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Research Paper

Depok City Informal Waste Facility Planning and Mapping using Geographic Information System (GIS)

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Abstract

Waste Bank, as the important pillar of waste management in Depok City have not been properly mapped. Based on these conditions, spatial analysis with Geographic Information System (GIS) helps to optimize the decision making process by the waste management stakeholder of Depok City related to informal waste facility. The stakeholder could also plan and assess the appropriate strategy for overall waste infrastructure in Depok City. The result shows that the active waste bank facility in Depok City (both the municipal solid waste bank and the unit waste bank) amounts to 82 waste banks of 428 registered waste banks. Most active garbage banks are in Tapos and Pancoran Mas sub-districts, while in Sawangan and Cinere sub-districts, there is no active waste bank exist. From the 67 interviewed waste bank managers in Depok City, 79% of waste bank units choose to deposit their waste to a municipal solid waste bank (Rumah Harum Waste Bank), and 12% to a bigger waste bank such as Depok Hijau Beji Waste Bank, the rest of waste bank units deposit their waste to collectors and one waste bank unit deposit the waste to Mr. Isnarto's Waste Bank at Merdeka Street. 20% of waste bank collects and weighs the waste at 9 AM while 14% of waste bank collects and weighs the waste at 8 AM. 11% of waste bank transport the waste at 12 PM. 67% waste bank operate in private locations and residence of the garbage bank managers. The maps produced in this research are distribution of Waste Banks, its cooperation, collection frequency, number of customer and operational location.

Keywords: *Geographic Information System, Waste Bank, Depok City, Landfill, Municipal Solid Waste Management.*

1. Introduction

Depok City is the youngest city in West Java Province Indonesia. The location is directly adjacent to the capital city Jakarta. The current condition of Depok City needs to conduct waste reduction activities because the capacity of Cipayung Landfill is now in a state of over capacity. In addition to Final Dispossal Site (*Tempat Pembuangan Akhir-TPA*) Cipayung, no other landfill site has been planned or prepared yet. Finding landfill location is a challenging task, especially in dense population area [1]–[4]. Under these circumstances, waste reduction activities, especially from the household sector, are expected. Department of Sanitation and Gardening of Depok City has a target that 20% of families conduct waste separation by 2019. Separation of waste is divided into 3 (three) types: organic waste, inorganic waste that still has value to be used, and residue. Organic waste will be transported to a formal waste facility, namely the Waste Processing Unit *(Unit Penolahan Sampah-UPS*) and processed into compost. Inorganic waste which still has value to be collected at the informal waste facility (Waste Bank or collector) that spread in Depok area, whereas the waste that cannot be processed anymore (residue), will enter into formal waste facility that is Temporary Disposal Site (*Tempat Pembuangan Sementara-TPS*) and then to TPA or landfill. If the waste segregation activities are running well, it should be only 15% of total household waste that goes to the Cipayung Landfill. Therefore, it can extend the life of the landfill.

Waste generation has been an important issue in recent years due to uncontrolled urban population growth, urbanization and industrialization [1], [5], [6]. Urbanization can improve the condition of poor area and lift many people out of poverty [7], but it also increase the need of infrastructure and public facilities that require land conversion [8]. The presence of population growth and changes in the socioeconomic status of urban communities will lead to an increase in the volume of waste generation and characteristics. Therefore, environmentally sound waste management system is needed to avoid negative impact to the society and environment [9]. Recents studies related to municipal solid waste has beed conducted to help waste governance [10]–[12]. According to Law no. 18 Year 2008 on Waste Management, garbage is the residu of human daily activities and/or natural processes in the solid form. Waste management is a systematic, thorough, and continuous activity that includes waste reduction and handling. The notion of management is not only about the aspects of technical, but also includes non-technical aspects, such as how to organize, how to finance and how to engage the waste-producing community to participate actively or passively in the handling activities [13].

Based on the mandate of the Act, along with other related laws, in 2014, the Mayor of Depok City issues the Local Regulation of Depok City no. 5 Year 2014 on Waste Management [14]. In the framework, reduce, reuse, and recycle activities are conducted from household level. Waste reduction is done through supporting the activities of communities and agencies in developing and utilizing recycled products, marketing of recycled products, and reuse of waste. Waste Management Unit (*Unit Pengolahan*

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Sampah-UPS) and Temporary Disposal Sites (*Tempat Pembuangan Sementara-TPS*) and informal sectors such as waste banks in Depok City have not been properly mapped. Spatial analysis with Geographic Information System (GIS) can be an excellent alternative to assist the decision-making process [4], [15]–[34]. Some researchers have conducted spatial analysis with GIS to help provide input for government, public policy makers, and community to solve environmental problems [36]–[41]. By providing maps, this paper is aims to give inputs for stakeholders related to the city's garbage system especially informal waste disposal facilities.

2. Methodology

The research was conducted in 11 subdistricts of Depok City, namely Beji, Pancoran Mas, Cipayung, Sukamaja, Cilodong, Limo, Cinere, Cimanggis, Tapos, Sawangan, and Bojongsari Sub-district. The study was conducted in several stages. Data obtained are primary data and secondary data. Primary data consist of location of waste banks in the form of coordinate data, interview result with waste bank managers, questionnaire result with bank managers, and documentation of field observation. From 75 waste banks observed in Depok City, 67 interviews has been done and questionnaires were collected. Secondary data consist of population data, infrastructure facilities, administration and land use map of Depok City and monthly waste banks recapitalization data. This research was conducted in 5 stages, namely (1) Literature study and field survey, (2) Primary data collection of coordinate points of Waste Bank and distribution of questionnaires, interviews, documentation and secondary data collection, (3) Spatial data making, (4)) Spatial analysis with GIS, and (5) Mapping the results of analysis. The following figure 1 is the research flow diagram.

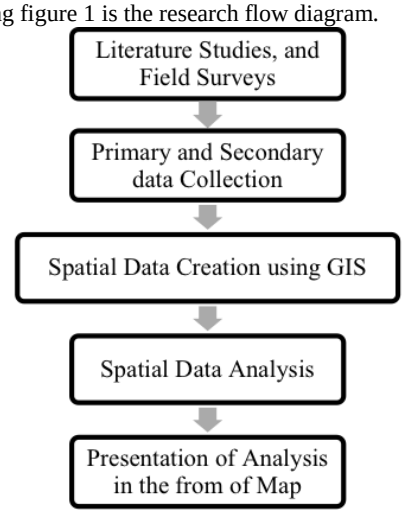


Figure.1: Flowchart of the Research

3. Results and Discussion

The informal sector waste facility in Depok City consists of garbage banks, medium collectors and major collectors. In this study, the informal sector waste disposal facility is represented only by garbage banks due to the enormous amount of informal waste disposal facilities, gaining more than 800 points based on Department of Sanitation and Gardening of Depok City data. From 800 points, 428 points are garbage banks, and 372 points consist of medium collectors and major collectors. Information and organization of garbage banks is more consistent to be researched. The mapping of active waste banks distribution in Depok City can provide complete information related to the nearest location for Depok community to deposit their inorganic waste which is still worth selling. Mapping also can provide an overview for the Government of Depok to organize and make decisions related to informal waste disposal facilities.

The research has been identified active garbage banks, both the municipal solid waste banks and the unit waste banks in Depok City. From 428 waste banks, 82 waste banks area active. From active waste banks, 75 of its were observed and spatial data for mapping of 74 waste banks were collected. Table 1 presents the observed garbage banks in Depok City by each sub-district. The distribution of observed waste banks in Depok City is presented in Figure 1.

Table.1: Observed Waste Banks in Depok City

No.	Sub-district	Amount of Active Waste Bank
1	Sawangan	0
2	Bojongsari	1
3	Pancoran Mas	16
4	Cipayung	10
5	Sukmajaya	9
6	Cilodong	7
7	Cimanggis	4
8	Tapos	21
9	Beji	6
10	Limo	1
11	Cinere	0
Total		75

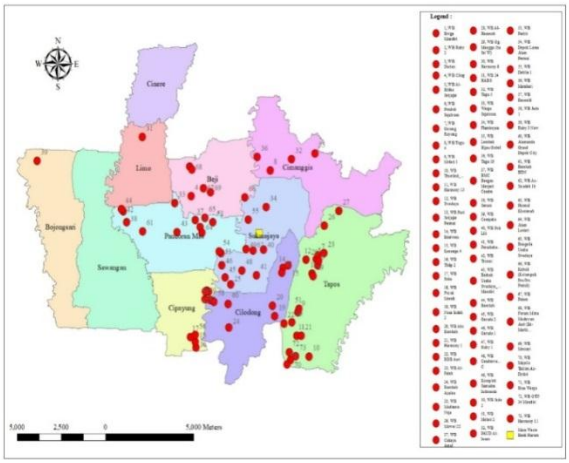
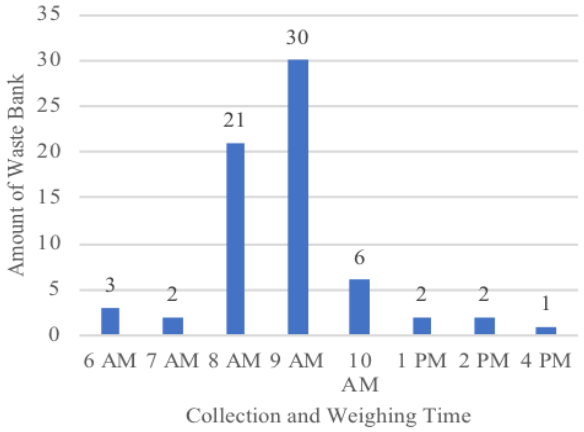


Figure.1: The Distribution of Observed Waste Banks in Depok City

The yellow box in the figure 1 shows the location of municipal waste bank namely Rumah Harum waste bank that located in Sukmajaya sub-district. The red dots shows units waste banks that distributed in 11 sub-districts in Depok City.

The waste bank operation time is the result of the agreement between the customer and the waste bank manager. The operating time of the waste bank consists of the timing of garbage collection and weighing as well as the time of transporting the garbage from the unit garbage bank to the main waste bank. Figure 2 presents the operating time of garbage banks in Depok City. 20% of waste bank collects and weighs the waste at 9 AM while 14% of waste bank collects and weighs the waste at 8 AM. 11% of waste bank transport the waste at 12 PM.



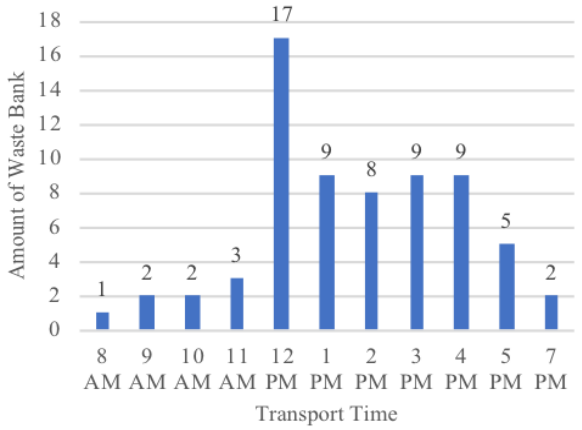


Figure.2: Operational Time of Garbage Banks

The garbage collected in the unit's garbage bank will be sold again to another larger place, such as a municipal solid waste bank, medium or major collector. The fundamental difference between the medium or major collector and the municipal waste bank is the location. The medium collector can operate anywhere without government permission while the municipal waste bank is established with the permission of the government and a special land is provided. The municipal waste bank receives more garbage than the medium collector, whereas the medium collector receives only spicable waste such as glass bottled water and bottled water. Of the 67 interviewed waste bank managers in Depok City, 79% of waste bank units choose to deposit their waste to a municipal solid waste bank (*Rumah Harum* Waste Bank), and 12% to a bigger waste bank such as Depok Hijau Beji Waste Bank, the rest of waste bank units deposit their waste to collectors and one waste bank unit deposit the waste to Mr. Isnarto's Waste Bank at Merdeka Street (Table 2). The municipal waste bank uses a set price list, providing more stable price than other medium collectors that often determines the price of waste without a clear foundation. A stable price means that the banks buying price is more reasonable, not too low so it is more profitable for people who deposit the waste to the bank. However, collector can pay the waste deposit faster, maximum in three days when municipal waste bank only pays the deposit once a year.

Table.2: The Cooperation Number of Waste Bank

Name of Waste Bank or Collector that Receive the Waste from Smaller Waste Banks Unit	Number of Waste Bank Cooperation
Depok Hijau Beji Waste Bank (Mr. Hendra Sogir)	8
Rumah Harum Waste Bank (Mr. Hermansyah)	53
Merdeka Street Waste Bank (Mr. Isnarto)	1
Collector at Omas Street in Mekarsari (Mr. Jaya)	1
Collector in Grand Depok City (Mr. Pardi)	1
Collector at Sari Jaya Street in Depok Jaya (Mr. Raya)	1
Collector at Aseli Blok Lontar Street in Ciganjur (Mr. Slamet)	1
Collector in Curug (Mr. Charli)	1
Total interviewed waste bank managers	67

The distribution of waste banks in cooperation with other smaller waste banks is illustrated in Figure 3. This map can be a reference when deciding to choose a waste bank based on its cooperation with smaller waste bank.

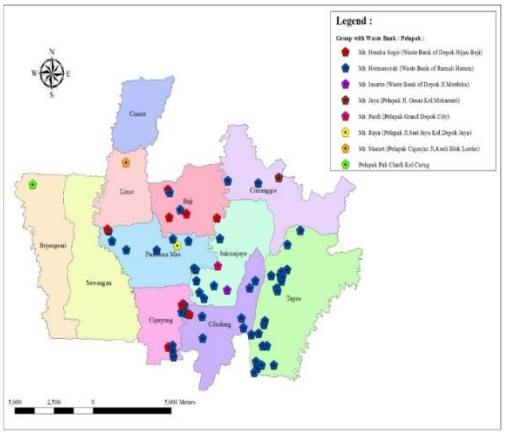


Figure.3: Garbage Bank Mapping Based on Cooperation

Waste from the unit waste bank is collected on average every two weeks or once a month before being transported for collection and weighing in the nearest municipal waste bank (Figure 4). A group of citizens will collect the waste and they will deposit to the waste bank in a place and time that has been agreed together, such as at a patrol post or at waste bank manager's house to be weighed and transported. This is related to the effectiveness, as it is inefficient in terms of time and transport cost when any inorganic waste produced every day is directly collected to the nearest waste bank unit.

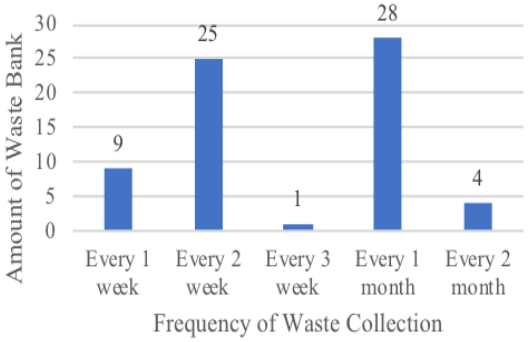


Figure.4: Garbage Collection Frequency

The distribution of waste banks according to the frequency of waste collection is presented in Figure 5. This map can be a guide in making decisions to choose a waste bank that suits customers' preferences. If a household produces a large amount of inorganic waste every day, it would be wise to choose the nearest garbage bank whose frequency of garbage collection is more frequent so that the waste in the house is not overloaded. Vice versa, if the production of inorganic waste is little, the costumer can choose the nearest waste bank which garbage collection frequency is longer, for example two months.

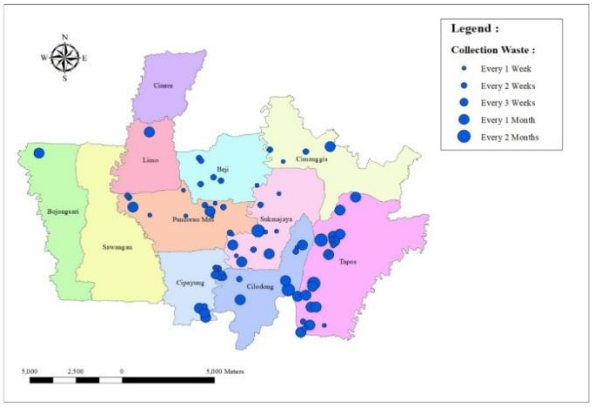


Figure.5: Waste Banks Mapping based on Waste Collection Frequency

The active customer is a bank customer who routinely collects and weighs waste in the time and place determined by the waste bank, while the inactive or customers do not routinely collect and weighs the waste. As many as 73% of waste bank units have no more than 30 active customers (figure 6). The trust factor between the waste bank management and customer plays an important role, especially regarding the inflexibility of fund disbursement.

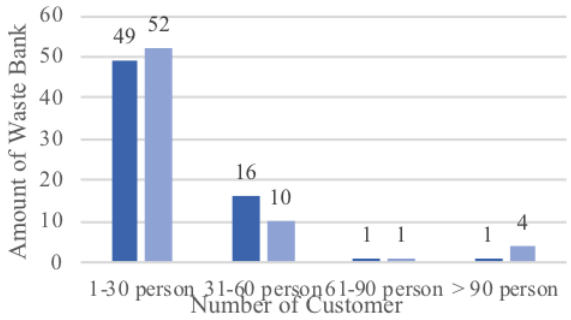


Figure.6: Number of Active Customers (Blue) and Inactive Customer (Grey)

Figure 7 illustrates the map of the distribution of waste banks based on the number of active customers. The more number of active customers, shows that the track record of the waste bank is better because it has loyal customer. This map can also be a suggestion for the related sub-district government in assisting or socializing the waste banks program to non-customer residents. The non-customers residents are suggested to apply in waste banks that have less than 30 customers.

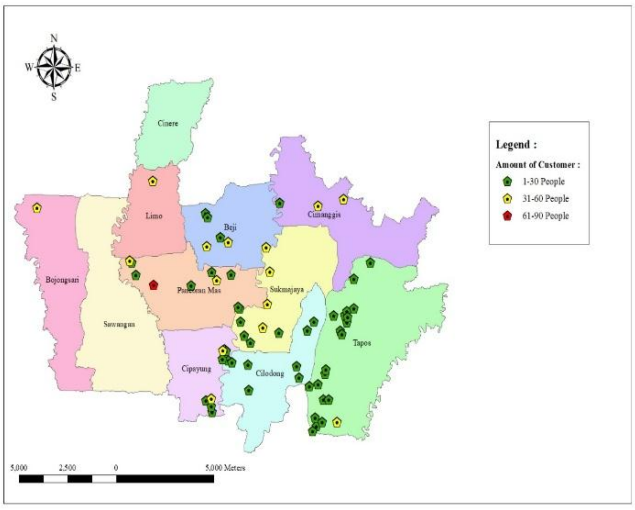


Figure.7: The Distribution of Waste Bank based on Number of Customer

Based on figure 8, 67% (28 waste banks) operate in private locations and residence of the garbage bank managers, while the remain are located in public facilities such as village offices, patrol posts, local health post, schools, landfill, fields and mosques. The location should not be in the form of office or permanent building. This result is in line with the data of land ownership where the waste bank operates.

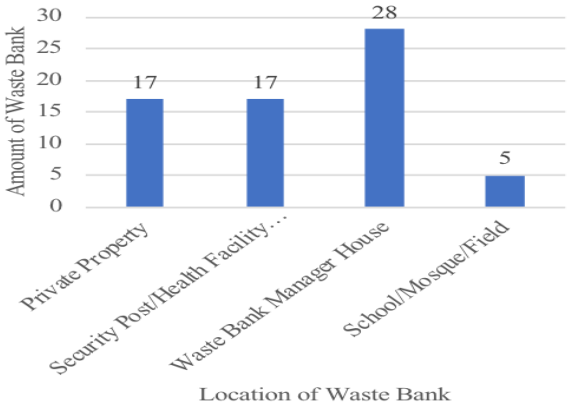


Figure.8: The Operational Location of Waste Bank

In figure 9, the distribution of waste bank based on the operational location are mapped. The waste bank located in the residence of the bank's managers is more flexible in terms of operational time because the caretaker lives in the same place. On the other hand, garbage banks located in public facilities such as landfill, mosques, village offices and schools are usually has more regular operational time due according to the operational time of the facilities. This map can be an input for prospective customers in choosing the nearest waste bank according to their preferences.

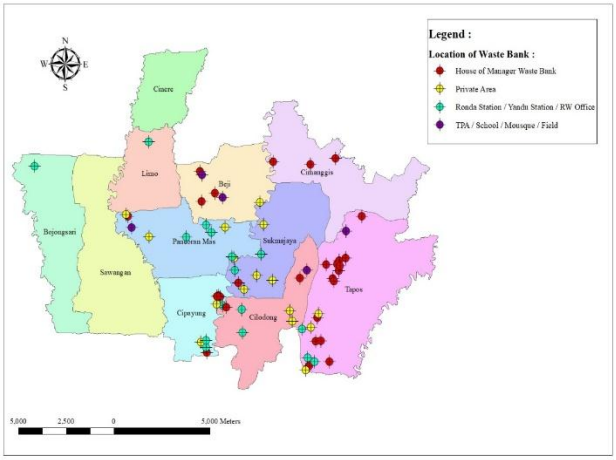


Figure.9: The Distribution of Waste Bank based on Operational Location

4. Conclusion

The active waste bank facility in Depok City (both the municipal solid waste bank and the unit waste bank) amounts to 82 waste banks of 428 registered waste banks. Most active garbage banks are in Tapos and Pancoran Mas sub-districts, while in Sawangan and Cinere sub-districts, there is no active waste bank exist.

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