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An Economic Analysis of Urban Waste Recycling within a Zero-Waste Framework

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Abstract
Waste possesses economic value when it is utilised appropriately. Effectively managing waste from its sources proves to be a valuable approach, enhancing the market value of waste and mitigating the disposal of refuse into landfills. Recycling waste contributes to economic benefits for communities; however, the pricing of waste or used goods is significantly influenced by global market conditions. In Banda Aceh, only 5.08% of the population engages in frequent recycling, 3.35% participate quite often, while 24.57% and 67% are categorised as rarely engaging in recycling and never engaging in recycling, respectively. This paper contends that the proper recycling of used goods can yield economic benefits for urban communities. Key elements include waste separation and prevention, establishing community recycling centres, and implementing incentives and disincentives. The objective of this paper is to explore the economic benefits that urban communities can achieve through the effective implementation of Zero Waste principles in Banda Aceh. The research methodology involves surveys, in-depth interviews with diverse experts, including academics, government officials, and waste activists, as well as a thorough review of relevant documents.

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1. Introduction

Developing nations, such as Indonesia, characterise Municipal Solid Waste (MSW) as refuse originating from households, commercial activities, industries, specific areas, social facilities, and other establishments (Ministry of Environment, 2008). The issue of urban solid waste generation has evolved into a multifaceted environmental challenge, giving rise to health and ecological concerns for individuals globally, particularly in developing nations. This challenge arises from the rapid pace of urbanisation and the concurrent growth of the population (Bustos, Borregaard & Stilwell, 2004).

The urban population in Indonesia is experiencing a swift increase, leading to adverse effects such as compromised environmental quality and sanitation. Inadequate waste management practices in urban areas further intensify these challenges. On a national scale, it is estimated that only 60% to 70% of the entire urban waste can be transported appropriately to landfills through authorised government entities (Damanhuri, 2005). The remaining portion that exceeds the government's capacity is either incinerated or disposed of in open spaces or rivers. Scavengers collect a small fraction of the waste for recycling or resale to waste treatment facilities.

In 2008, the Indonesian Government enacted Law Number 18 of 2008 on Waste Management, serving as the overarching national legislation. The district/city governments and local private sector entities designated for municipal solid waste (MSW) management at the regional and provincial levels are tasked with enhancing their services through environmentally sustainable waste management practices, ensuring that all waste disposal sites (TPAs) adhere to environmental standards. Additionally, local authorities are obligated to phase out all open dumping landfills within a maximum timeframe of five years (until 2013). Simultaneously, a new waste disposal site (TPA) will be constructed to replace the existing one. The construction of the new landfill must adhere to the Sanitary Landfill system, complying with the relevant standards and regulations stipulated by the law (Pemerintah Indonesia, 2008).

The constrained accessibility of natural resources, particularly non-renewable resources, compels individuals to contemplate strategies for preserving the remaining resources. The Zero Waste (ZW) waste management system emerges as a comprehensive solution for the sustainable management of waste and resources within an urban environment (Zaman & Lehmann, 2011). Furthermore, waste deemed as having no inherent benefit possesses economic value. Proper recycling practices can enhance the financial value of refuse, starting from its initial generation at the source (upstream). The derived economic value can stem from conserving materials, reselling waste, repurposing waste into alternative materials, and preventing environmental harm. Implementing waste management measures upstream can diminish governmental expenditure on waste management, thereby enhancing operational efficiency.

2. Literature Review

Several factors contribute to the composition of Municipal Solid Waste (MSW), including norms, culture, waste management policies, and geographic regions. However, one of the primary determinants is community income. Community income significantly influences consumption habits and lifestyles, with organic waste generation being notably substantial in low-income populations and conversely less in high-income communities.

In nations with high-income populations, diverse waste processing methods are employed to achieve waste management objectives, including safeguarding human health, preserving the environment, and conserving natural resources. This strategic approach is recognised as Integrated Waste Management (IWM), wherein waste management is selected and implemented based on technological and managerial programs aligned with regional characteristics (Tchobanoglous & Kreith, 2002).

In numerous countries where the domestic per capita gross domestic product exceeds $ 1,600 per day, the provision of urban waste collection services has achieved a rate of 99 per cent or higher. Middle-income countries typically achieve a waste management rate of at least 95 per cent, whereas low-income nations struggle to manage their waste, achieving only a 50 per cent control rate. For low and middle-income countries, a key focus is on expanding the network of waste management services and reducing unregulated waste disposal. Projections indicate that recycling activities are anticipated to encompass 20-30% by weight, as outlined in **Table 1** (Wilson, Rodic & Velis, 2013).

Table 1. The recycling rate of 20 reference countries in 2009

Income Level	Range (%)	Average (%)	Average contributed by the informal sector
High	30-72	54	0
Upper-middle	7-27	15	15

Lower-middle	6-39	27	16
Low	6-85	27	26

Source: Adaptation from Scheinberg *et al.* (2010) and Wilson *et al.* (2010)

Numerous developing nations and those in the process of transitioning to developed status feature an informal sector engaged in waste recycling, the reuse of second-hand items, and the repair of used goods. This practice is motivated by the community's demand for affordable used products. Effectively addressing challenges associated with integrating the informal sector into the formal domain requires a systematic approach (Velis et al., 2012).

The recycling rate within a country is not necessarily correlated with its population's income level. As illustrated in **Fig. 1**, some countries exhibit no discernible correlation between recycling rates and the income levels of their populations. Notably, certain highly developed countries demonstrate high recycling rates, whereas others with similar levels of development exhibit lower rates. Concurrently, some developing countries display commendable recycling rates, ranging between 20-40% (Simonett & O. Wilson D. C. Rodic L. Modak P. Soos R. Carpintero A. Velis K., 2015).

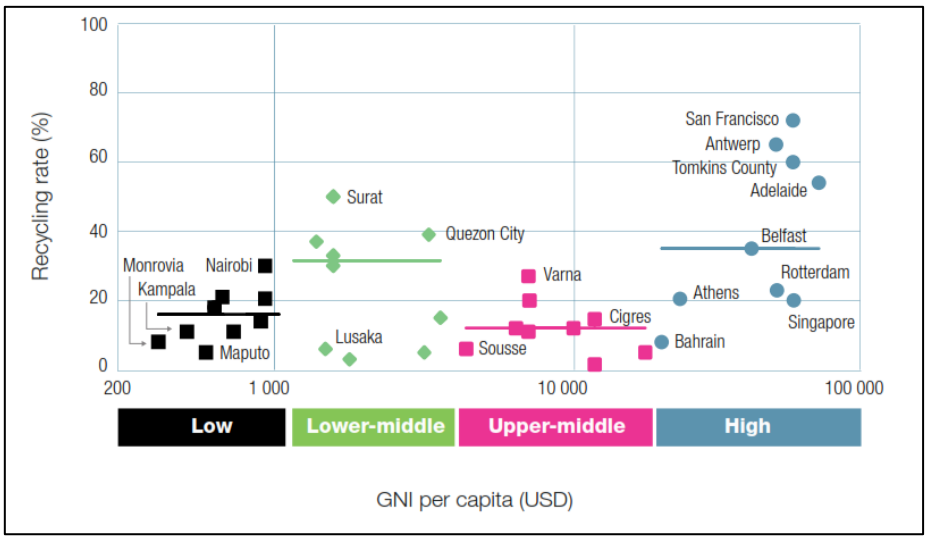

Fig. 1. Mean recycling rates across 39 cities categorised by income level.

The Zero Waste (ZW) concept, as delineated by experts, is characterised as a strategy for rectifying the misallocation of resources that necessitate restoration. This definition diverges from the perspective held by a considerable number of individuals who perceive waste as an inevitable and valueless entity. The ZW principle emphasises the prevention of waste generation at the initial stages whenever possible (Lehmann, 2011).

The Zero Waste (ZW) philosophy integrates considerations of product design and waste management principles to mitigate potential environmental threats stemming from human activities and unsustainable behaviour. ZW product design is geared towards facilitating easy reuse or repair, thereby extending the lifespan of products. ZW products are manufactured in accordance with the cradle-to-grave concept, eliminating residues from the production cycle. ZW waste management ensures that discarded items can be recycled, restored, or naturally degraded without causing environmental pollution. As a protective measure within the ZW concept, there is an emphasis on optimising the use of natural resources while minimising environmental degradation (Zaman, 2014).

The escalation in waste production is attributed to a linear material flow rate system, ultimately resulting in waste disposal in landfills. Nonetheless, of the roughly four billion metric tonnes of waste generated globally, approximately 20% has the potential for recycling or recovery (Chalmin & Gaillochet, 2009). Currently, the prevailing paradigm in global waste management is characterised by a linear economic system, resulting in products being ultimately disposed of in landfills. In contrast to this linear model, the Zero Waste (ZW) concept advocates for a circular system. In this approach, a product at the end of

its lifecycle serves as the starting point for another product, ensuring that nothing becomes waste. **Fig. 2** illustrates the comparison of substantial flow rates between the linear and circular structures.

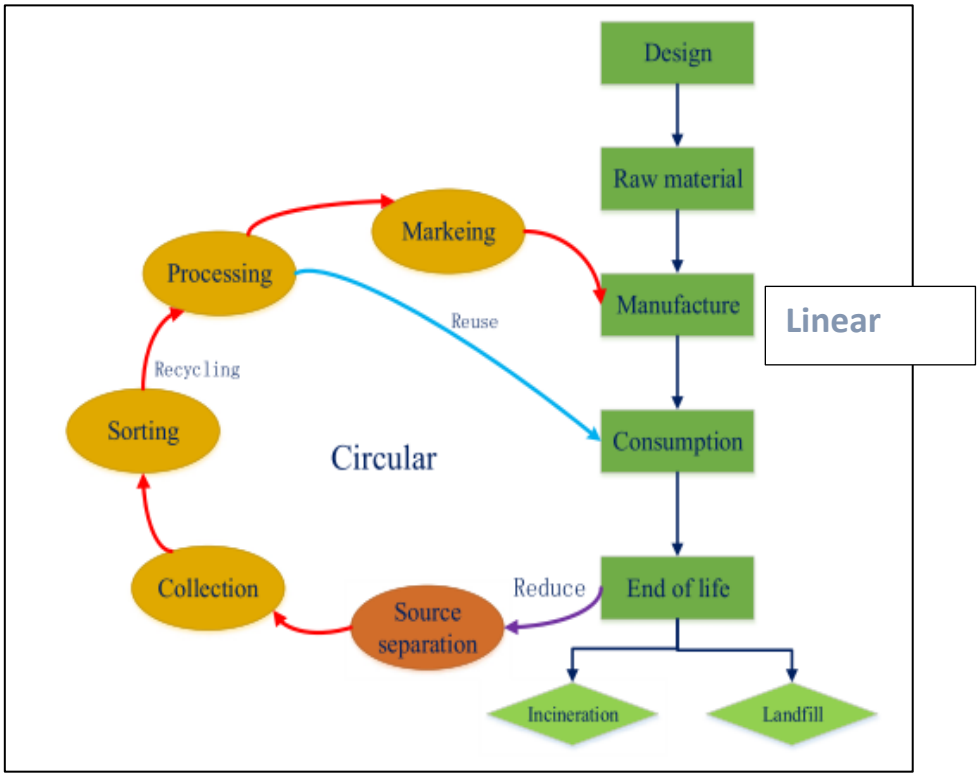

Fig. 2. The flow rate of material according to the concept of circular and linear
Source: Song, Li, and Zeng (2014)

The 2010 population census indicates that the total population of Indonesia was 237.5 million, a notable increase from 205.1 million in 2000. This denotes a population growth of approximately 32.5 million over the past decade, with an annual growth rate of 1.49% (Soleh, 2011). The surge in population has resulted in challenges across various stages of solid waste management, including temporary disposal, collection, transportation, and final disposal, with compounded issues at landfill endpoints (Meidiana & Gamse, 2010). According to Indonesia's Ministry of Environment and Forestry, the country generates a total of 64 million tons of waste annually, with plastic waste accounting for 14% of this total (Sudirman, 2016).

In addition to plastic waste, there is a substantial and challenging influx of electronic waste that requires effective management. Electronic waste refers to unwanted components of electronic and electrical equipment incorporated into the recycling and disposal processes. The cumulative electronic waste generated from Indonesian households is estimated to be approximately 285,000 tons in 2015 and projected to increase to 622,000 tons by 2025. The implementation of an effective recycling system in Indonesia has the potential to tap into new material sources, thereby safeguarding the environment and public health (Andarani & Goto, 2014).

Numerous research studies conducted in Indonesia have identified effective waste management strategies. One notable approach involves engaging the private sector in waste treatment. The processing of non-organic waste can be effectively undertaken by small businesses, which, when collaborating with scavengers, can yield significant benefits (Aye & Widjaya, 2006). Despite scavengers earning incomes equivalent to the minimum wage in certain areas, they often prefer informal sector work, primarily due to the challenges associated with securing alternative employment opportunities (Sasaki, Araki, Tambunan, & Prasadja, 2014).

Banda Aceh, as a developing city, confronts similar challenges in the waste management sector. The devastating earthquake and tsunami on December 26, 2004, severely impacted a substantial portion of

the densely populated Banda Aceh region. In the aftermath, reconstruction efforts were undertaken with funding from international institutions, leading to the establishment of new infrastructure, including housing and transportation. Support in urban solid waste management (MSW), encompassing waste collection, recycling, and landfill systems (TPA), was integrated into these reconstruction initiatives.
Various programs outlined in the Banda Aceh Solid Waste Management Master Plan, initiated in 2007, have been implemented. These include the introduction of waste recycling, the refurbishment of the old landfill in Kampung Jawa, and the construction of a new Sanitary Landfill in Aceh Besar district (Dinas Kebersihan dan Pertamanan Kota Banda Aceh & Roteb, 2007). However, the Banda Aceh city government continues to grapple with numerous challenges in waste management. These challenges encompass relatively low public awareness, particularly among market vendors, inadequate garbage collection facilities, and a limited number of sanitation extension workers, resulting in a comparatively low frequency of outreach efforts (Faisal, 2014).
The Banda Aceh City Government possesses the opportunity to address the prevailing challenges related to waste management promptly. However, the practical advancements in the Waste Management System in Banda Aceh have been minimal, primarily limited to the collection and disposal of garbage in landfills. This is despite the escalating daily production of waste and the diminishing availability of land for landfills due to population growth and the expansion of residential areas. The foundational element for planning the waste management system should involve the systematic separation of recyclable materials such as paper, metal, plastic, and glass bottles, along with the consolidation of all waste categories.
The municipal administration of Banda Aceh, facilitated by the designated agency, primarily directs its efforts towards landfill-based waste disposal. Only a minimal fraction of the waste undergoes processing in recycling facilities or participates in waste avoidance initiatives. The achieved level of waste reduction in Banda Aceh was merely 13% as of 2015 (Gunawan, 2017). The runoff from landfills and the leachate generated pose a threat to both surface water and groundwater. Nonetheless, even waste disposed of in landfills retains economic value when appropriately utilised. Recycling such valuable waste transforms it into raw materials for the production of other goods.

3. Research Method

This research employs a qualitative methodology to investigate the economic advantages of urban waste management in Banda Aceh. Primary data are gathered through interviews with experts and practitioners in solid waste management, conducting focus group discussions (FGDs), administering questionnaires to community members who benefit from waste services, and undertaking field observations. Additionally, an analysis of existing policy documents related to solid waste is conducted, focusing on the Zero Waste perspective outlined in the Republic of Indonesia Law Number 18 of 2008 on Waste Management (the Waste Act) and the Banda Aceh City Regulation Number 1 of 2017 on Waste Management (the local regulation). This comprehensive approach aims to provide a thorough understanding of the economic implications of urban waste management in the context of Banda Aceh.

4. Result & Discussion

Respondent Characteristic
This research conducted thorough interviews with experts in waste management, including individuals from academic, practitioner, and government backgrounds. **Table 2** outlines the profiles of respondents who participated in the in-depth interviews.

Table 2. Characteristics of the respondents

No.	Quantity	Description
1.	3 person	Academicians
2.	8 person	Practioner
3.	3 person	Government of DLHK3 Banda Aceh

Regarding the community survey aimed at understanding waste recycling habits, the sample was selected using the Slovin formula, considering the population of Banda Aceh City (Umar, 2004), that is:

$$N = N/(1+n\alpha^2)$$

Where "n" represents the minimum required sample size, "N" denotes the population size, and "α" signifies the significance level. The population under consideration comprises households (KK) receiving waste services. To ensure a representative sample, respondents were selected using a random cluster sampling technique based on the sub-district areas. **Table 3** provides an overview of the sample distribution across each sub-district in the city of Banda Aceh.

Table 3. The sub-district samples the number of populations and households in Banda Aceh

No.	Subdistrict	resident (person)	Household (KK)	Percentage KK	Sample (KK)
1.	Meuraxa	18.861	6.394	8,57	9
2.	Jaya Baru	24.640	7.161	9,60	10
3.	Banda Raya	22.941	6.446	8,64	9
4.	Baiturrahman	35.218	10.743	14,41	14
5.	Lueng Bata	24.560	7.116	9,54	10
6.	Kuta Alam	49.503	14.978	20,09	20
7.	Kuta Raja	12.819	4.084	5,47	5
8.	Syiah Kuala	35.617	10.652	14,29	14
9.	Ulee Kareung	25.148	6.960	9,33	9
	Amount	249.307	74.534	100	100

Source: Adaptation from BPS Banda Aceh (2015)

Management of waste from its downstream phase

The attributes of community waste can be discerned by examining the level of community prosperity, which directly influences purchasing power, consumption patterns, and the nature of generated waste. Households with elevated purchasing power often do not consider alternatives to replace their equipment, resulting in the eventual disposal of used items as waste. In such cases, individuals may remain indifferent to the ultimate destination of their discarded items. It is imperative to advocate for the avoidance of over-consumerism as a critical measure to mitigate and diminish waste generation.

Banda Aceh is characterised as a medium-sized city based on its population (Kementerian Pekerjaan Umum, 2013). The per capita income of Banda Aceh residents stands at Rp. 26 million, which is below the national average of Rp. 42 million per capita (Rafiie, 2018). The percentage of the population living in poverty in Banda Aceh was 7.41% in 2016 (Badan Pusat Statistik Banda Aceh, 2018). The community's purchasing power is influenced by the overall welfare level, with higher purchasing power correlating to a heightened potential for solid waste generation. In Banda Aceh, the variety of waste types is less extensive than in larger cities. Industrial waste, electronic waste, and waste resulting from reconstruction and development activities are relatively minimal in Banda Aceh.

The nature of the residence plays a pivotal role in determining the effectiveness of waste collection systems and recycling processes. For instance, the specific types of housing significantly impact the strategic positioning of Temporary Disposal Sites, the establishment of recycling centres, and the choice of transportation modes. This strategic planning contributes to enhanced efficiency in managing municipal solid waste (Cole, 2013). In Banda Aceh, the absence of large-scale industries is notable, with waste generation primarily stemming from small-scale household enterprises, such as tofu factories and tempeh production.

Banda Aceh's waste management system currently relies primarily on landfilling. Only a limited portion of the city's waste undergoes reprocessing through composting or recycling initiatives. To promote waste avoidance, the city can introduce a waste separation system supported by dedicated sorting

facilities. Engaging the community from the outset is crucial. This can be achieved by raising awareness about the final destination of waste, particularly the portion that could be diverted from landfills. A significant proportion of Banda Aceh's waste can be diverted from landfills. This presents an opportunity for the city to explore alternative waste management strategies, such as reuse or resource recovery, with potential economic benefits.

Waste management in Banda Aceh remains predominantly focused on technical and technological aspects, neglecting essential community-oriented components. The absence of programs aimed at raising community awareness through socialisation, community involvement, and effective communication about solid waste renders the current waste management program unsustainable. While technical and technological tools are integral, the lack of emphasis on public awareness undermines the overall system's efficacy. Educating the public, especially those indifferent to waste-related matters, requires sustained and continuous efforts, demanding considerable energy and commitment. A crucial responsibility of the government is to establish a waste management system that not only addresses the technical aspects but also fosters a sense of responsibility among the public to manage their waste.

Despite the fundamental importance of waste separation in waste management, practical observations in Banda Aceh reveal shortcomings in the implementation of waste sorting. The provided sorting bins have not yielded the expected results, as observed in the city. The segregation of waste is ineffective, as mixed refuse is often found in bins designated for specific types of garbage. Additionally, even when waste is initially separated, it tends to become mixed again during transportation in trucks. **Fig. 3** illustrates the process of waste being deposited into a separation bin, only to be combined later in the same container.

Fig. 3. The state of garbage sorting bins in Banda Aceh

An examination of waste management practices in Banda Aceh revealed a concerning trend: a low prevalence of waste sorting among residents. As illustrated in **Fig. 4**, only a minority of respondents (17.1%) reported sorting their waste frequently or quite frequently. Conversely, a significant majority (58.97%) indicated that they never sort waste. Combining this figure with those who rarely sort waste (23.93%), it becomes evident that a substantial portion of the community does not engage in waste sorting practices.

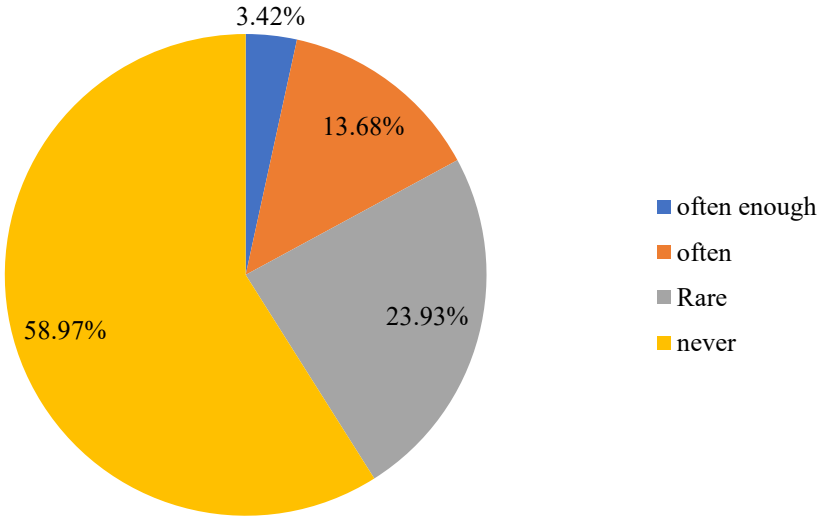

Fig. 4. Percentage of community habits to sort waste

An analysis of waste recycling practices in Banda Aceh depicted a pattern of infrequent recycling behaviour among residents. As shown in **Fig. 5**, a relatively small proportion of the population reported frequently recycling (5.08%) or quite often recycling (3.35%). Conversely, a considerably larger segment (24.57%) indicated that they rarely recycle, while the majority (67%) revealed that they never recycle waste.

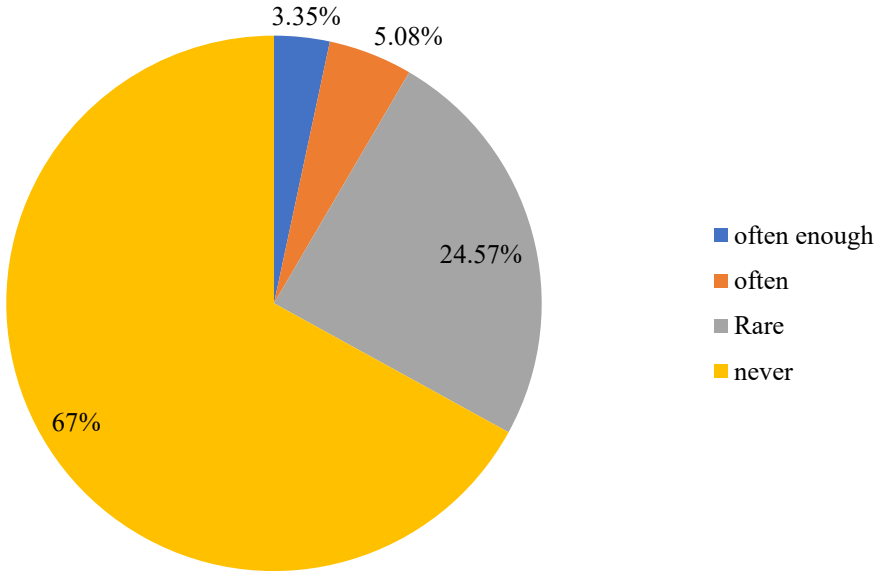

Fig. 5. Percentage of Banda Aceh inhabitants doing recycling

An examination of income generated through the sale of used goods revealed a trend of modest financial returns. As depicted in **Fig. 6**, most individuals (61%) reported earning less than Rp. 50,000 per sale. A smaller portion (15.05%) indicated earnings between Rp 50,000 and Rp 100,000. The remaining respondents were unable to recall their earnings from such infrequent transactions. This suggests that the sale of used goods is a relatively uncommon practice, possibly due to the low financial rewards associated with it.

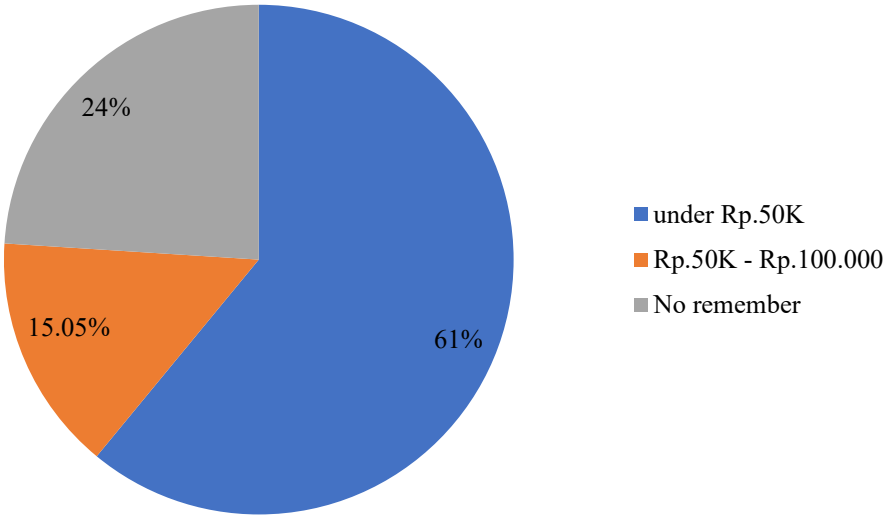

Fig. 6. Community income from selling garbage

Financial Advantages of Effective Waste Management: Waste management practices can become a substantial source of income for communities. This can be achieved through initiatives such as selling used goods, transforming household waste into organic fertiliser, and promoting product reuse. While the waste sector in Banda Aceh currently offers limited economic opportunities, its proper management could significantly contribute to the city's economic growth.

A significant portion of waste materials possesses residual economic value. The sale of used goods, primarily conducted by individuals in the informal sector, serves as an alternative source of income for many. Residents may occasionally sell "waste" directly to used goods depots. However, a more prevalent practice involves scavengers collecting waste from communities and subsequently selling it to these depots. The sale of used goods by residents is typically an irregular occurrence, often triggered by the accumulation of "valuable" items at home.

A survey conducted in Banda Aceh revealed a low prevalence of used goods collection among residents. The data indicate that 53.8% and 31.6% of households rarely and never collect used goods, respectively. Only a combined 7.7% collect them frequently. This suggests a limited participation in waste collection for economic gain. According to Irwansyah et al. (2017), professional collectors, often referred to as scavengers, contribute up to 80% of the collected materials, with the remaining 20% coming from direct sales by the public.

The waste collection system in Banda Aceh operates conventionally, with collectors working independently without formal contracts for regular supplies of used goods. Collectors rely on trusted individuals who consistently sell their used goods to them. Even scavengers, motivated primarily by favourable prices, are willing to sell their goods without considering environmental concerns, viewing it purely as a business transaction. Currently, waste collectors in Banda Aceh receive minimal guidance from relevant authorities.

Plastic waste is the predominant type of waste in the region, with its price heavily influenced by global market dynamics and crude oil costs. The Indonesian government's proposed plastic tax and restrictions on plastic imports may affect the pricing of plastic waste, potentially significantly impacting the recycled plastic industry, which relies on these factors. The plastic business is particularly susceptible to price fluctuations, as evidenced by the closure of several plastic collection businesses in Banda Aceh due to declining plastic prices (Didi, 2018). To mitigate these fluctuations, some entrepreneurs in Banda Aceh engage in plastic processing to increase the value of goods before resale. This value-added approach has led to the emergence of plastic processing facilities in the region. Furthermore,

secondhand goods entrepreneurs in Aceh often sell their goods to factories in Medan, which seek processed used plastic in small pieces.

The plastic trade in Banda Aceh encompasses a variety of plastic materials, including clear plastic bottles, oil bottles, and beverage containers. Approximately 9-10 distinct types of plastic are commercially viable. Collectors meticulously sort these collected items before processing them into "plastic ore," which involves chopping them into smaller flakes. This size reduction increases material density, allowing for more efficient and cost-effective transportation.

As with any business venture, the used goods trade is not without its risks. However, in Banda Aceh, business failures are often attributed to poor management practices rather than a lack of demand. The plastic chopping industry currently enjoys favourable prospects due to the limited availability of alternative materials. Ultimately, the economic value dictates the pricing structure for various types of plastic waste, as detailed in **Table 4**. Notably, used plastic collectors incur additional costs associated with cleaning and sorting the collected materials.

Table 4. Prices of used plastic materials in Banda Aceh

No.	Description	Buying price (Rp/kg)	Information
1.	Plastic (PET) bottle, dirty, label not removed	1500	
	Plastic (PET) bottle, dirty, label removed	2700 – 3000	
	After sorting		
	- Clear bottle	2000	
	- Bluebottle	3000 - 3200	
2.	Colored bottle, EQ Sprite, Coca-Cola, Mizon, etc	1000	(cheap since colour)
3.	Cup plastic (PP) mambo eq aqua cup, Cleo, sling, etc	2000-2500	
	Quality:		
	A1	6500	
	A2	4000	
	A3	2000-2500	
4.	White plastic cup to hold tea, ale-ale, etc	1000-2000	
5.	HD Plastic eq shampoo container, fry oil container, etc	3500-4500	
6.	Colour plastic (atom) such as a chair, a plastic desk, etc	2500-2800	
7.	Paralon eq water paralon, etc.	1200	
8.	Plastic bag (kresek)		
	- Plastic bag HD	800	
	- Plastic bag PE (clean)	5000	
	- Plastic bag PE (dirty)	1500	

Source: an interview with Nadir and Indra (2017)

A significant obstacle hindering the plastic recycling industry is the volatile nature of plastic pricing. Prices can fluctuate every week due to the influence of global crude oil prices and China's policies regarding plastic ore imports. Consequently, implementing appropriate import regulations is crucial to safeguard the economic viability of domestically recycled plastic.

On the other hand, the supply of used plastic from the community remains relatively stable. Residents, markets, and temporary landfills all contribute to this consistent flow of waste. Even government waste collection services and scavengers at the Kampung Jawa landfill participate in the collection process,

demonstrating the widespread economic benefits derived from plastic waste. However, collecting used plastic requires significant effort due to its low density. Large volumes are necessary to achieve economic value. **Table 5** provides an overview of the most prevalent types of plastic packaging waste, including their weight and quantity.

Table 5. Types of plastic waste, weight, and number

No.	Plastic	Weight per unit	The amount is within 1 kg
1.	Plastic bottle 1,5 Ltr	30 gram	33,33 unit
2.	Plastic bottle 600 ml	20 gram	50 unit
3.	Plastic cup	5 gram	200 cup

Other commonly discarded materials with inherent value include metals. However, the availability of certain metal types has diminished over time, particularly with advancements in material engineering. Many metal materials have been replaced by cheaper alternatives as material technology progresses. For instance, optical fibre, once crafted from brass, is now predominantly composed of plastic. This evolution in material composition has resulted in a reduction in the diversity of metal materials, with plastic and iron varieties on the rise while brass and copper materials become increasingly scarce. Zinc metal, categorised as a low-quality type of iron metal by collectors, commands a lower price.

Certain used goods that previously held economic value have seen a decline in worth due to material advancements. For instance, synthetic leather, once a valuable commodity, has become increasingly inexpensive, leading to reduced interest among scavengers. Conversely, the price of used paper remains stable due to its consistent demand and supply. However, it is conceivable that this scenario may evolve in the next five to ten years as technological advancements in paperless systems continue to progress.

The quantity of recycling depots in Banda Aceh is deemed sufficient, adhering to the principles of economic law contingent upon supply and demand dynamics. Approximately 30 used goods depots operate within the city, a number considered appropriate for the urban landscape of Banda Aceh. These establishments are strategically situated in densely populated areas, where a substantial number of individuals serve as "producers" of used goods. Notably, the Banda Aceh City Government operates the sole waste recycling depot in Indonesia, which was established under DLHK3 in 2009. With a capacity of 146 tons every eight months, the depot yielded 162 tons in 2016, contributing significantly to the local government's revenue generation. In 2016 alone, the recycling depot accrued a revenue of Rp. 600,360,890 through the sale of five plastic types (DLHK3 Banda Aceh, 2016).

Currently, many individuals lack precise knowledge of the pricing of used goods due to limited access to relevant information. For those engaged in the used goods trade, practical experience plays a pivotal role in gauging the market value of such items. Nevertheless, certain undesirable practices persist among some used goods vendors, such as the inclusion of non-valuable items during transactions with collectors. Acquired experience is instrumental in determining the value of used goods, a prerequisite for attaining profitability. Indeed, diligent involvement in collecting used products holds the promise of prosperity when approached with earnest dedication.

The Economic Advantages of Electronic Waste

Electronic waste remains a significant challenge in Banda Aceh, as its reuse and recycling efforts are still inadequate. However, there has been growing awareness in recent years regarding the value of used electronic materials, leading to increased buying and selling activities. Electronic devices utilising analogue systems typically contain Printed Circuit Board (PCB) components, which are highly sought after and command considerable prices, sometimes reaching up to $ 40,000 per kilogram. However, the prevalence of digital systems in modern electronic equipment has made PCBs increasingly scarce and less expensive. Additionally, electronic equipment yields various materials besides PCBs, including plastics, zinc, aluminium, and copper, all of which can be extracted and sold, thereby contributing to the recycling process. For instance, VCD players consist of multiple materials that can be repurposed and traded, further highlighting the economic potential of electronic waste recycling.

The most traded electronic equipment components include the Central Processing Unit (CPU) and the standard Uninterruptible Power Supply (UPS), typically found in households. These devices contain various materials, such as a dry battery weighing 2 kilograms and a transformer composed of metal. Over time, the diversity of materials used in transformer manufacturing has increased, with some transformers from China utilising aluminium, which results in lower prices compared to other types. Companies continually enhance their material engineering to enhance competitiveness and accessibility to a broader consumer base. Despite this, phone batteries are not commonly traded due to their small size, leading to limited interest from collectors. Similarly, laptop batteries are often discarded in Banda Aceh due to the absence of buyers. Additionally, cellular number chip cards are disposed of as there is no demand for their processing, rendering them waste.

Entrepreneurs engaged in waste recycling seek government attention and support in terms of business facilities and infrastructure. Collaboration with large corporations could facilitate the retrieval of packaging or products through used goods collectors. Currently, the government encourages producers to recall unused products; however, participation in this scheme remains voluntary, unlike the mandatory nature of such programs in some developed nations. This highlights the concept of extended producer responsibility (EPR), which holds producers accountable for managing the end-of-life disposal of their products.

5. Conclusion

In conclusion, waste management guided by the Zero Waste concept has been incorporated into national and municipal policies, including those in Banda Aceh. Although some principles of this concept have been implemented, their effectiveness is hindered by constraints such as legal limitations, limited financial resources, and the need for collaboration between government and community stakeholders. Thus, there is a pressing need for robust engagement and involvement from diverse stakeholders to ensure the successful implementation of waste-to-economic-benefits initiatives. When executed effectively, the Zero Waste concept holds significant potential to generate substantial economic gains for communities while also reducing the operational expenses associated with municipal waste management. The financial advantages stemming from the Zero Waste approach have the potential to augment community incomes; however, further investigation is warranted to determine the precise extent to which regional financial growth is attributable to waste-related activities. Within the framework of Zero Waste, all waste materials are viewed as valuable resources that can be repurposed into new products.

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References

Andarani, P., & Goto, N. (2014). Potential e-waste generated from households in Indonesia using material flow analysis. *Journal of Material Cycles and Waste Management*, 16(2), 306–320. Retrieved from https://doi.org/10.1007/s10163-013-0191-0

Badan Pusat Statistik Banda Aceh. (2018). *Statistik Banda Aceh 2017*. Banda Aceh.

BPS Banda Aceh. (2015). *Banda Aceh dalam Angka 2015*. Banda Aceh, Indonesia: BPS Banda Aceh.

Bustos, B. N., Borregaard, & Stilwell, M. (2004). *The Use Of Economic Instruments In Environmental Policy: Opportunities And Challenges*.

Chalmin, P., & Gaillochet, C. (2009). From Waste to Resource: An Abstract of World Waste Survey

2009.
Cole, N. J. (2013). *Getting to Zero Waste in the City : The Case of Oakland, California*. Technical University of Berlin.
Damanhuri, E. (2005). Some Principal Issues On Municipal Solid Waste Management In Indonesia. In *In Expert Meeting on Waste Management in Asia-Pacific Islands, Oct (Vol. 2729)*. Tokyo: Expert Meeting on Waste Management in Asia-Pacific Islands.
Didi. (2018). Indonesia Terancam Jadi Pengimpor Sampah plastik Terbesar di Dunia.
Dinas Kebersihan dan Pertamanan Kota Banda Aceh, & Roteb. (2007). *Laporan Master Plan Kota Banda Aceh Pasca Tsunami Republik Indonesia (Solid Waste Management Master Plan - Report for Post-Tsunami Banda Aceh Republic of Indonesia)*. Retrieved from Banda Aceh, Indonesia:
DLHK3 Banda Aceh. (2016). *PROFIL DLHK3*. Banda Aceh.
Faisal, M. (2014). Analisis Laju Alir Sampah Dan Emisi Carbon Yang Dihasilkan Kota Banda Aceh. *Jurnal Teknik Kimia USU*, 3(4), 6–11.
Gunawan, A. (2017). *Laporan Upaya Pengurangan Timbulan Sampah Banda Aceh*. Retrieved from Banda Aceh, Indonesia:
Irwansyah, Syahputra, I., Nadir, M., & Bakri, G. (2017). *Indepth interview on Waste Community*. Retrieved from Banda Aceh:
Kementerian Pekerjaan Umum. (2013). *Materi Bidang Sampah I, Diseminasi dan Sosialisasi Keteknikan Bidang PLP*. Jakarta, Indonesia: Ditjen Cipta Karya.
Lehmann, S. (2011). Resource Recovery and Materials Flow in the City: Zero Waste and Sustainable Consumption as Paradigms in Urban Development. *Sustainable Development Law & Policy*, 11(1).
Meidiana, C., & Gamse, T. (2010). Development of Waste Management Practices in Indonesia. *European Journal of Scientific Research*, 40(2), 199–210.
Ministry of Environment. (2008). *Indonesian Domestic Solid Waste Statistic Year 2008*. Jakarta, Indonesia.
Nadir, & Indra. (2017). *Wawancara dengan Pengepul barang bekas*. Retrieved from Banda Aceh:
Pemerintah Indonesia. UU Republik Indonesia No. 18 Tahun 2008 tentang Pengelolaan Sampah (2008). Indonesia: DPR RI.
Rafiie, S. A. K. (2018, April). Perekonomian Aceh 2017. *Koran Serambi Indonesia*. Banda Aceh.
Sasaki, S., Araki, T., Tambunan, A. H., & Prasadja, H. (2014). Household income, living and working conditions of dumpsite waste pickers in Bantar Gebang: Toward integrated waste management in Indonesia. *Resources, Conservation and Recycling*, 89, 11–21. Retrieved from https://doi.org/10.1016/j.resconrec.2014.05.006
Scheinberg A, DC, W., & L, R. (2010). *Solid Waste Management in the World's Cities*. *Earthscan for UN-Habitat*. Retrieved from London:
Simonett, ... &, & O. Wilson D. C. Rodic L. Modak P. Soos R. Carpintero A. Velis K. (2015). *Global Waste Management Outlook*. UNEP.
Soleh, A. (2011). Pertumbuhan Ekonomi dan Kemiskinan di Indonesia. *Ekombis Review*, 2(2), 197–209.
Song, Q., Li, J., & Zeng, X. (2014). Minimizing the increasing solid waste through zero waste strategy. *Journal of Cleaner Production*, 1–12. Retrieved from https://doi.org/10.1016/j.jclepro.2014.08.027
Sudirman. (2016). Sampah di Indonesia Capai 64 Juta Ton Per Tahun.
Tchobanoglous, G., & Kreith, F. (2002). *Handbook of Solid Waste Management*. New York. USA: McGraw-Hill.
Umar, H. (2004). *Metode Penelitian untuk Skripsi dan Tesis Bisnis* (VI). Jakarta, Indonesia: PT Raja Grafindo Persada.
Velis, C. A., Wilson, D. C., Rocca, O., Smith, S. R., Mavropoulos, A., & Cheeseman, C. R. (2012). An analytical framework and tool (' InteRa ') for integrating the informal recycling sector in waste and resource management systems in developing countries. *Waste Management & Research*, 30, 43–66. Retrieved from https://doi.org/10.1177/0734242X12454934
Wilson, D. C., Rodic, L., Scheinberg, A., & Alabaster, G. (2010). COMPARATIVE ANALYSIS OF

SOLID WASTE MANAGEMENT IN CITIES AROUND THE WORLD. In *Proceedings of Conference Waste 2010: Waste and Resource Management – Putting Strategy into Practice* (pp. 28–29). Stratford-upon-Avon, UK.

Wilson, D. C., Rodic, L., & Velis, C. A. (2013). Integrated sustainable waste management in developing countries. In *Proceedings of the Institution of Civil Engineers* (Vol. 166, pp. 52–68).

Zaman, A. U. (2014). Identification of key assessment indicators of the zero waste management systems. *Ecological Indicators*, 36, 682–693. Retrieved from https://doi.org/10.1016/j.ecolind.2013.09.024

Zaman, A. U., & Lehmann, S. (2011). What is the 'Zero Waste City'Concept? *Online]. Accessed At< Http://W3. Unisa. Edu. Au/Artarchitecturedesign/ZeroWasteSAR EsearchCentre/Docs/ZWC% 20Concept. Pdf>[Consulted on 01-05-2012]*, 7, 11–18.