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Enhancing Community Knowledge Capacity in Waste Management Through a Waste Bank in Siwal Village, Sukoharjo

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Abstract

The increase in the volume and variety of waste in Siwal Village, Baki, Sukoharjo, has prompted the need for a management strategy that is not only technically oriented but also focuses on improving the knowledge capacity of the community. The growing population and settlements have led to waste that has not been managed optimally, with much of it still scattered on roads and public areas. This initiative aims to enhance community understanding and engagement in waste management through system digitalisation and continuous education. The partner in this initiative is BUMDes Citra Abadi Siwal, which currently lacks a structured waste management system and faces limitations in terms of human resources and infrastructure. Through outreach, training, and mentoring, the community is actively involved in developing community-based waste management systems. The education provided includes waste sorting, the use of a web-based waste bank system, and the importance of waste management as an economic opportunity. The results of the activity show an increase in community knowledge and participation, particularly in terms of waste disposal and sorting. The implementation of a digital system also facilitates record-keeping, monitoring, and enhances transparency in management. Despite challenges such as old habits and infrastructure limitations, this initiative has positively impacted environmental cleanliness and economic contributions through the BUMDes business unit. Thus, this initiative serves as a strategic step in enhancing community capacity toward sustainable waste management.

1. Introduction

The population growth in various urban buffer zones, including Siwal Village, has contributed to the increasing volume and variety of household waste. This issue has become a critical concern in environmental management, particularly as many areas are still unable

to manage waste effectively (Nagong, A, 2020; Wahyudi, A, 2016). Consequently, various negative impacts have emerged, such as air and water pollution, and even social conflicts within communities (Darmawan, D., et al, 2018; Aprillia, R., & Anggraini, I. M, 2019; Kusumadinata, A. A, 2016).

Siwal Village, located in Baki Subdistrict, Sukoharjo Regency, borders directly with the city of Surakarta and has experienced significant population growth over the past decade. According to data from the Sukoharjo Central Bureau of Statistics, the population of Siwal Village increased from 3,281 inhabitants in 2014 to 5,346 in 2023, with a density exceeding 3,000 people per square kilometre. This surge has directly contributed to a rise in waste generation, which is not matched by the existing waste management system. A visual representation can be seen in Figure 1.

Figure 1. Waste Conditions in Siwal Village, Baki Subdistrict, Sukoharjo Regency

Field observations indicate environmentally unfriendly behaviours among residents, such as excessive consumption of packaged products, the use of disposable nappies, and the habit of discarding waste in open spaces such as riversides and roadsides. These practices increase health risks, particularly for children and the elderly, and exacerbate environmental pollution in the surrounding areas.

Currently, the waste management system in Siwal Village relies solely on a third party responsible for collecting waste from specific designated points. However, access to these points is uneven, prompting many residents to dispose of waste indiscriminately. With only two waste collection personnel and no structured waste management system in place, the economic potential of waste has yet to be optimally harnessed. Waste is merely collected and

transported to a final disposal site (TPA) without any sorting, recycling, or processing innovations.

BUMDes Citra Abadi Siwal, the designated community partner for this engagement programme, has been operating since 2021 and manages several business units, including waste collection. Nevertheless, the BUMDes continues to face several challenges in implementing effective waste management, such as the high volume of waste—reaching approximately 700 kg per week—which remains poorly managed due to limited human resources, inadequate infrastructure, and the absence of an integrated management system.

Survey and interview results identified three main issues: (a) the lack of an organised waste management system covering collection to recycling, (b) limited human and material resources, and (c) low levels of public participation. These issues have led not only to environmental pollution but also to missed economic opportunities from waste, increased pressure on existing infrastructure, and a decline in the overall quality of life.

Through this community service initiative, the implementation team and its partners are committed to addressing waste management challenges as a top priority. The objective is to develop an innovative and efficient system capable of contributing to the village's own-source revenue (PADes). This programme will utilise information technology to support the digitalisation of waste management while simultaneously empowering the local community. The implementation team brings prior experience in similar initiatives, such as the development of community-based waste bank models (Anna, A. N, 2017), a web-based household waste management application (Anna, A. N, 2019), student empowerment programmes in waste sorting (Santhyami, S., et al, 2022) and capacity building for health workers in waste management (Kusumawati, Y., 2023). These experiences provide a valuable foundation for designing a sustainable waste management solution for Siwal Village.

2. Methods of Implementation

2.1 Method of Programme Implementation

The digitalisation of waste management in this programme was carried out through three main approaches: socialisation, mentoring, and training. Socialisation aimed to introduce the programme to the local community. Mentoring focused on establishing a waste management institution and developing a web-based management system. Meanwhile, training was

intended to equip the partner organisation with the skills required to independently operate the digital waste management system.

2.2 Stages of Implementation

The programme consisted of six main stages: (1) socialisation with partners and the community through a forum held at the village hall involving neighbourhood representatives (RT), (2) mentoring for the formation of an organisational structure for waste management under the BUMDes, (3) adjustment and deployment of a web-based waste management system prepared by the implementation team in accordance with partner needs, (4) intensive training for designated admin personnel on the use of the web-based application, (5) bimonthly monitoring and evaluation (M&E) to assess the programme's success based on indicators such as the number of members, economic potential, and impact, and (6) reporting and dissemination in the form of activity reports, journal articles, and video documentation.

2.3 Partner Participation

The programme partner actively participated in all stages, including socialisation, institution-building, training, evaluation, and reporting (Ismail, Y, 2019). In addition to providing the venue for activities, the partner also assigned technical personnel to be part of the field implementation team.

2.4 Evaluation and Sustainability

Evaluation was conducted every two months through internal forums and surveys administered via Google Forms. Programme sustainability is ensured through active partner participation, successful knowledge and technology transfer, geographical proximity between the implementer and the partner, and a formal cooperation agreement (MoU) between both parties (Mahlil, M., et al, 2021).

3. Results and Discussion

3.1 Profile of BUMDes

BUMDesa Citra Abadi Siwal is a Village-Owned Enterprise established through a community deliberation in Siwal Village, Baki Subdistrict, Sukoharjo Regency, and was

officially inaugurated by a Village Head Decree on 20 April 2021. In line with the spirit of Law No. 6 of 2014 on Villages, this BUMDes aims to serve as a driver of rural economic independence by managing local potential collectively and professionally. The organisational structure is designed to be participatory and transparent, comprising a director, heads of business units, supervisors, and involving both community and village government representatives.

The business activities managed by the BUMDes include clean water services, party equipment rental, a village store, and plans for integrated waste and agricultural management, as well as utility payment services (electricity and water). In its operations, the BUMDes collaborates with various stakeholders to enhance community welfare and serve as a model for successful rural economies rooted in local wisdom.

From 2024 to early 2025, a community engagement programme was implemented focusing on the development of a web-based waste management system. The programme included four stages: coordination, system development, management presentation, and community outreach. Initial analysis revealed an increase in waste volume, suboptimal waste handling, and limited human resources and infrastructure within the BUMDes. To address these challenges, training was provided, an organisational structure for a waste bank was established, supporting equipment such as a plastic shredder and composting tools were procured, and a creative economic unit was formed to process recyclable materials.

The programme's final results demonstrated improved human resource capacity, a more integrated waste management system, and economic contributions from recycled products and compost—developments which have the potential to enhance village income.

Respondent Characteristics

The respondents' characteristics in this community engagement programme include aspects of age, education, occupation, and income, all of which significantly influence the effectiveness of digital waste management system implementation. Of the 23 respondents, all were of productive age, ranging from 19 to 56 years old, with an average age of 37.48 years. This age distribution indicates that participants are in a favourable physical and mental condition to undergo training and apply digital waste management practices in their surroundings.

In terms of educational background, most respondents had completed lower- and upper-secondary education, with 9 individuals (39%) in each category. Meanwhile, 3 respondents (13%) had tertiary education (diploma, bachelor's, or postgraduate degrees), and 2 respondents (9%) had only completed primary education. These details are presented in Table 1 below:

Table 1. Educational Background of Respondents

No	Education Level	Number	Percentage (%)
1	Higher Education (e.g. Diploma/Bachelor's/Master's/Doctorate)	3	13
2	Upper Secondary Education (e.g. SMA/MA/SMK)	9	39
3	Lower Secondary Education (e.g. SLTP/MTs)	9	39
4	Primary Education (e.g. SD/MI)	2	9
Total		23	100

The predominance of respondents with secondary education indicates that most participants possess sufficient literacy skills to comprehend the digital training materials. However, practical and visual learning methods are strongly recommended to accommodate those with lower educational backgrounds.

In terms of occupation, the majority of respondents are labourers (43%), followed by private sector employees (26%), traders or entrepreneurs (26%), and one respondent working as a teacher or lecturer (4%). Further details are presented in Table 2:

Table 2. Occupation of Respondents

No	Occupation	Number	Percentage (%)
1	Private Sector Employee	6	26
2	Trader / Entrepreneur / Self-employed	6	26
3	Labourer	10	43
4	Teacher / Lecturer	1	4
Total			23

The labourer group requires a technological approach that is simple and practical, while private employees and entrepreneurs can serve as outreach agents due to their relatively higher familiarity with technology. Although only one respondent is a teacher, their role is strategic in delivering educational messages.

In terms of income, the majority of respondents (43%) earn between IDR 100,000 and IDR 1,000,000 per month. Meanwhile, 30% have an income between IDR 1,000,000 and IDR 2,000,000, and 26% earn between IDR 3,000,000 and IDR 4,000,000. Details are presented in Table 3 below:

Table 3. Income of Respondents

No	Monthly Income Range	Number	Percentage (%)
1	IDR 100,000 – IDR 1,000,000	10	43
2	> IDR 1,000,000 – IDR 2,000,000	7	30
3	> IDR 3,000,000 – IDR 4,000,000	6	26
Total		23	100

The low level of community income presents a challenge in the implementation of digital systems due to limited access to devices and internet connectivity. Therefore, the system must be device-friendly, data-efficient, and provide alternative access options such as SMS gateways or WhatsApp integration to enhance inclusivity.

3.2 Programme Evaluation

The evaluation was carried out through pre-tests and post-tests to assess participants' understanding of the waste bank concept, operational system, benefits, and digitalisation aspects. Results across four key indicators demonstrated significant improvements following the socialisation and training sessions.

Table 4. Understanding of the Waste Bank Concept

Response Option	Pre-Test		Post-Test	
	Number	Percentage %	Number	Percentage %
Waste management system based on savings with economic value	20	87%	22	96%
A storage place for money made from waste	3	13%	1	4%
Total	23	100%	23	100%

Based on table 4 above, 96% of participants understood that a waste bank is a savings-based system with economic value, up from 87% in the pre-test. This understanding is essential to support an incentive-based digital system.

Table 5. Understanding of the Operational System of a Waste Bank

Response Option	Pre-Test		Post-Test	
	Number	Percentage %	Number	Percentage %
Residents deposit sorted waste and receive money/savings in return	19	83%	20	87%
Waste is collected and processed by the village without involving residents	4	17%	3	13%
Total	23	100%	23	100%

The improvement in participatory understanding reflects the success of the educational approach that promotes active community involvement through a digital waste bank system.

Table 6. Understanding of the Benefits of a Waste Bank

Response Option	Pre-Test		Post-Test	
	Number	Percentage %	Number	Percentage %
Increasing public awareness of waste management	18	78%	22	96%
Reducing the amount of waste dumped into the environment	5	22%	1	4%
Total	23	100%	23	100%

After the training, participants' perceptions shifted towards community awareness and empowerment rather than merely reducing waste volume. This reflects a strategic shift in how residents view digital-based waste management.

Table 7. Understanding of Waste Bank Digitalisation

Response Option	Pre-Test		Post-Test	
	Number	Percentage %	Number	Percentage %
I have heard of it, but do not fully understand how it works	17	74%	20	87%
No, I have never heard of digital waste banks	6	26%	3	13%
Total	23	100%	23	100%

A notable increase in digital literacy was observed, with 87% of participants gaining a clearer understanding of digital waste bank systems compared to 74% at the outset. This signifies that the educational approach was effective in introducing digital concepts.

The implementation of the waste management digitalisation programme in Siwal Village has shown promising results, as evidenced by respondent characteristics and evaluation outcomes from pre-tests and post-tests. Demographically, all respondents fall within the

productive age range, suggesting their theoretical readiness to absorb and apply new knowledge an important social asset for sustaining the programme. Although most respondents have a secondary education background (junior and senior high school), they demonstrated sufficient capacity to comprehend the training materials. Those with lower levels of education could still be effectively engaged through practical and communicative learning approaches.

Analysis of respondents' occupations and income revealed technological access challenges, particularly among labourers and low-income residents. However, these challenges can be addressed by using simple, data-efficient digital systems and leveraging widely used platforms such as WhatsApp or SMS gateways. On the other hand, private employees and entrepreneurs have the potential to become technology adopters and serve as community educators.

The evaluation results demonstrated a significant increase in community understanding regarding the waste bank concept, its operational system, benefits, and digitalisation aspects. For example, awareness of the economic value embedded in the waste bank system rose from 87% to 96%, while understanding of the digital mechanism increased from 74% to 87%. These improvements indicate that the digital education approach was effective in shifting public perception and encouraging active participation. This shift from passive to structured and economically driven engagement highlights the strong potential for further application of the system.

Overall, the digitalisation of waste management in Siwal Village is considered feasible for long-term implementation. The keys to its success lie in a step-by-step strategy, the use of inclusive technology, and the enhancement of community digital literacy. Through collaboration among community groups, village leaders, and appropriate technical support, the programme has the potential to serve as a replicable model of technology-driven community empowerment.

3.3 Challenges and Constraints

The implementation of this programme has not been without its challenges, which must be clearly identified for future development. The first major challenge concerns behavioural

change among residents, especially regarding waste sorting at the source. Despite the educational campaigns, some community members still exhibit resistance to altering long-standing habits.

Secondly, there is a limitation in supporting infrastructure and facilities. Although basic tools such as composters and plastic shredders have been provided, both the quantity and quality of infrastructure still fall short of operational needs in the field.

Thirdly, funding remains a constraint, particularly during the initial operational phase. To optimise the functionality of the digital system and support the sustainability of creative economic units, additional financial support is required. This may come from the Village Budget (APBDes), strategic partnerships with the private sector, or external funding from donors.

3.4 Programme Impact

Despite facing various obstacles, the programme has produced tangible outcomes that serve as a foundation for further development. First, a cleaner and more organised environment has been created, with previously scattered waste now systematically managed through the waste bank system.

Second, there has been a significant increase in public awareness about the importance of waste management, as reflected in residents' active participation in sorting and depositing waste.

Third, the initial contributions to the village's locally generated income (PADes) from the sale of recycled and compost products produced by the BUMDes creative economy unit show promising potential. Although currently modest, this contribution could be developed into a sustainable income source for the village.

3.5 Programme Sustainability

To ensure the programme does not stall at the initial intervention stage, a comprehensive sustainability strategy must be developed. First, it is essential to enhance human resource capacity through advanced, technical, and application-focused training so that the community can manage the system independently. Second, the addition and upgrading of

infrastructure must be based on actual field needs particularly tools for digital recording, waste sorting facilities, and waste logistics transportation. Third, funding strategies must prioritise collaboration with the private sector, including CSR initiatives, local cooperatives, and grant institutions.

Additionally, proposals submitted to local government agencies can serve as alternative sources of sustainable support. With the right backing and active community engagement, the digitalisation of waste management in Siwal Village has the potential to become an innovative model for other villages in Sukoharjo Regency and beyond.

4. Conclusion

The community service programme implemented in Siwal Village has successfully encouraged BUMDesa Citra Abadi Siwal to take on a strategic role in community-based waste management. Through a structured approach of digitalisation and education, the BUMDes has transformed from a facilitator of environmental management into a promising contributor to the village's locally generated income (PADes). This initiative has positioned the BUMDes as a competitive entity committed to community welfare.

The digital waste bank socialisation and training activities have yielded positive outcomes, as evidenced by improvements in public understanding based on pre-test and post-test evaluations. The application of a web-based management system has facilitated record-keeping, monitoring, and enhanced transparency in waste handling. This demonstrates that digital transformation in the environmental sector at the village level is not only feasible but also effective.

Furthermore, the programme has succeeded in increasing community participation in sorting and depositing waste. Nonetheless, challenges such as behavioural resistance, infrastructure limitations, and funding constraints remain issues to be addressed in the next phase. Therefore, sustaining the programme will require adaptive and participatory strategies.

The programme's impact is twofold: first, the creation of a cleaner and healthier environment; and second, the opening of new economic opportunities through creative economic units, such as compost production and recycled goods. This represents a strategic

starting point for establishing a sustainable and empowerment-based waste management system. As a future development, the programme will incorporate a "waste points" feature within the waste bank application. This feature will allow residents to earn points based on the waste they deposit, which can later be redeemed for household necessities, village services, or utility subsidies. This innovation is expected to further boost resident participation and reinforce a fair and engaging incentive ecosystem.

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