Analysis and Design of Waste Management System Using the Spiral Model Towards Smart Cities

N. Tri Suswanto Saptadi
Universitas Atma Jaya Makassar
ntsaptadi@yahoo.com

Phie Chyan
Universitas Atma Jaya Makassar
phie_chyan@lecturer.uajm.ac.id

Andrew Christhoper Pratama
Universitas Atma Jaya Makassar
, andrewchristhoper71@gmail.com

Abstract— IT Governance has provided hope in human life, especially waste management and environmental cleanliness services. The role of IT becomes very important when people want services that are fast, accurate and relevant. Technology using Geographic Information Systems (GIS) has provided opportunities and made it possible to interact easily. The purpose of this research is to provide a GIS for the city environmental and sanitation services in order to provide good services in creating a clean environment. The research method uses the system analysis method with a spiral model approach in system design. The results of the design of GIS have been able to improve the performance of waste management in the city of Makassar.

Keywords—analysis, design, GIS, smart city

I. INTRODUCTION

IT Governance is an effort to guarantee IT management to support and even align with the business strategy of an enterprise carried out by the board of directors, executive management, and also by IT management [1]. IT Governance is a relationship structure and process for managing and controlling a company that aims to achieve the stated goals of the company by adding value while still balancing the risks with the value obtained from the application of IT and its processes. IT Governance Standards are not a separate field from general institutional management, but rather are a component of overall and integrated institutional management, with a focus on main responsibilities, namely: ensuring that stakeholder interests can be included in the preparation of institutional strategies; provide direction to the processes that implement institutional strategies; ensure that the process produces measurable outputs; ensure information about the results obtained and measure it; ensure outputs are generated as expected by stakeholders [2].

The definition or understanding of smart city is very diverse. The concept has been popularly known, but in practice it is used in different countries with different terms and situations to make services more efficient and low cost [3]. There are uses of various types of concepts to replace smart with other adjective terms. Smart city is a vision of urban development to integrate several Information Computer of Technology (ICT) and Internet of Things (IOT) solutions in a secure form for managing city assets [4]. The definition of smart city is so broad that it encompasses a whole range of digital technologies that can improve the quality of life, reduce costs and sources of consumption, and can increase active interactions between cities and their citizens effectively [5].

Smart city is a city that has a new breakthrough in solving problems in the city, and has successfully improved the performance of the city [6]. The development of the concept of smart city brings

understanding in terms of technology. Its application still looks at other aspects that are also needed by a city in general with these aspects considered as a whole that is called a smart city [7].

Waste management regulations have been contained in the Republic of Indonesia Government Regulation Number 81 of 2012 concerning Management of Household Waste and Similar Household [8]. In order to support waste management activities, the minister who carries out government affairs in the field of public works carries out research and development of environmentally friendly technologies in accordance with national policies and strategies in waste management, and facilitates local governments in research and development of environmentally friendly technologies. Provincial, district/city governments are obliged to provide information regarding the management of household and similar household waste. Information on waste management includes: the source of waste, the generation of garbage, the composition of waste, the characteristics of waste, household waste management facilities and similar garbage in household waste; and other information related to household waste management and similar household waste that is needed in the context of waste management.

According to Article 4 of Law No. 18 of 2008, waste management aims to improve public health and environmental quality and make waste a resource [9]. The information is expected to be connected as a network of household waste management information systems and similar household waste that is coordinated by the city government that carries out government affairs in the field of environmental protection and management so that it will later be accessible to the public.

According to nawaris.com, there is a waste management module, namely: Introduction to Waste Management, Policy, Implementation, Compensation, Application of Technology and Information Systems, Community Role, and Coaching. Makassar, the capital of South Sulawesi, has a population of 1,469,601 people. This number is somewhat higher compared to other cities in South Sulawesi such as Bone which only has a population of 746,973 people, followed by the Gowa Region as much as 735,493 people (Makassar Statistics Agency, 2016). With the large number of residents in Makassar directly proportional to the amount of waste generated per day, the total amount of waste that enters the Tamanagappa Final Disposal Site is around 1200 tons per day [10]

Geographic information system (GIS) is an information system created based on spatial and non-spatial data based on spatial [11] and can be used in decision making [12]. In GIS the process of providing information starts from storing, manipulating and analyzing geographic information based on location [13]. GIS can also conduct statistical analysis based on spatial information in a map, so that GIS is widely used by industry and government [14].

The study was conducted to obtain answers to the following questions:
1. Does the design with a spiral model can build a waste management system?
2. Can the Geographic Information System approach help the community in finding information about waste management?
3. Can the system monitor the performance of waste management in every district in Makassar?

The research aims to build a waste management system that can help the government in knowing the performance of waste management and the community in obtaining information.

The waste management system that is built based on the Geographic Information System is expected to help the government and the community to create a clean, healthy and safe environment in order to reach a smart city.

II. METHOD

Research is conducted through the stages of analysis and design. The analysis phase involves the following steps [15]:

1. Determine the need for a system to assist a business process
2. Define that system's goals
3. Gather business requirements

4. Convert business requirements to system requirements
5. Design the database and accompanying applications
6. Build, test, and implement the database and applications.

For System Design using the Spiral model with the following steps [16]:

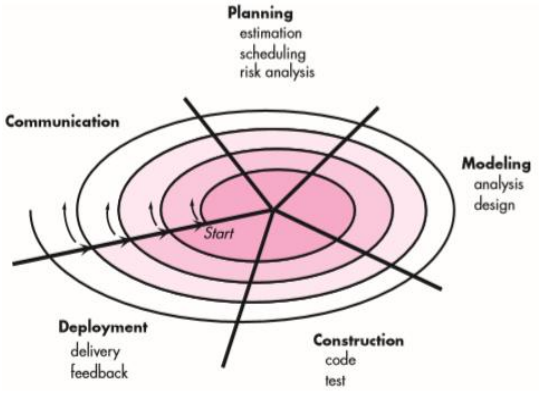

Figure 1. Spiral Model

III. RESULTS AND DISCUSSION

The study consisted of two main stages, namely: system analysis and design.

A. System Analysis

1) Determine the need for a system to assist a business process

The results of interviews with the environmental services show the need for system services in the form of geographic information systems that can support the performance of official services.

2) Define that system's goals

Provide a geographic information system that can improve services to the community and the performance of the Office of Environment and Hygiene in Makassar.

3) Gather business requirements

To be able to perform services, it requires government, community and waste officials who are able to reach and service waste transportation to maintain environmental cleanliness.

4) Convert business requirements to system requirements

To meet the system requirements, hardware, software and human resources are needed to spoil the system.

5) Design the database and accompanying applications

This system is made using PHP programming and MYSQL database. The tool used is the Google Maps Application Programming Interface (API) that supports the availability of human resources and network infrastructure.

6) Build, test, and implement the database and applications

System development is carried out in consultation with the environmental and sanitation department to obtain input. It also communicates with potential community users of the system by creating a system model that is easy to understand and can be used. Before it is implemented, the system is tested several times to find out the errors that can occur. After that the system was assessed for eligibility for use. System users are given the opportunity to fill through the resulting system.

B. System Designing

1) Communication

To create a system that is in accordance with the needs, the construction of the system is based on communication that occurs between the government and the community.

The communication that was built came from the city government, environmental services, officers and the community.

2) Planning

The Planning Phase uses GIS in Makassar through observation and interviews by looking at the work process from the sub-district to the Environmental Department. To find out the needs of two different agencies, an interview is needed. The results of this system planning are expected to provide information and images that can help the Smart City Makassar program and can provide direct information to the public regarding information about waste management in the city of Makassar.

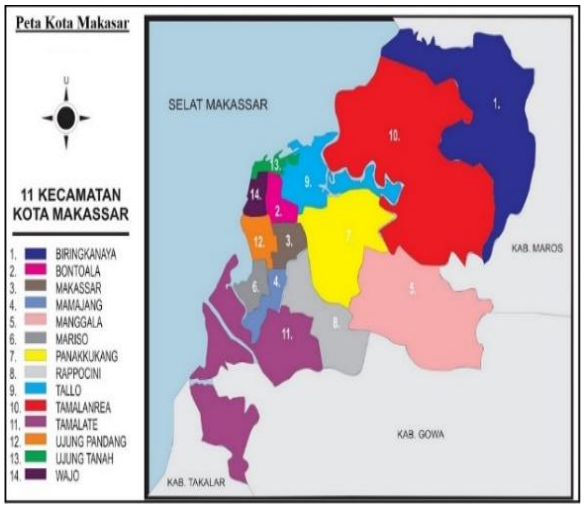

Figure 2. Makassar City Map

The research obtained data and analyzed some data that had been used to determine the needs in developing GIS-based governance. Where this system displays garbage data that has been previously entered by service officers into the system and then the data is processed for later display. The public can see directly the results of waste processing that takes place in the field in addition to being useful to the community this data can also be reused by the sanitation office to further optimize the performance of officers.

3) Modeling

Based on the results of the interview, the next stage is to design the development of the system created. The design starts by making a context diagram.

Context diagram consists of entities that have the task of managing data through the data flow. Every data flowing in a process comes from data sources in the storage media on a computer system.

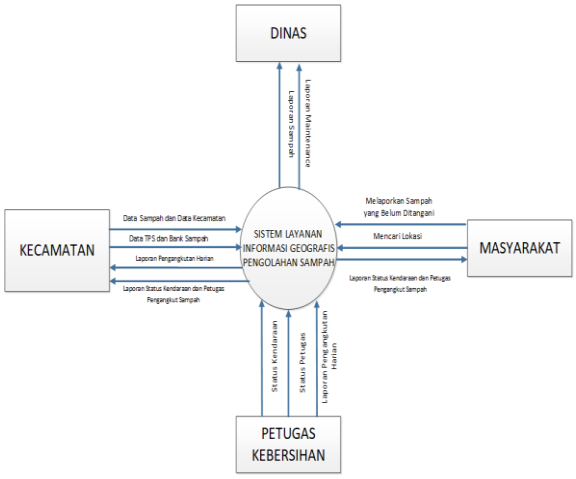

Figure 3. Context Diagram

Based on the context diagram, it can be seen that GIS for waste processing consists of 4 entities namely the Office of the Environment, Districts in Makassar city, Sanitation Officers, and Makassar City Communities. Admin comes from the district where inputting data such as subdistrict data and garbage data are stored in the database. Janitors input data such as the number of daily garbage transport reports, the status of the vehicle used to the status of workers in the field.

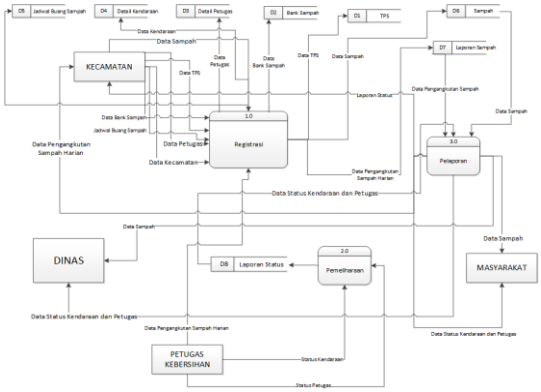

Figure 4. Level 0 Diagram

The Department of Environment and the people of Makassar City can see the results of reports from the two previous entities. The Office of the Environment can directly monitor the performance of officers from each sub-district to the status of the vehicle. The public can see waste information on the city of Makassar. The level diagram in Figure 4 shows the relationships that occur between entities, processes, and data storage needed.

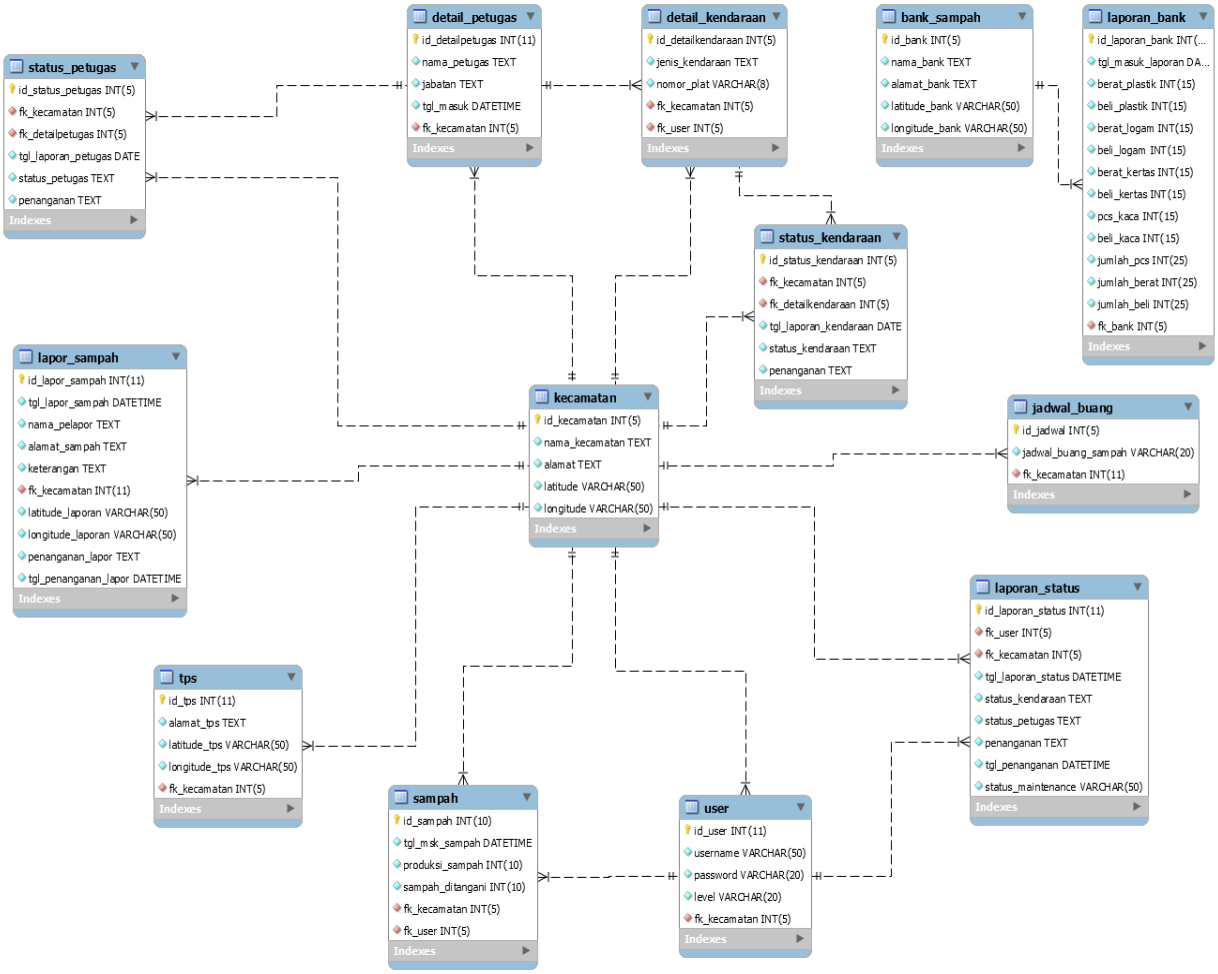

Figure 5. ER-Diagram

Figure 5 shows the ER-Diagram with 13 tables. The subdistrict table is a source of transactions for other tables and thus requires sufficient data support in order to provide accurate information.

ER-Diagram consists of sub-district tables, garbage banks, tps, users, vehicles, disposal schedules, vehicle status and officer status, as well as vehicle details and officer details.

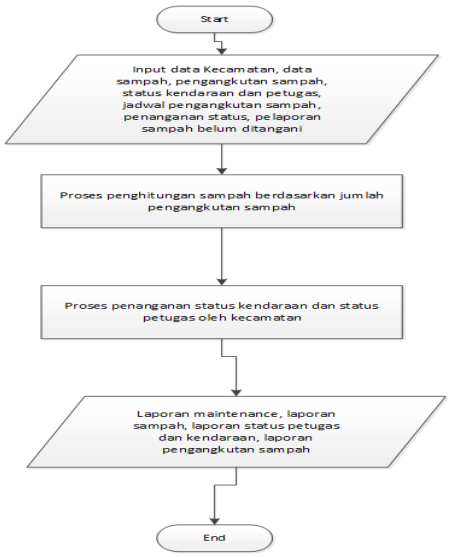

Figure 6. Flowchart

Figure 6 shows a system flowchart which explains that officials enter District data in the form of landfills, garbage banks, officer

details, vehicle details. Then, it continues the process of calculating the results of transportation of garbage that has been previously entered by the janitor to count. The process of handling the status by sub-district officials is in the form of vehicle status and personnel pre-filled by cleaning staff. Then the final filling is the process of making a system report in the form of maintenance, garbage, officer status and vehicle status, as well as waste transportation reports.

4) Construction

The Construction Stages start by building a system interface to facilitate user interaction with the system. The following structure diagram in the waste treatment system.

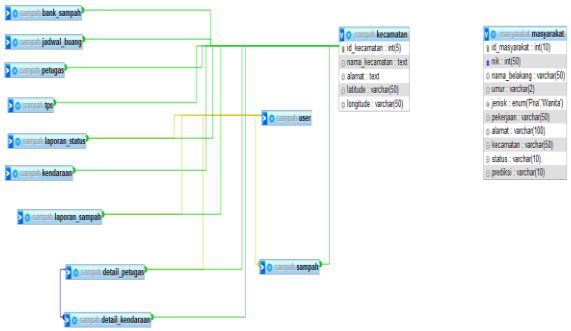

Figure 7. Structured Diagram

To be able to use the system, it is needed to log in to the system. Users need to have a user and password to enter the system as shown in Figure 8 below.

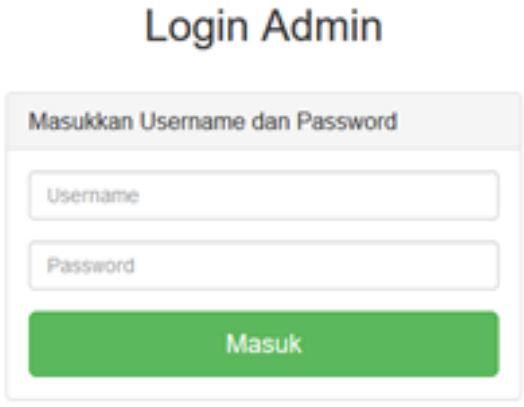

Figure 8. Login

Based on the results of the interview, the next stage carried out by the author is to design the development of the system created.

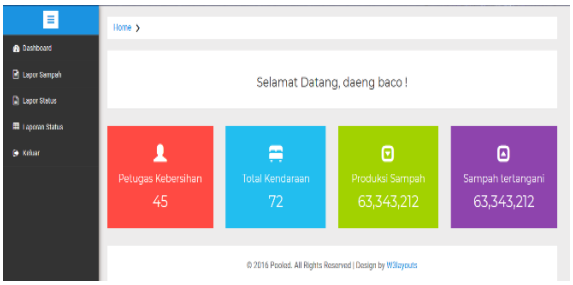

Figure 9. The page for the Janitor Admin

Figure 9 shows the appearance of the janitor admin page that contains the number of janitors, total vehicles, waste production, and garbage handled.

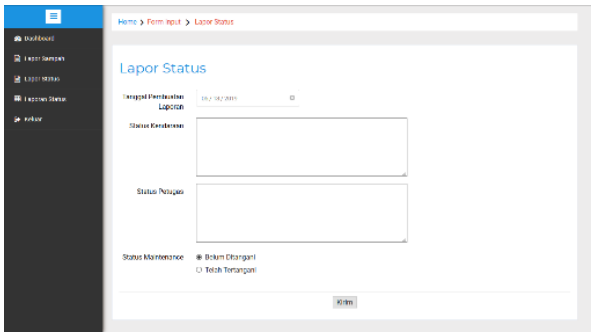

Figure 10. Officer Status Report

Figure 10 shows the form for filling vehicle status, personnel, and maintenance status as a report.

```
{
 date_default_timezone_set("Asia/Makassar");
 $title = "Admin";
include "koneksi.php";
if (isset($_POST['btnkirim']))
{
$tanggal = date("Y-m-d");
$status_petugas = $_POST['status_petugas'];
$penanganan = $_POST['penanganan'];
$petugas = $_POST['petugas'];
$sql = "INSERT INTO status_petugas VALUES
('','$kecamatan','$petugas','$tanggal','$status_petugas','$penanganan')";
if(mysqli_query($koneksi, $sql)){
        header("Location: lapor_status_petugas.php");
    }else{
        echo mysqli_error($koneksi);
    }
}
```

Figure 11. Script Officer Status Report

Figure 11 shows the program script about the officer status report created with the PHP program.

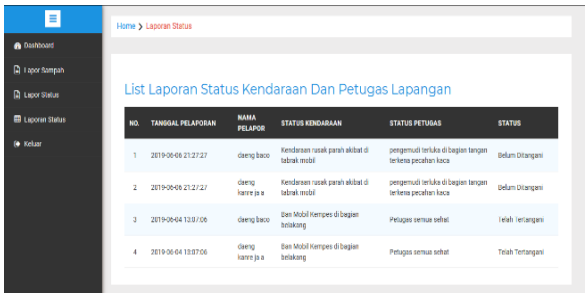

Figure 12. Status Report List

Figure 12 shows a list of vehicle and field officer status reports that are useful for knowing the date, time, and name of the officer.

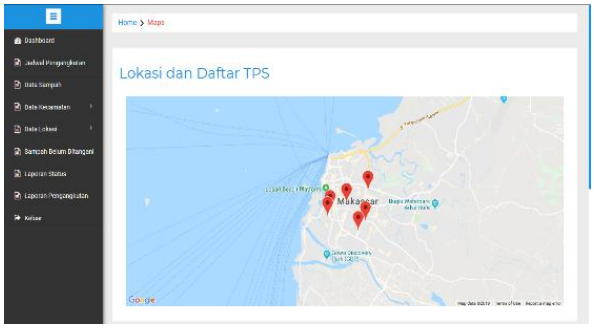

Figure 13. Location and List of Sub-District Landfills

Figure 13 shows the location and list of the District Garbage Disposal Sites in the city of Makassar. The number of sub-districts is 14 and spread in various regions.

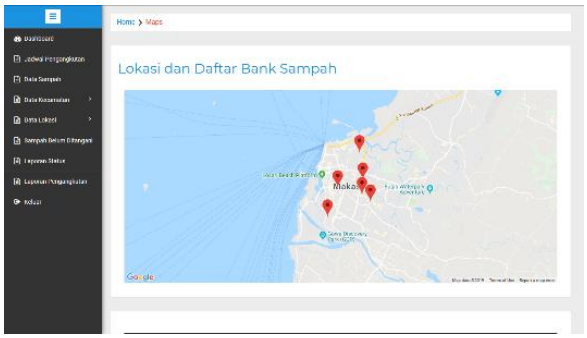

Figure 14. Location and District Garbage Bank

Figure 14 shows the location and waste bank located in each district in the city of Makassar. The location of the waste bank is needed so that people know the right location to facilitate the management of waste around the house. Easy and affordable access will have the opportunity to create environmental cleanliness that makes the community healthy.

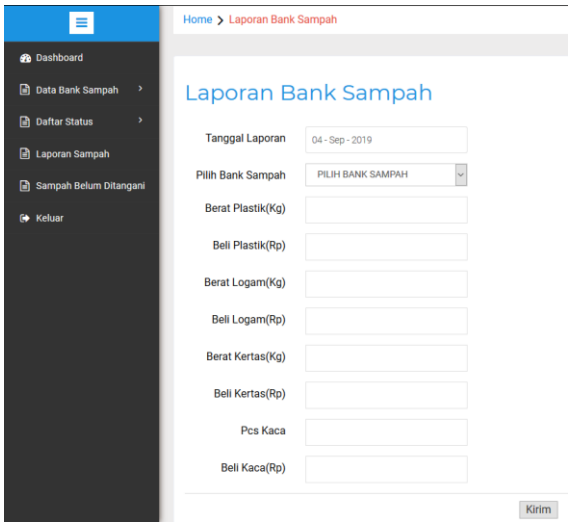

Figure 15. Garbage Bank Report

Figure 15 shows a garbage bank report containing types of waste such as metal, plastic, paper and glass. This report is filled out by officers or the public and then sent into the system.

Figure 16. District Details

Figure 16 shows the community who wanted to obtain complete information on names, addresses, transportation schedules for the sub-district, waste production, transport vehicles, and the number of officers in the sub-district.

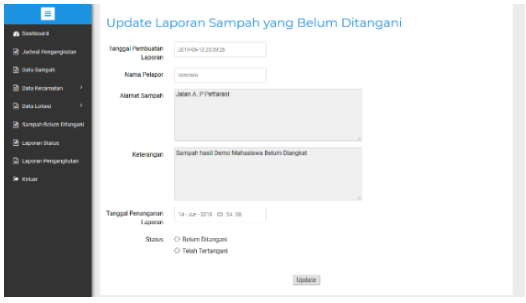

Figure 17. Waste Handling Reports Not Yet Treated

Figure 17 shows the garbage report that has not been handled by the community to officials so that it can be transported by vehicle.

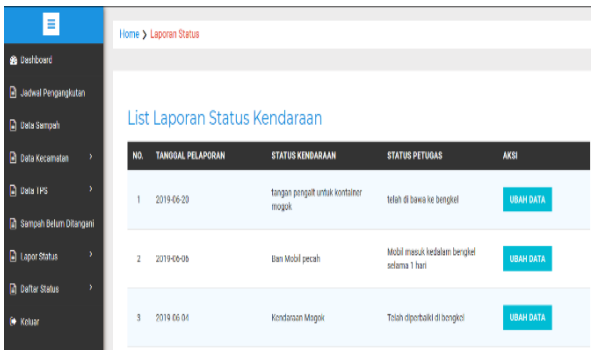

Figure 18. List of Vehicle Status Reports

Figure 18 shows a list of vehicle status reports that are transporting waste. It is hoped that the information of vehicles that are available and ready to operate will help the community in bringing waste to landfills.

Testing is done by the Black Box method to find out the truth of the GIS by finding fault loopholes whether in the form of coding, design or database. The test focuses on the functional requirements of the system with the aim to find errors of function errors, interface errors, data structure errors, or other performance errors.

Testing input data includes: admin login, district admin system, environmental office admin system, community system. The results showed 90% of respondents agreed that this application could be used.

5) Deployment

This stage has resulted in the deployment of GIS which will be carried out during the construction phase. Smart city governance contributes to develop program for mapping and reporting waste that has been made in accordance with what is needed such as features and user interface programs. This stage uses a web browser. A system demonstration was conducted in front of several respondents to get a response back from the respondents. The results of system demonstrations and simulations of respondents indicate that:

1) The system has produced a service system that helps officers and the community.
2) System users are more enthusiastic about the report features, such as reporting waste that has not been handled up to vehicle and officer status reporting.

Existing features have been used by respondents and in accordance with the needs of respondents.

IV. CONCLUSION

The development of GIS-based smart city governance can be concluded as follows:

1. The spiral model can help in designing waste treatment systems for government and community needs.
2. GIS has been able to help the public find out information about the process of waste management and distribution in the city of Makassar to make the public more aware of the ongoing waste management.
3. Makassar city Government through this system can monitor the performance of waste management that takes place in every district of Makassar city so that it can maximize the performance of officers and can support the smart city program of the Makassar city Government.

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REFERENCES

[1] Surendro, "Utilization of Enterprise Architecture Planning for Strategic Planning of Information Systems," Journal of Information 8 (1), pp. 1-9, 2009

[2] Petruru Raj, Anupama C. Raman, "Intellegent Cities: Enabling Tools and Technology," Auerbach Publications. CRC Press. Francis, 2015

[3] Mike Barlow, "Smart Cities Smarter Citizens," USA, 2015

[4] Carol L, Stimmel, "Building Smart Cities: Analytics, ICT, and Design Thinking," Auerbach Publications. CRC Press. Francis As, 2015

[5] Chandra, "Smart City Development Strategies and Challenges for Urban Communities," Journal of Strategy and Business Vol. 4, No. 2, 2016
[6] Widyaningsih, "Jakarta Smart City Website User Review of Community Trust in the Provincial Government of DKI Jakarta," Jakarta, 2013
[7] Manuel Pedro Rodríguez-Bolívar. "Transforming City Governments for Successful Smart Cities," San Antonio, Texas, USA, 2015
[8] Republic of Indonesia Government Regulation Number 81 Year 2012 concerning Management of Household Waste and Similar Household Waste
[9] Article 4 of Law Number 18 of 2008, Waste management
[10] Head of Makassar Environment Agency, 2017
[11] U. Ependi, "Geographic Information System of High School Distribution in Palembang City Based on Web," in the National Seminar on Innovation and Trends (SNIT), Kaliabang, 2014
[12] R. Arismunandar, "Geographic Information Systems as a Monitoring Tool for PT Bayer Indonesia Cooperation Pharmacy," TEKNOSI Journal, volume 3, number 1, pp. 187-198, 2017
[13] K. I. Santoso and M. N. Rais, "Implementation of the Android-Based Geographical Information System for Tourism in the Temanggung Regency with a Global Positioning System (GPS)," Scientific Journal of Informatics, volume. 2, number 1, pp. 29-40, 2015
[14] H. Suryamen, I. Aminuddin and F. Akbar, "Web-Based Geographic Information System Design in Padang City," Journal of TEKNOSI, volume 2, number 1, pp. 45-54, 2016
[15] Langer Arthur, "Analysis and Design of Information Systems," Columbia University, New York. USA, 2008
[16] Pressman, Roger S., "Software Engineering: a practitioner's approach," 7th ed, The McGraw-Hill Companies, New York. USA, 2010