Empowerment Of Community-Based Information Technology In Irrigation Waste Management Systems For Institutional Strengthening And Promoting Local Circular Economy

M. Yani Syafe'i[1] , Siti Kurnia Rahayu[2] , Masduki[3]*, Dony Susandi[4]

[1,2,3,4] Doctoral Program in Management Science, Postgraduate School, Universitas Komputer Indonesia, Bandung, Indonesia
*Corresponding Author:
Email: masduki.75422006@mahasiswa.unikom.ac.id

Abstract.

Waste problems in the irrigation channels of Bendung Rentang, Majalengka, have disrupted water distribution functions, polluted the environment, and increased public health risks. This community service program aims to empower the local community by strengthening technical capacity, institutional development, and downstreaming of waste processing products based on appropriate technology. A participatory approach was adopted involving 20 members of Komunitas Hujan Keruh in training to operate the Waste Processing System (WPS), establishing a formal waste management group, and providing assistance in marketing products such as Refuse Derived Fuel (RDF), liquid fertilizer, and maggot feed. The results showed a significant increase in participants' technical knowledge by up to 50%, the formation of a management group with clear standard operating procedures (SOP), and initial trials of product downstreaming to local markets. In conclusion, this program effectively supports a circular economy and is feasible to be replicated in other regions facing similar waste management challenges.

Keywords: *Community Empowerment; Circular Economy; Irrigation Waste; Appropriate Technology and Institutional Strengthening.*

I. INTRODUCTION

Waste management issues have become a crucial global concern, particularly in developing countries like Indonesia, which faces serious challenges due to the increasing volume of waste and its impact on the environment. According to the What a Waste 2.0 report by the World Bank (2022), the world generates more than 2 billion tons of solid waste annually, with projections reaching 3.4 billion tons by 2050 if no significant interventions are made. Indonesia is recorded as the second-largest contributor of plastic waste to the ocean, with an estimated 5.7 million tons entering marine waters each year (Our World in Data, 2023). This high volume of waste not only pollutes marine ecosystems but also worsens environmental conditions on land and in waterways, including irrigation channels that are vital for the agricultural sector. At the national level, the Indonesian government has responded with various strategic policies. Presidential Regulation No. 97 of 2017 on the National Policy and Strategy for Household Waste Management (Jakstranas) serves as a legal framework directing waste reduction at its source, reuse, and recycling. Furthermore, Government Regulation No. 27 of 2020 on Specific Waste Management emphasizes the need for multi-stakeholder collaboration to address types of waste requiring special handling. However, field implementation still faces major challenges, including limited technology, low community participation, and weak institutional capacity at the local level (Mulyana et al., 2023).

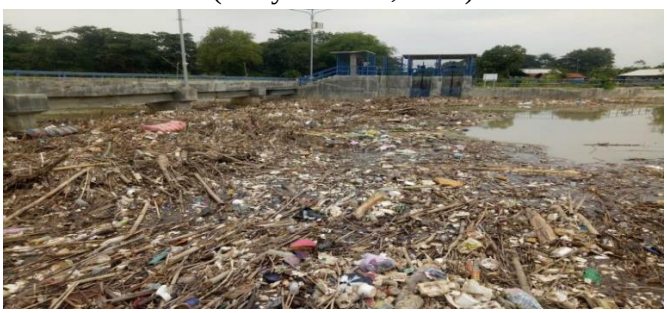

Fig 1. Waste Problems Become in the Bendung Rentang Area

Specifically, in Majalengka Regency, waste problems have become acute in the Bendung Rentang area (see figure 1), a strategic irrigation infrastructure that irrigates thousands of hectares of rice fields in the Ciayumajakuning region (Cirebon, Indramayu, Majalengka, Kuningan). Domestic waste carried by river currents often clogs irrigation channels, disrupting water distribution, causing local flooding, and increasing waterborne disease risks (Rahmawati et al., 2022). This condition not only reduces agricultural productivity but also worsens the quality of life for surrounding communities.

Fig 2. Integrated Waste Processing System Rentang

As a mitigation effort, Komunitas Hujan Keruh has developed an integrated waste processing system (See Figure 2), the Waste Processing System (WPS), at Bendung Rentang. This facility is equipped with conveyor technology, sorting machines, shredders, and briquette molding machines, enabling the conversion of waste into economically valuable products such as Refuse Derived Fuel (RDF), liquid fertilizer, and maggot feed. This initiative aligns with the circular economy concept, which aims to reduce waste through the principles of reduce, reuse, recycle, and recover (Geissdoerfer et al., 2020). However, the sustainability of WPS faces several issues, including limited technical capacity of local operators, weak community institutional structures for operational management, and the underdeveloped value chain for downstreaming processed waste products to the market.

Theoretically, community empowerment in waste management has proven effective in various studies. Yulianti & Suryani (2021) revealed that community-based waste management models can enhance waste management efficiency while empowering the local economy. Furthermore, Rahmawati et al. (2022) emphasized the importance of appropriate technology transfer to build community capacity, while Mulyana et al. (2023) asserted that the success of similar programs heavily depends on active community participation and cross-sector support. Thus, strengthening community institutions and providing technical assistance are key to ensuring the sustainability of community-based waste management systems (See Figure 3).

Fig 3. Community Empowerment in Waste Management

Currently, the main challenges are the low effectiveness of waste management in Bendung Rentang's irrigation channels due to insufficient technical capacity of the community in operating WPS technology, weak institutional structures, and an underdeveloped value chain for processed waste products. Without appropriate interventions, WPS risks suboptimal functionality, and the waste problem in irrigation systems will persist, threatening the sustainability of local ecosystems and agricultural sectors.To address these challenges, a community service program initiated by Universitas Komputer Indonesia adopts a holistic and participatory approach. The problem-solving plan includes: (1) technical training on WPS operations for

community members to enhance their competencies; (2) institutional strengthening through the formation of the WPS Rentang Waste Management Group with clear organizational structures and SOPs; and (3) assistance in downstreaming processed waste products through the development of marketing strategies and distribution networks.

This approach is expected to build a sense of ownership among the community and improve the operational sustainability of WPS.The aim of this community service activity is to empower the local community in managing irrigation waste using appropriate technology, focusing on enhancing technical capacity, strengthening institutions, and optimizing product downstreaming. More broadly, the program is expected to serve as a model for community-based circular economy waste management at the local level, supporting the achievement of several Sustainable Development Goals (SDGs), particularly Goal 6 (Clean Water and Sanitation), Goal 11 (Sustainable Cities and Communities), Goal 13 (Climate Action), and Goal 8 (Decent Work and Economic Growth).Through a collaborative approach involving the community, local government, academia, and the private sector, this program is anticipated to deliver sustainable positive impacts on environmental, social, and economic aspects. The success of this model may also be replicated in other regions facing similar challenges, contributing to a more effective and sustainable national waste management system.

II. METHODS

This community service activity was carried out using a participatory approach, emphasizing active collaboration among local communities, regional governments, universities, and other stakeholders. This approach was chosen to ensure program sustainability by fostering a sense of ownership within the community toward the established waste management system.

Data Sources

The data in this activity consisted of primary and secondary data:

1. Primary data were obtained through field observations, in-depth interviews with members of Komunitas Hujan Keruh, focus group discussions (FGDs), and pre-test and post-test results administered to training participants.
2. Secondary data were collected from relevant documents, such as environmental condition reports from the Majalengka Environmental Agency, statistical data on irrigation waste volume, and academic literature on community-based waste management and appropriate technology (Geissdoerfer et al., 2020; Mulyana et al., 2023).

Data Collection Procedures

The data collection process was carried out in several stages:

1. Identifying partner needs through initial surveys and FGDs to map problems, potentials, and the technical capacity of the community.
2. Conducting training and workshops, which included materials on community-based circular economy waste management, operating WPS machines (conveyor, sorting machine, shredder, briquette molding machine), and product downstreaming strategies.
3. Observation and documentation, to record participants' activities during training and field practice.
4. Pre-test and post-test, to measure improvements in participants' knowledge and technical skills.

Data Analysis Techniques

The collected data were analyzed using a qualitative descriptive approach to describe the achievements of the activity and its impacts on the community. The analysis involved the following steps:

1. Simple quantitative analysis of pre-test and post-test results to calculate the percentage increase in participants' technical knowledge after training (Rahmawati et al., 2022).
2. Qualitative analysis, through data triangulation from interviews, field observations, and documentation to gain in-depth insights into changes in community technical capacity, institutional strengthening, and the effectiveness of product downstreaming strategies.

3. Impact evaluation, conducted by comparing pre- and post-intervention conditions, particularly in environmental aspects (reduced waste volume in irrigation channels), social aspects (active community participation), and economic aspects (added value from processed waste products).

The integration of technical education, institutional strengthening, and marketing network development in this method is expected to produce sustainable impacts. The program's success is assessed not only from the technical aspects but also from the community's ability to manage WPS independently and expand the benefits of a circular economy in the Bendung Rentang area.

III. RESULT AND DISCUSSION

Results

The community service activity titled "Empowerment of Community-Based Information Technology in Irrigation Waste Management Systems for Institutional Strengthening and Promoting Local Circular Economy" was successfully held on July 10, 2025, at the Waste Processing System (WPS) building, Bendung Rentang, Desa Panongan, Jatitujuh Subdistrict, Majalengka Regency. The activity involved 20 participants from Komunitas Hujan Keruh, supported by the Majalengka Environmental Agency, Jatitujuh Subdistrict Office, and academics from Universitas Komputer Indonesia.

The main results of the activity included:

1. Improved Knowledge and Technical Skills
   Pre-test and post-test results showed an average increase in participant scores of 35–50% in understanding circular economy principles, WPS machine operations, and downstreaming strategies for processed waste products.
2. Institutional Strengthening of the Community
   The activity facilitated the establishment of the WPS Rentang Waste Management Group, a formal entity equipped with an organizational structure and Standard Operating Procedures (SOPs) to guide daily operations.
3. Downstreaming of Processed Waste Products
   Products such as Refuse Derived Fuel (RDF), liquid fertilizer, and maggot feed were successfully produced and trialed with local partners. RDF was tested as an alternative fuel by a brick-making entrepreneur, while liquid fertilizer was applied by local farmers.
4. Environmental and Social Impact
   There was a significant reduction in waste volume in the irrigation channels, improved water quality, and heightened environmental awareness among community members.

Table 1. summarizes the outcomes and impacts of the activity:

Aspect	Outcomes and Impacts
Environment	Reduced waste volume in irrigation channels; improved water quality
Economy	Potential additional income from sales of RDF and liquid fertilizer
Social	Increased community participation in waste management
Institutional	Established formal group with organizational structure and SOPs

Discussion

The results of this community service program indicate that a participatory approach is highly effective in building the technical capacity of local communities and strengthening local institutions for irrigation waste management. The observed 35–50% increase in participant knowledge following training reflects the effectiveness of combining theoretical and practical learning methods. This aligns with Rahmawati et al. (2022), who found that practice-based training in waste management significantly enhances community technical competencies.The formal establishment of the WPS Rentang Waste Management Group is a critical milestone in ensuring program sustainability. According to Mulyana et al. (2023), the success of community-based waste management depends heavily on strong local institutions and high levels of community engagement. This newly formed group not only manages daily WPS operations but also serves as a local hub for environmental education and advocacy (see figure 4).

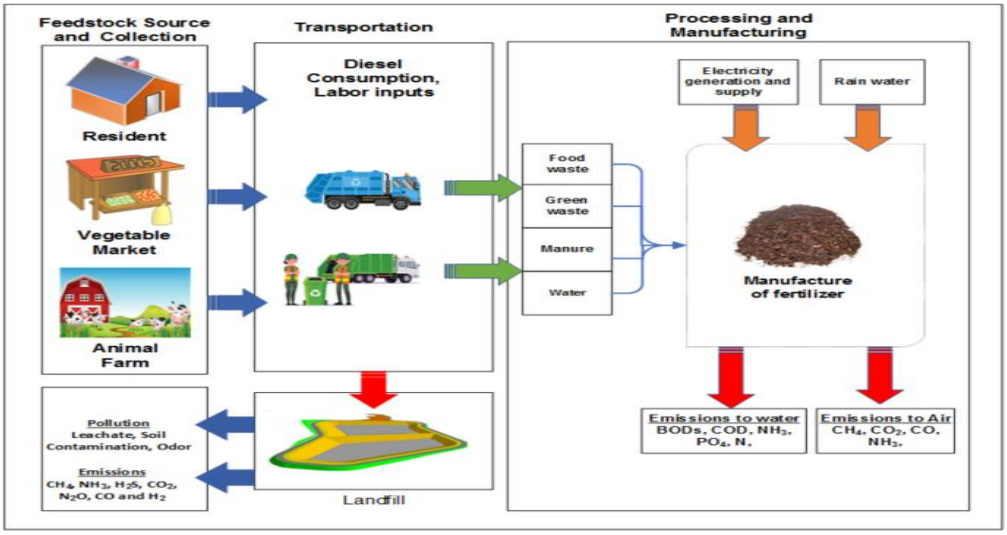

Fig 4. WPS Rentang Waste Management Group

The downstreaming of processed waste products, including RDF, liquid fertilizer, and maggot feed, represents a strategic step toward strengthening the local circular economy (see figure 5). The initial acceptance of RDF as an alternative fuel and liquid fertilizer by local users demonstrates promising economic potential. This finding supports Geissdoerfer et al. (2020), who emphasized that circular economy practices not only reduce waste but also create added economic value through the principles of reduce, reuse, recycle, and recover. Nevertheless, product downstreaming still faces challenges, particularly in marketing and distribution. Developing digital marketing strategies and collaborating with cooperatives and private sectors are essential for expanding distribution networks and improving product competitiveness.

Fig 5. The downstreaming of processed waste products, including RDF, liquid fertilizer, and maggot feed

The environmental impact of the program was also significant. The substantial reduction of waste in irrigation channels improved water quality and reduced the risk of blockages that threaten the functionality of Bendung Rentang, a strategic irrigation infrastructure for the Ciayumajakuning region. These positive outcomes align with several Sustainable Development Goals (SDGs): Goal 6 (Clean Water and Sanitation), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action).From a social perspective, the program successfully increased community awareness and active participation in waste management. This level of involvement was evident from the high engagement of Komunitas Hujan Keruh members during training and mentoring sessions. As Yulianti and Suryani (2021) noted, active community participation is a critical factor in the success of rural community-based waste management programs. With greater understanding of circular economy concepts, behavioral changes toward sustainable environmental practices are expected to emerge.Despite these positive outcomes, several challenges remain to ensure program sustainability. Limited access to capital for scaling up WPS production capacity and the need for advanced training in business management and digital marketing were identified as critical issues.

Strengthening these areas will help the community group expand the market for processed waste products and increase their income.Furthermore, multisectoral collaboration between universities, local governments, community organizations, and private sectors should be maintained and expanded. The World Bank (2022) highlights that multi-stakeholder synergy is key to developing sustainable environmental solutions, particularly in regions with limited institutional capacity. Strengthening partnerships with financial institutions, cooperatives, and local businesses can further develop the circular economy ecosystem, supporting independent community waste management initiatives.Conceptually, these findings reinforce the theory of community empowerment in waste management using appropriate technology. The integration of education, technology, and local institutional strengthening has proven to generate multidimensional impacts—environmental, social, and economic. The model developed in this program has strong potential to be replicated in other regions with similar waste challenges, with adjustments tailored to local contexts.Thus, this discussion highlights that the success of this community service program lies not only in achieving technical outputs but also in developing community capacity and institutional resilience to support sustainable circular economy-based waste management systems. For broader impact, continuous policy support from local governments and ongoing mentoring by academics and business partners are essential.

IV. CONCLUSION

The community service program entitled “Empowerment of Community-Based Information Technology in Irrigation Waste Management Systems for Institutional Strengthening and Promoting Local Circular Economy” was successfully implemented at the Waste Processing System (WPS) building in Bendung Rentang, Desa Panongan, Jatitujuh Subdistrict, Majalengka Regency. The results demonstrated significant achievements in three main areas.First, there was a notable improvement in the technical capacity of the community in managing irrigation waste through training on WPS machine operations and understanding circular economy principles. The 35–50% increase in pre-test and post-test scores reflects the success of the practice-based training method.Second, the formal establishment of the WPS Rentang Waste Management Group, complete with an organizational structure and operational SOPs, provides a strong foundation for the program’s sustainability.Third, processed waste products such as Refuse Derived Fuel (RDF), liquid fertilizer, and maggot feed were successfully produced and trialed in local markets, opening opportunities to strengthen the circular economy at the community level.This program’s impact was evident not only environmentally, through reduced waste volume in irrigation channels, but also socially, by enhancing community participation and awareness in sustainable waste management practices.

To ensure the sustainability and further development of the program, the following recommendations are proposed:

1. Advanced Training and Intensive Mentoring

Provide further training for community members, particularly in business management, digital marketing, and product innovation, to enable independent and professional management of the WPS.

2. Strengthening Product Downstreaming

Develop more structured marketing strategies, including the use of e-commerce platforms and collaborations with cooperatives, private sectors, and financial institutions to expand distribution networks and increase product value.

3. Replication in Other Regions

The community empowerment model using appropriate technology implemented in Bendung Rentang has proven effective and is feasible for replication in other regions facing similar waste management challenges, with adjustments to local contexts.

4. Sustained Multisector Collaboration

Strengthen partnerships among local governments, academia, communities, and private sectors to reinforce the circular economy ecosystem and support long-term program sustainability.

5. Regular Monitoring and Evaluation

Conduct routine monitoring and evaluation of the WPS Rentang Waste Management Group's performance to identify field challenges and formulate timely solutions.

With these recommendations, the program is expected to serve as a model for effective community-based waste management that supports the achievement of the Sustainable Development Goals (SDGs) and contributes significantly to improving environmental quality and local community welfare.

V. ACKNOWLEDGMENTS

The authors express their highest appreciation to all parties who contributed to the implementation of this community service program. Special thanks are extended to Komunitas Hujan Keruh as the primary partner for their active participation throughout the stages of planning and field implementation. We also extend our gratitude to the Majalengka Environmental Agency and the Jatitujuh Subdistrict Office for their policy support and institutional facilitation, which were vital to the success of this program. The support from the Irrigation Management Unit (UPI) of Bendung Rentang also contributed significantly to the smooth execution of activities at this strategic location. Our deepest gratitude is also directed to the Dean of the Postgraduate School of Universitas Komputer Indonesia, Assoc. Prof. Dr. Rahma Wahdiniwaty, Dra., M.Si., for her support and guidance, which greatly facilitated the success of this program. Finally, sincere appreciation goes to all resource persons and team members, namely Prof. Dr. Ir. H.M. Yani Syafe'i, M.T., CSBA; Prof. Dr. Hj. Siti Kurnia Rahayu, SE., M.Si.; Dony Susandi, ST., MT; and Ir. H. Masduki, M.Si., for their invaluable knowledge sharing, experience, and technical assistance provided throughout the program. It is our hope that the outcomes of this program will bring tangible benefits to the community and serve as a replicable model for other regions facing similar challenges.

REFERENCES

[1] Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2020). The circular economy – A new sustainability paradigm? ***Journal of Cleaner Production***, 247, 119575. https://doi.org/10.1016/j.jclepro.2019.119575

[2] Mulyana, A., Wicaksono, A., & Sari, R. P. (2023). Strengthening community-based waste management institutions in rural areas. ***Journal of Environmental Management and Sustainability***, 12(2), 45–58. https://doi.org/10.1016/j.jems.2023.02.005

[3] Our World in Data. (2023). Plastic pollution. Retrieved from https://ourworldindata.org/plastic-pollution

[4] Peraturan Pemerintah Republik Indonesia. (2020). Peraturan Pemerintah Nomor 27 Tahun 2020 tentang Pengelolaan Sampah Spesifik. Jakarta: Sekretariat Negara.

[5] Peraturan Presiden Republik Indonesia. (2017). Peraturan Presiden Nomor 97 Tahun 2017 tentang Kebijakan dan Strategi Nasional Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Sampah Rumah Tangga. Jakarta: Sekretariat Negara.

[6] Rahmawati, E., Kurniasih, D., & Syahputra, F. (2022). Community capacity building through appropriate technology in waste management: A case study in Indonesia. ***International Journal of Community Development***, 8(1), 22–35. https://doi.org/10.1177/ijcd.2022.081002

[7] The World Bank. (2022). What a waste 2.0: A global snapshot of solid waste management to 2050. Retrieved from https://datatopics.worldbank.org/what-a-waste/

[8] Yulianti, R., & Suryani, I. (2021). Community-based waste management model in rural areas: The case of East Java, Indonesia. IOP Conference Series: Earth and Environmental Science, 717(1), 012048. https://doi.org/10.1088/1755-1315/717/1/012048

[9] Fathurrahman, F., Irawan, A. ., & Fridayanti, sri . (2023). Effectiveness Of Regional Regulation Number 20 Of 2001 Regarding Regulation Of Street Traders And Seasonal Street Traders In Tarakan City. ***International Journal of Educational Research &Amp; Social Sciences,*** *4*(3), 429–434. https://doi.org/10.51601/ijersc.v4i3.652.

[10] Sulaiman, S., Halim Soebahar, A. ., & Mundir, M. (2023). Madrassa Diniyah Curriculum Transformation In Pesantren: A Study Of Wali Songo Mimbaan And Salafiyah Syafi'iyah Sukorejo Pesantren In Situbondo. ***International Journal of Educational Research &Amp; Social Sciences***, *4*(3), 444–453. https://doi.org/10.51601/ijersc.v4i3.659.

[11] Mutiara Cipta, D. ., & Alvin, S. (2023). Safeguarding Personal Information: Communication Privacy Management By Gen-Z Influencers. ***International Journal of Educational Research &Amp; Social Sciences***, *4*(3), 465–471. https://doi.org/10.51601/ijersc.v4i3.653.

[12] Mohammad Solekhan, Kunarto, & Mahmuda Pancawisma Febriharini. (2022). Forest And Land Fire Management Strategies : Prevention And Law Enforcement. ***International Journal of Educational Research &Amp; Social Sciences,*** *3*(2), 567–580. https://doi.org/10.51601/ijersc.v3i2.306.

[13] D. Yuliana Sinaga. (2022). The Effect Of Ralistic Mathematics Learning Model And Project-Based Learning Model On Problem Solving Ability And Motivation Of Students In Class V Private Sd Markus Medan Helvetia. ***International Journal of Educational Research &Amp; Social Sciences***, *3*(2), 590–600. https://doi.org/10.51601/ijersc.v3i2.268.