



Environmental Sustainable in Household Waste Management For Urban Resilience: Insight From Makassar City, Indonesia

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Abstract

This study only focuses on a small aspect of environmental protection, namely proper household waste management for urban resilience in Makassar City, Indonesia. This study discusses how household waste in Makassar City can be converted into useful products and economic value that will reduce waste generation and maintain the preservation of densely populated urban environments in Makassar City, Indonesia. This study methodology is qualitative with a case study approach in looking at environmental degradation caused by an increase in household waste generation in Makassar City which has an impact on the environment and socio-economic activities of Makassar City community. The results of this study indicate that the development of environmental problems in household waste management in Makassar City is still experiencing problems. So in good governance, it is driven by the helix innovation system which involves various stakeholders to turn household waste into useful products with economic value. The helix innovation system as a solution to the problem of increasing household waste in Makassar City utilizes Incineration Technology and the Waste Bank and Composting Innovation Program for organic waste as environmental preservation for densely populated cities in Makassar City, Indonesia which involves community groups. Wet household organic waste is made into compost which can be used in plantations and livestock. Waste management in Makassar City is regulated in Makassar Mayor Regulation No. 4 of 2011 concerning Waste Management and Makassar Mayor Regulation No. 35 of 2018 concerning Policies and Strategies for Household Waste Management and Household Waste.

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Introduction

Environmental-sustainable is needed to improve the quality of life of citizens in a region and country, this development project affects the environment, ecology, economy, society, and proper waste management (Marshall, R. E., & Farahbakhsh, K., 2013). Therefore, over the past few decades, people have been talking about sustainable development from an innovation perspective. Innovation spearheads the creation of competitiveness, environmental preservation, and economic growth of a country (Carayannis & Campbell, 2018; Bayeh, E., 2016). The creator of this innovation began to be known for the concept of the helix. The concept of Helix is based on the idea that innovation is an interactive outcome involving different types of actors. Contributions to innovation are considered in terms of knowledge sharing and knowledge transfer (Carayannis & Campbell, 2018; Bayeh, E., 2016). This helix model establishes and formalizes the right role for each field in supporting environmental improvement and economic growth through innovation (Carayannis & Campbell, 2018; Bayeh, E., 2016; Jalil, 2010). The focus of this paper is on environmental protection. Many factors cause a decline in environmental quality. One of the factors that contribute seriously to the decline in environmental quality is the high incidence of household waste. For example, household waste secretes nitric oxide and methane gas which contribute 20% to the greenhouse effect. Therefore, household waste should be managed in such a way that it can minimize emissions of harmful gases such as methane gas that cause global warming and have 21 times more potential than carbon dioxide (Bassi, et al., 2017; Bavani & Phon, 2009; Jalil, 2010).

If waste is defined as the waste of humans or animals that are dense or semi-dense, which has no use-value or economic value (Laguë, C., & Eng, P., 2020; Omilani, O., et al., 2019; Yangm J., 2022). The waste generation that continues to increase along with increasing population growth in a region comes from the production of household waste (Moh, Y.C., & Abd Manaf, L., 2014; Abrokwah, S. et al., 2021; Liu, B. et al., 2021). Waste will not be a problem as long as the natural capacity of the environment can recycle non-organic waste or decompose organic waste through microbial metabolic activities into non-organic matter that can be reabsorbed by the environment without disturbing its natural balance (Yangm J., 2022; Abrokwah, S. et al., 2021; Liu, B. et al., 2021). The problem is, in densely populated and narrow urban conditions and situations of land, daily waste production exceeds environmental capacity, and its disruption to the balance of environmental quality can no longer be tolerated (Yangm J., 2022; Abrokwah, S. et al., 2021; Liu, B. et al., 2021). Garbage is always synonymous with waste or worthless waste (Laguë, C., & Eng, P., 2020; Liu, B. et al., 2021). Although everyday humans always produce garbage, humans also avoid garbage the most (Abrokwah, S. et al., 2021; Liu, B. et al., 2021). So far waste is managed with the concept of *just throwing (open dumping)*, burning (with an incinerator or just burned), dig a lid (*sanitary landfill*), it does not provide a good solution, especially if the implementation is not disciplined and effective (Nyarai, M.P. et al., 2016; Ijgosse, J., 2019). The cause of the flooding is generally organic waste, plastic, or cans that are difficult to decompose, this type of waste also needs attention to be managed

properly (Debrah et al., 2021). In this context, it is necessary to find the right city waste management solution, especially household waste production, which can minimize the accumulation of landfills, until it reaches *zero-waste* levels in a city, region, and country. In the identification and analysis of research on the topic of household waste management, it is found as follows:

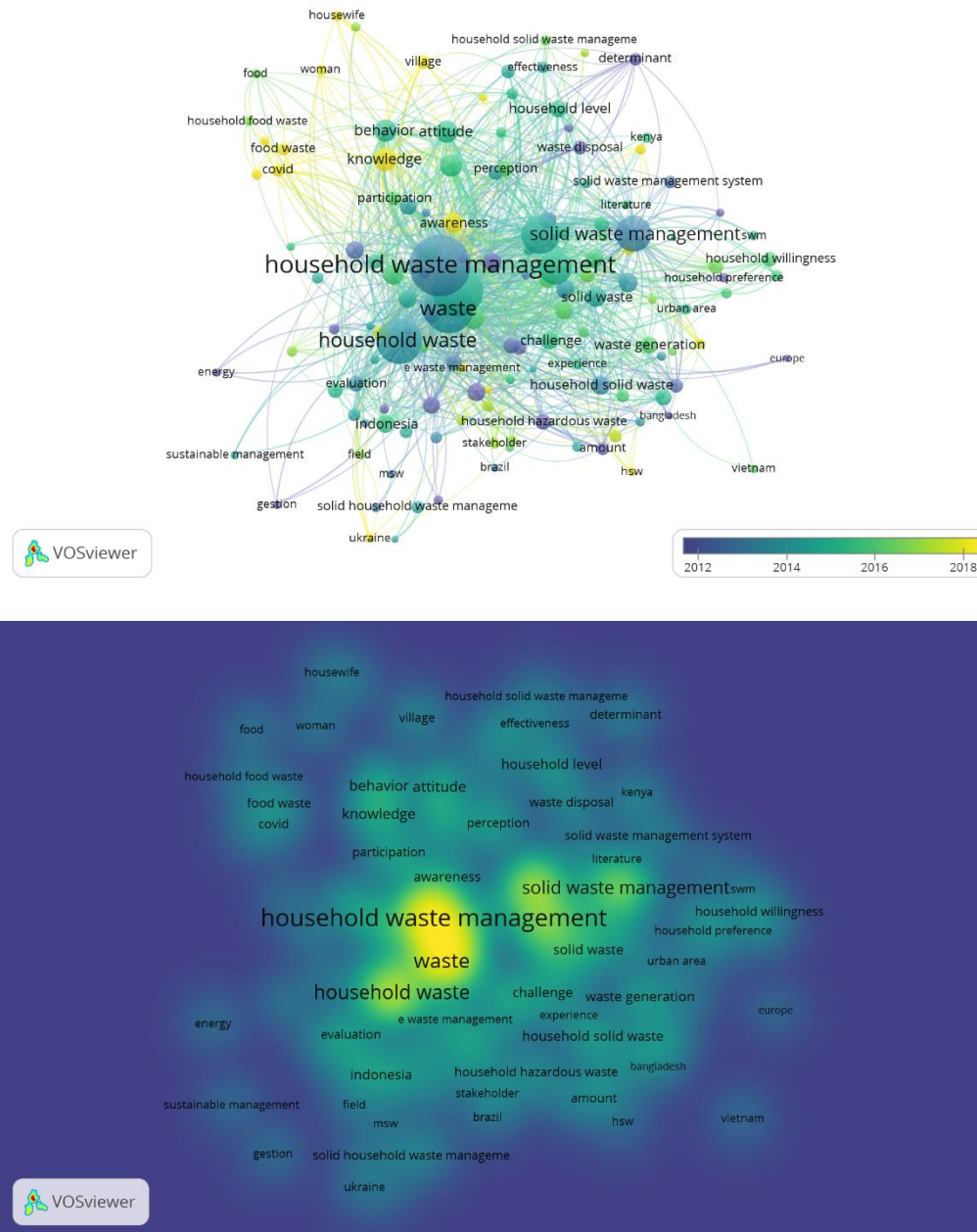


Figure 1. *Identification and Analysis of Research Issues (OverlayVisualisation). Source: Processed From VosViewer, 2022*

In Figure 1 above explains that the identification and analysis of research problem topics through Vosviewer using a database from google scholar gets updated research related to household

waste management about: (1) Awareness related to the knowledge and behavior of housewives in rural areas in household waste management (Chen, M., 2015; Zulfa & Nugraheni, 2020; Raghu & Rodrigues, 2020; Akil & Ho, 2014) as a topic that is still rarely researched; (2) Management of food waste as household waste (Matsuda, et al., 2012; Lebersorger & Schneider, 2011; Papargyropoulou, et al., 2014; Parizeau, et al., 2015); (3) the continuity of the latest research is a topic related to the study of electronic management of household waste (Kang, et al., 2020; Chi, et al., 2014; Abbondanza & Souza, 2019; Lu, et al., 2015); (4) There is also about wisdom related to household waste management (Andersson & Stage, 2018; Kirakozian, 2016) as an interesting topic in the study of household waste management that is still rarely researched; and (5) there is household plastic solid waste management (Mwanza & Mbohwa, 2017; Samah, et al., 2013; Thanh, et al., 2011) as the latest topic to research. So that is the reason why this research topic raises the topic of household waste management into a useful product and economic value in activating the concept of sustainable development of the helix innovation system in Makassar City, Indonesia which will complement the first research related to household waste management in densely populated urban areas.

Household waste dominates waste production in Makassar City which averages 900 tons per day brought to tamangapa-Antang landfill, in Makassar City, Indonesia. The amount of household waste in Makassar City is 2.18 ltr / org/day or 0.28 kg/org/day, while the density (waste density) is 0.31 kg / ltr. The composition of household waste in Makassar city is dominated by organic waste 67.14%, plastic (14.09), paper (12.84%), wood (0.22%), cloth (0.14%), rubber (0.13%), metal (0.13%), glass (4.98%) and other waste (0.33%). The economic potential of Makassar city household waste that can be recycled amounted to Rp. 4,109,183 per day, and to be used as compost raw materials from the organic waste of 130 tons per day (Zubair & Mahendra, 2011; Sham, 2017). This was stated by the Head of the Makassar City Environment Office H Andi Iskandar (in Mappong, 2020) said that household waste which is organic waste should be used as compost and inorganic ones can be used as handicrafts or recycled. Regarding the intensity of public consumption during the COVID-19 pandemic both before and during the implementation of Large-Scale Social Restrictions (PSBB), it is recognized that it is not too significant to reduce waste production in Makassar City which is in the range of 850 tons - 900 tons per day (Mappong, S., 2020; Fakhruddin, M., 2020).

Meanwhile, before the COVID-19 pandemic, the Makassar City Environment Office recorded 1,200 tons per day, because some companies were still actively producing (Mappong, S., 2020; Fakhruddin, M., 2020). According to WCD Core Team Leader Sulsel Fina Irnawati (Fakhruddin, 2020) said the Makassar City government collaborates with various communities that focus on managing waste. It is expected that the waste will not only end up in landfills but can be processed or utilized into useful and economically valuable items. Therefore, it takes education and awareness of the community to be able to process their waste, before those that cannot be processed anymore are sent to landfills. This is justified by the Head of DPLH Sulsel Hasdullah (in Mappong, 2020) saying the waste problem is the responsibility of all parties, so it is not enough to only be taken care of by one institution or service, but must synergize with each other.

This study discusses and analyzes the experience of Makassar City in household waste management, which decreases the quality of the urban environment for urban resilience in Makassar City through the helix innovation system. This study only focuses on a small aspect of environmental

protection, namely proper household waste management in Makassar City, Indonesia. This is one of the continuous development efforts in the eastern metropolitan city of Indonesia because waste and its management is now an increasingly urgent problem in major cities. After all, if not done good handling will result in changes in environmental balance that are detrimental or unexpected to pollute the environment both water, soil, and air. Therefore, to overcome the pollution problem, handling and controlling waste is needed. Problems that often arise in handling municipal waste are the problem of high operational costs and the increasingly difficult space appropriate for disposal. This study discusses how household waste in Makassar City can be converted into useful products and economically valuable for reuse and into products that can be resold. The production of organic and non-organic waste recycling to make products for use and economic value from household waste in Makassar city can reduce the amount of production of household waste as one of the largest contributors of waste and bring problems to Makassar City, Indonesia.

Research Methods

Qualitative-explorative research methodology with a case study approach (Creswell, J. W., & Poth, C. N., 2016) in looking at environmental degradation that occurs from the intensive level of population scouting in Makassar City as the largest metropolitan city in eastern Indonesia. Therefore, to protect the environment, the Makassar City government needs to propose sustainable development to overcome the problem of high enough household waste production rates for urban resilience in Makassar City so as not to impact workers for the community and the environment in Makassar City, Indonesia. This study uses the theory of sustainable development through the helix innovation system (Carayannis, E. G., & Campbell, D. F., 2018) in looking at the problem of the challenges of domestic waste generation into opportunities in economic development; social development; and environmental protection where each actor contributes according to his institution in Makassar city, Indonesia. This helix model establishes and formalizes the right role for each field in supporting environmental improvement and economic growth through innovation. The transformation of household waste problems in Makassar City from useless waste turned into products of economic value into challenges as well as opportunities for sustainable environmental development in Makassar City, Indonesia. This study is to analyze data obtained from books, journal articles, government working papers, and laws on The Management of Household Waste. Household Waste in the principles of sustainable, environmental, economic, and social development in Makassar City, Indonesia, newspapers, and magazines. This study data analysis uses in-depth interactive analysis (Miles et al., 2018) then assisted by Nvivo 12 Pro tools as qualitative data analysis software (Woolf, N. H., & Silver, C., 2017) to get the best and most in-depth study results. Analysis through Nvivo 12 pro is carried out through the following stages (see Figure 2):

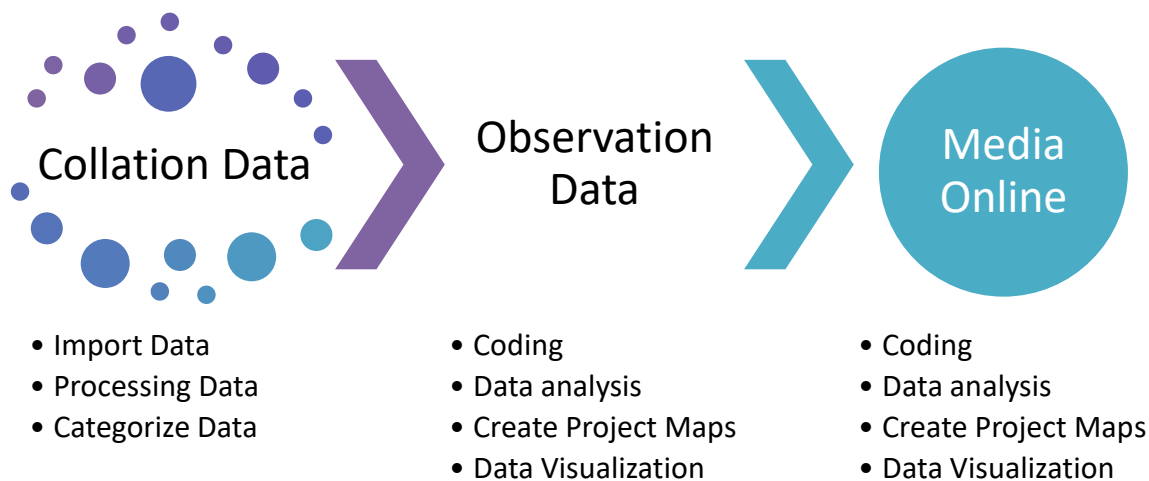


Figure 2. Data collection and analysis techniques with NVivo 12 Pro. Source: processed from Woolf & Silver (2017), 2022

Analysis of this study through Nvivo 12 pro is carried out through the following stages: (1) Collation Data with (a) Import Data; (b) Processing Data; (c) Categorize Data. Then (2) Interview with: (a) Coding Data; (b) Data Analysis; (c) Create Project Maps; (d) Data Visualization. and (3) Observation Data with (a) Coding Data; (b) Data Analysis; (c) Create Project Maps; (d) Data Visualization.

Results and Discussion

Makassar City Government Reaction to Household Waste And Policy Instruments

Household waste dominates waste production in Makassar City which averages 900 tons per day brought to landfills (TPA) Makassar city (Mappong, S., 2020). Household waste that is organic waste should be used as compost and inorganic ones can be used as handicrafts or recycled. Regarding the intensity of public consumption during the COVID-19 pandemic both before and during the implementation of Large-Scale Social Restrictions (PSBB), it is recognized that it is not too significant to reduce waste production in Makassar City which is in the range of 850 tons - 900 tons per day (Mappong, S., 2020; Fakhruddin, M., 2020). Meanwhile, before the Covid-19 pandemic, the Makassar City Environment Office recorded 1,200 tons per day, because some companies were still actively producing (Fakhruddin, M., 2020). According to WCD Core Team Leader Sulsel Fina Irnawati (in Mappong, 2020), waste management in Makassar City involves the government collaborating with various communities that focus on managing waste. It is expected that the waste will not only end up in landfills but can be processed or utilized into useful and economically valuable items. Therefore, it takes education and awareness of the community to be able to process their waste,

before those that cannot be processed anymore are sent to landfills. This is justified by the Head of DPLH Sulsel Hasdullah to make the waste problem the responsibility of all parties, so it is not enough to only be taken care of by one institution or service, but must synergize with each other (Mappong, S., 2020; Fakhruddin, M., 2020). Procedures for regulating household waste management that include the development, supervision, and control carried out by the Makassar City Government's First and Hygiene Office are based on the policy of Makassar City Regional Regulation No. 4 of 2011 concerning Waste Management and Regulation of Mayor Makassar City No. 36 of 2018 concerning policies and strategies in the management of household waste and household waste, through activities:

Table 1. Government Reaction to Household Waste In Makassar City, Indoneisa

No.	Waste Formula	Management	Description and description of waste management in Makassar City, Indonesia
1	Procedures for Regulating Household Waste Management by the Makassar City Government in Makassar City, Indonesia.		(1) Extension and technical development of waste management; (2) Inspect installations, waste deputies, and means of transportation; (3) Requesting reports and information from parties responsible for waste management activities The implementation of waste management based on principles, namely: a. The principle of responsibility, which is intended here is the Makassar City Government through certain agencies/agencies/parties responsible for waste management; b. Sustainable principles, which are intended here to perform continuously; c. The principle of benefits, which is intended here waste management activities that provide the greatest benefit for the benefit of humans and the environment; d. The principle of justice, which is intended here is to provide opportunities and guarantees for the community; e. The principle of awareness, which is intended here is not only for the government, public awareness is also very necessary in terms of waste management; f. The principle of togetherness, which is intended here is an activity carried out together for the common interest in waste management; g. The principle of safety, which is intended here is to be able to guarantee safety; h. The principle of security, which is intended here is to be able to provide security guarantees; i. The principle of economic value, which is intended here is how waste can be managed so that it has economic value (not just waste).

2	Waste Removal Flow in Makassar City based on policy	Procedures for transportation/collection of waste as stipulated in Article 15 of Regional Regulation No. 4 of 2011 waste management: (1) Transportation as intended in Article 12 letter c is carried out by a. household waste to TPS / TPST is the responsibility of waste management institutions established by RT (Neighbourhood) / RW (Hamlet); b. Waste from TPS / TPST to landfill is the responsibility of the City Government; c. Waste residential areas, commercial areas, industrial areas and special areas from waste sources to TPS / TPST and landfills become the responsibility of area management d. Waste and public facilities, social facilities, and other facilities from waste sources and from TPS / TPST to the landfill are the responsibility of the City Government; (2) The implementation of waste transportation as intended in paragraph (1) still guarantees the separation of waste by the type of waste; and (3) Waste transport equipment must meet the requirements of safety, environmental health, comfort, and cleanliness.
3	Javanese Responsibility of Makassar City Government in Managing Household Waste	The City Government also drew up a waste reduction and management plan outlined in the strategic plan and work plan for the Regional Work Unit (<i>Satuan Kerja Perangkat Daerah</i> , SKPD) year. The intended reduction plan contains at least: (1) waste reduction targets; (2) targets for the provision of waste reduction and infrastructure facilities and infrastructure ranging from waste sources to landfills; (3) Patterns of regional cooperation development, partnerships, and community participation; (4) The need for providing financing borne by the City Government and the community; (5) Plan for developing environmentally friendly technology to meet the needs of reusing, recycling, and handling the end of waste.

Source: Processed from various sources, 2022

Table 1 above shows the reaction of the Makassar City government to household waste management to conduct construction, supervision, and control of waste management carried out by the First and Hygiene Office of the Makassar City government through extension and technical development of waste management, and checking installations, waste generation and transportation equipment, and requesting reports and information from parties responsible for waste management activities (Huduri, A. N. A., 2018; Mappong, S., 2020).

In the work plan of the Makassar City government in the management of household waste in Regulation of Mayor Makassar City No. 36 of 2018 concerning policies and strategies in the management of household waste and household waste, including: (1) implementing norms, standards, procedures, and criteria in reducing household waste and household waste; (2) strengthen coordination and cooperation between the central government and local governments; (3) strengthening the commitment of executive and legislative institutions in the region in providing budgets to reduce household waste and household similar waste; (4) increase the capacity of leadership, institutions, and human resources in efforts to reduce household waste and household waste; (5) information system analysis; (6) strengthening community involvement through communication, information, and education; (7) implementation and development of investment, operational and maintenance schemes; (8) Strengthening law enforcement; (9) strengthening business involvement through partnership with the central government; (10) application of technology to handle the reduction of household waste and similar household waste; and (11) strengthening the commitment of the business world through the implementation of producer obligations in reducing household waste and household waste. There are also 248 units of garbage trucks in Makassar City, which comes from private corporate CSR available 21 units, 2014 APBD is available 40 consisting of 32 units and bonus 8 units from dealers, and 2015 APBD as many as 100 units. Tangkasaki's truck fleet of 210 units is distributed to as many as 15 units per sub-district in 14 sub-districts in Makassar City, Indonesia. 145 fleet of Arm-Roll trucks on operational standby. There are also 21 units of the private special waste fleet (hotel/restaurant/industry/housing) and 603 units of garbage tub motors available in Makassar City, Indonesia. There are also 620 cleaners, 420 people (30 people / sub-districts), and 143 managers, 1 per village (Kasie Kebersihan / beauty). The available fleet drivers are around 57 service honorees, 12 authorized fleet drivers, and 42 garbage carriers from containers (Huduri, A. N. A.A., 2018; Mappong, S., 2020; Fakhruddin, M., 2020). This will help the Makassar City government increase the effectiveness of household waste management in Makassar City which is one of the most sources of waste generation in Makassar City, which has an impact on reducing the quality of the environment in Makassar City, Indonesia.

So that the target of government reaction and policy instructions in reducing household waste by the Makassar city government is carried out: (1) Reduction of household waste and household waste by 30% (three puluh percent) of the number of household waste and household waste before the national policy and strategy for reducing household waste and household waste in 2025; and (2) handling household waste and household waste amounting to 70% (seventy percent) of the number of household waste and household waste before the policy and national strategy for handling household waste and similar household waste in 2025. Figure 1 below shows the management of household waste as a reaction of the Makassar city government in household waste management divided into 3 big points as explained earlier, namely: (1) Makassar City government work plan; (2) household waste management targets; and (3) household waste management patterns. The work plan and targets for household waste management of Makassar city government which is referred to in Makassar City Regulation No. 4 of 2011 concerning waste management and Regulation of Mayor Makassar City No. 35 of 2018 concerning Policies and Strategies in The Management of Household Waste and Household Waste, explained in the following figures:

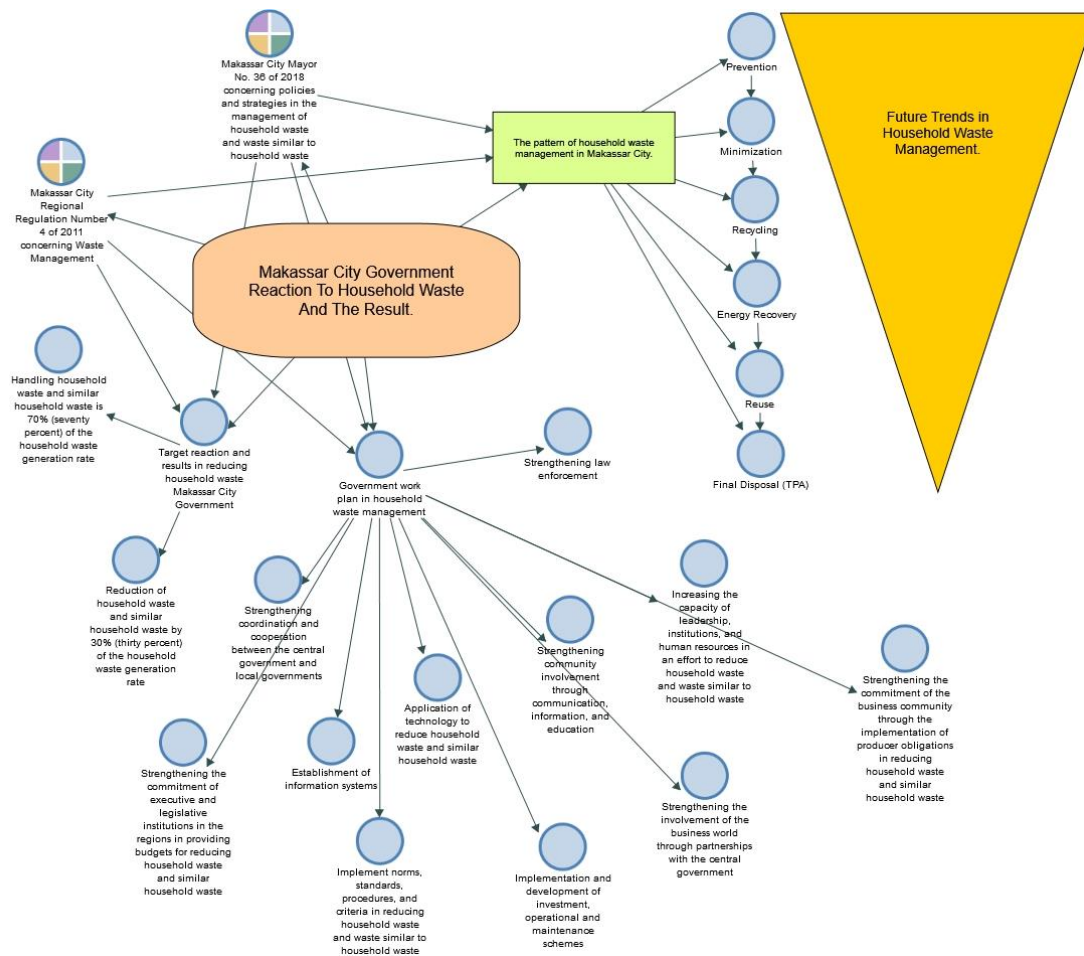


Figure 1. Household Waste Management in Makassar City, Indonesia. Source: Processed from Nvivo 12 Pro, 2022

The pattern of municipal waste management can be described hierarchically in Figure 1 above the future trend of household waste management with the higher the level of the hierarchy of waste management activities, the lower the cost needed by improving the stage of prevention management rather than waste should end up in landfills. Improved management in resistance prevention, minimization, recycling, energy Recovery, and Reuse, is better done than waste must end up in a landfill This pattern is a traditional waste management pattern that is commonly done. The lowest hierarchical level of waste management pattern in conventional municipal waste management is final disposal. In this hierarchy, waste is considered to have no value and must be disposed of or destroyed. As a consequence, high investment and operational costs are needed, including costs to overcome various environmental impacts that occur. So that the Makassar City government's household waste management pattern needs to pay attention to the use of disposal technology and efficient management patterns so that it does not have an adverse impact on waste management which generates odor, methane, and other gas emissions into the atmosphere, impacting soil and groundwater pollution resulting in the formation of leachate. , and the breeding of disease vectors, such as flies and rats.

Composition of household waste and its management using environmentally friendly technology in Makassar City, Indonesia

Looking at the composition of household waste becomes more and more complex over time. The components of wet waste are decreasing, while the content of dry components, especially the rest of the packaging, is increasing (Zubair, et al., 2011; Mappong, S., 2020). In Table 2, data can be seen on the composition of household waste (settlements) in Makassar based on the quality of residential areas (luxury, medium, and simple settlements) still dominated by wet (organic) waste with an average percentage of 67.14%, while inorganic waste in the form of plastic and paper waste is 14.09% and 12.84% respectively. Plastic and paper waste is dominant in luxury settlements, this happens because both wastes are widely used as crushers or packaging. While metal, rubber, wood, and fabric waste percentage is relatively small (Zubair, et al., 2011; Mappong, S., 2020; Fakhruddin, M., 2020). Shown in Table 2 below:

Table 2. Composition of Household Waste in Makassar City, Indonesia

Waste Composition	Household Waste Composition (%)			
	Simple Housing	Medium Housing	Luxury Housing	Average
Organic	71.15	68.16	62.12	67.14
Paper	10.55	11.67	16.32	12.84
Wood	0.37	0.10	0.20	0.22
Cloth	0.05	0.08	0.29	0.14
Rubber/Leather	0.09	0.00	0.29	0.13
Plastic	12.30	13.12	16.85	14.09
Metal	0.14	0.13	0.12	0.13
Glass	5.11	6.23	3.61	4.98
Etc	0,25	0.51	0.21	0.33
Sum				100,00

Source: Processed from various sources, 2022

The physical characteristics of household waste can be analyzed as a unit of household waste generation in Makassar city, in a simple settlement of 1.85 liters/person/day, medium settlement of 2.17 liters/person/day, while in luxury settlements of 2.51 liters/person/day. There is a significant difference between simple and luxurious settlements of 35.6%. This means that waste production in luxury settlements is 35.6% greater than in simple settlements under the same number of occupant (people) conditions. The density (density) of waste in simple, medium, and luxurious settlements is 0.34 Kg/ltr, 0.30 kg/ltr, and 0.28 kg/ltr, respectively. From this data, it can be seen, that in simple

settlements, the density of waste is greater than that of medium and luxurious settlements, This is because the waste of wet waste (organic) in simple settlements is greater than in luxury settlements. Where the average household wastewater content is 53.36%, the wastewater content in simple settlements is greater than the wastewater content in medium and luxurious settlements. The average volatile level of household waste is 32.55% while the average waste ash content is 9.92%. Ash levels indicate the remaining burning of about 9.92% of ash (Zubair, et al., 2011; Mappong, S., 2020; Fakhruddin, M., 2020).

In Makassar City, the goal of proper waste management is to condition the community environment in handling and processing waste that is appropriate, hygienic, and environmentally friendly starting from the process of sorting waste in households, the process of composting organic matter, and recycling non-organic materials to marketing. Household organic waste management can be utilized as compost by using waste reactor technology that utilizes several strains of mushrooms, some strains of fermented bacteria, lactobacillus, etc. So that the effect of odor caused by waste can be reduced and the process of compost formation can be accelerated. While non-organic waste will be processed into materials that can be recycled for industrial raw materials and up-to-craft products that are of economic value (See Table 3 and Table 4). Household waste in the form of organic and non-organic materials can be used into useful products and materials of economic value such as waste that can be exchanged for gold at PT Pengadaian or sold at the Makassar City Center Waste Bank in collaboration with PT Unilever Indonesia (Farmawati et al., 2019; Ridwan et al. 2017). There are 2 forms of household waste development prospects in Makassar city, namely: (1) Recycling (Recycle); and (2) Composting as described in table 3 below:

Table 3. Composition of Household Waste and Prospects for its development

No.	Composition	Percentage (%)	Weight (kg/org/day)	Economic Potential
1	Organic Waste	67,14	0,19	Compost Material
2	Plastic	14,09	0,04	Recycled Materials
3	Paper	12,84	0,03	Recycled Materials
4	Glass and Metal	5,11	0,01	Recycled Materials
5	Etc.	0,92	0,01	
Total		100	0,28	

Source: Processed from various sources, 2022

Table 4. Economic Value and Potential Utilization of Household Waste

No.	Composition	Percentage (%)	Weight (kg/org/day)	Recovery Factor (%)	Weight (kg/hr)	Price (Rp/kg)	Potential (Rp)
1	Organic Waste	67,14	0,19	80	129.846		
2	Plastic	14,09	0,04	50	3.585	750	2.689.109
3	Paper	12,84	0,03	40	1.960	600	1.176.260
4	Glass and Metal	5,11	0,01	75	488	500	243.814
	Total	100	0,28				4.109.183

Source: Processed from various sources (Waste Selling Value based on Waste Price at Makassar City Waste Bank), 2022

If the population of Makassar City in 2022 amounted to 1,571,812 people (BPS, 2022), then the economic potential of household waste as seen in Table 4 amounted to Rp. 4,1091.83 per day and the potential for organic waste raw materials to be processed into compost amounted to 130 tons per day. In addition, household organic waste is the most typical waste in terms of the amount of waste generated in the city of Makassar, such as food waste which can be converted into compost which can be used in plantations and livestock in Makassar City, non-organic waste can be exchanged for gold and sold in waste banks Makassar city center. In addition, in the final disposal to improve the city's environmental class in the management of household waste, the Makassar City government utilizes environmentally friendly incineration technology, This is in line with the support of the regional government policy of Makassar City (Makassar City Regional Regulation No. 4 of 2011 concerning Waste Management and Regulation of Mayor Makassar City No. 36 of 2018 policies and strategies in the management of household waste and household waste) regarding management environmentally friendly and sustainable waste. In Indonesia, in general, in overcoming waste problems by conducting partnerships between the public, the private sector, and the government, this is based on Law No. 18 of 2008 concerning Waste Management, This policy regulates address the problem of waste such as household waste in accordance with the principles of environmental friendliness and sustainability (Sondang Siagian, E. et al., 2019a; Sondang Siagian, E. et al., 2019b).

Household Waste Management as a Helix Innovation System in Environmentally Sustainable Development

The principle of environmental development in the reduction of household waste through the perspective of the helix innovation system in Makassar City results from interactive involving various types of actors including, Makassar City Government, Private, and Makassar City Community until the University gave birth to innovations in waste management buildings based on environmentally friendly incineration technology at Final Damming Place (*Tempat Pembuangan Akhir*, TPA) Tamangapa Makassar. This building becomes a building so that the emergence of garbage does not interfere with the comfort of the people who live around it. The shape of the building is made expressive to change the negative image of society about waste. The creation of the shape of

the building refers to the process of integration of the environment and away from the impression of slums and squalid. The design application reinforces the image of an innovative, effective and educative waste processing building. The designed building specifications are capable of burning garbage up to 700 tons per day, using incineration machines with an electrical output of 10,000 KWh as much as 2 units, for incinerator operations using 50% of the total electrical output (Wasilah, A.H., 2017; BPS, 2022).

The application of incineration technology in reducing household waste in the city of Makassar is to reduce waste into waste fuel a strategic choice in reducing waste generation (Muliaawaty, L., & Framesthi, D. B., 2020). The potential for waste reduction with incineration technology is very effective and the main thing is to be able to provide output in the form of electrical energy that can be utilized and used by the people of Makassar city on electricity needs. Other advantages of incineration technology include reducing waste volume by 90%, and the presence of energy recovery, if managed properly, the air pollution released will be low, requiring minimal land. Although in Wasilah et al. (2017) this innovation is still limited, although this technology can reduce waste volume by 70%, incineration technology requires high investment, operation, and maintenance costs. Waste-burning facilities are recommended to only be used to destroy/burn waste that cannot be recycled or is not worth reducing. This tool must be equipped with a control and control system to meet the limits of particle and exhaust emissions so that it is ensured that the smoke coming out of the garbage kiln is a neutral smoke/gas. Ash produced from the combustion process can be used for building materials, made as compost mixture materials, or thrown into landfills. While residues from waste that cannot be burned such as metal waste can be recycled. With innovation efforts to reduce household nonorganic waste can reduce the incidence of household waste that is increasing as well as efforts to maintain the quality of the urban environment so as not to get worse due to waste.

In addition to incineration technology in reducing household waste, helix innovation in sustainable development in Makassar City there is an innovation program for household waste management through waste banks in Makassar City, Indonesia. A waste management innovation policy program is exchanged for gold, with environmental conservation efforts while providing opportunities for people to live better. The management innovation program through waste banks can be exchanged for gold or sold is a program from various elements such as PT Pegadaian, PT Unilever Indonesia Makassar City, until environmentalist civil society groups then cooperate with the Makassar City government, with the reason to help the community about the importance of clean and healthy living. This waste management innovation program also carried out by Pegadaian has been widely spread in areas in Indonesia. In the process, the waste bank program was formed at the RW level which currently has about 1000 waste banks. At the sub-district level, there is the name of sectoral Waste Bank and at the city level, there is a central waste bank managed by Service Technical Implementation Unit (*Unit Pelaksana Teknis Dinas*, UPTD) under the auspices of the Makassar City Government Environment Office (see Figure 3). This Makassar City government innovation program through a waste bank is considered capable of improving the welfare of the community to make waste economically valuable (Sham, F., 2017; Farmawati et al., 2022).



Figure 3. *Waste Bank of Makassar City, Indonesia. Source: Processed from Various Sources, 2022*

Although in the research Farmawati et al (2019) and Ridwan et al. (2017) mentioned the impact felt by some parties, especially the community in the implementation of the waste management innovation program in Makassar city has a very positive impact/good, because the various impacts and benefits felt by some parties that can be involved in this program are reviewed from various aspects related to both ecological aspects, health, economy, and aesthetic value (beauty and comfort).

Household waste in Makassar City is in various forms such as organic waste, household solid waste, and household electoral waste that is used as compost for household organic waste, household electoral product waste is reused (Reduce, Reuse, Recycle), and inorganic is used as handicraft materials and exchanged into gold. This is supported by the policy of Makassar City Regulation No. 4 of 2011 concerning Waste Management and Regulation of Mayor Makassar City No. 35 of 2018 concerning Policies and Strategies in The Management of Household Waste and Household Waste. Innovation in sustainable development in the innovation helix system for reducing household waste in the city of Makassar is utilizing incineration technology, namely a final damming building (*Tempat Pembuangan Akhir*, TPA) into a building so that waste generation does not interfere with the comfort of the people who live around it. Panel and building shapes are made expressive to change the negative image of the community about waste. This will ensure a healthy and fresh environment in Makassar City and can also encourage people to be involved in innovative waste management and the economy.

Table 5. Community Behavior-Based Waste Reduction Program in Makassar City, Indonesia

Waste Reduction Program	The description of waste management in Makassar City, Indonesia
Waste Bank	The process of implementing the Waste Bank management, namely residents who want to join as customers of the Waste Bank Unit, then you have to bring the sorted garbage. The waste received at the Unit Waste Bank is inorganic waste with 4 types of classification, namely the plastic group, the metal group, the paper group and the glass group. Residents who bring waste based on the classification according to the inorganic waste group to the Unit Waste Bank are immediately weighed, then the weighing results are calculated based on the waste price list that has been determined by the Central Waste Bank. Customers can take their money every day, once a month or every 3 months so that the Waste Bank is really also used as a place to save.
Garden aisle	This program utilizes existing hallways to be more productive. Where we strive for green and clean hallways, by planting various plants such as vegetables, tomatoes, chilies, and others. The next step is to create a hallway business entity. The results of this plant will be marketed so that it becomes the economic value of the residents, especially the mothers who live in the hallway. If this movement is carried out massively to all the alleys in the city of Makassar with the involvement of all parties from the Government, the private sector and the community, a clean, safe, comfortable and green alley will be realized.
Picking Up Trash (LISA)	The LISA (Picking Up Trash) movement is an action or action to implement MTR program. LISA's slogan aims so that the people of Makassar have initiative not to throw waste carelessly and pick up trash they met on the street and throw it where it already is. The waste problem is caused by by the behavior patterns of the people who tend to still throw garbage in any place so that create an unsanitary environment lead to various disease, flooding, and the spread of germs. The existence of this movement has begun to educate people's behavior towards environmental conditions, especially on the issue of garbage which is usually thrown away in random places or whether people have started to wake up their awareness to pick up garbage if they get it, but people are not fully aware of it.

Source: Processed from various sources, 2022

The Table 5 describes a sustainable environmental improvement and management program in the city of Makassar, where the Makassar city government encourages community participation in improving the densely populated urban environment. The impact of this program has given changing patterns of people's lives in Makassar City, Especially in the sub-district Tamalate in Makassar City with the waste bank program, Picking Up Trash (*Lihat Sampah Ambil*, LISA), and garden aisle. But that change was not maximized due to lack of program socialization and commitment change in attitude towards hygiene environment. This will ensure a healthy and fresh environment in Makassar City while also encouraging the community to be involved in innovative and economic waste management. In the principle of sustainable development, which is also a helix innovation system in Makassar City. The implementation of an Innovation system for managing household waste by involving various actors as a program that is useful and has economic value through the use of incineration technology, an innovation in incineration-based waste processing buildings that are environmentally friendly (Wasilah, A. H., & Suradin, M. Z., 2017; Syam, F., 2017; Debrah, J. K., Vidal, D. G., & Dinis, M. A. P., 2021; McIntyre-Mills, J. J. et al., 2023; Widianingsih, I. et al., 2023). The application of incineration technology in reducing household waste in Makassar City turns waste into waste fuel into a strategic choice in reducing regional waste generation in residents such as Makassar City, Indonesia (Barokah, A. A. N., & Muchlis, M., 2022; Wasilah, A. H., & Suradin, M. Z., 2017; Syam, F., 2017). The potential for reducing waste with incineration technology is very effective and the main thing is being able to provide output in the form of electrical energy that can be utilized and used by the people of Makassar (Barokah, A. A. N., & Muchlis, M., 2022; Wasilah, A. H., & Suradin, M. Z., 2017; Syam, F., 2017). Other advantages of incineration technology include reducing the volume of waste by up to 90%, energy recovery, if managed properly, the air pollution released will be low, requiring minimal land. In addition, there is a waste management innovation program through a waste bank (Fatmawati, A. et al., 2019; Fatmawati, F. et al., 2022).

The implementation of the Domestic Waste Management Innovation system involves various actors taking strategic steps in the principles of sustainable development based on the helix innovation system (Abdillah, A. et al., 2022) which is being pursued in Makassar City, Indonesia. The waste management program in Makassar City is innovative, environmentally friendly and economically valuable by utilizing incineration technology, to the waste bank program. The application of incineration technology in reducing household waste in Makassar City to reduce waste into waste fuel is a strategic choice in reducing regional waste generation in residents such as Makassar City, Indonesia (Wasilah, A. H., & Suradin, M. Z., 2017; Barokah, A. A. N., & Muchlis, M., 2022). The potential for reducing waste with incineration technology is very effective and the main thing is that it is able to provide output in the form of electrical energy that can be utilized and utilized by the people of Makassar City, Indonesia. Another advantage of incineration technology is reducing the volume of waste by up to 90%, and energy recovery, if managed well the air pollution released will be low so it requires minimal land (Wasilah, A. H., & Suradin, M. Z., 2017; Barokah, A. A. N., & Muchlis, M., 2022).

Apart from that, there is a waste management innovation program through a waste bank. A waste management innovation policy through a waste bank in collaboration with PT Pengadaan, PT Unilever, Environmental Civil Society Groups, and the Makassar City Government which can exchange waste for gold and money (Fatmawati, F. et al., 2022). This innovation program transforms the value of useless waste into waste of economic value so that it can be profitable while reducing

waste generation in final disposal sites (TPA) from waste produced by dense residential areas in the city of Makassar. Not only that, large-sized wet (organic) waste produced from household waste can be used as compost which can be used for agriculture and sanitation (Abdillah, A. et al., 2023). This has an impact on urban environmental sustainability from the problem of high waste generation for urban resilience in Makassar City, Indonesia (Abdillah, A. et al., 2023). Environmental preservation efforts also provide opportunities for people to live better (McIntyre-Mills, J.J. et al., 2023; Widianingsih, I. et al., 2023). The household waste management innovation program that needs to be scaled up in Makassar City, Indonesia is to help people understand the importance of living clean and healthy.

Conclusion

In our conclusion, household waste management in Makassar City is driven by the principles of environmentally friendly sustainable development through the perspective of the Hilex innovation system in Makassar City involving various types of actors such as universities, the private sector, government and civil society. Waste management in Makassar City is regulated in Makassar City Regional Regulation No. 4 of 2011 concerning Waste Management and Makassar City Mayor Regulation No. 35 of 2018 concerning Policies and Strategies for Management of Household Waste and Types of Household Waste, which is in line with Indonesian national policy on Law No. 18 of 2008 concerning Waste Management. This policy supports household waste management innovations that are useful and have economic value through the use of incineration technology and environmentally Friendly Incineration-Based Waste Processing Building Innovations. The application of incineration technology to reduce household waste in Makassar City makes waste into waste fuel a strategic choice in reducing waste generation in Makassar City, Indonesia.

Apart from that, there is an innovative waste management program through waste banks which can exchange waste for gold or money which also has economic value for the community. This innovation program changes the value of useless waste into waste of economic value so that it can be profitable and can reduce waste generation in final disposal sites (TPA) from waste produced by densely populated settlements in Makassar City. Not only that, large organic waste originating from household waste can be turned into compost which can be used for agriculture and plantations. This has an impact on the sustainability of the city's environment on urban resilience from the problem of high waste generation in Makassar City, Indonesia. However, we also underline that the program for utilizing incineration technology and the waste bank program in managing household waste in Makassar City, Indonesia requires the support and participation of various stakeholders in the implementation (including the Central Government, Regional Government, Private Sector, Environmental Activists, the Community, and Academics).), especially to ensure that implementation runs well, it needs to be supported by appropriate policies/regulations as control and legacy for the implementation and evaluation of environmentally friendly waste management in Makassar City, Indonesia.

The limitations of this study occur because the researchers did not conduct in-depth studies regarding the distribution of waste, waste storage in residential areas or people's homes, and the process of collecting waste carried out at night and in the morning. This research is also limited because it only conducts an assessment of waste management in promoting environmental sustainability in Makassar City, Indonesia. With these limitations, the researcher hopes that improvements can be made for future research so that the shortcomings of this research can be complemented by other researchers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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