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Preliminary Study of Smart Urban Waste Recycling in Semarang, Central Java, Indonesia

Preliminary Study of Smart Urban Waste Recycling in Semarang, Central Java, Indonesia

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Abstract. The emergence of waste management technology innovation is able to inhibit the accumulation of waste in temporary collection sites and landfill. Innovations that have been developed in developed countries and summarized in the concept of "Smart Waste Management" are still not able to be applied to cities in developing countries, such as Indonesia. This is because the technologies that already exist in Indonesia are still far behind by developed countries in the world. In addition to sophisticated technology, the understanding and behaviour of the community has also been more advanced in the field of waste management, which starts from the process of sorting waste in each household to the recycling process of waste to minimize the amount of waste entering the landfill. This study took place in the city of Semarang, Central Java where the area is an urban area with waste problems that must be addressed immediately. The lack of technology, especially the city-scale recycling technology makes land in the landfill increasingly unable to accommodate the production of waste that enters every day. Therefore, the aim of this study is to define the high level of application of the Smart Waste Recycling concept that has been carried out in Semarang City by utilizing the technology currently available.

1. Introduction

Urbanization is one of the main issues of urban development which can cause the complexity of problems in urban areas to grow rapidly. In 2018, 55% of the world's population prefers to live in urban areas compared to rural areas and is predicted to continue to increase to 68% by 2050 [1]. This high level of urbanization indirectly contributes to increasing economic activity in that area [2]. The number of population that is directly proportional to the needs will result in greater waste produced if the population continues to grow. Environmental aspects and human health also become a threat if the problem of waste cannot be resolved [3]. This is one of the concerns for the city government that urban development is not only focused on physical, economic and social aspects, but also considers environmental aspects and sustainable development [4]. Waste management activities are needed which consist of all activities, starting from the measurement of waste production, storage, collection, sorting, transportation, treatment and landfill. As one of the sustainable city development strategies in resolving waste problems that occured, waste recycling activities become an alternative to reuse resources that

still have use value. This activity reduces the amount of waste brought to the landfill, and is able to provide opportunities for urban communities, especially in developing countries, by creating jobs and increasing income [5].

In carrying out the management of solid waste in urban areas, the Semarang City Government through the Environmental Agency has made regulations regarding the management of solid waste and domestic waste listed in Article 32 of the Semarang City Regional Regulation Number 13 of 2006 concerning Environmental Control. In the article explained that every person who produces domestic waste is obliged to carry out the management of waste from sorting to process organic waste independently into compost, and not be allowed to burn waste in open spaces. But in reality, the regulations that have been made have not been implemented well. This is evidenced by the amount of solid waste generation in Semarang in 2018 at around 1270.13 tons/day, with unmanaged waste approximately 100 tons/day [6], so that there is still a possibility that waste that can be recycled and has a value is not used properly.

Waste management in cities in developing countries is different from waste management activities in cities in developed countries. The emergence of technological innovations in the field of waste management is able to inhibit the accumulation of waste in temporary collection sites and landfill. Innovations that have been developed in cities in developed countries are summarized in the Smart Waste Recycling concept which is part of Smart Waste Management can be categorized as successful. The concept that is identical with this technology has been started since the process of storage. The waste storage used in public areas are mostly in the form of waste bin compactors and have sensors that can detect the waste is full and must be transported to the landfill. The sensor will be received by the waste manager and then the waste transportation will be sent to the waste bin which sends a signal to be directly taken to the landfill. In the landfill, the waste that has been transported will be sorted using technology by detecting the color of the plastic used to wrap the waste. Waste that has been sorted is certainly easier to recycle in accordance with the type of waste and at the same time can reduce waste entering the landfill. The use of different color plastics is done by each household. They sort and put it on each plastic according to the type of waste. So, it can be said that the success of the Smart Waste Recycling concept depends not only on technology, but also on the collaboration between the Government and the citizen. In this context, the citizen becomes one of the stakeholders that is very influential in shaping and improving the quality of the environment [7].

However, this concept cannot yet be fully implemented in large cities in developing countries, such as in Semarang City. This is because the technology is still less compared to technology in developed countries. In addition to sophisticated technology, understanding and behavior of people in developed countries towards the importance of waste management is even higher. Despite having limited recycling machine technology, Smart Waste Recycling concept in Semarang City can be achieved by utilizing internet-based technology that is accessible to the public, so that people can control the mass of waste generation, waste recycling management that has been carried out by the government, and the mass of recycled waste. Therefore, the aim of this study is to define the high level of application of the Smart Waste Recycling concept that has been carried out in Semarang City by utilizing the technology currently available.

2. Data and Methods

2.1. Study area

Several studies on the waste problem of Semarang City have been conducted. For example, the impact of transportation and the stationary emission source on rain water [8], and the impact of the implementation of a Community-Based Waste Management system on changes in community behavior and reduction in the amount of waste generation [9]. However, discussions on the management of information technology-based urban solid waste have not been carried out. This indicator is very important in realizing the Smart Waste Recycling concept that has been initiated by Semarang City.

The research study area took the city of Semarang where the city represented the characteristics of urban communities in waste management. The city of Semarang consists of 16 districts, namely Gunungpati,

Mijen, Tembalang, Banyumanik, Semarang Timur, Candisari, Genuk, Tugu, Ngaliyan, Semarang Tengah, Semarang Utara, Semarang Barat, Gayamsari, Pedurungan, Semarang Selatan, and Gajahmungkur. In the preliminary study and introduction shows that waste management activities in the Semarang City are under the control of the Environmental Agency. Regulations on waste management have been issued, but have not been carried out properly by each household because there is still waste that is not transported to the landfill and is not managed independently. Lack of monitoring from the Government and the community has caused in waste management, especially in the process of waste recycling management, which is increasingly out of control. Although they have not yet found recycling equipment technology innovations such as those used in developed countries, Semarang City can apply the concept of Smart Waste Recycling based on technology through the internet because basically the concept of "smart" is all activities supported by using technology.

2.2. *Method*

The method used in this study is a scoring method in GIS to map the difference in the level of convenience of the people of Semarang City in accessing information related to the conditions of urban solid waste management in each district. The data needed in this analysis is information that lists waste management in the study area through the official government website. Information search is adjusted to the Smart Waste Recycling indicator that has been determined. Indicators are taken from Law Number 18 of 2008 concerning Waste Management. The basis for selecting these indicators is that in Law Number 18 of 2008 can be used as a reference for the citizen in managing waste in accordance with environmentally sound methods and techniques, so that the public can minimize the negative impacts of waste generation independently. Based on these regulations, the indicators used in this study are divided into several aspects, namely the operational technical aspects, regulatory aspects, community participation aspects, financing aspects, and institutional aspects. In addition, the success of the recycling process can also be measured by knowing the type and mass of waste generation, and the type and mass of waste generation that has been recycled every day. Research indicators will be presented in Table 1.

Table 1. Indicators of smart waste recycling.

No	Aspects		Indicators
1	Waste generation		Type of waste generation
2			Mass of waste generation
3	Waste management	Operational technical aspects	Waste storage
4			Waste collection
5			Waste transport
6			Waste treatment
7			Landfill
8		Regulatory aspect	Regulation of recycling
9		Community participation aspects	Public campaign of recycling
10			Waste bank
11		Financing aspect	Budget for recycling
12		Institutional aspects	Recycling program
13	Recycled Waste		Type of recycled waste
14			Mass of recycled waste

Each indicator is given a score based on the available information and can be accessed by the people of Semarang City through the official government website. The range of assessment used in this study is 0, 1, and 2. Number 0 indicates that there is no published data, number 1 indicates that the data sought is available on the website but is incomplete, and number 2 indicates that the data sought is complete on the website. The total score calculated from each indicator in each district is then processed using Arcgis

10.6 Software and presented in the form of a map. Each total score will show a different color. This color difference can be interpreted as the level of completeness of information that is already available on the internet and can be easily accessed by the citizen in supporting the Smart Waste Recycling concept.

3. Results and Discussion

3.1. Waste recycling management information through the official government website

Information about the waste management recycling viewed through official website of the Semarang City Government (http://semarangkota.go.id/), official website of each district in Semarang City, and official website of Semarang City Environmental Agency (https://dlh.semarangkota.go.id/). Information collected in accordance with the indicators that have been determined in previous chapter.

3.1.1. Type of waste generation. Data related to the type of waste or waste composition for each district is not available on the website. However, the citizen can find this type of data for Semarang City on the website http://sipsn.menlhk.go.id/. There are 9 types of waste, namely food waste, garden waste, paper, plastic, metal, fabric, rubber and leather, glass, and other waste. In this data, it can be seen that the highest percentage of waste in Semarang City is 31,6% of food waste, and the smallest percentage of waste is 0,5% of rubber and leather waste. Because the type of waste data is not available for each district, the score is 0.

3.1.2. Mass of waste generation. Total data on waste generation for each district is available on the Semarang City Environmental Agency website. Data availability starts from 2013-2018. In addition to knowing the total waste generation every day at this time, the citizen also knows the increase in waste generation every year. So, the mass of waste generation indicator is given a score of 2, because the data is complete.

3.1.3. Waste storage. The type of waste storage used for each household and public place in not currently mentioned on the website. Besides that, the number of waste storage placed in public areas is also unknown. So, the waste storage indicator for all districts in Semarang City is given a score of 0, because the data is not available.

3.1.4. Waste collection. Data on waste collection consists of the amount of waste collection transportation and the number of temporary collection sites in each district. On the Semarang City Environmental Agency website, data about temporary collection sites for all districts is available, except Gunungpati and Mijen. Whereas the amount of waste collection transportation sought through the website of each district, only Gunungpati and Mijen do not specify the type and total of waste collection transportation. Therefore, Gunungpati and Mijen were given a score of 0 and the other districts were given a score of 2.

3.1.5. Waste transport. The data related to waste transport that is available is only data about the type of transport, while the number of waste transportation is unknown. However, not all districts provide the data, only Gunungpati and Mijen do not have the data. Thus, the score for Gunungpati and Mijen is 0, while the score for the other districts is 1, because the data is incomplete.

3.1.6. Waste treatment. Data related to waste treatment which used in this study are the number of TPS3R and TPST (integrated waste treatment facility). The districts that provide data about the location of waste treatment are Tembalang, Pedurungan, and Semarang Selatan. This data can be searched through the news on the official website of the Semarang City Government. So, the three districts were given a score of 2 and the other districts were given a score of 0.

3.1.7. Landfill. In the city, there is only one landfill. Semarang City has a Jatibarang landfill which serves all administrative areas. The data about landfill in Semarang City can be seen on the website http://sipsn.menlhk.go.id/. In the website, there are data about the number of waste that is piled up in the landfill and the number of waste that is not managed, so the score for this indicator is 2 in each district.

3.1.8. Regulation of recycling. Aspect of recycling regulation have been issued by the Semarang City Government through the Environmental Agency. Regulations for managing solid waste and domestic waste are listed in Article 32 of the Semarang City Regional Regulation Number 13 of 2006 concerning Environmental Control. In the article explained that every person who produces domestic waste is obliged to carry out the management of waste from sorting to process organic waste independently into compost, and not be allowed to burn waste in open spaces. This regulation can be downloaded through the Semarang City Environmental Agency website. In the regulation of recycling indicator, the score for each district is 2.

3.1.9. Public campaign of recycling. The existence of "Lomba Kelurahan Ramah Lingkungan" program initiated by Semarang City Environmental Agency is one of the ways to empower urban communities in terms od waste recycling management. This is because one of the competition assessment criteria is processing organic and anorganic waste. This program is held once a year and each district is required to take part in the competition. Indirectly, there is an increase in community participation in managing their waste. This information was obtained from the Environmental Agency website, so the score for each district is 2, because the data is complete.

3.1.10. Waste bank. Data on waste banks in Semarang City can be searched through the website http://sipsn.menlhk.go.id/. This website mentions the address, year of establishment, number of customers, amount of waste per month, and monthly turnover. However, this data is not available in Semarang Timur, Semarang Tengah, and Gayamsari District. So, the score for those district is 0, while the other is 2.

3.1.11. Budget for recycling. There is information about the cost for making integrated waste treatment facility (TPS3R or TPST) in the Semarang City APBD of Rp 405.290.000,00. This information was obtained from the official website of Semarang City Government. However, because the location of the TPST was not mentioned, the score for each district is 1.

3.1.12. Recycling program. There is a recycling program initiated by the Semarang City Environmental Agency, namely "Kelurahan Ramah Lingkungan" program. One of the activities is a "Lomba Kelurahan Ramah Lingkungan" which has been implemented since 2011 with 16 villages from representatives of each district. The main criteria in the competition assessment are waste management including sorting waste, organic and anorganic waste recycling. Indicator of recycling program in each district is given a score of 2.

3.1.13. Type of recycled waste. The type of recycled waste is not listed on the website, so the score on this indicator for each district is 0.

3.1.14. Mass of recycled waste. The mass of recycled waste is not listed on the website, so the score on this indicator for each district is 0.

3.2. Accessibility level for waste recycling management information

In supporting the implementation of Smart Waste Recycling concept in Semarang City, a technological innovation is needed that can manage waste from the source until the landfill. However, the technology in Semarang City is not like the other cities in developed countries. Therefore, this study defines the

application of the Smart Waste Recycling concept that is deemed appropriate to the conditions in developing countries. The internet is one of the technologies that almost all of the people in Semarang are able to use it, so that throught the internet, the citizen can control the waste management process. Besides that, the citizen can also participate in waste management activities.

Determination of accessibility level to information on waste recycling management is done using the scoring method on each indicator that has been determined. There are 14 indicators that refer to Law Number 18 of 2008 concerning Waste Management. From the total score of this indicator, it will be known how the level of ease of accessing information about the management of waste recycling in supporting the implementation of the Smart Waste Recycling concept. The total score in each district can be seen in Figure 1.

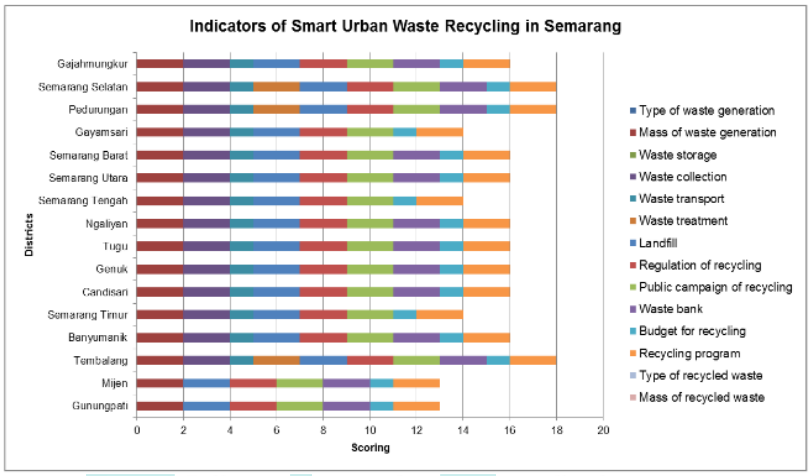

Figure 1. Indicators of smart urban waste recycling in semarang.

From the picture above shows that each district has a different total score. The range score for each district that has been assessed is 13-18. The difference in score will be used to analyze the district that have provided more complete information to district that have not later. The difference in score will be presented in the form of a map which can be seen in Figure 2.

Figure 2. Map of smart urban waste recycling in semarang, central java.

There are 4 different colors on the map, which means there are 4 levels in Semarang City in the ease of accessing information related to waste recycling management. The highest score is 18 in Pedurungan, Tembalang, adn Semarang Selatan. It is indicates that the information on waste management in these three districts is more complete than the others. The second highest score is 16 in Tugu, Ngaliyan, Semarang Barat, Gajah Mungkur, Banyumanik, Candisari, Semarang Utara, and Genuk. Then, a score of 14 in Semarang Timur, Semarang Tengah and Gayamsari. The lowest score is 13 in Mijen and Genuk. Although in 4 different levels, Semarang City did not occur inequality in accessing the information. Only the completeness of the data from each district needs to be added.

In applying the concept of Smart Waste Recycling, the Government actually has made an application that can be downloaded by every smartphone user. The application is called "SILAMPAH". Application creation is expected to facilitate the public to report the accumulated waste, so that it can be immediately addressed by the Semarang City Environmental Agency. The provision of this application service must be balanced with socialization from the Government to the community.

4. Conclusions

Based on the results, the use of internet-based technology is very suitable if used in cities in developing countries, such as Semarang City, in supporting the implementation of the "Smart Waste Recycling" concept. The website or application made by the Semarang City Government can be a connector between the citizen and the government to control the process of urban waste recycling. In accessing information, Semarang City did not occur inequality because most of the data related to waste recycling was available and citizen can access it easily.

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