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A Community Education-Based Waste Management System: Addressing Urbanization and the Impacts of Climate Change in Makassar

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Abstract
This study aims to analyze a waste management system based on public education in addressing urbanization and the impacts of climate change in Makassar City. Increasing urbanization has led to an increase in the volume of household waste and increasing pressure on the urban environment, particularly in Manggala District, the location of the Tamangapa Final Disposal Site (TPA). This study used a qualitative descriptive approach with data collection techniques through interviews, observation, and documentation. Research informants consisted of the Manggala District Government, waste bank managers, PT Pegadaian, and the community. The results showed that waste management based on public education is carried out through a collaborative governance approach between the government, the private sector, and the community through the Waste Bank and "The Gade Clean and Gold" programs. The education system is carried out through socialization of waste sorting, the formation of environmentally friendly behavior, and the provision of economic incentives in the form of gold savings. The study found that public education is an important instrument in increasing citizen participation in waste management while strengthening urban environmental resilience to the impacts of urbanization and climate change. However, low public awareness, limited facilities, and uneven distribution of environmental education remain major obstacles in program implementation. This study confirms that waste management based on public education can be a model for sustainable urban environmental development.

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1. INTRODUCTION

Urbanization is one of the main challenges facing urban development in Indonesia. Rising urban population growth puts pressure on environmental capacity, particularly in urban waste management. Makassar, as one of the metropolitan cities in Eastern Indonesia, experiences an annual increase in waste volume due to population growth, economic activity, and consumer consumption patterns.

The waste problem not only impacts environmental quality but also increases the risk of climate change through increased greenhouse gas emissions from landfills. The Tamangapa Final Disposal Site (TPA) in Manggala District is one of the areas directly impacted by urbanization and the accumulation of urban waste. Data from the Makassar City Environmental Agency shows that the volume of waste entering the Tamangapa TPA reaches approximately 900 tons per day.

This situation indicates that the traditional approach to waste management based on transportation and final disposal is no longer effective. Waste management requires a systemic transformation through active community involvement in the process of waste reduction, sorting, and utilization based on the 3R principle (Reduce, Reuse, Recycle).

In this context, public education is a crucial strategy for building environmental awareness and strengthening community participation in waste management. Education is not only understood as a process of conveying information, but also as a process of changing community behavior towards a culture of sustainable waste management.

The Manggala District Government then developed a collaborative approach with PT Pegadaian through the "The Gade Clean and Gold" program. This program integrates waste sorting education with economic incentives through gold savings. This approach is a social innovation in community-based waste management.

This study aims to analyze the waste management system based on community education in facing urbanization and the impact of climate change in Makassar. This study uses several relevant main theories in explaining the waste management system based on community education: 1) Collaborative Governance Theory – Ansell and Gash (2008). Ansell and Gash (2008) explain that collaborative governance is a governance process that involves government actors, the private sector, and the community in solving public problems through joint decision-making. This theory is used to analyze the form of collaboration between the Manggala District Government, PT Pegadaian, waste bank managers, and the community in education-based waste management. 2) Community Participation Theory – Arnstein (1969). Arnstein (1969) through the concept of Ladder of Citizen Participation explains that community participation is an important element in development. Community participation is not only interpreted as symbolic involvement, but active involvement in the decision-making process and program implementation. 3) Sustainable Development Theory – Brundtland (1987). The concept of sustainable development according to the Brundtland Report (1987) emphasizes meeting the needs of the present generation without compromising the capabilities of future generations. This theory is relevant in waste management that is oriented towards urban environmental sustainability. 4.) Theory of Environmental Behavior Change – Hines, Hungerford, and Tomera (1987). This theory explains that community behavior towards the environment is influenced by individual knowledge, attitudes, and motivation. Public education is an important instrument in developing environmentally friendly behavior through a social learning process. 5) Theory of Waste Management Based on 3R – Reduce, Reuse, Recycle. The 3R concept was developed in modern environmental management as a primary strategy for waste reduction. The Reduce, Reuse, and Recycle approach is the basis for waste bank management and public education in this study. 6) Social Capital Theory – Putnam (1993). Putnam (1993) explains that social capital in the form of trust, social networks, and collective norms is an important factor in the success of community collaboration. In the context of this study, social capital influences community participation in waste management.

Community Education-Based Waste Management System. A community education-based waste management system is an environmental management approach that positions the community as the primary actor in the process of waste reduction and utilization. Public education is a crucial instrument in shaping environmentally friendly behavior and raising public awareness of the impact of waste on the environment and climate change. According to Ansell and Gash (2008), collaborative governance is a crucial approach to solving public problems through the involvement of the government, the private sector, and the community. In the context of waste management, collaboration is necessary because the government has limited resources to address the issues of urbanization and climate change.

Initial conditions relate to the background of the collaboration, including conflict, resource inequality, and shared needs. Institutional design relates to the rules, structures, and mechanisms of cooperation between actors. Facilitative leadership serves as a driver of collaboration and a mediator between actors. The collaborative process emphasizes communication, face-to-face dialogue, trust, and shared commitment.

Waste Bank. A waste bank is a community-based waste management system that adopts a banking mechanism for waste collection. The community acts as customers who deposit sorted waste and then receive economic value from the results of waste management. According to the Ministry of Environment and Forestry, waste banks are a crucial instrument in supporting the implementation of the 3R concept (Reduce, Reuse, Recycle). In addition to reducing waste volume, waste banks also have social and economic value for the community.

Previous research, including research by Tanete Dg Maraja (2020), showed that waste management innovation in Manggala District still faces obstacles due to low public awareness of waste sorting. Another study by Andi Rahbil Fadly found that only a small number of waste bank units actively carry out sustainable waste management activities. The difference between this study and previous studies lies in its focus, which emphasizes a collaborative governance model between the government and the private sector in waste bank management.

2. RESEARCH METHODS

This research uses a descriptive qualitative approach with a case study method to investigate phenomena in a real-life context in depth and comprehensively. This method selection allows researchers to maintain the holistic characteristics of actual events occurring in the field, particularly regarding collaborative interactions between stakeholders (Yin, 2013). The research focused on the Manggala Sectoral Waste Bank to obtain a comprehensive picture of the effectiveness of community education through a gold savings mechanism. Data were collected through systematic observation, documentation, and in-depth interviews with informants selected based on the principles of relevance and depth of information (S. Nasution, 2003). Data analysis techniques involved organizing data into patterns and categories of basic descriptive units to provide significant meaning to the findings (Moleong, 2008). Conclusions were drawn strictly by referring to data reduction and objective data presentation to scientifically answer the problem formulation (Miles & Huberman, 1994).

3. RESULTS AND DISCUSSION

3.1.Research Results

a. Urbanization as the Main Factor in Increasing Urban Waste Generation

Urbanization is a global phenomenon closely linked to the increasing volume of urban waste. According to Louis Wirth (1938), urbanization is not only understood as the movement of people from rural to urban areas, but also as a shift in people's lifestyles toward urban characteristics, characterized by high consumption, changes in social behavior, and an increasing need for urban infrastructure. In the context of Makassar City, a population increase of 1.48 million by 2024 indicates increasing pressure on urban environmental capacity, particularly in waste management.

Empirically, research by Nicolò Ferronato and Vincenzo Torretta (2019) shows that urbanization in developing countries is directly proportional to the increase in domestic waste generation. The World Bank projects that global waste production will increase by 70% by 2050 if not balanced with sustainable

management systems. Developing countries in Southeast Asia are the regions with the fastest growth in waste production due to urban population growth and changing consumption patterns.

Furthermore, research by Hoornweg and Bhada-Tata (2012) explains that urban communities tend to produce waste with more complex characteristics than rural communities. Plastic waste, food waste, and electronic waste have increased significantly along with changes in urban lifestyles. In the context of Makassar, the development of shopping centers, new residential areas, and urban economic activity have also increased the volume of non-organic waste that is difficult to decompose naturally.

Table 1. Synthesis of Previous Research Results on Waste Management, Urbanization, and Climate Change

No	Researcher and Year	Research Focus	Method	Main Findings
1	Ferronato & Torretta (2019)	Waste management in developing countries	Literature Review	Urbanization increases waste volume and elevates the risk of environmental pollution due to weak waste management systems.
2	Guerrero, Maas, & Hogland (2013)	Challenges in urban waste management governance	Comparative Study	The main obstacles in waste management are weak institutional coordination, limited budgets, and low public participation.
3	Wilson et al. (2015)	Global waste management	Meta-analysis	Effective waste management requires the integration of regulations, technology, community participation, and institutional support.
4	Kaza et al. (2018)	Global waste projections	Global Review	Global waste production is projected to increase by 70% by 2050 due to urbanization and changing consumption patterns.
5	Lebreton & Andrady (2019)	Plastic waste and the environment	Environmental Analysis	Plastic waste poses a serious threat to urban and coastal ecosystems because it is difficult to decompose naturally.
6	Asteria & Heruman (2016)	Community-based waste bank programs	Case Study	Waste bank programs effectively increase environmental awareness and reduce household waste volume.
7	Ansell & Gash (2008)	Collaborative governance	Conceptual Study	Collaboration among government, communities, and the private sector improves the effectiveness of

				urban environmental management.

Source: Processed by the author, 2026.

The table above shows that most previous studies have identified urbanization as the primary factor contributing to the increasing urban waste problem. Furthermore, various studies have emphasized that effective waste management requires an integration of government regulations, public participation, and environmental technology innovation. Therefore, waste management in Makassar City requires a more collaborative and sustainable approach.

b. Waste Management from a Good Governance Perspective

Modern waste management is no longer understood simply as the collection and disposal of waste, but rather as an integral part of good governance-based urban environmental management. According to Wilson et al. (2015), effective waste management must encompass institutional dimensions, regulations, financing, public participation, and the use of environmentally friendly technologies. This approach positions the government not only as a service operator but also as a regulator and facilitator in creating a sustainable waste management system.

Research by Guerrero, Maas, and Hogland (2013), which examined 22 developing countries, found that weak coordination between government agencies is a dominant factor in the failure of urban waste management. Furthermore, low regional fiscal capacity and suboptimal waste policies contribute to uneven waste collection services. The study also highlighted the importance of policy integration between local governments, the private sector, and the community in creating an effective waste management system.

In the Indonesian context, waste management still faces challenges such as low recycling rates and the dominance of open dumping in landfills. According to Purba et al. (2021), the implementation of waste management policies in Indonesia is still hampered by low public awareness, weak government oversight, and limited innovation in waste processing technology. This demonstrates that waste management cannot be addressed solely through administrative approaches but requires institutional transformation and comprehensive changes in societal behavior.

Table 2. Dominant Factors in Urban Waste Management Based on Literature

Factor	Main Indicators	Impact on Waste Management
Urbanization	Population growth, urban density	Increases waste volume and pressure on landfills
Government Governance	Regulations, supervision, funding	Determines the effectiveness of the waste management system
Community Participation	Environmental awareness, waste sorting	Supports waste reduction at the source
Technology	Recycling, waste treatment	Reduces pollution and improves efficiency
Climate Change	Greenhouse gas emissions, pollution	Worsens environmental quality and public health

Source: Processed by the author, 2026.

Based on the table, urbanization and government governance are the dominant variables influencing the effectiveness of urban waste management. Meanwhile, community participation and the use of technology play supporting roles in creating a sustainable waste management system. The concept of collaborative governance is becoming an increasingly relevant approach to urban waste management. According to Chris Ansell and Alison Gash (2008), collaboration between the government, the private sector, environmental communities, and civil society can increase the effectiveness of public policy. In waste management, a collaborative approach allows for the distribution of responsibilities and increased community participation in environmental protection. Makassar City requires a more participatory governance model so that waste management does not rely solely on the local government.

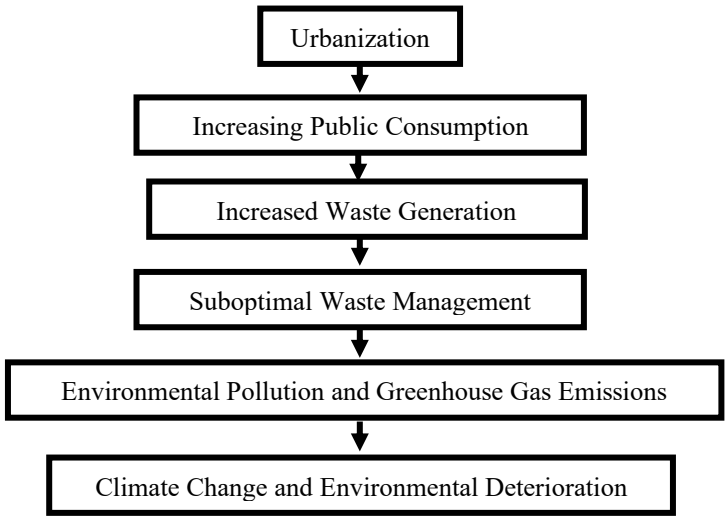
c. Waste Management and Climate Change

Urban waste contributes significantly to global climate change, primarily through methane emissions resulting from the decomposition of organic waste in landfills. According to the Intergovernmental Panel on Climate Change (2021), the waste sector contributes approximately 20% of global methane emissions, which have a greater warming impact than carbon dioxide. Poorly managed organic waste produces greenhouse gases, accelerating global warming.

Lebreton and Andrady (2019) explain that increased plastic consumption in urban areas exacerbates the global environmental crisis because plastic takes hundreds of years to decompose naturally. The study shows that most plastic waste in developing countries ends up in rivers and oceans due to poor waste management systems. Makassar, as a coastal area, faces serious threats to its marine ecosystem if plastic waste is not managed sustainably.

In addition to its environmental impact, waste also impacts public health. According to Ncube et al. (2021), the accumulation of waste in urban areas can increase the risk of environmental-related diseases such as diarrhea, respiratory infections, and skin diseases due to water and air contamination. This study emphasizes the importance of a preventative approach through strengthening environmental health-based waste management systems.

Figure 3. Framework of the Relationship between Urbanization, Waste, and Climate Change



Source: Adapted from Kaza et al. (2018), Ferronato & Torretta (2019), and Wilson et al. (2015).

The figure shows that urbanization is directly linked to increased urban waste production. If not balanced with good governance, it will impact environmental pollution and accelerate climate change. Therefore, strengthening sustainable waste management policies is a crucial need in modern urban development. The circular economy concept is one of the widely recommended approaches to addressing waste and climate change. According to Geissdoerfer et al. (2017), the circular economy encourages the reuse of waste as an economic resource through the principles of reduce, reuse, recycle, and recovery. This approach is considered capable of reducing pressure on the environment while creating new economic value from waste management.

d. Community Participation as the Key to Successful Waste Management

Community participation is a fundamental element in the success of environmentally-based waste management. According to Scheinberg, Wilson, and Rodic (2010), the success of a waste management system is greatly influenced by the level of public awareness regarding waste sorting and reduction at the source. Without community involvement, waste management systems tend to be reactive and unsustainable.

Research by Asteria and Heruman (2016) on waste banks shows that a community-based approach can increase environmental awareness while providing economic benefits to the community. The waste bank program is considered effective in reducing the volume of household waste through a community-based sorting and recycling system. This model can be a strategic alternative for Makassar City to increase community participation in waste management.

Furthermore, research by Putri et al. (2022) found that education level and access to environmental information significantly influence community behavior in waste management. Communities with a good understanding of the environment tend to be more active in implementing environmentally friendly behaviors, such as sorting waste and reducing the use of single-use plastics.

From a sustainable development perspective, waste management is not only oriented towards environmental cleanliness but also towards achieving the Sustainable Development Goals (SDGs), particularly Goal 11 on Sustainable Cities and Goal 13 on Climate Change Management. Therefore, strengthening environmental education, increasing public participation, and innovating waste management policies are strategic steps that the Makassar City Government needs to strengthen.

3.2.Discussion

The results of a literature review indicate that waste management issues in Makassar City are inextricably linked to the impact of urbanization and continued population growth. As a metropolitan city in Eastern Indonesia, Makassar has experienced the development of residential areas, commercial centers, and economic activities, which have direct implications for increasing urban waste generation. This situation aligns with Louis Wirth's (1938) view that urbanization drives changes in people's lifestyles to become more consumerist and complex. Consequently, the volume of household and non-organic waste has increased significantly each year.

Based on a synthesis of various previous studies, waste management in Makassar City still faces challenges in institutional aspects, infrastructure, and community

participation. Research by Guerrero, Maas, and Hogland (2013) confirms that weak coordination between government agencies is one of the causes of the low effectiveness of waste management in urban areas. This situation is also evident in Makassar, where the increase in waste volume has not been fully offset by adequate waste collection and processing capacity. Furthermore, the uneven distribution of waste management services has led to persistent waste accumulation in several densely populated residential areas.

On the other hand, research results indicate that community participation has a significant impact on the success of environmentally-based waste management. According to Asteria and Heruman (2016), community-based waste management through the waste bank program can increase environmental awareness while providing economic value to the community. In the context of Makassar City, the waste bank program and environmental cleanliness movement have been strategic steps taken by the government to encourage community involvement in waste reduction at the source. However, the low level of household waste sorting and the practice of littering remain major challenges in creating a sustainable waste management system.

This study also found that the waste problem is closely linked to climate change and environmental health. According to the Intergovernmental Panel on Climate Change (2021), organic waste accumulated in landfills (TPA) produces methane gas emissions, which contribute to global warming. Furthermore, the increase in plastic waste in urban and coastal areas of Makassar City has the potential to pollute the marine environment and urban drainage systems. Therefore, waste management should not only be viewed as an environmental cleanliness issue, but also as part of climate change mitigation efforts and sustainable urban development.

From a modern governance perspective, collaborative governance and circular economy approaches are the most relevant strategies for urban waste management. Collaboration between the government, the public, the private sector, and environmental communities is considered capable of increasing the effectiveness of sustainable waste management policies. Furthermore, the application of the principles of reduce, reuse, recycle, and recovery (4R) is a strategic solution to reduce pressure on landfills (TPA) while creating economic value from waste management. Therefore, the Makassar City Government needs to strengthen regulations, modernize the waste management system, and provide participatory environmental education to achieve effective and sustainable waste management.

4. CONCLUSION

Based on the literature review, it can be concluded that urbanization and population growth in Makassar City have significantly impacted the increase in urban waste volume. Increased economic activity, consumer consumption patterns, and urban development have led to increasingly complex waste generation, including both organic and inorganic waste. This situation has given rise to various environmental problems such as pollution, declining urban environmental quality, and increased greenhouse gas emissions, which contribute to climate change.

The study also shows that waste management in Makassar City still faces various challenges, particularly in institutional aspects, limited infrastructure, low waste processing capacity, and minimal community participation in environmentally-based waste management. Although the Makassar City Government has developed various programs such as waste banks and environmental cleanup movements, their implementation still requires strengthening through increased inter-agency coordination, public education, and the use of more modern waste processing technologies.

Furthermore, this study found that collaborative governance and a circular economy approach are the most relevant strategies to support a sustainable waste management system in Makassar City. Therefore, synergy between the government, the community, the private sector, and environmental communities is needed to create effective, participatory, and environmentally sustainable waste management.

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