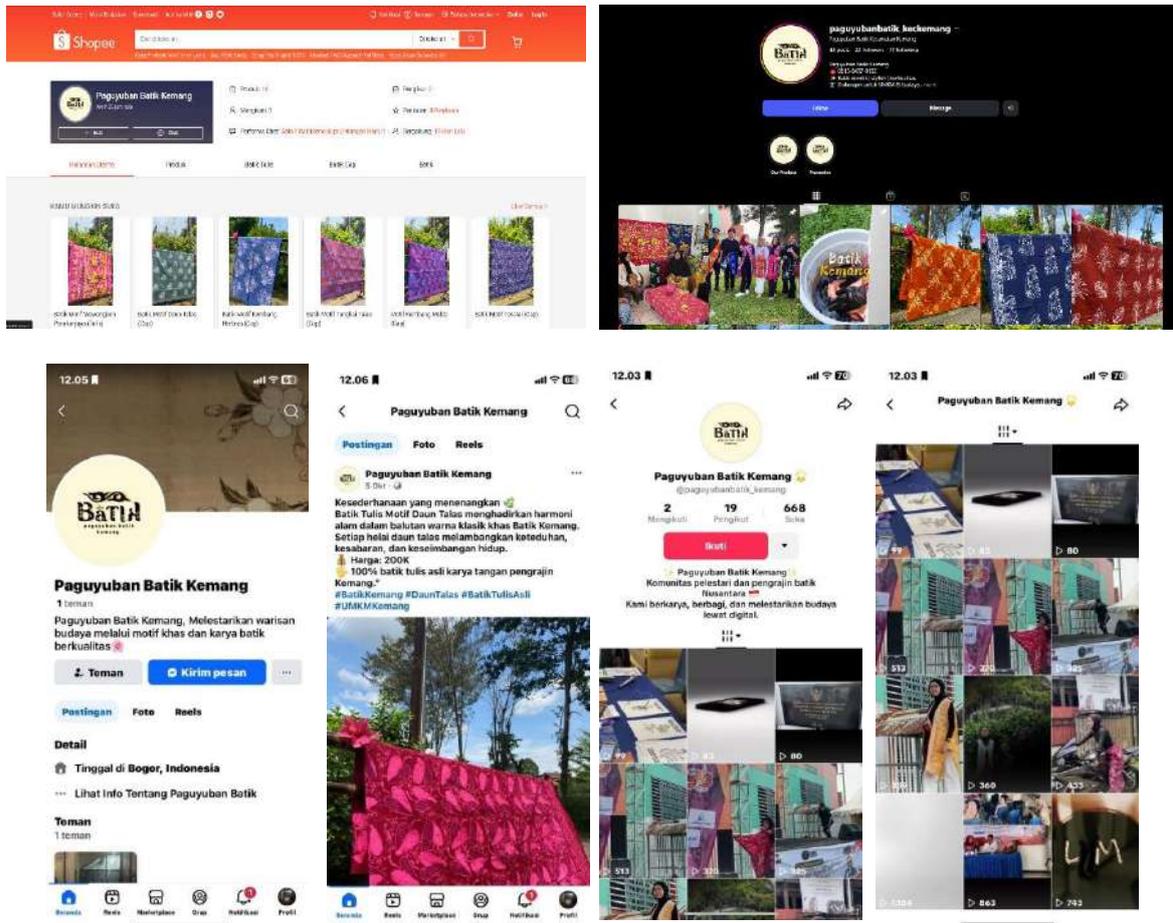


Figure 5: Social media interface of the Kemang Batik Association

Figure 6 presents the key features of the GARLaTik platform as an interactive augmented reality-based game used to support digital marketing and cultural education.





Figure 6: Main features of the GARLaTik platform, including augmented reality–based batik visualization, interactive gameplay, and cultural learning content.

Stage 5: Monitoring, Evaluation, and Mentoring

Periodic monitoring and evaluation were conducted biweekly over four months to assess system performance, community adoption, and sustainability. Key performance indicators included system functionality, user participation, and initial market engagement, summarized in Table 1.

Table 1: Identified Problems, Action Plans, Expected Outputs, and Performance Indicators

No	Problem	Action Plan & Solution	Expected Output	Plan & Performance Indicators
1	The partner does not have a wastewater treatment facility (IPAL).	Construction of a batik wastewater treatment installation based on electrocoagulation with a capacity of 100 L/day.	A technological package of electrocoagulation-based batik wastewater treatment (IPAL), namely Hydrobec.	The electrocoagulation-based IPAL (Hydrobec) is installed and operates according to its capacity for at least one year of production use.
2	The partner faces constraints in capital access and financial management.	Establishment of a cooperative.	Formation of the Kemang Batik Association Cooperative.	The Kemang Batik Association Cooperative is legally registered with approval from the Ministry of Law and Human Rights, has at least 20 active members, and operates effectively. Batik production of cooperative members increases by 10%.
3	The partner does not have digital marketing and promotional media.	Development of digital marketing and promotion through online marketplaces and independent social media–based marketing platforms.	One registered and operational digital marketing technology package on online marketplaces, including intellectual property registration. Managers and members of the Kemang Batik Association are able to operate the system properly.	The digital marketing and promotional package is actively used on online marketplaces and receives at least 5 orders per month or sells a minimum of 15 batik fabrics per month. The independent social media and marketplace–based marketing system is targeted to be accessed by at least 30 users per month.

4. Results and Discussion

4.1 Implementation of the Electrocoagulation-Based Batik Wastewater Treatment System

The implementation of the electrocoagulation-based batik wastewater treatment installation (IPAL) represents a key technological outcome of this program. A portable IPAL system, namely Hydrobec with a treatment capacity of 100 liters per day was successfully designed, constructed, and installed at the Kemang Batik Association production site. The system utilized aluminum electrode pairs and a direct current power supply, enabling effective electrocoagulation during batik wastewater treatment. Operational testing demonstrated that the electrical system functioned reliably, producing stable direct current output suitable for continuous operation. Visual observations indicated a substantial reduction in wastewater turbidity and color intensity after treatment, confirming the practical effectiveness of electrocoagulation for small-scale batik production. These findings are consistent with previous studies

reporting significant reductions in COD, TSS, and color in textile wastewater using electrocoagulation methods (Sutanto et al., 2021). The adoption of this environmentally friendly technology increased artisans' awareness of environmental protection and supported cleaner production practices aligned with green economy principles.

4.2 Integration of the Hydrobec 2.0 System for Smart Batik Wastewater Management

In addition to the conventional electrocoagulation-based wastewater treatment installation, this program introduced **Hydrobec 2.0**, an enhanced version of the batik wastewater treatment system integrated with Internet of Things (IoT) technology. Hydrobec 2.0 was designed as a continuous electrocoagulation system equipped with smart monitoring features to support real-time control and ease of operation for small-scale batik artisans.

The system integrates aluminum electrocoagulation electrodes with multiple sensors, including pH, turbidity, and water level sensors, which are connected to a microcontroller-based unit. These sensors continuously monitor wastewater quality parameters and transmit data to a digital dashboard that can be accessed via mobile devices. Automated control mechanisms were implemented to regulate pump operation based on water level thresholds, ensuring safe and efficient system performance.

Training activities were conducted to familiarize artisans with the principles of electrocoagulation, sensor-based monitoring, and basic system maintenance. Through hands-on simulations, participants learned how to operate the system, interpret sensor readings, and perform routine maintenance. This approach significantly reduced the technical barrier for technology adoption, enabling artisans to operate the system independently without advanced technical expertise.

The integration of Hydrobec 2.0 not only improved wastewater management efficiency but also enhanced environmental awareness and technological literacy among community members. Moreover, the system has potential to function as an educational and demonstration tool for eco-friendly batik production, supporting environmental education and edu-tourism initiatives. This smart wastewater management approach strengthens the sustainability dimension of the empowerment model and demonstrates the applicability of IoT-enabled green technologies in community-based creative industries.

4.3 Institutional Strengthening through Cooperative Development

Beyond technological intervention, institutional strengthening was achieved through the establishment of the Kemang Batik Association Cooperative. Training sessions on cooperative management and basic financial governance were conducted to address long-standing issues related to mixed household–business finances and limited access to capital. As a result, artisans gained a clearer understanding of cooperative principles, collective management, and transparent financial practices. The cooperative was prepared for formal registration and operationalization with active membership involvement. This institutional arrangement is expected to improve business resilience, facilitate access to financing, and enhance production coordination among members. Previous research has emphasized that cooperative-based governance significantly contributes to the sustainability of batik and tourism-related micro-enterprises by strengthening organizational capacity and economic independence (Andria et al., 2022a; Andria et al., 2022b).

4.4 Digital Marketing Adoption and Market Expansion

Digital marketing platforms utilizing social media and online marketplaces were developed to expand market access for Kemang batik products. Training activities enabled artisans to operate digital platforms independently, including content creation and basic online promotion. Initial observations indicated increased online visibility and engagement, with early transaction activity recorded through marketplace channels. The integration of digital marketing addresses the limitations of conventional sales methods and aligns with findings that digital platforms enhance competitiveness and visibility of local creative products (Tosida et al., 2020; Ardiansyah et al., 2020). Although long-term sales impacts require further monitoring, early adoption reflects improved readiness for digital transformation.

4.5 Integrated Empowerment Model and Sustainability Implications

Overall, the results demonstrate that integrating environmental technology, cooperative development, and digital marketing creates a synergistic empowerment model. This approach supports sustainable community development, strengthens local creative industries, and aligns with smart village and green economy frameworks (Tosida et al., 2023; Tosida et al., 2024). The model shows strong potential for replication in other batik-producing communities facing similar challenges.

5. Conclusion

This study confirms that an integrated community empowerment model combining environmentally friendly technology, institutional strengthening, and digital transformation can effectively enhance the sustainability of small-scale batik enterprises. The implementation of an electrocoagulation-based batik wastewater treatment installation, further enhanced through the Hydrobec 2.0 system, provided a practical and innovative solution for reducing environmental pollution while supporting cleaner production practices. The integration of Internet of Things (IoT)-based monitoring enabled real-time observation of key water quality parameters, simplified system operation, and increased technological accessibility for batik artisans.

Beyond environmental improvements, the establishment of the Kemang Batik Association Cooperative strengthened financial governance, collective management, and access to capital, thereby improving business resilience. In parallel, the adoption of digital marketing through social media and online marketplaces expanded market reach and improved product visibility. This digital transformation was further supported by the GARLaTik (Game Augmented Reality Batik) platform, which functioned as an interactive cultural education and experiential marketing tool to enhance user engagement, promote batik motifs, and strengthen cultural awareness.

The results demonstrate that the synergy between smart wastewater management (Hydrobex 2.0), cooperative-based institutional development, digital marketing, and augmented reality-based cultural promotion (GARLaTik) creates a holistic and scalable empowerment framework. This approach aligns with smart village and green economy principles and contributes to sustainable development goals related to environmental protection, decent work, cultural preservation, and inclusive economic growth. Future work should focus on long-term performance evaluation of the Hydrobex 2.0 system, continuous community mentoring, and broader integration of GARLaTik to support replication of this model in other batik-producing communities.

Acknowledgments

Acknowledgments (if any) need to be delivered if there are institutions or individuals who have an important role to support the implementation of research and publications conducted.

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