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Smart waste management in IoT-Based urban waste management in Surabaya City

S Sunarto[1*], T Sulistyaningsih[1] and U Kulsum[2]

[1] University of Muhammadiyah Malang, Malang, Indonesia
[2] University of Muhammadiyah Yogyakarta, Yogyakarta, Indonesia
[*]Corresponding author email: sunarto@umm.ac.id

Abstract

This study aims to describe the smart waste management implemented in the city of Surabaya as part of an effort to control IoT-based waste. The city of Surabaya, as the most populous city in East Java, will certainly have a waste problem that must be resolved every day, especially the problem of household waste generated by Surabaya residents every day. The average urban resident can produce around 0.64 kg of waste per day, whereas in Surabaya the amount of waste transported is around 75.6%. The Smart Waste Management system provides a waste management proposal from determining temporary waste disposal sites (TPS) and garbage transport fleets to scheduling waste transportation. Waste handling is optimized to obtain efficiency and effectiveness in handling urban waste. This research uses qualitative research with the help of Nvivo 12 Plus software to analyze data obtained from secondary data sources. The results of this study indicate that the successful implementation of smart waste management is determined by the active role of the government, the community, and the Garbage Bank, which has been formed from the RT/RW level per region. The system created with the help of AI is to see the state of the trash can, which is then interpreted into information. The system will automatically record the type and amount of waste disposed of.

Keywords

Smart waste, Management, IoT, Surabaya city

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Introduction

Waste management poses a significant challenge for metropolitan cities in Indonesia. Being the most populous city in East Java, Surabaya inevitably faces a daily challenge in waste management, particularly concerning the significant amount of household waste generated by its residents on a daily basis. The average urban resident generates approximately 0.64 kg of waste per day, and about 75.6% of this waste is transported for disposal. However, if the waste transportation process is not managed effectively, it can result in a buildup of waste within the city.

Surabaya has several local communities that are encouraged and facilitated by competitive programs to improve environmental quality and make their environment more livable. To accelerate this program, local governments are encouraged to adopt the right technology or system where the community and authorities can work together to address waste management issues. Because several solutions to overcome this waste problem continue to be made in order to find ways to solve the waste problem, starting from making trash cans, garbage banks to robots/waste detection machines [1]. Detection of waste is a problem in itself considering the shape of the waste is not fixed.

The Smart Waste Management system offers a comprehensive waste management solution, including the identification of temporary waste disposal sites (TPS), management of garbage transport fleets, and scheduling of waste transportation [2]. By optimizing waste handling processes, the system aims to achieve efficiency and effectiveness in managing urban waste.

The Smart Waste Management system is an IoT tool created to solve several city waste problems [3]. The system can detect garbage accumulated in real time [4] in landfills on every corner of the city. Communities and the government can determine which waste storage bins are empty, filled or full. In addition, if the garbage collection site is full, the system will automatically send information to the relevant agency to immediately deal with the dump site being full [5].

Based on the description of the problems above, the writer is interested in researching Smart Waste Management in IoT-Based Urban Waste Management in Surabaya City. Because the smart waste management system is one part of a smart city [6], [7] which has been implemented by the City of Surabaya based on Internet of Things (IoT) technology by imposing a large number of wireless sensors [8] everywhere for maximum use.

Methods

This study employs a qualitative research approach [9], utilizing Nvivo 12 Plus software to analyze data sourced from secondary data. The secondary data is derived from various documents, including those from the City of Surabaya, previous research, online media, books, and other references. The data processed with Nvivo 12 Plus software is extracted from Scopus journals using keywords such as “Smart Waste Management,” “Urban Waste Management,” and “IoT.” Initially, 154 Scopus journals were identified using these keywords and then analyzed using Nvivo 12 Plus software. Utilizing Nvivo 12 Plus software ensures accuracy in data analysis. The research employed NVivo 12 Plus, a qualitative data analysis tool that facilitates the collection, categorization, mapping, analysis, and visualization of qualitative data sourced from documents [10], [11]. By utilizing Nvivo 12 Plus, researchers can identify keywords relevant to Smart Waste Management studies and their respective authors, thereby enabling more accurate and systematic validation.

Result and Discussion

Realization of Smart Waste Management in the City of Surabaya

Figure 1 is the result of processing 154 journals that were downloaded on Scopus and processed using Nvivo software and produced a word cloud that shows concepts that have a close relationship with smart waste management. In implementing smart waste management, a "system," "internet," "monitoring," "environment," "application," "development," and "network" are needed.

Smart waste management is realized by creating requiring requires a network with various parties to integrate data. The data integration is used to collect TPS data for each place connected to the network, which in this prototype uses an Ethernet shield. After that, the data is sent to the Data Center to be processed and dias form of information on the web or mobile application. Apart from that, under certain conditions, the system will send WhatsApp to the relevant government or agency.

Figure 1. Word cloud of smart waste management (Source: Nvivo 12 Plus, 2023)

Surabaya City solid waste management, has a "Solid Waste Application Transportation" feature that makes it easier for the Sanitation and RTH Office to monitor and analyze waste conditions in the City of Surabaya served. As well as the factors that influence the implementation of public services using IT in the city of Surabaya are leadership, commitment and policies, and budget availability.

The implementation of Smart Waste Management places a strong emphasis on community involvement and the utilization of waste banks. Smart bins serve as educational tools, encouraging individuals to sort their waste before disposal. Citizens may be incentivized to participate by owning a smart card or using a mobile app to access the smart bins, which automatically record the type and quantity of waste disposed of [12]. This encourages residents to become more conscious of their waste production. Additionally, the system is expected to boost transactions at waste banks.

Through this system, waste banks can easily identify which districts produce more recyclable waste. This information provides authorities and policymakers with valuable insights for spatial analysis, enabling them to allocate resources such as trucks, smart bins, and personnel to specific districts more effectively.

Smart Waste Management System in Surabaya City

The system is initially implemented solely for food waste but is anticipated to be extended to other types of waste bins [14]. Within the system architecture, the Service Domain layer acts as the core component for gathering data from the Smart Garbage Bin. Equipped with IoT sensors, cameras, and low-energy AI technology, this layer monitors the status of the trash can (see Figure 2). The collected data is then transmitted to the Administrative Domain layer, where it undergoes processing and storage. Here, the application server plays a crucial role in analyzing the data and transforming it into meaningful information. Ultimately, this information can be presented through visually appealing and interactive visualizations in the User Domain layer, facilitating tasks such as interactive spatial analysis.

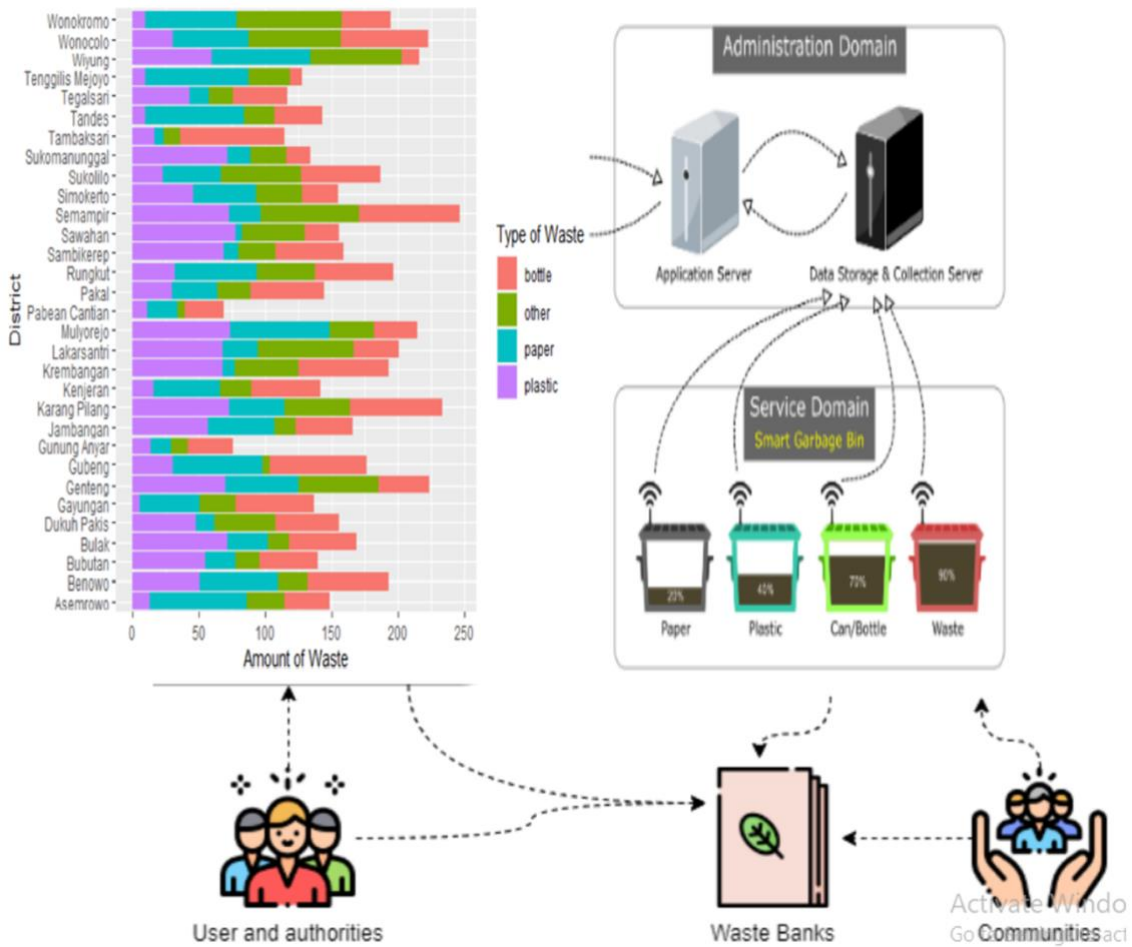

Figure 2. Smart Waste Management [13]

The effectiveness of implementing smart waste management hinges on the active involvement of the government, the community, and the Waste Bank established at the neighborhood (RT/RW) level within each region [15]. Utilizing AI technology, the system

is designed to monitor the status of trash cans, with the collected data then being translated into valuable information. Additionally, the system automatically records the type and quantity of waste being disposed of.

The system is made real-time so that it can be checked on the web/mobile application anytime and anywhere. In addition, the system is made on a Map so that it can find out the location of the place & trash information, such as on Google Maps. Furthermore, it will be equipped with an artificial intelligence-based algorithm to predict the loading time for each TPS. Arrange an optimal pick-up schedule for TPS and predict which bins will fill quickly so that special actions can be taken.

Conclusion

The Smart Waste Management System is an IoT tool created to solve several waste problems in the City. The system created can detect up to 74% of waste piled up in landfills in every corner of the city. Communities and the government can determine which waste storage bins are empty, filled or full. In addition, if the landfill is full, the system will automatically send information to the relevant agencies so that they can immediately deal with the full landfill. Future research is expected to be able to find and develop a waste management system capable of detecting up to 90% of waste in every corner of an urban area. In addition, the researchers hope that this waste management system is really carried out seriously by academics, the government, and the community so that urban waste problems can be resolved quickly.

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