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## Implementation of spatial smart waste management system in Malaysia

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**Abstract.** One of the challenges to innovate and create an IoT-enabled solution is in monitoring and management of the environment. Waste collection utilizing the Internet of Things (IoT) with the technology of smart wireless sensors will able to gather fill-level data from waste containers hence providing a waste monitoring solution that brings up savings in waste collection costs. One of the challenges to the local authority is how to monitor the works of contractor effective and efficiently in waste management. This paper will propose to the local authority the implementation of smart waste management in Malaysia to improve the city management and to provide better services to the public towards smart city applications.

### 1. Introduction

One of the challenges to innovate and create an IoT-enabled solution is in monitoring and management of the environment. Effective management of solid wastes is one of the prerequisites for Malaysia to achieve a developed country status. It is generally recognized that there is a strong relationship between the effective management of solid wastes and a good quality of life and a healthy environment. The attractiveness of the country to foreign visitors and investments is very much influenced by a clean and healthy environment. By 2030, almost two-thirds of the world's population will be living in cities. This requires the development of sustainable solutions for urban living. These trends support the development of Smart City concepts, which are intended to improve living in urban areas by using innovative technologies. The "Internet of Things" provides new opportunities for making cities smarter.

National Space Agency Malaysia (ANGKASA) under Ministry Of Science Technology, Innovation Malaysia (MOSTI) taking an initiative to developed Smart Waste Management System (SWMS). SWMS is one of the modules developed in Spatial Smart City Service Delivery Engine (SSCSDE) Project funded by Mosti under Technofund grant. The Objective of the project is to develop a spatial service delivery engine that are capable of exploiting the smart (geospatial) technologies to support city operations which includes managing, using, and exploring spatial data with scientific analysis in all possible phases of the decision making process in the organization.

The reason and idea for choosing SWMS as one of the development module is to monitor the environment by enforcement. Local authority always have difficulty to monitor the job done by waste collection services provider. Contractor doing waste collection services seems doing collection not follow the schedule as per agreed in contract. Hence SWMS will act as automatic enforcement system to penalize the contractor who break the contract. This solution not only help local authority to monitor the contractor, it's also brings information of garbage container status and report automatically when it's full. This valuable information can be used by local authority for monitoring purpose and enforcement. For waste collection contractor this information provide alerts on the status



of containers in terms of fill levels in order to optimize collection routes based on historical and real-time information hence save operation cost. For joint management body who in charge of the waste chamber in resident area can know the status of waste of each chamber and keep it clean. And for citizen there is no more waste issue complaint. The proposed SWMS had been operated as a pilot project in two places for pilot study area which is Cyberjaya in Sepang District and Bandar Saujana Putra, Taman Langat Murni in Kuala Langat District in Selangor, Malaysia.

The rest of this paper is organized as follow. Section 2 describes the case study for SWMS, Section 3 details the architecture of the SWMS consist of conceptual system design, conceptual workflow, web application and hardware structure. Section 4 elaborate further spatial elements of SWMS. Section 5 show the implementation of the SWMS in Sepang and Kuala Langat District and the operation result. Finally, some concluding remarks and direction for future work are given in Section 6.

## 2. Case Study for Smart Waste Management System

### 2.1. Enevo

Enevo one is a comprehensive logistics solution that saves time, money and the environment. It uses wireless sensors to measure and forecast the fill-level of waste containers and generates smart collection plans using the most efficient schedules and routes. The solution provides up to 50% in direct cost savings. Receive automatically generated schedules and optimised routes which take into account an extensive set of parameters future fill level projections, truck availability, traffic information, road restrictions, container and content types the vehicle can collect etc. New schedules and routes are planned not only looking at the current situation, but considering the future outlook as well. Enevo using WSN and Ultrasound sensor for measuring the fill level of waste container [1].

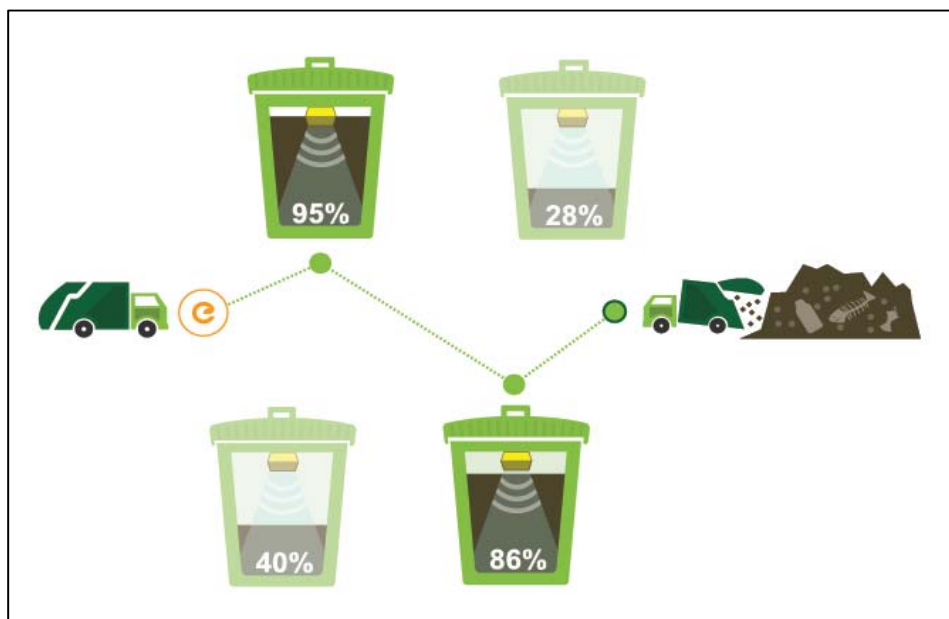


Figure 1. Enevo system architecture.

### 2.2. SENSdumprster filling level monitoring

SENSdumprster is an innovative device that monitors the filling level of a dumpster. SENSdumprster works with any kind of waste and fits to any type of dumpster. It makes use of a volumetric sensor that provides information of the level of filing of a dumpsters. SENSdumprster can be applied to any kind of waste, and a temperature sensor is able to detect significant temperature increases that may result in fire. SENSdumprster is a fully ZigBee wireless device that can be integrated to any ZigBee network deployment within the smart-city [2].

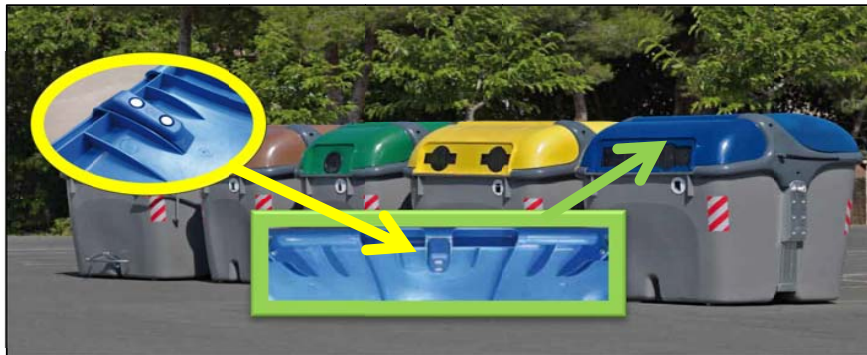


Figure 2. SENSdumprster wireless device to monitor filling level of a dumpster.

### 3. Smart Waste Management System Architecture

The SWMS can help local authority in decision making for future waste collection schedule. The waste collection regularity can be monitored, analysed, and rescheduled based on the waste level in garbage containers. The collection schedule for area with high regularity of full garbage container can reschedule to be more often. By using sensor technology in waste collection can help to reduce the operation time for waste collection process. This sensor can detect the level of garbage in garbage bin.

#### 3.1. Conceptual system design

GSM modules are used for communication for SWMS. GSM can be used to transmit data from the sensor to the local server. The sensors need to be equipped with the GSM module including the SIM card and need to subscribe mobile data packets. The coverage network depends to the providers like Celcom, Maxis, Digi, Red One, U mobile Altel and Tunetalk. Figure 3 show the concept GSM for Smart Waste Management.

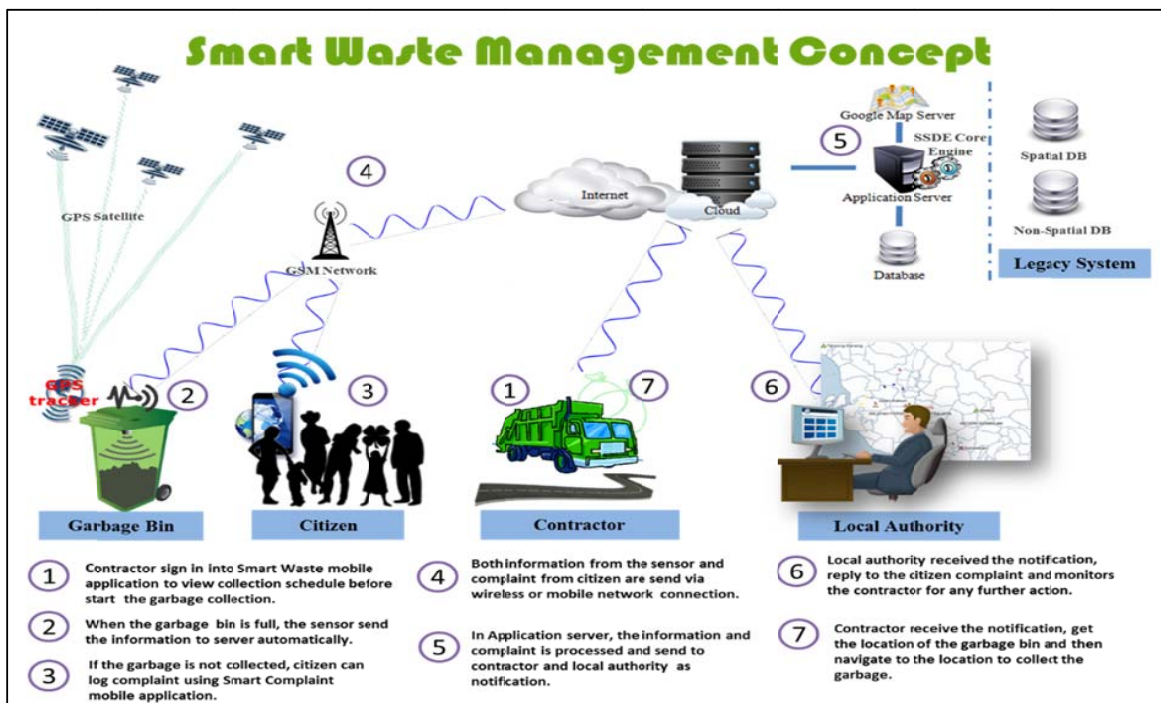


Figure 3. SWMS concept by GSM communication.

3.2. Conceptual workflow

There are three main actors in the work flow of SWMS consist of local authority, waste collection contractor and citizen. The first actor is the local authority who is responsible to add, register and view data sensor. The local authority also responsible to register, update and view contractor moreover the first actor will view and update waste schedule plus view and response to the complaints. The second actor is the waste collection contractor who is responsible to pick up waste based on the indicator appear on the map. This actor will response each of the status of bin in their job scope. The final actor is citizen who will give the feedback by fill in the complaint form online. Figure 4. Shows the overall work flow diagram of SWMS between the three main actors and Table 1 summarised function of each actor.

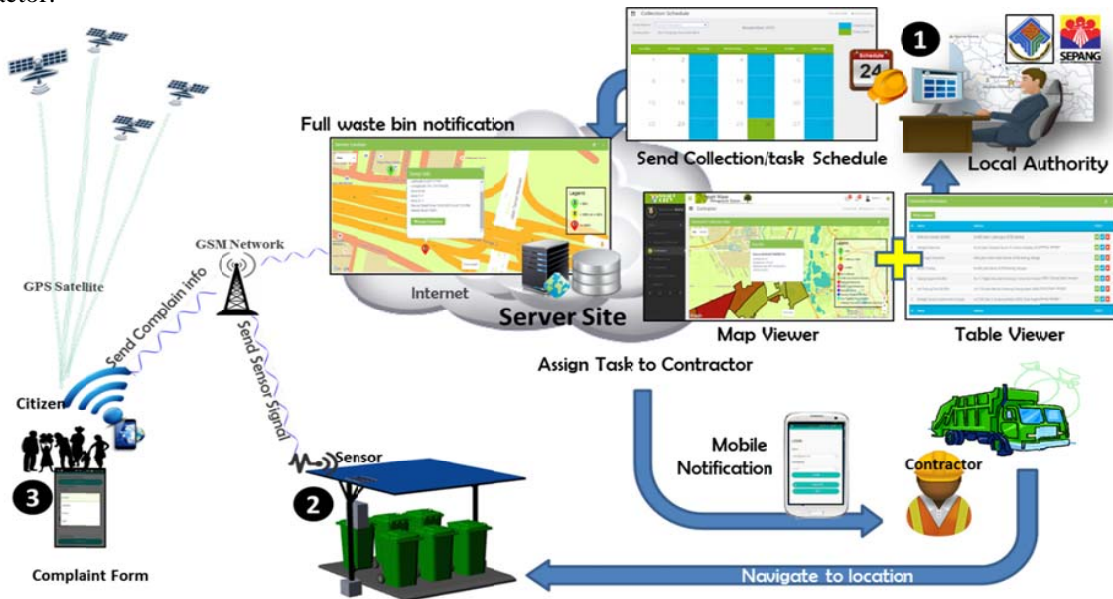


Figure 4. Work flow diagram of SWMS.

Table 1. Summary of the function of each actor.

No.	Module & Sub module	Functions
1	Web module	
	1. Sensor Management	<ul style="list-style-type: none"> <li>View data from sensor</li> <li>Register new sensor</li> <li>Delete sensor</li> <li>Assign contractor -&gt; Notify contractor</li> </ul>
	2. Contractor Management	<ul style="list-style-type: none"> <li>View contractor list</li> <li>Register new contractor</li> <li>Update contractor information</li> <li>Delete contractor</li> </ul>
	3. Waste Collecting Schedule Management	<ul style="list-style-type: none"> <li>View waste collecting schedule</li> <li>Update waste collecting schedule</li> <li>Delete waste collecting schedule</li> </ul>
	4. Complaint Management	<ul style="list-style-type: none"> <li>View complaint list</li> <li>Create task</li> <li>Assign enforcer -&gt; Notify enforcer -&gt; Verify complaint</li> <li>Assign contractor -&gt; Notify contractor -&gt; Valid complaint</li> <li>Response to the complaint</li> </ul>
2	Mobile_apps_module	



	1. Complaint	<ul style="list-style-type: none"> <li>• File a complaint</li> <li>• View response of their complaint</li> </ul>
3	Back end module 1. Smart Waste API	<ul style="list-style-type: none"> <li>• Manage request from Web and Mobile app module - &gt; read and write smart waste data</li> </ul>

### 3.3 Web Application

The web application for SWMS consist of web browser, mobile browser and mobile apps as shown in Figure 5. Interface response towards the device resolution. The method used to design and develop Core Smart City application is called Device Agnostic Solution. This is to address the increasing number of people browsing information over the web with difference devices, viewer resolutions and browsers. Device Agnostic Solution is suitable for most devices (ideally all devices) and be responsive nevertheless. These responsive designs which strictly obey the device-agnostic approach, without any doubt present the content in the best possible manner that is appropriate for the device on the screen.

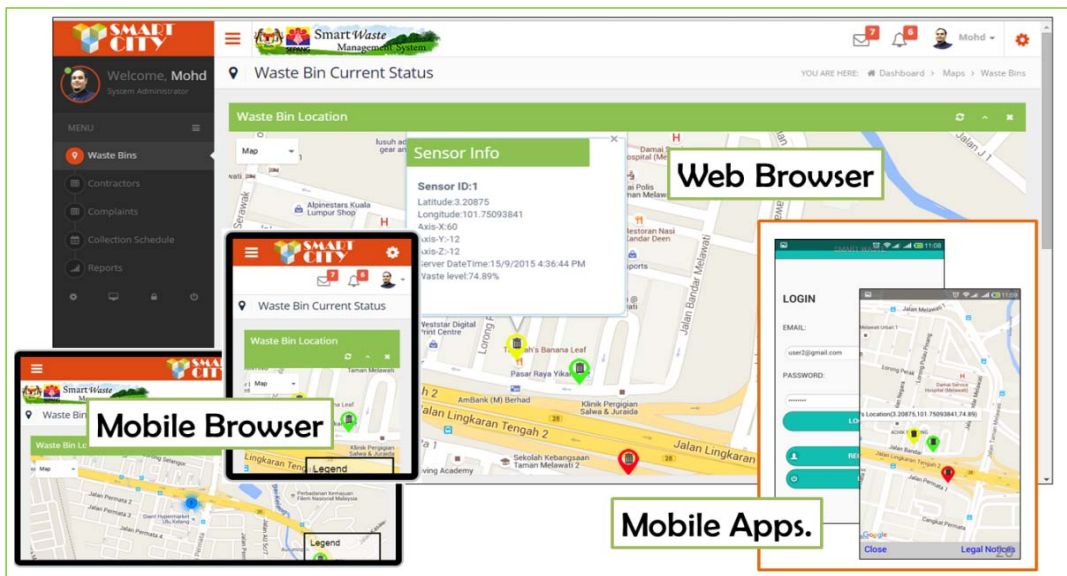


Figure 5. Web application for SWMS.

### 3.4 Hardware

The hardware involve during the development as shown in Figure 6. Three type of platform is been used which is waspmote [3], myrio and arduino. The platform powered by solar panel.

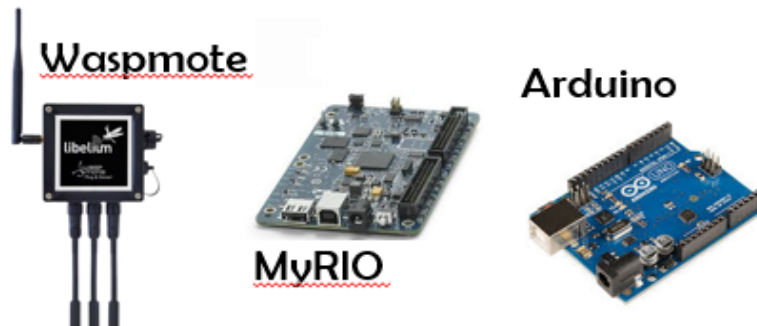
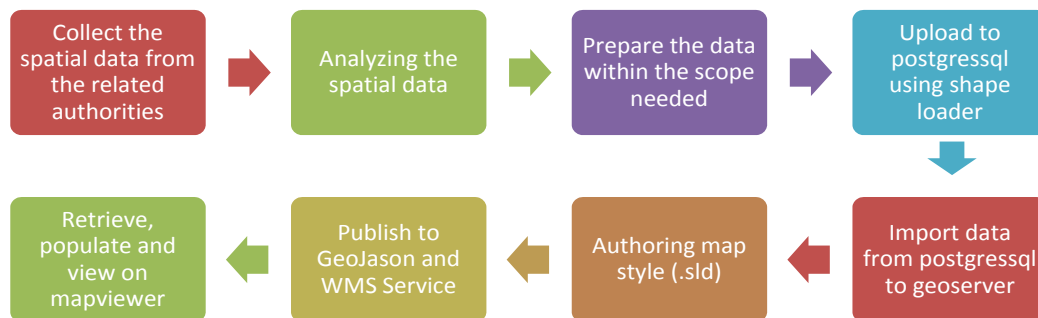


Figure 6. Hardware used for SWMS.

#### 4. Smart Waste Management System Spatial Elements

The scope of work for proposed SWMS GIS spatial data is to provide geo-location of authority boundary area, contractor maintenance area and waste bin location. Figure 7 summarised the methodology stages of spatial data process.



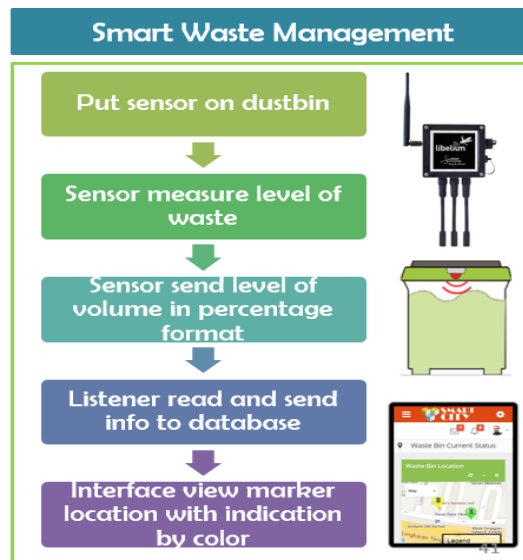
**Figure 7.** Methodology for spatial data process.

- i. Collect the Spatial Data: The data will be gather by meeting with related authorities, which is Majlis Perbandaran or Majlis Bandaraya for each selected area according to their Smart City GIS System proposed category.
- ii. Analysing the Spatial Data: Once receive the spatial data, the data will be analyse using certain GIS software's to make sure all data is in good condition and search for any issues related to the data.
- iii. Solve the Issues Occurred: After finish analysing and acquire the outcome results, some recommendations and solutions are suggested to overcome the issues.
- iv. Prepare the Data within the Scope Needed: After the data is corrected, the spatial data will be prepared according to each category of Smart City GIS System for each selected authorities.

#### 5. System Implementation

##### 5.1. Ultrasonic wireless sensor

Ultrasonic sensor measures the distance between the sensor and the waste inside the container and sends its information through the cellular network directly to the server. In the server the data is processed and transformed into useful information. The filling percentage of the container is estimated based on the latest measurements produced by the sensor. The information is been processed and the result is appear on the web application. There is criteria of sensor selection for ultrasound sensor. The sensor can continuously measure the fill level, the sensor work with any type of bin materials and the sensor able to measure without physical contact with materials. Figure 8 shows how the sensor works.



**Figure 8.** SWMS implementation.

There are four level indicator for waste bin level:

1. Green: less than 50%
2. Yellow: less than 100% and more than 50%
3. Red: more than 100%



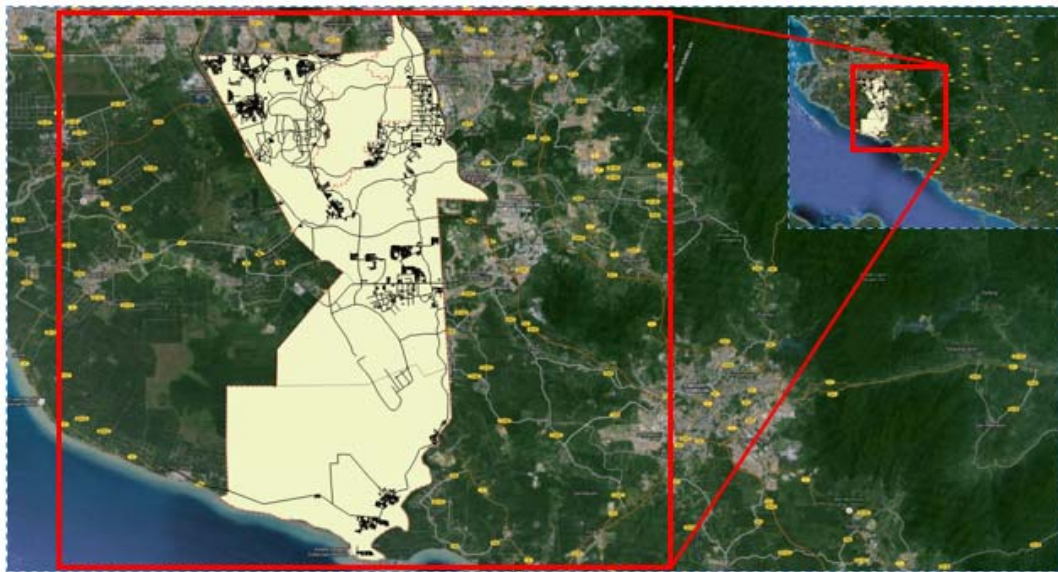
**Figure 9.** Ultrasonic fill level sensor.

A typical concept for Smart Waste Management has been concluded that the system will use ultrasound sensor and GSM network as tool to measure and transmit sensor data to the server. It will take time to find a total solution for SWM instrumental, in Malaysia does not have a ready-made instrument that can use in the system. There are two vendor has being selected that are Libelium and Visi. Libelium is the Internet of Things platform provider based in Zaragoza, Spain. Libelium delivers a powerful, modular, easy to program open source sensor platform for the Internet of Things enabling system integrators to implement reliable Smart Cities and M2M solutions with minimum time to market.

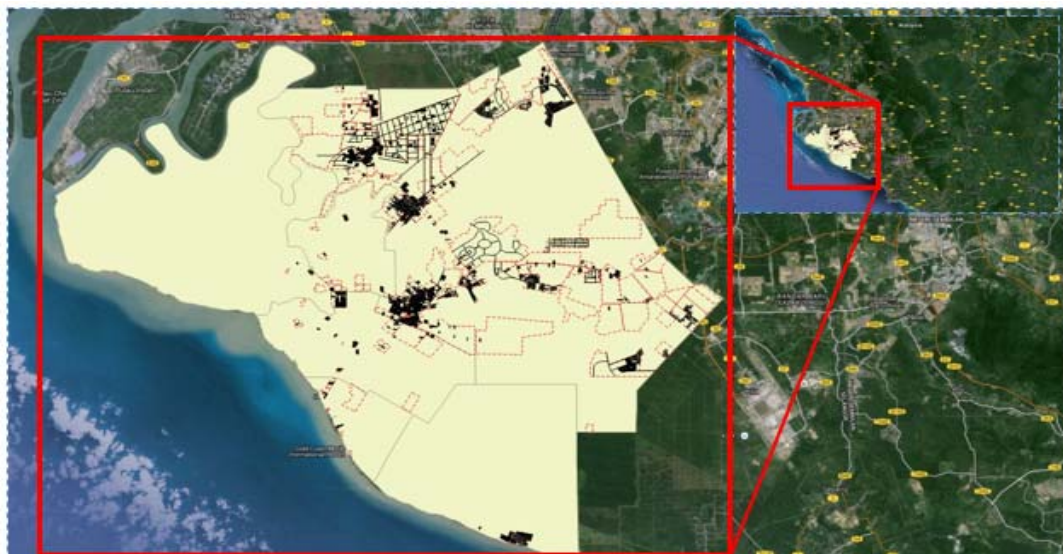


### 5.2 Pilot area

MP Sepang and MD Kuala Langat was selected as pilot test for SWM. Site visit was carried out to obtain the current condition and information regarding the waste container that includes detailed information such as location, type, size, materials, the capacity and the surrounding area. Discussion with Local Authority has conducted with MP Sepang and MD Kuala Langat respectively. Local Authority has suggested to plant level sensor on waste container MGB 660 litre type. Because this MGB 660 litre are commonly used in Apartment area and also withstand rugged conditions, light and inexpensive. Figure 9 and 10 shown the area that had been chosen for the pilot study of Smart City GIS System on Smart Waste Management are located at the area within MPS and MDKL authority.



**Figure 10.** District of Sepang, Majlis Perbandaran Sepang [4].



**Figure 11.** District of Kuala Langat, Majlis Daerah Kuala Langat [5].

## 6. Conclusion and Future Work

The objective of SWMS is to value-add existing Solid Waste Management process for waste management under local authorities, to help in decision making for waste management process, to ensure the contractors follow the work procedure, and to improved waste collection services delivery which comes under the responsibility of local authority. In this study, MPS and MDKL waste management monitoring process was reviewed. By manipulating geospatial technology and intelligence sensor such as ultrasonic sensors via IoT technology, SWMS application has provided the waste collection operator with a platform to work in real-time mode to improve the service by optimizing operation time and cost. SWMS application as a tools for local authority to monitor waste collection operator to ensure waste collection services is deliver accordingly as per contract. The impact of SWMS to resident, residents associations and joint management body is direct when the environment is now clean and give a healthier life.

Nevertheless, the proposed SWMS requires more maintenance cost than the existing system. There is a need to make it a sustainable which is the development cost is acceptable to implement in local authority. The most important issue is how to deliver to local authority with competitive price and less maintenance cost. With the current system, the implementation only limited for apartment and condominium which the sensor device put on top of the big garbage bin inside of apartment waste chamber. In the future, small IoT gadget for waste monitoring can be develop and put inside the waste chamber in front of each terrace house and bungalow to widening the implementation to the citizen.

## Acknowledgement

The authors would like to thank to Ministry of Science, Technology, and Innovation Malaysia (MOSTI) for funding the project. Thank to Sepang Municipal Council and Kuala Langat Municipal Council (MPS & MDKL) for the support given in providing information of the existing solid waste management process and platform to conduct the integration of modules and verification for the SWMS prototype. Thank to Cyber Heights Villa, Mutiara Ville Cyberjaya, Bandar Saujana Putra Joint Management Body and Taman Langat Murni Residents Association to allowed installation of sensor in their residents area.

## References

- [1] Enevo. (2015). Enevo ONE Waste Collection for Smart Cities.
- [2] Sensor, S. (2014). Dumpster Smart lling level monitoring.
- [3] Libelium. (2015b). Smart Metering 2.0 Technical Guide, 4.9. Retrieved from [http://www.gedigitalenergy.com/smartmetering/catalog/SGM3000\\_Residential.htm#sgm3000tab5](http://www.gedigitalenergy.com/smartmetering/catalog/SGM3000_Residential.htm#sgm3000tab5)
- [4] Portal Rasmi Majlis Perbandaran Sepang; (n.d.-b). Retrieved May 7, 2015, from <http://www.mpsepang.gov.my/peta-daerah-sepang>
- [5] Portal Rasmi Pejabat Daerah / Tanah Kuala Langat Peta - Peta Daerah Kuala Langat. (n.d.). Retrieved May 7, 2015, from <http://www.selangor.gov.my/kualalangat.php/pages/view/186>

## Nomenclature

SWMS:	Smart Waste Management System.
SSCSDE:	Spatial Smart City Service Delivery Engine.
GSM:	Global System Mobile Communication.
ANGKASA:	National Space Agency of Malaysia.
MOSTI:	Ministry of Science, Technology & Innovation Malaysia.
MPS:	Sepang Municipal Council.
MDKL:	Kuala Langat Municipal Council.
MGB:	Mobile Garbage bin
GIS:	Geographic Information System
M2M:	Machine to Machine
IoT:	Internet of Thing