# Policy Innovation of Waste Management in Banyumas, Indonesia

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## Abstract

This study examines the potential for policy innovation in waste management in Kabupaten Banyumas, focusing on three main aspects: community participation, infrastructure development, and regulatory improvement. Using a combination of desk study and Participatory Policy Analysis (PPA) methods, this study involved various stakeholders to identify challenges and opportunities for innovation. The results of the analysis show that although there have been initiatives such as waste banks and waste segregation programmes, their implementation is hampered by low community participation and limited infrastructure, especially in rural areas. Based on these findings, the research proposes a series of policy innovations, including: (1) development of an integrated community-based management system, (2) optimisation of technology in waste facility management, (3) implementation of incentive schemes to increase active community participation, and (4) strengthening of sustainable environmental education programs. This policy innovation is expected to increase the effectiveness of waste management, encourage community participation, and create a sustainable waste management model in Banyumas Regency.

Keywords: Waste Management, Community Participation, Public Policy, Sustainable Development.

## 1. Introduction

Waste management has become one of the main challenges in sustainable development across various countries. In Europe, waste management has seen significant progress over the past 50 years through systemic approaches and the interaction between science and policy (1). China has successfully transformed its industrial and technological structures to reduce waste and emissions (2), while Thailand is still grappling with plastic waste management through the implementation of the 3R strategy (3). These challenges illustrate that, despite progress, much work remains to be done to achieve sustainable waste management.

At the local level, Banyumas Regency faces similar challenges, with a population reaching 1.80 million people (Population Census, 2022). Data from the Environmental Agency indicate that daily waste generation amounts to 532-550 tons, consisting of 522 tons of household waste and 10-15 tons from non-household sources, with 300-350 tons being urban waste. With the growth of the population and economic activities, the complexity of waste management in this region has intensified, necessitating a more innovative and effective approach.

The waste issue in Banyumas Regency reached a critical point in 2016 with the closure of the Gunung Tugel landfill due to protests from residents over environmental pollution. This situation mirrors that of many regions, such as in Latin America and the Caribbean, where open dumpsites remain a major challenge, accompanied by low waste recovery rates (4). The closure of the landfill marked a pivotal moment that prompted the local government to evaluate and improve the existing waste management policies.

In response to this situation, in 2018, the Banyumas Regency Government initiated the "Sumpah Beruang" (Bear Oath) Programme as a response to these challenges. This programme aligns with the global trend of adopting waste-to-energy (WTE) technology, which offers sustainable solutions for large population centres (5). The programme employs a comprehensive approach that

includes mechanised processing, converting waste into economically valuable products, and utilising residues through environmentally friendly technologies.

Although the Sumpah Beruang Programme has demonstrated positive results, achieving a waste handling rate of 99% by the end of 2023 (32% managed, 67% reduced), technical and social challenges still remain. A study in Shanghai showed that economic and demographic policies significantly impact urban waste management (6), which is also relevant to the context of Banyumas. Community involvement and government support are crucial to achieving the programme's objectives.

Therefore, it is essential to conduct a more in-depth study of the factors influencing the success of the Sumpah Beruang Programme, as well as how various elements within the community can contribute to more effective waste management. This study of waste governance in Banyumas Regency aims to provide a comprehensive overview of the current waste management conditions, identify the factors influencing the programme's success, and formulate strategic recommendations to enhance the effectiveness and sustainability of the waste management system.

Specifically, this research aims to detail the waste management system in Banyumas Regency concerning community empowerment, identify root problems along with proposed solutions, and formulate strategies to enhance community participation. These strategies include education and awareness, incentives and rewards, technology utilisation, community involvement, government support, social networking, and interpersonal contexts. Thus, this study is expected to significantly contribute to the development of a more effective and sustainable waste management system in Banyumas Regency.

## 2. Method

The waste management study in Banyumas Regency employed several methodological approaches: (1) Desk Study Method, which involved analysing data obtained from various secondary sources, such as documents, legislation, and reports accessed through institutional archives, libraries, or the internet. This technique was used to review and examine already available information; (2) Participatory Policy Analysis (PPA), as proposed by Hajer and Wagenaar (2003), acknowledges that modern society is moving towards a network society. Therefore, public policy analysis is conducted using a PPA approach, where policy analysts act as facilitators, helping the public explore alternative solutions. Fisher and Forester (2002) emphasise that PPA techniques allow for the development of policy alternatives through dialogue between policy actors, as well as incorporating stakeholders' views into the process (8).

Data collection methods included interviews with relevant departments or agencies and document studies. Data analysis was conducted using both the Participatory Policy Analysis (PPA) and Desk Study approaches. The focus of the process was on the waste management system, community participation, and government support. Various indicators, such as the analysis of local regulations, waste collection systems, processing technologies, and community involvement in social networks, were also analysed to understand the multiple aspects of waste management in Banyumas Regency.

## 3. Results and Discussion

The waste management system in Banyumas Regency exhibits characteristics that require serious attention. Daily waste generation reaches 522-550 tonnes, predominantly composed of organic waste (40.49%) and plastic (17.91%), reflecting high consumption patterns. From a technical perspective, waste containment and sorting at the source remain suboptimal, with collection covering only about 60% of total waste generation. Waste treatment efforts through 3R (Reduce, Reuse, Recycle) facilities and waste banks are limited, while the final disposal system at the Regional Landfill is nearing full capacity. This evaluation identifies challenges in service coverage, source separation, treatment capacity, and community participation, all of which need to be addressed to achieve more effective and sustainable waste management.

Three scenarios for the development of the waste management system are proposed: optimising the existing system, developing an integrated system, and implementing the zero waste concept. The optimisation scenario focuses on improving service coverage and operational efficiency, while the integrated system scenario offers a comprehensive approach, with source separation implemented across the board and the construction of integrated treatment facilities. The zero waste scenario is a progressive option that requires a significant paradigm shift within the community. To achieve these goals, strong policy support, ongoing education programmes, and regular system performance monitoring and evaluation are needed. With the right commitment and approach, Banyumas Regency has the potential to become a model for effective and sustainable waste management, fostering local economic growth and improving the quality of life for its residents.

The analysis of Banyumas Regency's Regional Regulation on waste management highlights the evolution of policy towards a more integrated and community-based system. Regional Regulation Number 24 of 2023 emphasises the role of Community Self-Help Groups (KSM), the implementation of a circular economy, the use of technology, decentralisation of authority, stakeholder coordination, and more structured sanctions. However, challenges remain, such as monitoring and evaluation mechanisms, the integration of the informal sector, sustainable funding, and capacity development. Despite these challenges, this policy serves as a strong foundation for participatory and sustainable waste management in Banyumas.

The waste collection and transportation system in Banyumas Regency is undergoing a transition towards a more integrated management model, with the significant involvement of Community Self-Help Groups (KSM) and Recycling Centres (PDU). There are three main groups in waste management: formal management involving KSM and Waste Banks, informal management such as private collectors, and the unserved community.

Challenges include low community participation, limited facilities, and a lack of economic incentives. To address these issues, there is a need to strengthen KSM capacity, improve infrastructure, provide economic incentives, increase education, and foster partnerships with the private sector. Waste processing technology is also advancing, including the use of shredders for Refuse Derived Fuel (RDF) and trials of waste-to-energy plants, though challenges remain in implementation and economic sustainability.

Pengelolaan sampah di Kabupaten Banyumas telah mengalami perkembangan signifikan melalui adopsi teknologi maju yang berfokus pada keberlanjutan. Inovasi ini mencakup strategi multifaset untuk memaksimalkan pemulihan material, mengurangi dampak lingkungan, dan mengoptimalkan nilai ekonomi dari sampah. Salah satu terobosan utama adalah penggunaan mesin pencacah untuk mengolah residu anorganik menjadi Refuse Derived Fuel (RDF), yang tidak hanya mengurangi volume sampah yang masuk ke TPA tetapi juga membuka peluang energi alternatif. Selain itu, inisiatif uji coba pengolahan bubur sampah sebagai sumber energi terbarukan menunjukkan visi jangka panjang dalam mengubah sampah menjadi sumber daya yang berharga, meskipun masih menghadapi tantangan dalam hal konsistensi input, efisiensi energi, dan kelayakan ekonomi.

Analisis terhadap adopsi teknologi ini mengungkapkan beberapa aspek penting, seperti perlunya integrasi teknologi yang lebih baik, peningkatan efisiensi operasional, dan evaluasi keberlanjutan ekonomi jangka panjang. Dampak lingkungan dari proses pengolahan juga perlu dipantau, sementara pengembangan kapasitas sumber daya manusia menjadi kunci keberhasilan adopsi teknologi ini. Beberapa rekomendasi mencakup investasi dalam penelitian dan pengembangan (R&D), implementasi proyek percontohan, penerapan

teknologi smart waste management, diversifikasi teknologi pengolahan sampah, serta kolaborasi regional untuk memperkuat upaya ini. Dengan strategi yang lebih terintegrasi dan adaptif, Banyumas berpotensi menjadi model pengelolaan sampah berkelanjutan di Indonesia.

Waste management in Banyumas Regency has undergone significant advancements through the adoption of advanced technologies focusing on sustainability. These innovations involve multi-faceted strategies aimed at maximising material recovery, reducing environmental impacts, and optimising the economic value of waste. One of the key breakthroughs is the use of shredders to process inorganic residue into Refuse Derived Fuel (RDF), which not only reduces the volume of waste sent to the landfill but also creates opportunities for alternative energy sources. Additionally, experimental initiatives in processing waste slurry as a renewable energy source demonstrate a long-term vision of transforming waste into a valuable resource, although challenges remain in terms of input consistency, energy efficiency, and economic feasibility.

An analysis of this technological adoption reveals several critical aspects, such as the need for better integration of technology, improvements in operational efficiency, and the evaluation of long-term economic sustainability. The environmental impact of these processing methods also needs to be monitored, while the development of human resource capacity is essential to the successful adoption of these technologies. Recommendations include investing in research and development (R&D), implementing pilot projects, adopting smart waste management technologies, diversifying waste processing technologies, and fostering regional collaboration to strengthen these efforts. With a more integrated and adaptive strategy, Banyumas has the potential to become a model of sustainable waste management in Indonesia.

Community participation in waste management in Banyumas Regency remains low, with only about 1% of the population involved in waste bank programmes. Nevertheless, in areas with active waste banks, community awareness and understanding of waste management have increased. Waste Banks and Community Self-Help Groups (KSM) serve as agents of change, promoting education and mobilising the community, although there is still variation in participation across regions due to factors such as environmental awareness, economic incentives, and access to waste management facilities.

To enhance participation, several strategies are proposed, including the intensification of community-based education programmes, the development of a more comprehensive incentive system, and the utilisation of digital technology through waste management applications. Furthermore, strengthening the capacity of KSM through training and collaboration between waste banks, KSM, and local government is essential. With these strategies in place, it is anticipated that community participation will significantly increase, supporting a more effective and sustainable waste management system.

Efforts to educate and raise community awareness about waste management in Banyumas Regency are conducted through adaptive and responsive approaches implemented by the Central Waste Bank. A bottom-up approach serves as the main strategy, whereby educational programmes are tailored to meet community needs. Outreach activities are integrated into village events, and there is a responsive mechanism for community requests to provide resource persons for educational activities. Additionally, a complaint mechanism related to illegal dumping serves as an opportunity for further education. However, despite these positive efforts, community participation remains low, with only about 1% involved in waste bank programmes.

Several challenges persist, including the effectiveness of previous educational programmes, which have not yet reached their full potential, limited programme outreach, and variations in awareness levels across different regions. In areas with active waste banks, community awareness is notably higher. However, educational initiatives often rely on community demand, which restricts the dissemination of information to groups that lack initial awareness. To broaden participation, efforts are needed to expand outreach and enhance the effectiveness of educational programmes.

The incentive and reward system in waste management in Banyumas Regency has involved various forms of support from both the private sector and the government. Private sector support includes contributions from STT Telkom through technological innovations and infrastructure assistance, such as waste collection vehicles. The local government also provides incentives through the development and establishment of waste banks, the provision of equipment, and the involvement of waste banks in regional and national activities. Additionally, the provision of infrastructure, such as buildings for waste banks, serves as a form of incentive that encourages community participation in waste management.

However, despite the existing incentives, there are still several areas that require improvement, such as the need for more comprehensive data collection on waste banks, recognition and promotion of community efforts, and the enhancement of human resource capacity. These developments are essential for sustaining increased community participation. Moving forward, the main challenge will be to maximise and integrate the various incentives available to foster broader community involvement in waste management.

The utilisation of technology in waste management in Banyumas Regency has seen positive developments through several innovative initiatives. One such initiative is the use of sorting baskets, which encourages residents to separate waste at home. Although this has only been implemented in a few waste bank units, it has effectively raised community awareness regarding the importance of waste processing. Additionally, the Simbahnira application has been introduced for recording customer savings at waste banks and is integrated with 3R facility services, enhancing coordination between waste banks, customers, and waste processing facilities. There is also a local application developed by the community, with plans to consolidate the Jeknyong and SalinMas applications under the management of the Central Waste Bank, aimed at improving efficiency and transparency in waste management.

However, despite these advancements, there are still significant challenges in the implementation and adoption of these technologies. Budget limitations pose a primary obstacle, impacting the expansion of technology use and infrastructure support. The use of sorting baskets and other technological applications remains limited to a few waste bank units, and some applications, such as Jeknyong, have not yet been fully operational. To optimise the role of technology in supporting community-based waste management, there is a need for increased budget allocation, broader adoption of technology by the community, and more comprehensive system integration in the future.

Community involvement in waste management in Banyumas Regency encompasses various aspects, ranging from participation as customers of waste banks to contributions in providing land and infrastructure. Residents actively sort and deposit waste at the waste banks, and some even offer their land as storage space. However, the level of participation remains low, at about 1% of the total population, with variations in the forms of

involvement, where some community members are more active in providing physical resources. The primary challenge is to enhance widespread participation, and the development of engagement forms such as peer education and participation in decision-making still holds potential for further exploration. Moving forward, strategies are needed to raise awareness and provide incentives to broaden participation in waste management through waste bank initiatives.

Government support in coordinating between village authorities and communities regarding waste management in Banyumas Regency is crucial for enhancing community participation. The need for village-level regulations, such as Village Regulations (PerDes) and Village Head Regulations (PerKades), along with consistent monitoring and evaluation, forms the foundation for ensuring that waste management programmes operate effectively.

Additionally, enhancing human resource capacity through training and the provision of facilities and infrastructure is essential for supporting more efficient operations. However, challenges such as varying levels of support among villages, lack of cross-sector coordination, and limited resources hinder implementation. Comprehensive and equitable support is required to ensure that community-based waste management can operate optimally across all regions of Banyumas Regency.

An analysis of social networking in waste management in Banyumas Regency reveals positive developments, particularly through the role of the Central Waste Bank as the main facilitator. The establishment of a communication system among waste banks has helped build a more integrated waste management ecosystem. The Central Waste Bank provides training to enhance the capacity and performance of unit waste banks, as well as offering a platform for sharing knowledge and innovations in waste management. Furthermore, the Central Waste Bank bridges the gap between unit waste banks and a broader market.

However, despite these advancements, there are several areas that require attention, such as the intensity of communication among waste banks, which has not been detailed, the lack of information regarding the number of waste banks involved, and the unclear mechanisms of collaboration. Thus, while this social networking has significant potential to improve the effectiveness of the waste management system, there is a need for intensified communication, expanded coverage, and diversified collaborations to realise a more integrated and sustainable waste management system.

An analysis of the active role of Community Self-Reliance Groups (KSM) in promoting waste management programmes in Banyumas Regency highlights significant potential for collaboration between waste banks and KSMs managing TPS3R/TPST (Waste Processing Sites). The vision of forming an "integrated hybrid waste bank" represents a new paradigm where the community plays the role of active participants and beneficiaries. The development plans include the establishment of hybrid waste banks, integrating the waste bank system into TPST, and transitioning the community's status from customers to account holders, aiming to enhance engagement and a sense of ownership.

However, challenges remain, such as the lack of detailed practical implementation plans, the difficulty of integrating waste banks and TPST, and the need for community education and outreach. While interviews reveal an ambitious vision to create a more integrated and participatory waste management system, the success of implementation heavily depends on careful planning, stakeholder coordination, and strategies to overcome these obstacles. The active role of KSM in promoting and implementing these programmes will be crucial in realising this vision and delivering tangible benefits to the community.

The current condition of the waste management system in Banyumas Regency demonstrates positive progress, although challenges remain to be addressed. Annual waste generation increased from 195,357.75 tonnes in 2021 to 197,758.42 tonnes in 2023, with waste composition dominated by organic waste (40.49%) and plastic (17.91%). This increase in waste generation reflects the common challenges faced by regions in managing waste, particularly related to infrastructure limitations and waste management systems. (9), in his study, emphasises the importance of technological innovations in processing specific types of waste, particularly to tackle the dominance of organic and plastic waste.

Although the percentage of waste reduction has increased from 65.72% to 67.09%, further efforts are needed to achieve more ambitious targets. This increase reflects the gradual adoption of new practices in waste management, as outlined in Rogers' innovation theory (10). This achievement requires a more comprehensive approach, including the optimisation of waste bank programmes, the development of community-scale composting, and the strengthening of partnerships with the informal sector.

The operational performance of the waste management system in Banyumas Regency has shown improvement, with the percentage of managed waste increasing from 98.02% in 2021 to 99.31% in 2023. This improvement indicates the effectiveness of institutional innovations identified by (9), including the establishment of specialised waste management units and inter-regional cooperation. However, the capacity to handle waste must be enhanced to keep pace with the growing volume of waste generation.

Waste management infrastructure, such as waste collection systems and TPS 3R (Reduce, Reuse, Recycle Transfer Stations), still requires improvements to achieve broader service coverage. The Regional Landfill (TPA) is facing capacity challenges, nearing its maximum capacity, which underscores the need to develop alternative, more efficient waste processing solutions. The success of waste management is influenced by several critical factors, including the commitment of local leaders, institutional capacity, and community participation. Highlight the importance of policy innovation that integrates technological, social, and institutional aspects to achieve more efficient and sustainable waste management (11).

Overall, significant progress has been made, but continuous improvements in infrastructure capacity and operational systems are essential to creating a more efficient and sustainable waste management system in Banyumas Regency.

The implementation of the 3R (Reduce, Reuse, Recycle) concept in waste management in Banyumas Regency has yielded positive results, particularly in waste reduction. The percentage of waste reduction increased from 65.72% in 2021 to 67.09% in 2023, driven by initiatives such as plastic reduction campaigns and education on waste separation. According to the policy innovation theory proposed by Damanhuri & Padmi (2010), this success reflects the effectiveness of social innovation through educational programs and public awareness campaigns. However, the main challenge lies in the relatively low public awareness, as indicated by consumption behaviours that do not fully support optimal waste reduction efforts.

Community participation in waste separation has seen improvements, as evidenced by the increase in managed waste, although there are still mistakes in sorting practices. Programmes such as the waste bank and community-scale composting have significantly contributed to increasing public participation. Waste Banks and TPS 3R facilities play a crucial role in enhancing recycling efforts and reducing the volume of waste sent to landfills. Nevertheless, financial and operational sustainability challenges persist. The success of

waste management programmes largely depends on the availability of resources and strong support from stakeholders.

Rogers (2003), in his innovation theory, highlights that the adoption of new practices takes time and requires continuous support. Therefore, innovative efforts such as 'zero waste shopping' need to be gradually expanded to meet national waste management targets. Osborne & Brown (2011) also emphasize the importance of integrating technological, social, and institutional aspects into strategies for improving the self-reliance of waste management facilities. Strengthening business models and integrating them into broader recycling chains should be a priority in optimizing the implementation of the 3R concept, aligning with recommendations for the sustainable development of policy innovations.

Overall, the implementation of the 3R concept in Banyumas Regency has shown positive outcomes, with increased waste reduction percentages and greater community participation in waste separation. The Waste Bank programs and TPS 3R facilities have significantly contributed to improving recycling rates and reducing the volume of waste sent to landfills. However, challenges remain in terms of public awareness, financial sustainability, and operational capacity of waste management facilities. Strengthening business models and integrating with broader recycling chains should be prioritized to further optimize the application of the 3R concept in the future.

An analysis of the waste management situation in Banyumas Regency reveals various challenges and opportunities that reflect the complexities of the waste management system, as discussed in various literature. The main challenges faced include limited infrastructure capacity, suboptimal collection efficiency, and inadequate processing technology, particularly for inorganic waste and household hazardous waste (B3). This situation aligns with (12) findings that emphasise the importance of balancing environmental, social, and economic aspects in sustainable waste management.

The coordination issues among agencies and the insufficient enforcement of regulations in Banyumas highlight the need for an integrated approach, as outlined by (13) regarding the importance of public-private partnerships. This is further supported by (14), who emphasise the facilitative role of local government in supporting waste management initiatives. The budget constraints faced also indicate the necessity of implementing the "polluter pays" principle and extended producer responsibility (EPR), as recommended by the (15)

Despite facing various challenges, Banyumas has significant opportunities for innovation in waste management. The plan to utilise geographic information systems (GIS) for optimising collection routes aligns with the concept of technology integration discussed by (16). The development of community-scale waste processing facilities also reflects the implementation of the waste management hierarchy proposed by (17), which prioritises waste reduction and processing at the source.

The opportunities for developing a circular economy in Banyumas, including the enhancement of the recycled product market and the growth of green entrepreneurship, are in line with the concepts discussed by the (18) on the reuse of materials within closed cycles. This approach is reinforced by the 9R concept introduced by (19), which offers a comprehensive framework for implementing circular strategies in waste management.

Banyumas' planned community education programmes and consumer awareness initiatives reflect the importance of public participation, as emphasised by (20). This approach is crucial in supporting the successful implementation of a sustainable waste

management system. Global experiences summarised by (2) suggest that the success of technological innovations in waste management must be tailored to local contexts and supported by active community engagement.

To optimise the potential transformation of waste management in Banyumas, a consistent monitoring and evaluation system is required, as recommended by (21). Multi-stakeholder collaboration and long-term commitment are key to success, supported by institutional capacity-building and human resource development. By adopting an integrated approach that combines infrastructure strengthening, technological innovation, and circular economy development, Banyumas has the potential to transform waste management challenges into opportunities that support sustainable development.

The success of this transformation will depend on sustained commitment from all stakeholders, the contextual implementation of innovations, effective institutional capacity-building, and active participation from both the community and the private sector. Global experiences and existing theoretical frameworks provide valuable guidance for developing effective and sustainable waste management strategies in Banyumas Regency.

The analysis of strategies for optimising community-based waste management in Banyumas Regency can be examined using various theoretical perspectives from existing literature. The empowerment of Community Self-Help Groups (KSM) as the primary drivers reflects the importance of community participation, as emphasised by (20), in achieving the success of sustainable waste management systems.

Strengthening the capacity of KSMs through various skills development programmes aligns with the concept discussed by (14) regarding the facilitative role of local government in supporting citizen initiatives. This approach underscores the importance of balancing government support with providing space for communities to develop their own initiatives. The provision of infrastructure and networks supported by the local government reflects the implementation of the public-private partnership principle, as discussed by (13), in which the government acts as a facilitator by providing the framework and material support.

The community education programmes and involvement of local figures implemented in Banyumas align with the principles of sustainable waste management identified by (12), who emphasises the importance of social aspects in waste management systems. The use of incentive programmes to encourage participation reflects the implementation of the "polluter pays" principle recommended by the OECD (2016), but with a positive approach that promotes behavioural change through rewards.

The strategy of shifting the public's perception of waste as a valuable resource aligns closely with the circular economy concept discussed by the Foundation (2013). This approach supports the implementation of the 9R concept (19) at the community level, where waste is no longer seen as refuse but as a resource that can be reused within the economic cycle.

The participatory monitoring applied in this strategy reflects the recommendations of (21) on the importance of a sustainable evaluation system. Involving the community in the monitoring process can enhance a sense of ownership of the programme and encourage continuous improvements in the waste management system

The use of technology to support community-based strategies aligns with the findings of (16) on the importance of technology integration in modern waste management systems. Technology can help optimise the operations of KSMs, improve waste collection efficiency, and facilitate information sharing among stakeholders.

The success of this strategy heavily relies on multi-stakeholder collaboration, reflecting an integrated approach to waste management as discussed in various literature. Global experiences summarised by (2) suggest that successful innovations in waste management require support from a range of stakeholders and must be tailored to the local context.

Efforts to create sustainable behavioural change through this community-based strategy are in line with the principles of sustainable development and the transition towards a circular economy. This approach not only focuses on the technical aspects of waste management but also considers the social and cultural aspects that are essential for the long-term sustainability of the programme.

Therefore, the strategy for optimising community-based waste management in Banyumas Regency reflects the integration of various principles and concepts from the literature on sustainable waste management. Its successful implementation will depend on consistent government support, active community involvement, and the ability to adapt to changing conditions and local needs.

The analysis of the relationship between the waste management situation in Banyumas Regency and the Regulation of the Minister of Environment and Forestry No. 14 of 2021 can be viewed through theoretical perspectives from the existing literature. The implementation of this regulation reflects the government's efforts to adopt a sustainable waste management approach, in line with (12) concept of balancing environmental, social, and economic aspects.

The division of waste banks into Parent Waste Banks (BSI) and Unit Waste Banks (BSU) aligns with the integrated approach discussed by (13), which highlights the importance of a clear institutional structure in waste management. This hierarchical structure allows for better coordination and a clear division of roles among waste management units at various levels.

The regulation's focus on health and safety standards reflects the principles of social justice and inclusivity discussed by (22), who emphasises the importance of considering the welfare of informal sector workers in waste management. This is also consistent with the concept of sustainable waste management, which considers the social aspect as one of its main pillars.

The regulation's push towards a circular economy and the 3R principles aligns with the concepts discussed by the (18) on the importance of material reuse within closed cycles. Furthermore, this approach can be expanded into the 9R concept, as proposed by (19), to achieve a more comprehensive waste management system.

The two-year adaptation period granted to local governments to meet the requirements reflects an understanding of the importance of a gradual transition, as discussed in various literature. This is in line with ((2) findings on the need for policy adjustments to fit the local context and capacity.

The implementation of this regulation in Banyumas Regency must consider several important aspects:
a) Development of an effective monitoring and evaluation system to ensure compliance with established standards.
Developing a robust monitoring and evaluation system is essential to ensure adherence to the set standards. This will enable authorities to track progress, identify gaps, and ensure that the waste banks operate in accordance with the sustainability principles.

b) Integration of technology in waste bank operations to improve efficiency and transparency.

Integrating technology into the operations of waste banks can significantly enhance efficiency and transparency. Digital solutions, such as route optimisation and data tracking, can streamline processes and improve communication among stakeholders.

c) Strengthening community participation through education and empowerment.

Strengthening community participation is key to the success of waste management. Educational programmes and empowerment initiatives will help raise awareness and encourage active involvement from local communities.

d) Development of sustainable financing mechanisms using the 'polluter pays' principle and Extended Producer Responsibility (EPR).

Establishing sustainable financing mechanisms is crucial for the long-term sustainability of the waste management system. The application of the 'polluter pays' principle and Extended Producer Responsibility (EPR) ensures that waste generators contribute to the costs of waste management and disposal.

The success of the regulation's implementation will depend on effective collaboration between the local government, waste bank managers, and the community. The facilitative role of the government, as discussed by (14), is crucial in ensuring a smooth transition to a waste management system that complies with national standards.

Thus, the Minister of Environment and Forestry Regulation No. 14 of 2021 provides a clear framework for the development of waste banks in Banyumas Regency, in line with the principles of sustainable waste management discussed in the literature. Effective implementation will require an integrated approach that takes into account technical, social, and economic aspects, supported by a strong commitment from all stakeholders.

The Banyumas Regency Environmental Protection and Management Plan (RPPLH) 2024-2054 reflects a comprehensive approach to environmental management, aligned with the sustainable waste management concept presented by (12). This 30-year long-term planning adopts the waste management hierarchy principles, as explained by (17), with a particular emphasis on the concept of zero waste as its main target. This approach parallels the European Union's experience, which has developed waste management policies over the last 50 years, as highlighted in the study by (1), stressing the importance of a systemic approach to waste management.

The implementation of waste banks in Banyumas, with 153 units spread across various areas, reflects the adoption of circular economy principles as described by (18). However, the fact that only 31 units are active indicates challenges in maintaining community participation, a phenomenon also identified in (Castañeda, Chávez-Juárez, and Guerrero 2018 )study on the importance of community involvement in the success of waste management systems. This situation requires innovative approaches to community empowerment, in line with (14) findings on the importance of local government support in facilitating citizen initiatives.

RPPLH Banyumas integrates various aspects of environmental management, including waste management, wastewater treatment, and ecosystem protection, reflecting a holistic approach as advocated by (13). The goals set in three categories of time—long-term, medium-term, and qualitative—show the adoption of continuous evaluation and improvement principles put forward by (21)). This phased approach allows for strategy adjustments according to changing conditions and needs while maintaining a focus on long-term objectives.

The RPPLH's emphasis on the zero waste concept and increased recycling efforts aligns with the 9R strategy introduced by Potting et al. (2017). This approach not only focuses on recycling but also encompasses more comprehensive strategies like refuse, rethink, and reduce, which are crucial for achieving sustainable waste management targets. The implementation of waste banks as operational instruments reflects the integration of technology and innovation in waste management, as discussed by Esmaeilian et al. (2018), although the low activity level indicates a need to strengthen operational sustainability.

In the context of community empowerment, the low activity level of waste banks highlights the need to reinforce the principles of social justice and inclusivity, as discussed by Gutberlet (2015). It also underscores the importance of considering long-term financing aspects and applying the "polluter pays" principle, as recommended by OECD (2016), to ensure the sustainability of community-level waste management programs.

Overall, the Banyumas Regency RPPLH 2024-2054 reflects a comprehensive vision for sustainable environmental management, though it still faces implementation challenges, particularly in terms of community participation, as evidenced by the low activity levels of waste banks. The success of its implementation will depend on the local government's ability to mobilize resources and build effective partnerships with various stakeholders, supported by periodic evaluations to ensure the achievement of targets adaptable to the dynamic changes in Banyumas Regency.

### Regulator

The Environmental Agency (DLH) of Banyumas Regency acts as the main regulator of waste management, with responsibilities that include creating regulations, strategic planning, cross-sector coordination, and policy evaluation. DLH must implement adaptive regulations, encourage innovation, and involve stakeholder participation while maintaining environmental and health standards. The key challenge is balancing flexibility for operators with accountability. Furthermore, DLH plays a role in enforcing rules and empowering local governments. In the digital era, DLH needs to adopt a collaborative approach, utilise technology, and engage the community to achieve sustainable waste management.

### Operator

Operators in Banyumas Regency's waste management system play a crucial role in implementing waste management programmes on the ground. The three main groups of operators are Community Self-Reliance Groups (KSM), Waste Banks, and scrap collectors. KSM manages 40 TPSTs, focusing on community empowerment and waste efficiency, but varying capacity and performance remain challenges. Waste Banks turn waste into economic resources through savings schemes, though their success relies on relationships with the recycling industry. Scrap collectors, though informal, significantly contribute to the local recycling market. To enhance effectiveness, coordination, capacity building, and integration of digital technology are needed. Public-private partnership strategies can also strengthen synergies and efficiency between operators, creating a more resilient and sustainable waste management system.

### Stakeholders

The role of stakeholders in waste management in Banyumas Regency is crucial, even though they are not the main regulators. The three main groups in this category are independent waste producers, illegal waste, and scavengers. Independent waste producers, such as industries or specific communities, can reduce the burden on the system, but they often lack guidance on optimal waste management practices. Illegal waste indicates problems in service coverage and regulation enforcement, while scavengers play an

important role in recycling, though they are often marginalised from the formal system. To improve the system, it is essential to integrate the waste management practices of these three groups through incentives, education, and formalisation, making waste management more efficient, inclusive, and sustainable.

## 4. Conclusion

This study successfully provides a detailed explanation of the waste management system in Banyumas Regency, with an emphasis on community empowerment through technical operational aspects, institutional development of Community Self-Help Groups (KSM), and citizen participation. Waste management in Banyumas involves integrated strategies such as education, incentive schemes, technology utilisation, and government support, all aimed at enhancing community involvement in waste management programmes. The identification of key issues highlights challenges such as a lack of awareness, limited incentives, and insufficient technological support and coordination between the community and the government. However, initiatives like the introduction of Waste Banks and the Salinmas and Jeknyong applications represent crucial steps in addressing these obstacles.

The identified challenges in waste management in Banyumas Regency reveal several key issues that hinder the effectiveness of community empowerment programmes. One major problem is the low level of public awareness regarding the importance of proper waste management. Many residents are still unaware of the negative impacts of poor waste management on the environment and public health. This lack of awareness results in minimal community participation in waste management programmes. Without sufficient understanding, residents are less motivated to engage in activities such as waste sorting, processing, or recycling.

The incentives provided to encourage active community participation in waste management remain inadequate. In some cases, residents do not perceive sufficient direct benefits or appealing rewards from their independent waste management efforts. This limitation in strong incentives reduces the motivation for community members to engage in programmes like waste banks or other KSM activities. More effective incentives, such as rewards or economic benefits, could become key factors in increasing community involvement.

Modern waste management requires adequate technological support to facilitate waste collection, sorting, and recycling processes. However, in many areas of Banyumas, access to technology is still limited. Applications designed to aid in waste management, such as Sampah Online Banyumas (Salinmas) and Ojeke Inyong (Jeknyong), have not yet been fully optimised by the broader community. These challenges may stem from a lack of socialisation, limited internet access, or technical difficulties in using these applications.

Good coordination between the community and the government is crucial for the success of waste management programmes. However, in some cases, there are gaps in communication and coordination between village governments, KSMs, and the community. This disconnect can hinder the implementation of programmes and reduce the effectiveness of waste management activities. The lack of consistent support and involvement from government authorities in assisting communities is also a contributing factor to these challenges.

By implementing these strategies, community participation in waste management in Banyumas Regency could significantly increase, ultimately supporting the creation of a cleaner and healthier environment. The active role of KSMs and effective leadership are also considered essential elements in ensuring the sustainability of waste management programmes in the future.

## 5. Recommendations

The recommended strategic innovations include enhancing education and public awareness, providing incentives and rewards for active participants, and utilising technology to facilitate waste management. Direct community involvement, ongoing government support, and strengthening social networks are also considered key factors for success. Specifically, the recommendations from

this study are outlined in the Roadmap for the Action Plan of the Community-Based Waste Management Model in Banyumas Regency, as follows:

## 6. Conflict of Interest

There are no conflicts of interest related to the writing, research, or publication of this article. This research was conducted as an independent and objective scientific inquiry, and all findings, interpretations, and conclusions presented are solely based on the authors' academic and research efforts.

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