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Implementation of Digitalization and Technology-Driven Waste Management Education

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Abstract

Waste management remains a major challenge in Lengkong Village, Bandung Regency, due to the limited capacity of existing waste processing facilities and low community participation in source level waste reduction. The current TPS 3R is unable to accommodate waste generated by 13 neighborhood units, resulting in uncontrolled accumulation that poses environmental and public health risks, while community-based waste management practices based on the 3R principles have not been optimally implemented. As an initial effort, the Mekar Arum Mewangi Waste Bank Unit (BSU MAMMA), established in February 2024, has encouraged household level waste sorting among residents of RW 11; however, its impact remains limited. Therefore, this community service program focuses on education on segregated waste management and deposit procedures, training in the development of waste management educational content, and the development of a digital application to support waste bank operations, aiming to improve data management, transaction recording, and reporting. The initiative is implemented in collaboration with the Coimbatore Institute of Technology, which contributes expertise in decentralized and technology-based waste management, and targets BSU MAMMA members and residents of RW 11 with potential expansion to other areas. Through this approach, the program is expected to foster a more participatory, effective, and sustainable waste management system, ultimately enhancing environmental quality and public health in Lengkong Village.

Keywords: *waste; sorting; waste management;application*

1. INTRODUCTION

In 2021, Indonesia ranked second among the world's largest food waste–producing countries [1]. According to data from the Ministry of Environment and Forestry (KLHK), 37.3% of waste in Indonesia originates from household activities, while the next largest contributor, 16.4%, comes from traditional markets, as shown in Figure 1 [2]. It is estimated that each Indonesian citizen discards approximately 300 kilograms of food waste annually, resulting in significant economic losses ranging from IDR 213 to 551 trillion due to food loss and waste [3]. The Minister of Environment and Forestry, Siti Nurbaya has acknowledged that waste remains a major national challenge in Indonesia, with annual waste generation reaching approximately 67.8 million tons and continuing to increase in line with population growth [4]. Furthermore, data from the National Waste Management Information System (SIPSN) reported that Indonesia generated 19.45 million tons of waste in 2022, of which 39.63% originated from household sources, as shown in Figure 2 [5].

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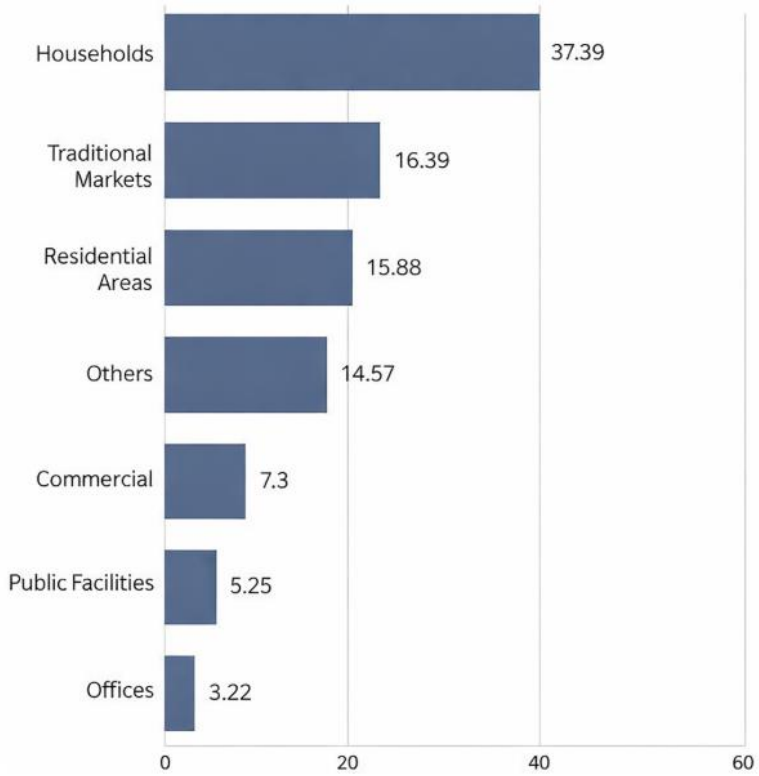

Figure 1. Organic Waste Composition in Indonesia

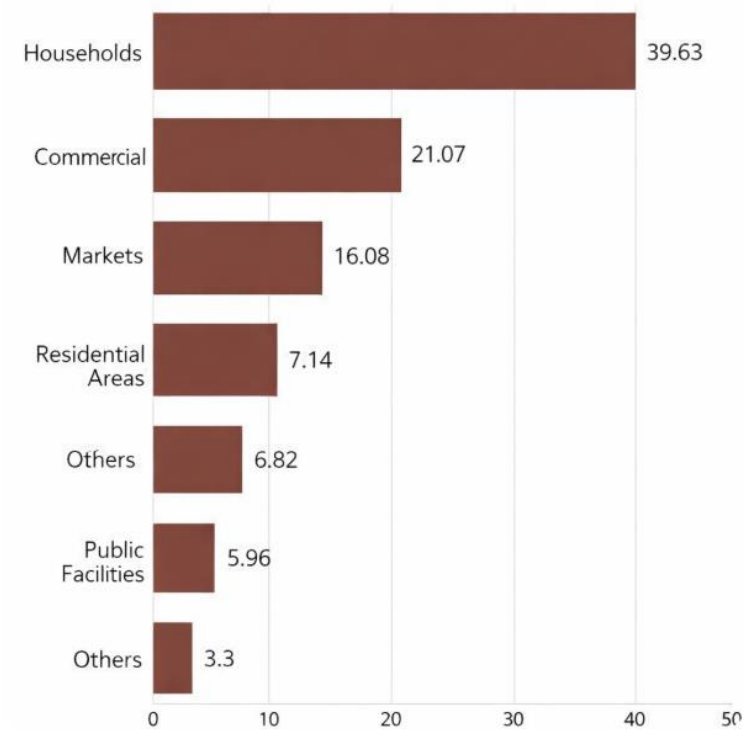

Figure 2. Waste generation composition in Indonesia

One of the regions in Indonesia facing significant waste management challenges is Greater Bandung (Bandung Raya), encompassing Bandung City, Bandung Regency, and West Bandung Regency. This region is particularly burdened by organic waste, which constitutes a dominant proportion of total waste

generation. Data from the Bandung City Environmental Agency (DLH) indicate that approximately 60% of the waste produced in Bandung consists of organic materials derived primarily from households, traditional markets, and restaurants. These conditions highlight the urgency of strengthening waste management strategies that emphasize waste reduction and processing at the source.

Community-based waste management has been widely recognized as an effective approach to addressing household waste issues, particularly when supported by environmental education and active community participation. In recent years, initiatives in Bandung Regency have increasingly incorporated digital media as a tool for environmental education and community engagement. Sisilia [9] demonstrated that application-based digital media can serve as a strategic platform to support *zero waste* movements at the community level by facilitating information dissemination, activity coordination, and youth participation. These findings suggest that digital approaches function not only as communication tools but also as drivers of behavioral change in community waste management practices.

In addition to technology-based approaches, waste literacy plays a crucial role in fostering long-term environmental awareness. Febriani *et al.* [10] emphasized that waste literacy assistance implemented through *learning by doing* methods is effective in enhancing systematic understanding of waste management, while simultaneously fostering a sense of ownership toward environmentally friendly solutions. Participatory and practical educational approaches are therefore essential in shaping sustainable mindsets and behaviors related to waste management.

One effective strategy for addressing household waste is processing organic and inorganic waste at the grassroots level, particularly within neighborhood units (RT), community units (RW), and villages. Lengkong Village, located in Bojongsoang Subdistrict, Bandung Regency, was identified as a target area due to its potential for waste management development and transformation. The village is situated approximately 2.9 km from Telkom University and consists of four hamlets, 17 RWs, 78 RTs, and 1,225 households, as shown in Figure 3.

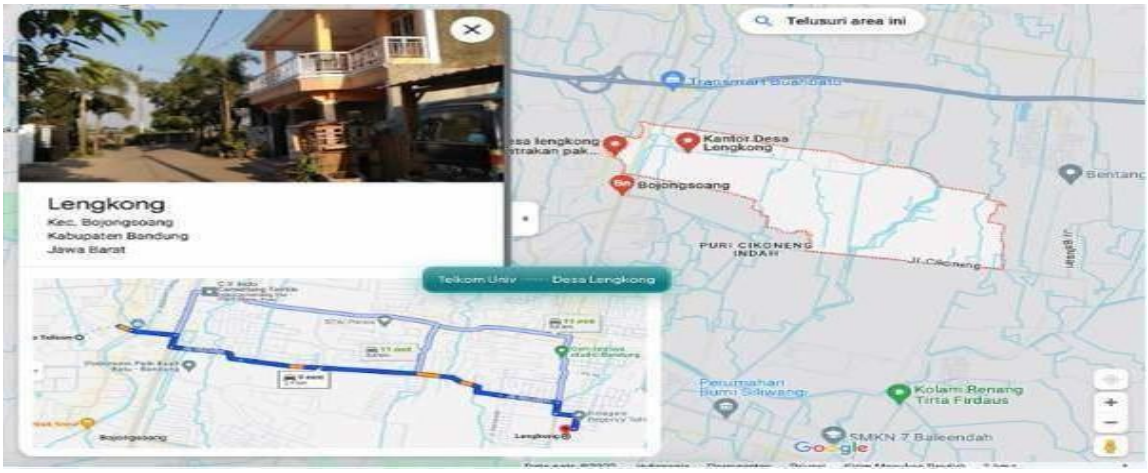

Figure 3: Map of the Coverage Area of Lengkong Village (Source: Google Maps)

To address waste management challenges in Lengkong Village, a community self-help initiative was established, primarily driven by residents of RW 12. In January 2025, this group, in collaboration with Telkom University and the Bersinar Waste Bank, conducted a socialization activity on the implementation of digitalization in waste management based on a circular economy model. Since its establishment in February 2024, the Mekar Arum Mewangi Waste Bank Unit (BSU MAMMA) has experienced gradual growth in community participation, increasing from approximately five initial clients to 40 active participants.

However, observations and interviews with waste bank managers revealed several challenges, including limited waste sorting at the household level and reliance on manual recording systems. From a demographic perspective, Bandung Regency had a population of 3,773,104 people in mid-2024, with approximately 65.19% belonging to the productive age group (15–59 years). The relatively high proportion of residents with secondary to higher education levels indicates favorable human resource potential to support community-based waste management programs. These conditions suggest that appropriate educational approaches and supporting technologies could be effectively adopted by the local community.

As part of waste management digitalization efforts, Lengkong Village is also equipped with a Reduce, Reuse, and Recycle Waste Processing Site (TPS3R), which utilizes technological innovations such as waste shredding and compost sieving machines to improve operational efficiency. However, the effectiveness of TPS3R operations is highly dependent on systematic waste segregation at the source and active community participation. Without adequate educational support and integrated management systems, the capacity of TPS3R facilities may not be optimally utilized.

Although various community service programs have integrated environmental education and digital media utilization [9], [10], most initiatives remain focused on awareness-raising and socialization activities, with limited integration of digital systems to support data management, transaction recording, and program monitoring. Consequently, there is a need for an approach that combines community-based waste management education with the development of digital applications that directly support waste bank operations.

To address this gap, the present community service program focuses on the implementation of digitalization and technology-driven waste management education through the development of a digital application to support the operational activities of the Mekar Arum Mewangi Waste Bank Unit (BSU MAMMA). This program aims to strengthen community participation, improve data management and transparency, and support the sustainability of TPS3R-based waste management systems in Lengkong Village.

2. PROPOSED SOLUTION AND METHOD

Based on the issues identified in the previous section, particularly the limited capacity of household-level waste management and the need for stronger community participation, a comprehensive community service program was designed to address these challenges. The proposed solutions focus on integrating waste management education, community empowerment, and digital technology to support sustainable waste management practices.

2.1. Proposed Solutions and Program Objectives

The community service program proposes several integrated solutions aimed at strengthening waste management at the source. These solutions include:

1. Providing training on social media content creation as a medium for waste management education.
2. Developing educational content to increase public awareness of household waste sorting and processing as part of environmental conservation efforts.
3. Conducting waste management education and training for community members.
4. Developing a digital application for waste bank clients to monitor waste deposit activities and savings balances.
5. Developing a digital application for BSU MAMMA managers to support waste management monitoring and reporting.

6. Organizing training and socialization activities related to the use of digital applications for partners and the wider community.

The objectives of the community service program are as follows:

1. To increase public awareness and understanding of the importance of waste management at the source based on the 3R principles (Reduce, Reuse, Recycle).
2. To optimize source-based waste management through community empowerment to improve effectiveness and efficiency.
3. To facilitate community members who have implemented waste sorting in properly depositing segregated waste.
4. To reduce the volume of waste transported to the final disposal site (TPA).
5. To support the implementation of a circular economy by enabling communities to gain direct economic benefits from waste management activities.
6. To enhance community capacity in creating digital content as a medium for waste management education.

2.2. Program Implementation Method

The implementation of this community service program emphasizes active participation and collaboration among various stakeholders, including village officials, community cadres, institutional representatives, business actors, and local residents. To ensure systematic problem-solving, the program implementation was structured by considering social, cultural, economic, service quality, and community life aspects through the following stages:

1) **Preparation of Educational Content**
   Educational materials were developed in the form of posters, videos, and banners to raise public awareness regarding household waste collection, sorting, and processing as part of environmental conservation efforts.
2) **Community Waste Management Education**
   Educational sessions were conducted to provide the community with knowledge and practical understanding of household waste processing and utilization, particularly related to organic and inorganic waste management.
3) **Workshops and Waste Management Training**
   Workshops on waste management based on the circular economy concept were organized, focusing on waste sorting practices and waste utilization. These activities involved village cadres, RT leaders, and schoolteachers as key agents to ensure program continuity and community engagement. The training aimed to foster awareness of the importance of waste management within the local environment and to strengthen community participation.
4) **Development of Digital Products**
   Digital products in the form of mobile-based applications were developed to support the operational activities of BSU MAMMA. These applications were designed for both waste bank clients and administrators to facilitate waste deposit recording, data management, and monitoring.

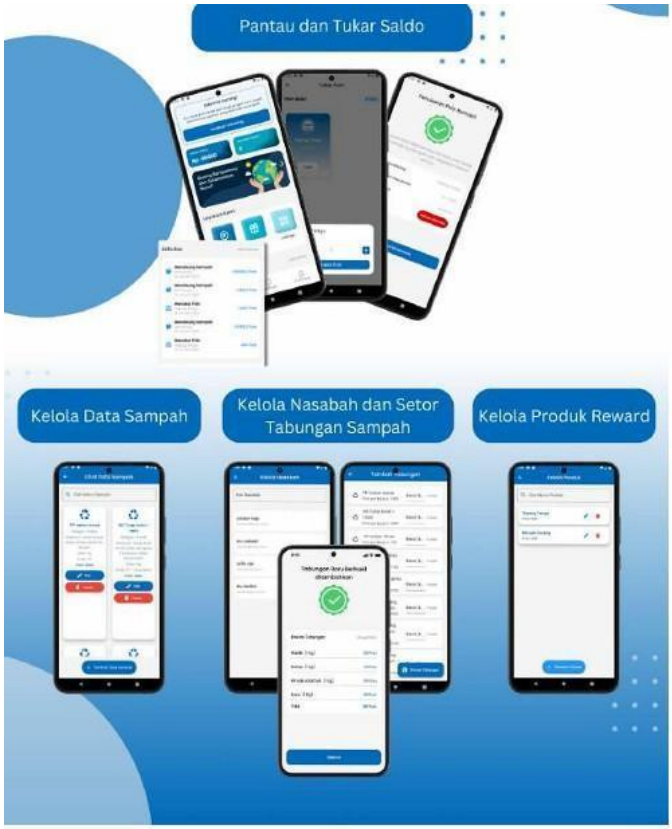

Figure 7: Digital Application for BSU MAMMA

5) Program Evaluation

Program evaluation was conducted to assess both the implementation process and the sustainability of activities after program completion. The evaluation methods included:

a. Measuring participant satisfaction with the training activities through questionnaire surveys.
b. Assessing the usability of the digital application, including ease of use, functionality, and user interface aspects.
c. Identifying further community needs based on training evaluation results.
d. Analyzing digital application feature requirements to support future development.
e. Establishing potential partnerships with institutions experienced in digital application and transaction system development.
f. Utilizing evaluation results as a basis for future research proposals, such as studies on the effectiveness of inorganic waste collection at designated collection points.

3. RESULTS

The community service program on the implementation of digitalization and technology-based waste management education was carried out through several interconnected activities, as outlined in Section 2. These activities included (1) training on social media content creation for waste management education, (2) development of a digital application to support waste bank operations, and (3) socialization and assistance related to the use of the digital application for BSU MAMMA administrators and the surrounding community. The results of each activity are presented in the following subsections.

3.1. Training on Social Media Content Creation for Waste Management Education

The training on social media content creation was conducted as a strategic effort to enhance community literacy and participation in waste management based on the 3R principles. This activity was targeted at members of the Mekar Arum Mewangi Waste Bank (BSU MAMMA) and representatives of residents from RW 11, Lengkong Village, with a focus on strengthening communication skills through digital media as a means of environmental education.

As shown in Figure 8, the training focused on enhancing participants' understanding of social media as a tool for environmental education rather than merely for personal communication. The survey results indicated an increase in participants' understanding of the role of social media as an educational tool for the community. Prior to the training, most participants used social media primarily for personal communication, without considering its potential as a campaign medium. After participating in the training, participants were able to understand the basic concepts of educational content, including identifying key messages, target audiences, and selecting appropriate platforms such as Instagram and WhatsApp, which were considered the most relevant to the characteristics of the local community. These findings are consistent with previous studies [6], which highlight the significant potential of social media in building awareness and promoting behavioral change through participatory communication.

Figure 8: Training on Social Media Content Creation for Waste Management Education

In addition to improved understanding, the training also resulted in the development of participants' practical skills in producing educational content. Participants were able to create various forms of simple content, such as digital posters, short videos, and informative messages related to waste sorting, procedures for depositing waste at the waste bank, and household-level organic waste management. The content emphasized the use of simple language and engaging visuals. This approach indicates to be effective, as environmental communication theory suggests that locally relevant messages are more easily accepted and more likely to encourage behavioral change within communities [7]. Furthermore, the use of digital media in community-based waste management programs has been shown to enhance community engagement and program sustainability [8].

Overall, the results of this activity demonstrate that social media content creation training not only improved participants' digital skills but also contributed to behavioral change in community waste management practices. Environmental education supported by digital communication technologies thus represents a strategic approach to strengthening community-based waste management systems.

3.2. Development of the BSU MAMMA Digital Application

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The application was developed through several main stages, including needs analysis, system design, feature development, and initial testing. During the needs analysis stage, the community service team conducted discussions and direct observations with waste bank administrators and community representatives to identify operational workflows, types of managed data, and commonly encountered challenges. The application development process followed several stages, including needs analysis, system design, feature development, and initial testing, as described in Section 2.

The results of this analysis formed the basis for the application design, which focused on ease of use, interface simplicity, and the application's ability to accommodate the core processes of the waste bank, ranging from recording waste deposits to reporting activities. The application was then developed as a mobile-based application, considering the high level of smartphone usage within the community and the accessibility advantages it offers.

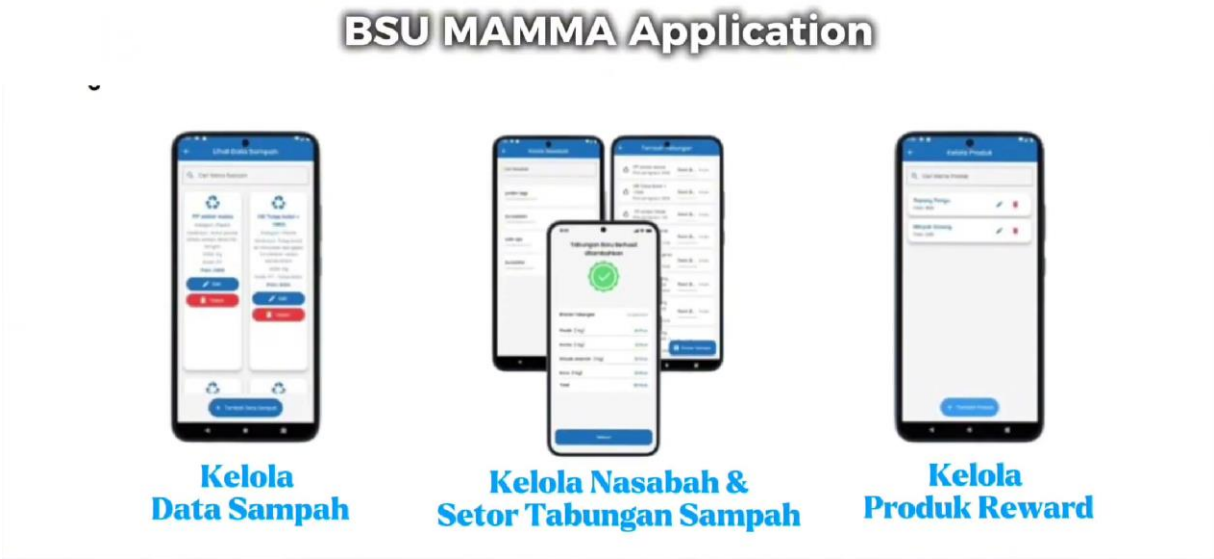

Figure 9. the BSU MAMMA Digital Application

As illustrated in figure 9 on the application interface, the main features of the BSU MAMMA digital application include:

1. Balance Monitoring and Exchange
   This feature allows waste bank customers to monitor their waste savings balance in real time. The balance accumulated from waste deposits can be exchanged for certain rewards in accordance with the waste bank's policies. The presence of this feature enhances transparency and encourages community members to regularly deposit their waste.
2. Waste Data Management
   The waste data management feature functions to record the type and quantity of waste deposited, including both organic and inorganic waste. Digitally stored data facilitate administrators in conducting data recapitulation, analyzing waste volumes, and evaluating the potential for waste reduction at the source.
3. Customer Management and Waste Savings Deposit
   Through this feature, administrators can manage customer data, record waste deposit transactions, and convert them into savings values. This process makes record-keeping more systematic and reduces the risk of errors that commonly occur in manual recording.
4. Reward Products
   This feature is used to manage the list of rewards that can be exchanged using waste savings

balances. With this system, reward management becomes more structured and transparent, both for administrators and customers.

The implementation of the digital waste bank application provides various benefits for both administrators and community members as customers. For BSU MAMMA administrators, the application improves operational efficiency through more organized, accurate, and traceable data and transaction records. In addition, the reporting process becomes faster and more data-driven, thereby supporting accountability in waste management programs. For the community, the application offers easy access to information related to savings balances, deposit histories, and available reward options. This transparency contributes to increased trust and participation in the waste bank program. Furthermore, the use of the digital application also serves as an indirect educational tool, as it raises community awareness of the economic value of waste and the importance of waste segregation at the source.

3.3. Socialization of the BSU MAMMA Digital Application for the Community

Figure 10: Socialization of the BSU MAMMA Digital Application

The socialization of the BSU MAMMA Digital Application represents an important stage in the implementation of community-based digital waste management. The development of technology without adequate user understanding and acceptance may lead to low system utilization in the long term. As shown in Figure 10, these activities were designed not only to introduce the technical aspects of the application but also to build awareness, trust, and readiness among users to adopt digital technology as part of daily waste management activities.

The socialization activities involved direct participation from BSU MAMMA administrators, environmental leaders from RW 11, and community representatives as the main participants. The initial stage of the socialization focused on introducing the concept of a digital waste bank application and the urgency of its implementation. The community service team explained the challenges commonly faced in manual waste bank management, such as inconsistent record-keeping and difficulties in data recapitulation. Subsequently, the BSU MAMMA application was introduced as a potential solution to facilitate waste deposit recording, waste savings balance management, and activity reporting. Practical benefits for the community were also explained, including easier monitoring of savings balances, the value of deposited waste, and a more transparent reward exchange system.

After participants understood the objectives and benefits of the application, the socialization continued with a live demonstration of the application's use. The community service team demonstrated how to access the application via smartphones, including the login process, recording waste deposits,

monitoring balances, and exchanging rewards. Simulation activities were also conducted, in which participants were asked to directly try using the application with sample data.

The socialization of the application did not stop at a single meeting but was followed by continuous assistance. Trained BSU MAMMA administrators served as local facilitators who assisted community members when they encountered difficulties in using the application. This assistance was provided informally during waste deposit activities and through online communication channels such as WhatsApp groups.

4. DISCUSSIONS

4.1. Social Media Content Development for Waste Management Education

The results of the social media content development training indicate that increased community digital literacy directly contributes to strengthening the role of the waste bank. Social media functions not only as a channel for information dissemination but also as a strategic medium for building environmental awareness and encouraging behavioral change. The success of the training is reflected in a shift in participants' perspectives, from using social media for personal purposes to utilizing it as a tool for environmental education and campaigns.

These findings are consistent with Kaplan and Haenlein [6], who emphasize that the effectiveness of social media depends on users' ability to manage messages and audiences. The training served as a catalyst in transforming social media use from individual activities into collective, environmentally oriented actions.

Furthermore, the use of simple language and locally relevant visuals proved to enhance message acceptance, supporting Moser's [7] argument regarding the importance of aligning communication with the audience's lived realities. Compared with previous studies, these results align with Gupta et al. [8], who highlight the critical role of community involvement in waste management. This activity complements earlier findings by demonstrating that social media can strengthen community engagement through sustainable educational efforts.

4.2. Development of the BSU MAMMA Digital Application

The development of the BSU MAMMA Digital Application demonstrates that the digitalization of waste bank operations can improve efficiency and transparency in waste management. The success of the application is primarily determined by its alignment with the needs and workflow of both managers and community members, rather than by the complexity of the technology itself. A user-centered development approach enables easier adoption of the application at the community level.

Features such as balance monitoring and reward management play a significant role in increasing community motivation and participation. Transparency in waste savings values enhances users' trust in the waste bank system. In addition, digital waste data recording provides a reliable foundation for managers to conduct reporting and program evaluation in a more systematic manner.

Ease of use is a key factor in technology adoption within the community. A simple interface and usage flow that mirrors manual processes help reduce barriers to adoption. These findings confirm that simple and practical digital technologies are more effective for implementation in community-based contexts.

4.3. Socialization of the Use of the BSU MAMMA Digital Application

The socialization of the Digital Application of the Mekar Arum Mewangi Waste Bank (BSU MAMMA) plays an important role in supporting the success of community-based waste management digitalization.

The results of the activity indicate that community acceptance and readiness are key factors in the effective utilization of the application, as technology that is not well understood tends to be unsustainably used.

The active involvement of waste bank administrators, community leaders, and residents during the socialization process helped build trust and enhance understanding of the application's benefits. Demonstrations and usage simulations enabled participants to practically comprehend the technical functions of the application, allowing it to be perceived as relevant to daily waste management needs.

Moreover, continuous assistance provided by BSU MAMMA managers as local facilitators further strengthened the technology adoption process and reduced barriers to application use. These findings emphasize that the success of waste management digitalization is determined not only by technological aspects but also by participatory approaches and sustained community-based support.

5. CONCLUSION

The implementation of digitalization and technology-based waste management education at the Mekar Arum Mewangi Waste Bank Unit (BSU MAMMA) demonstrated that the integration of environmental education, community participation, and digital technology can effectively support community-based waste management initiatives. The socialization and mentoring activities enabled both community members and waste bank administrators to understand the functions and benefits of the digital application, particularly in recording waste deposits, monitoring waste savings balances, and managing reward systems in a more transparent and systematic manner.

The adoption of the digital application contributed to improved operational efficiency and strengthened trust and participation among community members. The findings indicate that a participatory approach, supported by continuous assistance and user-centered system design, plays a crucial role in enhancing community readiness and acceptance of digital technology. These elements are essential for ensuring that digital solutions are not only adopted but also sustainably utilized within community-based programs.

Overall, the BSU MAMMA digital application has the potential to serve as an effective supporting tool for strengthening the sustainability of waste bank operations and optimizing the utilization of existing waste management infrastructure such as TPS3R. The approach applied in this community service program may be adapted and implemented in other communities facing similar waste management challenges, provided that local contexts and community capacities are carefully considered.

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