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IDENTIFYING DRIVERS AND BARRIERS IN THE INVOLVEMENT OF INTEGRATED TOWNSHIP AS AN E-WASTE COLLECTION HUB: A DEMATEL-BASED ANP APPROACH

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Abstract:
The growth of urbanization in Indonesia has led to a significant increase in waste generation, including e-waste, which has a negative impact on the environment if not managed properly. Independent cities, as integrated areas with modern infrastructure, have the strategic potential to become hubs for e-waste collection. However, his involvement is still minimally studied. This study aims to identify and analyze the driving and inhibiting factors of independent city involvement in e-waste collection, as well as determine the cause-and-effect relationship and priority of each factor using the Content Validity Index (CVI), Modified Kappa, DEMATEL, and Analytic Network Process (ANP) methods. The results of the analysis showed that, among the driving factors, the Population dimension (HD) had the highest level of interconnectedness, while the Government dimension (GD) exhibited the greatest net influence. On the other hand, in the inhibiting factor, the Developer (DB) dimension has the highest level of relevance, while the Collector (CB) dimension has the greatest net influence, with the Government (GB) dimension also showing significant linkage and net influence values. In terms of weight, the primary driving factors were public acceptance of the collection program (0.094), the level of environmental knowledge (0.082), and government supervision (0.082). Meanwhile, the main inhibiting factors include the population's lack of waste sorting (0.087), tax policies that do not support collectors (0.084), and the absence of government collection standards (0.082).

Keywords: Barriers, Collection, Drivers, E-Waste, Integrated Township

INTRODUCTION

Along with economic growth in Indonesia, rapid urbanization has encouraged the movement of people from villages to cities, posing problems such as poverty, unemployment, and pressure on suburban areas (Yasmin Budiyanti & Safitri, 2023). Urbanization increases waste generation, particularly in large cities that produce more than 500 tons per day, while medium-sized cities generate 100–300 tons per day (BPS, 2020). Most of this waste still ends up in landfills without adequate recycling processes, including e-waste, which is classified as Hazardous waste. With only 10–15% of the 67.8 million tons of total plastic waste recycled, urban waste management is becoming a crisis (INAPLAS, 2020). Santoso (2019), using a population balance model, estimates that by 2028, the total generation of e-waste in Indonesia will be around 487 kilotons.

High urbanization has also fueled the growth of self-sustaining cities that serve as buffer cities and offer sustainable integrated settlement solutions (Widodo, 2018). Integrated townships are starting to show potential as an e-waste collection hub, given their strategic position and large impact (Alif, 2023). Although some Integrated township developers have adopted self-sustaining recycling systems and waste treatment facilities, there is no national operational standard that specifically governs the collection of e-waste, such as in the framework of Extended Producer Responsibility (EPR). A review of the literature reveals that although many studies have addressed e-waste collection systems at the city and national levels, the involvement of self-sufficient cities as collection hubs remains underexplored. Therefore, research is needed to identify the driving and inhibiting factors that influence the involvement of independent cities in e-waste management, providing a basis for government policies and concrete actions from industry.

Literature Review. Based on a literature review using the keywords "critical factors, barriers, drivers, waste collection, integrated township, and collection center," previous studies have extensively examined various electronic waste (e-waste) collection systems at the city, provincial, and national levels. These studies have also identified several critical factors that influence the effectiveness of such systems, including public awareness, efficiency of collection mechanisms, and the role of government policies (Bui et al., 2020; Singh et al., 2020; Wang et al., 2017). However, the involvement of integrated townships as e-waste collection hubs remains underexplored, revealing a significant gap in the current body of literature.

To address this, this study identified several barriers relevant to the context of integrated townships. These include low environmental awareness among households (Wang et al., 2017), the lack of proper sorting and source-level waste separation systems (Alavi Moghadam et al., 2009; Bui et al., 2020), and the dominance of informal collectors who offer cheaper and more convenient disposal options (Conke, 2018). Additionally, developers face their own set of challenges, such as limited technical and financial resources, operational uncertainties, and high initial investments required to establish and maintain e-waste collection hubs (Jangre et al., 2022; Stojic & Salhofer, 2022).

On the other hand, several drivers can support the role of integrated townships as e-waste collection hubs. These include a clear regulatory framework and supportive government policies (Kwabena et al., 2018; Yin et al., 2023), increased public awareness and participation (Fogt Jacobsen et al., 2022; Sima & Maulana, 2023), and incentives for both formal collectors and developers, such as the economic benefits of corporate social responsibility (CSR) and cross-stakeholder collaboration (Yin et al., 2023;). Hence, identifying these barriers and drivers provides a foundation for developing effective strategies for e-waste collection in the context of integrated townships in Indonesia.

Urbanization in Indonesia is a natural demographic phenomenon driven by the need for individuals to adapt and fulfill their basic needs. Economic factors are the primary determinants of population mobility, influenced by centrifugal and centripetal forces in rural areas (Kasto, 2002). These forces contribute significantly to the migration flow, often resulting in poverty and unemployment issues in urban centers, as well as the uncontrolled expansion of urban fringes. (Yasmin, 2024) describes this rural-to-urban migration process as a sociological shift towards metropolitan living. Economic growth, especially since the 1960s, has paralleled rising urbanization rates. BPS (1982, 1992, 2002) reported that the proportion of the urban population increased from 22.3% in 1980 to 55% in 2013, with projections reaching 66.6% by 2035 (BPS, 2020).

The impact of urbanization in Indonesia is significant, especially in cities like Jakarta, which has grown into a megacity of over 30 million people (Silver, 2024). The shift from agricultural to urban land use was already apparent in the 1960s (Mcgee, 1991), driven by industrialization, foreign investment, and rural poverty (Kurnianti et al., 2015). Urban growth has primarily occurred in the peripheries rather than city centers, propelled by real estate development and public transportation investment (Silver, 2024). However, this rapid and diverse urban expansion has generated informality, disorder, and governance challenges (Zhu & Simarmata, 2015). Moreover, urbanization has exacerbated solid waste issues due to lifestyle changes and rising consumerism, creating public health and environmental risks (Wikurendra et al., 2024).

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In developing cities with dense populations and limited land, the emergence of self-contained cities reflects the state's failure to provide adequate urban governance. In response, the private sector steps in to deliver civil goods and services, leading to an apparent dichotomy between informal settlements and exclusive townships (Zhu & Simarmata, 2015). These planned developments often offer security and exclusivity, responding to the rising demand for housing from growing urban middle-class migrants. In Jakarta, large-scale land development began around two decades ago, aligning with the Jabotabek Metropolitan Development Plan (Goldblum & Wong, 2000). Developers launched integrated projects after the 1997 crisis, offering residential, commercial, and recreational facilities in large superblocks known as integrated townships (Kota Mandiri) (Herlambang et al., 2019).

Integrated township significantly contributes to Indonesia's growing volume of municipal solid waste (MSW). Their importance stems not only from the volume of waste generated due to their scale and economic activity but also from their operational flexibility. Developers often manage waste independently, helped by legislation such as the Spatial Planning Law No. 26/2007 and Presidential Decree No. 54/2008, which shifts planning authority to local governments. Due to the lack of capacity in many municipalities, developers often assume planning and infrastructure responsibilities under a build-own-transfer model (Dielman, 2011; Herlambang et al., 2019; Winarso, 2000). This has led to the ongoing privatization of urban development in Indonesia (Shatkin, 2008), positioning integrated townships as potential models for addressing urban waste challenges (Alif, 2023).

Waste management in these developments is generally governed by several national laws and regulations, including Law No. 18/2008 on Waste Management, as well as related government and ministerial regulations. In practice, most Integrated township developers implement their waste reduction programs, such as eco-enzyme initiatives, green waste composting, and plastic-to-food conversion. Some even adopt waste-to-construction-material solutions, such as using incinerated waste to produce paving blocks. However, while many developments offer well-structured systems for managing household municipal solid waste (MSW), there is minimal direct treatment of hazardous waste (B3), such as electronic waste.

The continuous release of new information and communication technology (ICT) products, along with other electronic devices, has contributed significantly to the global rise in electronic waste (e-waste). These discarded electrical and electronic equipment (EEE) are often composed of complex materials, many of which are potentially hazardous (Baldé et al., 2016; Williams, 2016). E-waste has become one of the fastest-growing waste streams worldwide, reaching 53.6 million metric tons in 2019 alone, marking a 21% increase in just five years (Ikhlayel, 2017). Asia leads global e-waste generation, with 24.9 million tons, and within Southeast Asia, Indonesia is the highest contributor, accounting for 745,000 tons annually (Forti et al., 2020; Wibowo et al., 2021). However, only 17.4% of the global e-waste generated in 2019 was properly recovered and recycled.

Indonesia, as one of the world's largest consumers of electronics, faces increasing challenges in managing e-waste (Steubing et al., 2020). Until recently, the country lacked a specific regulatory framework for e-waste. Instead, it was managed under general hazardous waste laws, such as Law No. 32/2009 on Environmental Protection and Management and Government Regulation No. 101/2014 for industrial hazardous waste. For household waste, Law No. 18/2008 applied. It was only in 2020 that Government Regulation No. 27/2020 formally categorized e-waste under specific household waste (Mairizal et al., 2021).

Future projections indicate a sharp rise in e-waste generation. By 2025, Indonesia is expected to generate 622 kilotons of household e-waste (Andarani & Goto, 2014), while another study

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estimates 487 kilotons by 2028 (Santoso et al., 2019). Mairizal et al. (2021) further estimate that by 2040, discarded ICT products, such as smartphones and laptops, will reach 132 kilotons, or approximately 270 million units. These trends emphasize the urgent need for targeted e-waste management policies in Indonesia.

In this research, Content validity assessment involves expert involvement to evaluate the relevance of each indicator using the Content Validity Index (CVI) and modified kappa coefficient. CVI measures experts' agreement on item suitability, while the modified kappa corrects for chance agreement, thus enhancing the reliability of the validity assessment (Lynn, 1986; Polit & Beck, 2006). Once valid criteria are established, the DEMATEL method is applied to map cause-and-effect relationships among criteria, clarifying direct and indirect influences between elements (Gabus & Fontela, 1972). The DEMATEL results then form the network structure for the Analytic Network Process (ANP), which calculates priority weights considering interdependencies among criteria (Saaty & Vargas, 2013). This integration facilitates complex multi-criteria decision-making based on a strong validity foundation.

METHODS

Data validation using CVI and Modified Kappa. In the secondary data collection stage, a literature review was conducted focusing on the factors that hinder and drive the involvement of integrated townships as hubs for electronic waste collection. Keywords such as waste collection, collection hub, e-waste, and municipal solid waste guided the review. From previous studies, four dimensions consisting of 24 Barriers and 23 enablers related to the involvement of integrated townships as electronic waste collection hubs were identified.

Expert opinions were gathered through questionnaires and in-depth interviews. During the validation stage using questionnaires, a minimum of three and a maximum of 10 experts were required (Lynn, 1986). The selected experts met specific criteria, including having more than five years of experience and holding managerial positions in their respective fields (Ermolaeva, 2019). Initially, experts were asked to suggest any additional factors that might influence the process of electronic waste collection in integrated townships. Other experts then validated these newly proposed factors. In the first questionnaire, experts evaluated the relevance of each factor in relation to the current context in Indonesia. Accordingly, this study distributed a questionnaire to a group of six experts representing four types of stakeholders: Township developers, government, Waste collection companies and academics.

Table 1. List of Expert Profiles and Availability of Participation in the Questionnaire

Expert	Background	Brief Company Profiles	Types of company; position of expert; job description; years of experience	Participation Q1	Participation Q2
A	**Academic**	Environmental engineering faculty in University in Indonesia	Lecturer & Environmental Analyst, University of Indonesia	√	√
B	**Government**	Regional government institutions are responsible for environmental management in their respective areas.	Government body; Hazardous waste (B3) Waste Management Subdivision; 15 years.	√	
C	**Collector**	This company offers waste management solutions for	Responsible waste management company;	√	√

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		corporate, small businesses, and personal residences.	Township Collect Commercial Coordinator; 6 years		
D	**Township Developer**	A township in West Java, Indonesia, built in 2005 that covers 1100 hectares of land area	township developer; Customer Relations Administrator; 5 years	√	
E	**Township Developer**	The company builds residential landed houses, apartment towers, commercial facilities, and public open space areas	township developer; Infrastructure Supervisor; 7 years	√	
F	**Township Developer**	The company is one of the largest developers and most diversified property developers in Indonesia.	township developer; Chief Risk & Sustainability Officer; 22 years		√

The quantified primary data, using a Likert scale, were analyzed using the Content Validity Index (CVI) by comparing the total number of agreed-upon experts with the total number of experts. The results present valid drivers and barriers for the participation of integrated townships in e-waste collection hubs. A total of 15 Barriers and 16 Drivers were found valid with I-CVI = 1 and overall S-CVI values of 0.91 and 0.93, respectively. To enhance reliability, these results were further validated using the modified Kappa method, as recommended by Wynd et al. (2003), which adjusts for chance agreement with Equation.

$$\kappa^* = \frac{\text{I-CVI} - P_c}{1 - P_c}$$

Where N=number of experts and A=number of agreeing on good relevance. And then interprets k* values as poor (<0.40), fair (0.40–0.59), good (0.60–0.74), and excellent (≥0.74). Due to the small number of experts and relatively new field of study, only factors rated as "excellent" were retained. The final validation yielded 15 valid and 8 invalid Drivers and 16 valid and 8 invalid Barriers across four dimensions each. Invalid factors were removed due to insufficient expert agreement. The remaining validated factors will be used in the next stage of the questionnaire.

Data Processing of Weighting and Factor Influence Using the DEMATEL-ANP Method. After the drivers and barriers to the involvement of Integrated townships as e-waste collection hubs were validated using the CVI and modified kappa methods, the validated items were further assessed using the DEMATEL-ANP method. The first stage of this process involved developing the Network Relationship Map (NRM), which visualizes the interrelationships among barriers based on data collected through the second questionnaire.

Expert responses, rated on a scale from 0 to 4, were converted into a Matrix of Direct Influence and then averaged to produce the Direct Relation Matrix (Z).

$$Z = \frac{\sum_{h=1}^{H} Z^h}{H}, h = 1, 2, 3, \ldots, H$$

This matrix was normalized using a λ value to obtain the Normalized Direct Relation Matrix (D).

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$$\lambda = min\left[\frac{1}{max\ 1 \le i \le n\sum_j^n Z_{ij}}, \frac{1}{max\ 1 \le i \le n\sum_i^n Z_{ij}}\right]$$

Next, the Total Relation Matrix (T) was calculated, consisting of the total relationships among individual barriers (Tc) and dimensions (Td).

$$T = D(I - D)^{-1}$$

From these matrices, the R (sum of columns) and S (sum of rows) values were obtained, and a Threshold Value (TV) was calculated to classify each relationship as either a cause or an effect.

The process continued by forming the Normalized Total Relation Matrices T_c^{norm} and T_d^{norm}.

$$T_D^{\alpha} = \begin{pmatrix} t_{11}^D/d_1 & \cdots & t_{1j}^D/d_1 & \cdots & t_{1n}^D/d_1 \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ t_{i1}^D/d_i & \cdots & t_{ij}^D/d_i & \cdots & t_{in}^D/d_i \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ t_{n1}^D/d_n & \cdots & t_{nj}^D/d_n & \cdots & t_{nn}^D/d_n \end{pmatrix}$$

Which were then transposed to construct the Unweighted Supermatrix (W).

This matrix was multiplied by the total relation matrices to generate the Weighted Supermatrix (W*).

$$W^* = (x') \times W = \begin{pmatrix} t_D^{\text{norm}11} \times w^{11} & \cdots & t_D^{\text{norm}ji} \times w^{ji} & \cdots & t_D^{\text{norm}m1} \times w^{m1} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ t_D^{\text{norm}1j} \times w^{1j} & \cdots & t_D^{\text{norm}ji} \times w^{ji} & \cdots & t_D^{\text{norm}mj} \times w^{mj} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ t_D^{\text{norm}1m} \times w^{1m} & \cdots & t_D^{\text{norm}jm} \times w^{jm} & \cdots & t_D^{\text{norm}mm} \times w^{mm} \end{pmatrix}$$

In the final step, the Global Priority Vector was obtained by limiting the W* matrix through iterative calculations until it reached stability.

$$W^{limit} = (W^*)^{\propto}$$

In this study, the iteration process was performed three times consecutively to achieve a stable and reliable result. The final output presents the global priority weights of each barrier, reflecting both direct and indirect influences in the context of effectively engaging self-sufficient cities as e-waste collection hubs.

Furthermore, the creation of the NRM between dimensions begins with the calculation of the values of R and S, which are derived from the number of rows and columns in the Td matrix. The Td values are then compared to the corresponding Dimension Threshold Value (TV). If the value of Td is greater than the Dimension TV, it indicates a significant influence and is assigned a predicate of 1. Conversely, if the value is smaller, it reflects an insignificant influence and is rated as 0. This comparison process and its results are illustrated in Table 2

Table 2. R and S values, causal groups, and ranking order on the Barrier dimensions

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		Dimension				R	S	Causal Value		Category	Rank	
		GB	HB	CB	DB			R+S	R-S		R+S	R-S
Dimension	GB	0.29	0.31	0.28	0.36	1.25	1.13	2.38	0.12	Cause	2	2
	HB	0.30	0.28	0.27	0.34	1.19	1.12	2.31	0.07	Cause	3	3
	CB	0.29	0.28	0.25	0.34	1.17	1.05	2.22	0.12	Cause	4	1
	DB	0.25	0.25	0.24	0.30	1.04	1.35	2.38	-0.31	Effect	1	4

Table 3. Relation Value between Dimensions

		Dimension			
		GB	HB	CB	DB
Dimension	GB	1	1	0	1
	HB	1	0	0	1
	CB	1	0	0	1
	DB	0	0	0	1

Next, the two calculations above will be visualized using a scatter plot and an arrow representing the relationship between each dimension. In the NRM, the arrow line will be drawn based on the relationship between the dimensions that can be seen based on the row in Table 1. In this study, the Research and Government (GB) dimension has a significant influence on the Population (HB) and Developer (DB) dimensions. Consequently, a line will be drawn from the GB point to HB and DB, as depicted in Figure 1. Similarly, other dimensions will be connected based on their relationships. This visualization highlights the interconnectedness of the dimensions, underscoring the importance of considering these relationships in the analysis.

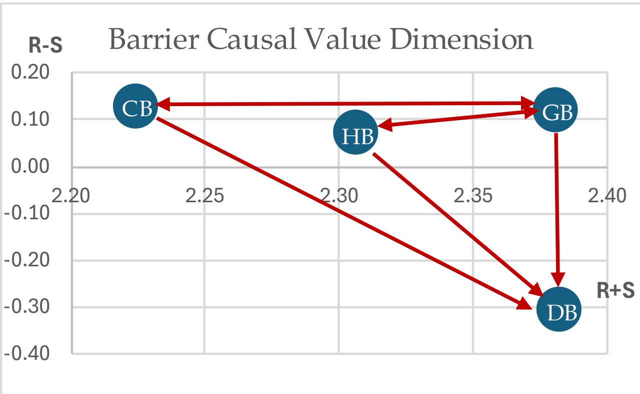

Figure 1. Network Relationship Map between Barrier Dimensions

Similar to the interdimensional NRM, calculations are made for barriers within each dimension through R and S calculations, comparisons with TVs, and the creation of scatter plot diagrams. In this session, the author will summarize the overall NRM calculation for each dimension. The factors within the four dimensions are categorized in a causal manner. Subsequently, the Tc matrix values of each factor are compared to the local threshold values (local TV) applicable to each dimension. These two calculation processes are then visualized in the form of an NRM (Network Relations Map), as illustrated in Figure 2.

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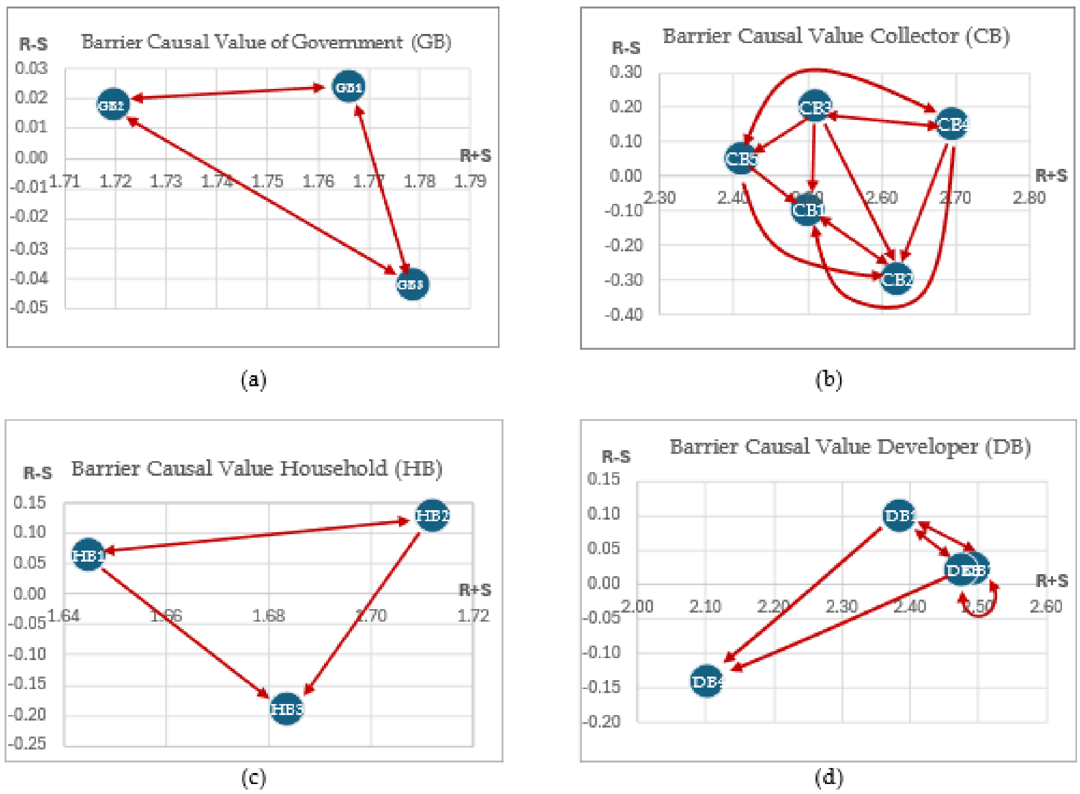

Figure 2. Network Relationship Between factors in each Barrier Dimension

Furthermore, the creation of NRM between dimensions begins with the calculation of the values of R and S based on the number of rows and columns in the Td matrix. Furthermore, the Td value is compared to the Dimension TV. If the value of Td is greater than the TV Dimension, it shows a significant influence and is given a predicate of 1. If it is smaller, it shows an insignificant influence and is rated 0. The results of the dimension comparison can be seen in Table 4

Table 4. R and S values, causal groups, and ranking order on the Barrier dimensions

		Dimension				R	S	Causal Value		Category	Rank	
		GD	HD	CD	DD			R+S	R-S		R+S	R-S
Dimension	GD	0.79	0.96	0.97	0.96	3.67	3.09	6.76	0.59	Cause	4	1
	HD	0.77	0.90	0.94	0.94	3.55	3.52	7.07	0.03	Cause	1	2
	CD	0.77	0.80	0.81	0.80	3.17	3.61	6.79	-0.44	Effect	3	4
	DD	0.77	0.87	0.89	0.87	3.39	3.56	6.95	-0.17	Effect	2	3

Table 5. Relation Value between Dimensions

		Dimension			
		GD	HD	CD	DD
Dimension	GD	0	1	1	1
	HD	0	1	1	1
	CD	0	0	0	0
	DD	0	1	1	1

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The calculations above will be visualized using the scatter plot and the arrow of the relationship between each dimension in Figure 1. In the NRM, the arrow line will be drawn based on the relationship between the dimensions. In this study, the Research and Government (GB) dimension has a significant effect on the Population (HB) and Developer (DB) dimensions. Therefore, a line will be drawn from the GB point to HB and DB. The same is also done to other dimensions.

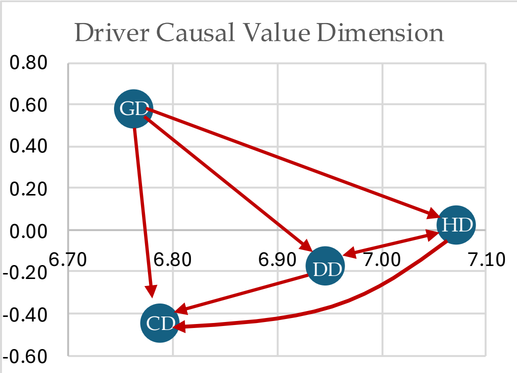

Figure 3. Network Relationship Map between Driver Dimensions

Similar to the interdimensional NRM, calculations are also made to identify inhibiting factors through R and S calculations, comparisons with TVs, and the creation of scatter plot diagrams. The factors that exist in each driver dimension are divided into causal types. Furthermore, the Tc matrix values of each factor are compared to the local threshold values (local TV) that apply to each dimension. The two calculation processes are then visualized in the form of an NRM, shown in Figure 4.

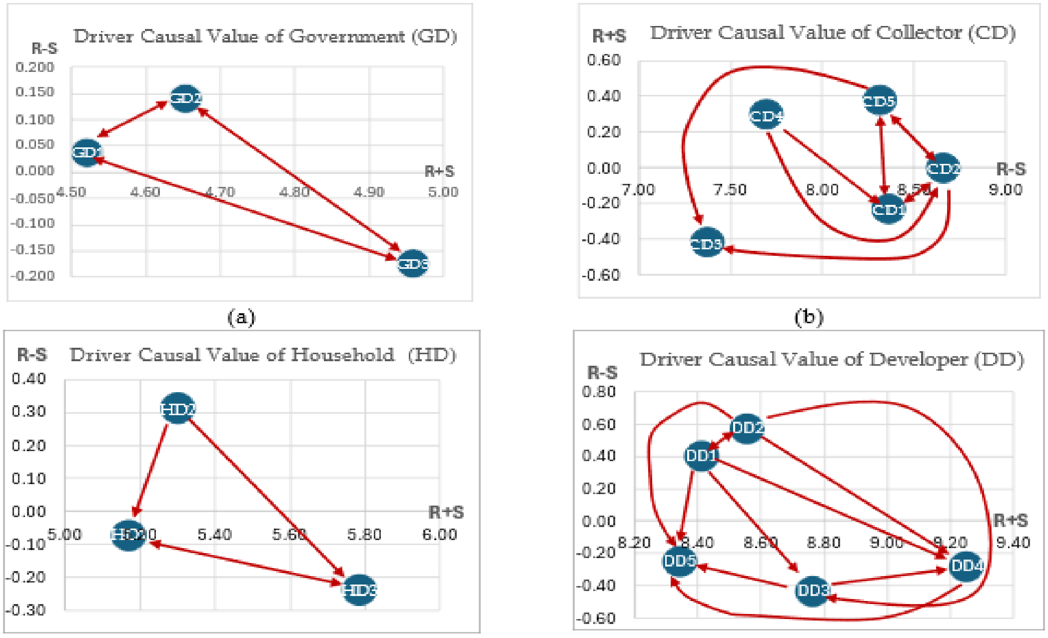

Figure 4. Network Relationship Between factors in each Driver Dimensions

After obtaining the causality effect of the DEMATEL process, the next process is to 9weight the driving and inhibiting factors by doing ANP until the weight of each factor or dimension is obtained from the diagonal value on the Supermatrx Limit. The results of the weighting data and causality values in this study can be seen in Tables 5 and 6

Table 6. Factor scale weight and Barriers Priority scale Based on Global Priority Vector

Weight	rank	Dimension	code	Barriers	Local weight	Local Rank	Global Weight	Global Rank
0.243	2	Government (GB)	GB1	There is no effective standard in the collection of e-waste	0.339	2	0.08	3
			GB2	Lack of regulations controlling informal e-waste collectors."	0.315	3	0.08	5
			GB3	Lack of tax policies that support formal e-waste collection companies."	0.346	1	0.08	2
0.241	3	Household (HB)	HB1	Ignorance of the public	0.327	2	0.08	4
			HB2	Low environmental concern	0.308	3	0.07	6
			HB3	Lack of waste sorting at the source	0.362	1	0.09	1
0.227	4	Collector (CB)	CB1	Lack of implementation of sustainability design practices from electronics manufacturers	0.201	2	0.05	12
			CB2	Lack of effective collection models from e-waste collection companies	0.221	1	0.05	11
			CB3	Lack of competitive advantage over informal collectors	0.179	4	0.04	14
			CB4	Lack of adequate logistics system	0.199	3	0.05	13
			CB5	Resistance of informal collectors and their uncooperative work ethic	0.147	5	0.04	15
0.289	1	Developer (DB)	DB1	Resources to be expended for e-waste collection hubs	0.241	3	0.07	9
			DB2	Expensive employee salaries and operating costs	0.260	2	0.08	8
			DB3	A large initial investment by the developer	0.262	1	0.08	7
			DB4	Lack of Initiation and commitment of management	0.236	4	0.07	10

Table 7. Factor scale weight and Drivers Priority scale Based on Global Priority Vector

weight	rank	Dimension	code	Drivers	Local Weight	Local Rank	Global Weight	Global Rank
0.225	4		GD1	Clear regulatory framework	0.317	3	0.071	6

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		Government (GB)	GD2	Good policies and stricter laws	0.318	2	0.072	5
			GD3	Government supervision and control of the rules made	0.365	1	0.082	3
0.255	3	Household (HB)	HD1	The level of knowledge of independent city dwellers about the environment	0.322	2	0.082	2
			HD2	Data security in e-waste collection	0.310	3	0.079	4
			HD3	Good public acceptance of e-waste collection programs	0.368	1	0.094	1
0.262	1	Collector (CB)	CD1	Good construction of waste collection system	0.212	2	0.056	9
			CD2	E-waste collection network and ease of collaboration options	0.215	1	0.056	8
			CD3	Advantages that collectors get when working with developers	0.195	4	0.051	12
			CD4	Facility conditions and technical capabilities of workers	0.182	5	0.048	14
			CD5	Facility design that is integrated with public space	0.195	3	0.051	11
0.258	2	Developer (DB)	DD1	The benefits that developers get from the government for carrying out CSR	0.184	5	0.047	16
			DD2	Economic benefits of CSR	0.184	4	0.048	15
			DD3	The developer's brand image rises in the public eye because of carrying out CSR	0.213	2	0.055	10
			DD4	The developer's ability to cooperate with other stakeholders in the collection of electronic waste	0.220	1	0.057	7
			DD5	Effective publicity from independent cities to increase population awareness	0.198	3	0.051	13

RESULT AND DISCUSSION

This study consists of three main stages. The first stage involves validating the identified Drivers and Barriers, followed by examining the relationships between factors and dimensions using the NRM (Network Relation Map), and finally, performing a weighting of the factors. The focus of the first stage is to identify the relevant factors through a literature review that covers both drivers and barriers, including related criteria and sub-criteria. The Drivers and Barriers were collected from various academic sources, and in this study, the researcher identified 23 inhibiting factors grouped into four main dimensions, with additional input from experts. After compiling the data, the first questionnaire was distributed to experts to validate the gathered information using a combination of the Content Validity Index (CVI) and the modified Kappa method for both drivers and barriers.

Factors Validation Analysis. Based on the Content Validity Index (CVI) method, 15 Barrier factors were found to be valid, each exceeding an I-CVI value of 1. Additionally, using the modified kappa method, all factors were considered valid, with kappa (k*) values above 0.74, indicating an excellent level of agreement. From these assessments, 15 validated factors across four dimensions

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were selected for the next stage of analysis. Using the Content Validity Index (CVI) method, 16 driving factors were found to be valid, each scoring above an I-CVI value of 1. The modified kappa method confirmed this, with all factors achieving a kappa (k*) score above 0.74, an "excellent" rating. Based on these parameters, 16 factors across four dimensions were selected for further analysis.

Factor Relationship Analysis Based on NRM. Based on the level of overall influence on Barrier, the Developer (DB) dimension ranked first with the highest prominence score (R+S) of 2.38 on the X-axis of the NRM inter-dimension map, indicating it is the most significantly impacted and influential within the system. However, when considering the tendency to influence other dimensions (R−S), the Collector (CB) dimension comes out on top with a value of 0.12. It suggests that formal waste collectors in self-sufficient cities have the strongest impact on other dimensions. Despite the Developer dimension showing the highest overall prominence and the Collector dimension showing the highest influencing tendency, the Government (GB) dimension maintains a high value in both dominance and causal influence. In terms of cause-effect classification, the Collector (CB), Household (HB), and Government (GB) dimensions fall into the "cause" category due to their positive R−S values, meaning they tend to influence other dimensions. Meanwhile, the Developer (DB) dimension, with a negative R-S, is considered an "effect" dimension, indicating that others have more influence on it.

At the factor level, within the Government dimension (GB), factor GB2, "Lack of regulations controlling informal e-waste collectors," ranks highest in overall importance (R+S = 1.78), reflecting its strong capacity to influence and be influenced. GB1 and GB2 have positive R−S values (0.02), categorizing them as cause factors, while GB3, with a negative R−S (−0.04), is considered an effect. In the Household (HB) dimension, HB2, "Low environmental concern," has the highest R+S (1.71) and also the highest R−S (0.13), making it the most dominant cause factor in its category. For the Collector (CB) dimension, CB4, "Lack of effective logistics and distribution systems," leads in importance with the highest R+S (2.70), but CB3, "Lack of competitive advantage over informal collectors," has the highest R−S (0.20), making it the key causal factor. Within the Developer (DB) dimension, DB2 "High labor and operational costs" ranks highest in R+S (2.49), indicating it is the most central factor. However, DB1, "Resources required for e-waste collection hubs," has the highest R-S (0.10) and is therefore the most influential cause, whereas DB4, "Lack of managerial initiative and commitment," with an R-S of −0.14, is the most affected and is thus categorized as an effect.

For the Driver side, the Resident (HD) dimension has the highest prominence (R+S) value of 7.07, making it the most involved in the overall system, both as an influencer and one being influenced. Meanwhile, the Government (GD) dimension has the highest R−S value at 0.59, indicating it is the most dominant causal dimension, exerting the greatest influence over others. As a result, both GD and HD are classified as "cause" dimensions due to their positive R−S values, meaning they tend to drive system dynamics. Conversely, the Collector (CD) and Developer (DD) dimensions fall into the "effect" category, as their negative R−S values show they are more likely to be influenced by other dimensions rather than to influence them.

Factor Weighting Analysis. In terms of individual drivers, within the Government dimension, GD3 ("Government oversight and enforcement") has the highest R+S (5.96), indicating it is the most significant factor overall. However, GD2 ("Sound policies and stricter legislation") is the top cause factor with a positive R−S of 0.14, while GD3, with a negative R−S of −0.17, is categorized as an effect. In the Resident dimension, HD3 ("Public acceptance of e-waste collection programs") has the highest R+S (5.79), but HD2 ("Data security in e-waste collection") has the highest causal impact (R−S = 0.31). For the Collector dimension, CD2 ("E-waste collection network and collaboration options") ranks first in R+S (8.66), while CD5 and CD4 are the most influential causes, with R−S values of 0.37

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and 0.29, respectively. CD1, CD2, and CD3 are categorized as effects. In the Developer dimension, DD4 ("Developer's ability to collaborate with stakeholders") exhibits the highest involvement (R+S = 9.25) but is considered a negative effect (R−S = −0.28). The most dominant cause factor here is DD2 ("Economic benefits from CSR"), with the highest R−S (0.57), making it the key driver in the Developer dimension despite ranking third in R+S.

The study reveals that the most influential driver dimension supporting the role of Integrated townships) as e-waste collection hubs is the Formal Waste Collectors (26.2%), followed by Developers (25.8%), Residents (25.5%), and Government (22.5%). The top global driving factors include strong public acceptance of e-waste collection programs (9.4%), environmental awareness among residents (8.2%), data security in e-waste collection (7.9%), governmental oversight and enforcement (8.2%), and well-structured policies and regulations (7.2%). At the local level, the leading factors in each dimension are government oversight (Government), public acceptance (Residents), logistical networks and collaboration opportunities (Collectors), and developers' ability to engage stakeholders (Developers).

Conversely, the most significant barrier dimension is Developers (29%), followed by Government (24%), Residents (24%), and Formal Waste Collectors (23%). The top five global hindering factors are lack of household-level waste separation (8.7%), absence of fiscal policies supporting formal waste companies (8.4%), lack of standardized e-waste collection procedures (8.2%), low public awareness (8.0%), and weak regulation of informal collectors (7.7%). The highest local hindrances in each dimension are inadequate fiscal incentives (Government), limited household waste separation (Residents), ineffective collection models (Collectors), and high initial investment requirements (Developers)

CONCLUSION

After going through the stages of identification, weighting, and analysis of the influence between Drivers and Barriers on the involvement of the Integrated township as a hub for electronic waste collection, the following conclusions were obtained:

Among the driving factors, the dimensions with the highest total value of linkage are the population dimension (HD) and the dimension with the highest net influence value, namely the government dimension (GD). Meanwhile, in the inhibiting factor, the developer dimension (DB) has the highest level of linkage, and the collector factor (CB) has the highest net influence value. In terms of weight, the factor that must be prioritized in the driving dimension, namely the good public acceptance factor, is the factor with the highest global weight, with a weight value of 0.094. Meanwhile, the inhibiting factor, namely the lack of waste separation at the source by the population, had the highest weight (0.087). Based on the findings of this study, the government should play an active role in promoting environmental awareness among households to enhance public acceptance of environmental initiatives. Supported by developers, the government can also educate or regulate communities to sort waste before disposal, as improper waste separation has been identified as the most significant barrier in the overall process.

Limitations and Suggestions. In future studies, involving local leaders such as neighborhood and hamlet heads (RT and RW) in integrated townships can significantly enhance the quality of research. These figures play a crucial role in facilitating electronic waste collection by acting as a communication bridge between residents and developers/ and by coordinating community participation. Additionally, conducting on-site surveys of the electronic waste disposal and management systems within the studied integrated township would provide a more accurate picture of real-world practices. Such fieldwork could reveal insights into existing infrastructure,

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community behavior, stakeholder involvement, and both technical and social challenges that may not be fully captured through literature reviews or limited interviews.

REFERENCES

Alavi Moghadam, M. R., Mokhtarani, N., & Mokhtarani, B. (2009). Municipal solid waste management in Rasht City, Iran. *Waste Management*, *29*(1), 485–489. https://doi.org/10.1016/j.wasman.2008.02.029

Alif, B. (2023). Fenomena Modernitas Kota Mandiri: Studi Sosiologi Perkotaan di Kota Bintaro Jaya, Tangerang Selatan.

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. https://doi.org/10.1007/s10163-013-0191-0

Baldé, C. P., Wang, F., & Kuehr, R. (2016). Transboundary movements of used and waste electronic and electrical equipment, United Nations University, Vice Rectorate in Europe.

BPS. (2020). Central Bureau of Statistics (2020a) Indonesian environmental statistics. In Central Bureau of Statistics, Republic of Indonesia. https://www.bps.go.id/id/publication/2020/04/29/e9011b3155d45d70823c141f/statistik-indonesia-2020.html

Bui, T. D., Tsai, F. M., Tseng, M. L., & Ali, M. D. H. (2020). Identifying sustainable solid waste management barriers in practice using the fuzzy Delphi method. Resources, Conservation and Recycling, 154. https://doi.org/10.1016/j.resconrec.2019.104625

Conke, L. S. (2018). Barriers to waste recycling development: Evidence from Brazil. Resources, Conservation and Recycling, 134, 129–135. https://doi.org/10.1016/j.resconrec.2018.03.007

Dielman, M. (2011). New town development in Indonesia: Renegotiating, shaping and replacing institutions. *Journal of the Humanities and Social Sciences of Southeast Asia 167*(1): 60–85.

Ermolaeva, Y. (2019). Problems of modernization of the waste management sector in Russia: expert opinion. *Revista Tecnologia e Sociedade, 15*(35). https://doi.org/10.3895/rts.v15n35.8502

Fogt Jacobsen, L., Pedersen, S., & Thøgersen, J. (2022). Drivers of and barriers to consumers' plastic packaging waste avoidance and recycling – A systematic literature review. In Waste Management (Vol. 141, pp. 63–78). Elsevier Ltd. https://doi.org/10.1016/j.wasman.2022.01.021

Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential. United Nations University (UNU)/United Nations Institute for Training and Research (UNITAR) co-hosted the SCYCLE Programme, International Telecommunication Union (ITU), and International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam.

Goldblum, C., & Wong, T. C. (2000). Growth, crisis and spatial change: A study of haphazard urbanization in Jakarta, Indonesia. *Land Use Policy*, *17*(1), 29–37. https://doi.org/10.1016/S0264-8377(99)00043-5

Herlambang, S., Leitner, H., Tjung, L. J., Sheppard, E., & Anguelov, D. (2019). Jakarta's Great Land Transformation: Hybrid Neoliberalisation and Informality. *Urban Studies*, *56*(4), 627–648. https://doi.org/10.1177/0042098018756556

Ikhlayel, M. (2017). Environmental Impacts and Benefits of State-of-The-Art Technologies For E-Waste Management. *Waste Management, 68*, 458–474. https://doi.org/10.1016/j.wasman.2017.06.038

Jangre, J., Prasad, K., & Patel, D. (2022). Analysis of Barriers in E-Waste Management in Developing Economy: An Integrated Multiple-Criteria Decision-Making Approach. *Environmental Science and Pollution Research, 29*(48), 72294–72308. https://doi.org/10.1007/s11356-022-21363-y

Kasto. (2002). Mobilitas Penduduk dan Dampaknya Terhadap Pembangunan Daerah Dalam Mobilitas Penduduk Indonesia. Tinjauan Lintas Disiplin, PSKK UGM, Yogyakarta.

Kurnianti, D., Rustiadi, E., & Baskoro, D. (2015). Land Use Projection for Spatial Plan Consistency in Jabodetabek. *Indonesian Journal of Geography, 47*, 124–131. https://doi.org/10.22146/ijg.9249

Kwabena, B.-Y., Clifford, A., & Kwasi, K. A. (2018). Stakeholder perceptions on key drivers for and barriers to household e-waste management in Accra, Ghana. *African Journal of Environmental Science and Technology, 12*(11), 429–438. https://doi.org/10.5897/ajest2018.2409

Leisch, H. (2002). Gated communities in Indonesia. In Cities (Vol. 19, Issue 5). www.elsevier.com/locate/cities

Lynn, M. (1986). Determination and Quantification of Content Validity.

Mairizal, A. Q., Sembada, A. Y., Tse, K. M., & Rhamdhani, M. A. (2021). Electronic Waste Generation, Economic Values, Distribution Map, and Possible Recycling System in Indonesia. Journal of Cleaner Production, 293. https://doi.org/10.1016/j.jclepro.2021.126096

Mcgee, T. (1991). The Emergence of Desakota Regions in Asia: Expanding a Hypothesis. https://api.semanticscholar.org/CorpusID:59884466

Oktaviani, R., & Soetomo, S. (2016). The Effect of Existence New Town Lippo Karawaci toward Development of Physical, Economic, and Social of Surrounding Area. *JANUARY, 1*(1), 1–10.

Polit, D. F., & Beck, C. T. (2006). The Content Validity Index: Are You Sure You Know What Is Being Reported? Critique And Recommendations. Research in Nursing and Health, 29(5), 489–497. https://doi.org/10.1002/nur.20147

PT Alam Sutera, R. (2021). PT Alam Sutera Realty Sustainability Report.

PT Bumi Serpong Damai. (2023). PT Bumi Serpong Damai Tbk Sustainability Report.

Saaty, T. L., & Vargas, L. G. (2013). Decision Making with the Analytic Network Process (Vol. 195). Springer US. https://doi.org/10.1007/978-1-4614-7279-7

Santoso, S., Zagloel, T. Y. M., Ardi, R., & Suzianti, A. (2019). Estimating the Amount of Electronic Waste Generated in Indonesia: Population Balance Model. *IOP Conference Series: Earth and Environmental Science, 219*(1). https://doi.org/10.1088/1755-1315/219/1/012006

Shatkin, G. (2008). The city and the bottom line: Urban megaprojects and the privatization of planning in Southeast Asia. *Environment and Planning A 40*(2): 383–401.

Silver, C. (2024). Rapid Urbanization: The Challenges and Opportunities for Planning in Indonesian Cities. In: Resosudarmo, B.P., Mansury, Y. (eds) The Indonesian Economy and the Surrounding Regions in the 21st Century.

Sima, H., & Maulana, H. A. (2023). Potential of Circular Economy Implementation in Managing Plastic Waste in Kabupaten Bengkalis. *J-MIND (Jurnal Manajemen Indonesia), 8*(1), 35. https://doi.org/10.29103/j-mind.v8i1.11086

Singh, A., Panchal, R., & Naik, M. (2020). Circular Economy Potential of E-Waste Collectors, Dismantlers, and Recyclers of Maharashtra: A Case Study. *Environmental Science and Pollution Research, 27*(17), 22081–22099. https://doi.org/10.1007/s11356-020-08320-3

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INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By :

Steubing, B., Boni, H., Schluep, M., Silva, U., & Ludwig, C. (2020). Assessing Computer Waste Generation in Chile Using Material Flow Analysis. Waste Manag. 30,473-482. https://www.statista.com/

Stojic, S., & Salhofer, S. (2022). Capacity Development for Plastic Waste Management—A Critical Evaluation of Training Materials. *Sustainability (Switzerland)*, *14*(4). https://doi.org/10.3390/su14042118

Wang, W., Tian, Y., Zhu, Q., & Zhong, Y. (2017). Barriers for household e-waste collection in China: Perspectives from formal collecting enterprises in Liaoning Province. *Journal of Cleaner Production, 153*, 299–308. https://doi.org/10.1016/j.jclepro.2017.03.202

Wibowo, N., Piton, J. K., Nurcahyo, R., Gabriel, D. S., Farizal, F., & Madsuha, A. F. (2021). Strategies for improving the e-waste management supply chain sustainability in Indonesia (Jakarta). *Sustainability (Switzerland), 13*(24). https://doi.org/10.3390/su132413955

Widodo, H. (2018). Perencanaan Transportasi Umum Terpadu pada Kawasan Kota Mandiri (Studi Kasus: Kawasan Bumi Serpong Damai, Kota Tangerang Selatan*). In Planners InSight (Vol. 1*, Issue 1).

Wikurendra, E. A., Csonka, A., Nagy, I., & Nurika, G. (2024). Urbanization and Benefit of Integration Circular Economy into Waste Management in Indonesia: A Review*. In Circular Economy and Sustainability (Vol. 4*, Issue 2, pp. 1219–1248). Springer Nature. https://doi.org/10.1007/s43615-024-00346-w

Williams, I. D. (2016). Global Metal Reuse and Formal and Informal Recycling from Electronic and Other High-Tech Wastes.

Winarso, H. (2000). Residential land developers' behavior in Jabotabek, Indonesia. PhD Disser Tation, Architecture and Planning, University College London.

Yasmin, B. N., & Safitri, D. (2023). Pengaruh Urbanisasi Terhadap Perubahan Kondisi Sosial dan Ekonomi di Indonesia.

Yasmin, N. (2024). Pengaruh Urbanisasi Terhadap Perubahan Kondisi Sosial dan Ekonomi di Indonesia.

Yin, H., Qu, Y., & Guo, L. (2023). Critical Factors for Implementing Collection Target Responsibility in E-Waste Collection in China: A DEMATEL-ISM analysis. *Waste Management, 172*, 278–289. https://doi.org/10.1016/j.wasman.2023.10.041

Zhu, J., & Simarmata, H. A. (2015). Formal Land Rights Versus Informal Land Rights: Governance for Sustainable Urbanization In The Jakarta Metropolitan Region, Indonesia. *Land Use Policy, 43*, 63–73. https://doi.org/10.1016/j.landusepol.2014.10.016