Development of Smart Trash Management Tools to Improve the Quality of Waste Bank Services to Customers

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Abstract

The waste problem is a problem that will continue to occur along with the increasing population and human activities. Based on the results of discussions, interviews, and observations of the team with several waste bank managers, a smart waste scale is needed to make it easier to weigh household waste. The purpose of this study is to develop smart trash management tools that can improve the quality of waste bank services to customers. The research method used is R&D Borg & Gall targeting to 20 partners at Madiun and Magetan cities. The results of the study show that smart trash management tools can improve the quality of waste bank services to customers. In addition to accelerating the process of recording and reporting waste data, this innovation can increase transparency and accountability in waste management. Smart Trash Management Tools are an innovative digital-based solution to overcome household waste problems.

Key words: Smart Trash Management Tools, Waste Bank Services, Customers

1. Introduction

Waste is a problem that will continue to occur as the human population and activities increase. We need to making peace with waste [1], exemplify a zero-waste lifestyle [2], and provides solutions for waste management [3].

Waste management has been widely implemented. There are waste management in the Sepatan area of Tangerang Regency [4]. waste management strategies at the Bantargebang final disposal site, Bekasi [5], waste management in the school environment to increase students' ecological awareness [6], results of the analysis of inorganic waste management in Sukawinatan,

Palembang city [7], a study on waste management in Indonesia [8], community-based waste management [9], and review of waste management [10].

Waste management is closely related to the environment. We have environmental communication strategies in building public awareness in household waste management [11], a study on the generation, composition and characteristics of domestic waste in Bukittinggi city [12], the role of environmental education in increasing public awareness about waste management [13], and the role of circular product waste to increase the productivity of Bagorejo village community businesses [14].

To optimize waste management, empowerment is carried out. There have been done the process of empowering the community of Sitimulyo village, Piyungan district, Bantul regency in the formation of an independent waste management group (KPSM) [15]. There have been done the women's empowerment in increasing income through paper waste processing in Dewasari village Ciamis [16].

To optimize waste management, several places have conducted training, counseling, and education. There are team that provided training on organic waste processing using the eco enzyme method [17]. There are team that provided counseling on waste sorting to improve cadre knowledge in Sanrobone village south Sulawesi [18]. There are team that provided education on local wisdom-based waste management for a sustainable environment [19].

The waste produced by Madiun city residents increases every year. Waste can improve the economy. There are team that improved the community's economy through creative products from plastic waste processing [20]. There are team that the income level and waste retribution collection process in increasing the original regional income of Binjai city [21]. There are team that explained how to improve community welfare through waste management [22].

The volume of waste is increasing at the landfill. Waste management cannot be separated from reduction, reuse, and recycling. There are team that increased awareness of waste sorting with the 4R concept (reduce, reuse, recycle, replace) in Gedongarum village, Kanor, Bojonegoro [23]. There are team that using waste management through TPS3R (reuse-reduce-recycle waste processing place) in Selat village, Sukasada district, Buleleng regency [24]. There are team that provided waste management education by waste sorting and 3R at SDN Pondok Cina Depok [25].

There are team that increased community participation in waste recycling center management [26]. There are team that provide ecobrick innovation as an effort to reduce plastic waste [27].

Household waste is a group of waste that is of concern. There are team that provide innovation in the waste management system in riverbank communities through household waste sorting as a health promotion effort [28]. There are team that provided training on household waste management in Kedungsumur village, Krembung district, Sidoarjo regency [29].

The level of public awareness of Madiun City to sort and manage waste is starting to increase. There are team that made efforts to increase public awareness of environmental health through the waste bank program [30]. There are team that explain the need for waste processing through waste banks to increase the economic value of the community [31]. There are team that explain the role of waste banks in increasing the income of housewives in Sait Buttu village, Pematang Sidamanik district [32]. There are team that explain how waste bank management improves the community's economy in Banangkah village, Burneh district, Bangkalan regency [33]. There are team that explains the utilization of waste banks in improving the welfare of the Kersik Village community [34].

Several efforts have been made to improve the capabilities of waste banks. There are team that explain the improvement of waste bank management through community service programs at the Simojawar waste bank [35]. There are team that explain the use of waste bank applications for community empowerment at the environmentally friendly community waste bank [36].

Based on the team's discussions, interviews, and observations, a smart waste scale is needed to simplify weighing. Several scales already exist in the community. One such scale is a hanging scale. The problem with existing hanging scales is that they are still manual; none are digital. Furthermore, some use bench scales. Some bench scales are manual, while others are digital. However, bench scales generally only provide weight information and do not provide price information. Furthermore, due to their large size, they are too expensive. Some bench scales do provide price information. However, this type of scale is too small for weighing waste, which is usually large in size or volume. The sacks, bags, or wrappers of waste often reach the floor, disrupting the weighing process. A waste scale is needed to assist in measuring the weight of waste so that it is clear in sales calculations. Waste scales are needed by waste processors or waste

banks. Hanging scales are a favorite, or at least often found, for weighing waste because they are more flexible. This is because the volume of waste is usually large (sacks or large plastic bags).

Based on the description above, the problem faced is how to create a smart hanging garbage scale. Hanging garbage scales that are not too large are important for ease of portability and more economical in terms of manufacturing costs. Hanging garbage scales that can provide important weight information as the main function of the scale with an additional calibration feature. Hanging garbage scales that can provide important price information to simplify calculations so that they are automatic although they can also be manual. Hanging garbage scales that are integrated with the web/Android are important for simplifying monitoring and data storage for savings.

2. Method

The method used in this study was Borg & Gall's research and development (R&D). The focus of this research was the design of a smart trash management tool. This scale was designed solely for feasibility testing, but not for effectiveness in improving the quality of waste bank services to customers.
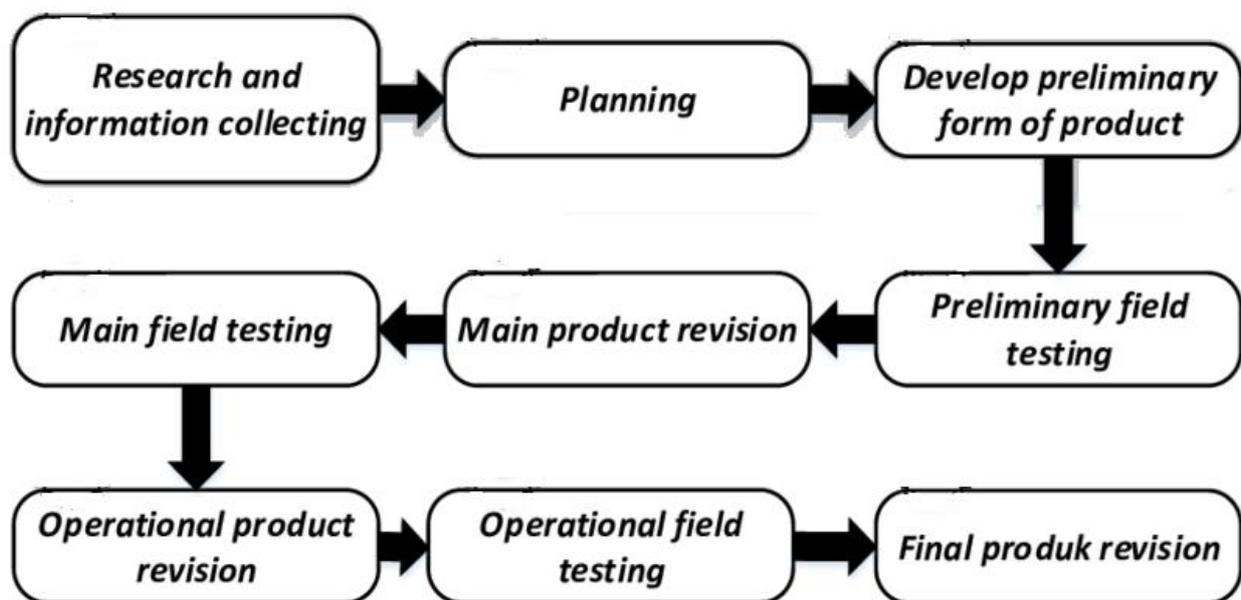

Figure 1. Borg & Gall's Research and Development (R&D) Method

Research and information collecting was conducted with a survey on December 23, 2024 and InterVIEWS/DISCUSSIONS with partners on december 23, 2024. Planning was conducted with a

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Discussion with the team on December 24-26, 2024 and innovation determination on December 27, 2024. Developing a preliminary form of product was conducted with prototype making on December 27-31, 2024. Preliminary field testing was conducted with Trial 1 on January 1-2, 2025. Main product revision was conducted with Development 1 on January 3-13, 2025. Main field testing was conducted with Trial 2 on January 14-15, 2025. Operational product revision was conducted with development 2 on January 16-26, 2025. Operational field testing was conducted with limited applications on January 27-30, 2025, socialization 1 on January 21, 2025, and Socialization 2 on January 23, 2025. Final product revision was carried out with development on January 23 – April 25, 2025. The tool design can be described as follows.
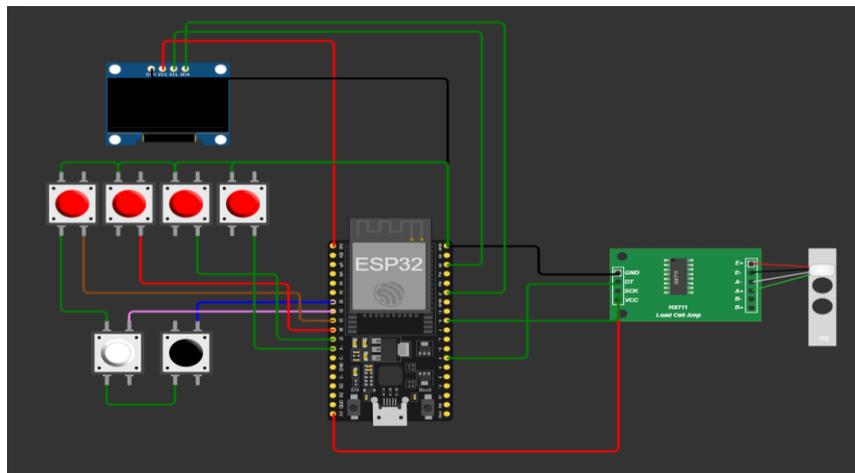

Figure 2. Smart Trash Management Tools Design Diagram

There are 20 partners for the research. The innovation actors/stakeholders involved include Universitas PGRI Madiun, Selopangung village, Karangtaruna Selopangung Magetan, Pasangrahan waste bank, Madiun main waste bank, Nurul Darusalam waste bank, Madiun city environmental agency, Winongo landfill manager, Winongo landfill collector, Matahari waste bank, and mentari waste bank of Madiun city.

3. Result and Discussion

Innovation (smart trash management tools: smart trash scales) is an innovation developed or built to solve the problem of household waste scales, namely smart trash management tools (smart trash scales). The dimensions of this scale are 2 cm thick, 20 cm wide, and 15 cm high. These dimensions are taken by considering the needs of component placement and the practicality of the

scale itself. The type of hanging scale is chosen based on the results of considering user desires. Features such as buttons that are usually needed for scales are provided with the ability to calibrate. The output of the scale can be seen on the scale itself manually or can be monitored digitally on a computer or cellphone as long as there is WiFi in the area around the weighing. The description of the tool is as follows.
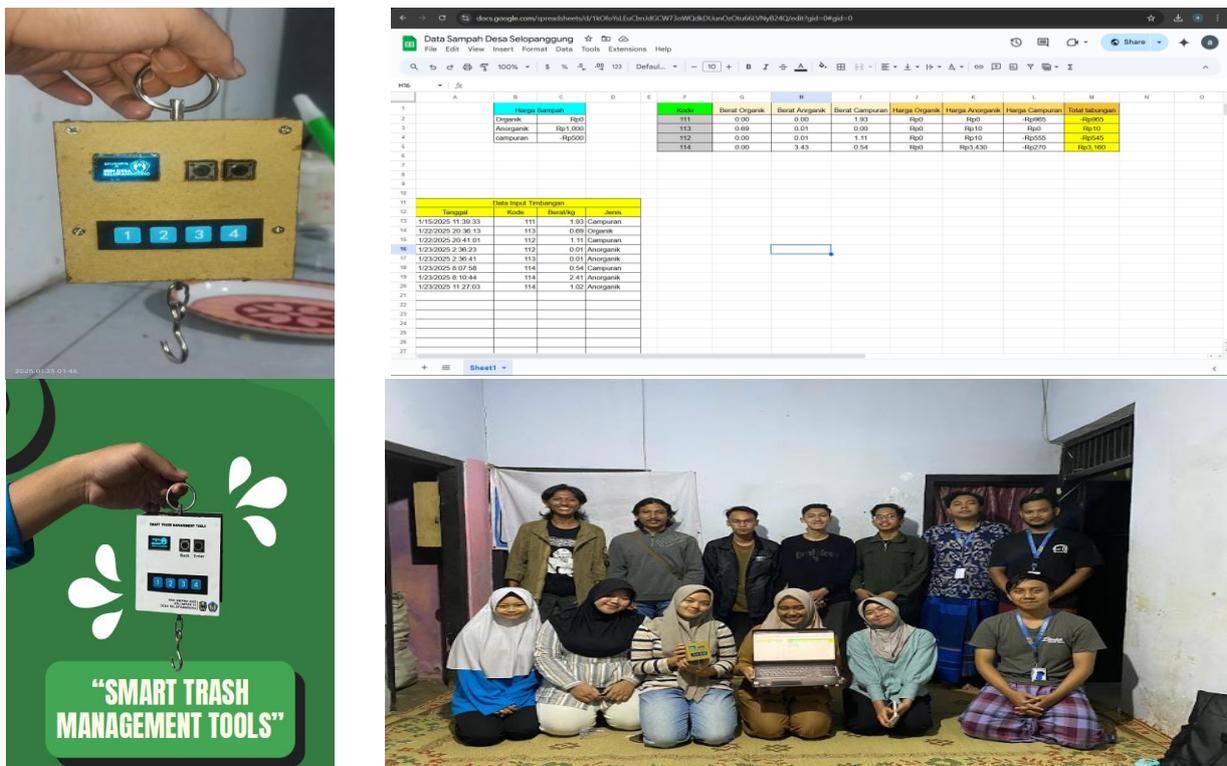

Figure 3. Smart Trash Management Tools and their Display

Smart trash management tools are designed to make it easier for people to weigh their waste independently. These tools are integrated with a web-based/Android-based waste management system, enabling real-time data transmission. Here's how the tool works:

1. Enter unique code

   The user enters the unique code registered in the system.

2. Select waste type

   The user selects the type of waste (organic, inorganic, or other) to be weighed.

3. Weigh waste

   The waste is placed on the scale, and its weight is automatically measured.

4. Send data

The weighing data (date, time, unique code, waste type, and weight) is sent to the waste management system via the internet (WiFi/hotspot).

5. Automatic calculation

The system will calculate the rupiah value based on the type and weight of the waste, and add it to the user's savings account.

There are several main components of smart trash management tools. The ESP32 is used as a microcontroller that regulates the tool's operation and internet connection. The HX711 Loadcell module is used to measure the weight of the waste. A 128x64 OLED display is used to display information such as weight, menus, and instructions. An 18650 battery is used to provide power for the tool. A Type-C charger is used to charge the battery. The Enter, Back, and Number buttons are used for navigation and data input.

The novelty or uniqueness of this Innovation is digital integration, providing information related to savings-based incentives, providing ease of use, and can be used in dual mode (online and offline). This tool is connected to a web/android-based waste management system, enabling real-time and transparent data delivery. The community receives incentives in the form of rupiah savings based on the weight and type of waste weighed, thus encouraging active participation. The interface is simple and easy to understand, equipped with visual guidance on the OLED screen. The tool can operate both in online mode (connected to the internet) and offline (data is stored temporarily).

This innovation has provided a smart waste scale, provided a waste scale that is not too large, provided a waste scale that can provide weight information, provided a waste scale that can provide price information, Provided a waste scale that is integrated with Web/Android. Thus, this innovation has optimized waste management by facilitating the process of weighing, recording, and sending waste data digitally. This innovation has provided Incentive information, namely providing incentives in the form of rupiah savings to the community as a form of appreciation for their participation. This innovation supports the Waste Bank Program, namely being a supporting tool for a more effective and transparent waste bank program.

The Smart Trash Management Tools are already good, but the team feels they still need to be tested and developed, as well as packaged better and more attractively. The Smart Trash Management Tools still need to be tested for reliability, even though a calibration tool is already

available. Reliability testing will be conducted using research. Smart Trash Management Tools still need to be developed, especially in terms of marketing, so that they are accepted by the public. Smart Trash Management Tools will be protected by copyright or patents so that they are safe and cannot be copied carelessly. Smart Trash Management Tools will be packaged better so that they are not easily damaged when dropped.

4. Conclusion

The development of smart trash management tools can improve the quality of waste bank services to customers. Some of the benefits of this innovation are: the community or customers receive financial incentives from waste management, are more motivated to sort and weigh waste independently, increase awareness of the importance of waste management, reduce the volume of unmanaged waste, increase the effectiveness of waste recycling, facilitate monitoring and evaluation of waste management programs, encourage community participation in waste bank programs. For Waste Bank Managers, it accelerates the process of recording and reporting waste data, increases transparency and accountability in waste management.

Smart trash management tools is an innovative digital-based solution to address waste issues at the household level. Integrating IoT technology, savings-based incentives, and a user-friendly interface, this tool is expected to increase community participation in waste management and support a more effective and transparent waste bank program. With funding, this tool will continue to be developed.

5. Acknowledgement

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