Managing sewage treatment facilities using geographical information system application: a user requirement analysis in state of Penang, Malaysia

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Abstract. Rapid development of economy in Malaysia and the large city scale expansion has led to increase in number of domestic sewage and industrial water waste. In managing sewage treatment facilities, Indah Water Konsortium Sdn Bhd (IWK) has developed the Integrated Geographical Information System (IGIS) to help them in decision making process. The face to face interview method with IGIS users has been used in getting the feedback on examining the main attribute data needed and then analyze it by using content analysis. It is conducted by updating the required attribute data into the IGIS application and removing unrelated attributes. In addition, the spatial information that can help to improve the IGIS application also be included in new version. Based on the findings of this paper, the improvement of this information will help the IWK to manage this sewerage system more effectively and to control the increasing number of sewerage treatment plant (STP). The upgraded IGIS application improves the management efficiency, management level and decision-making capacity of sewage treatment in state of Penang and provide a good demonstration and reference in sewage treatment infrastructure in others city.

1. Introduction
The higher demand in property sector in Malaysia has created many new development areas in major cities especially in Kuala Lumpur, Johor Bharu, Ipoh and Butterworth in state of Penang. To ensure the well-being and comfort of the property buyer or owners, a few a guideline has been gazetted in which the developers must adhere to provide all relevant amenities such as Sewerage Treatment Plant (STP) facility. The Indah Water Konsortium Sdn Bhd (IWK) is the national sewerage company that responsible to manage, operate and maintain a sewerage system nationwide except the state of Kelantan, Sabah, Sarawak and two local authorities in the state of Johor, it is Johor Bahru and Pasir Gudang. Existence of the new development areas has led to an increasing number of Public Sewerage Treatment Plant (LRKA) and the number of Public Sewerage Sewer line (SPPA) that need to be maintain and operate by IWK every year.

With the latest capabilities of information technology (IT), the use of the Geographical Information System or more commonly known as GIS in Malaysia has become most popular application and it is used by many departments and agencies because of it various capabilities to assist with data and information storage, helping decision making for planning and development and as a medium for management [1]. IWK is currently facing a significant challenge such as in identifying the critical SPPA,
an illegal connection from industrial, pollution river nearest LRKA, the squatter in the LRKA land and other issues. Thus, IWK company has developed a system based on IT such as the Integrated Geographical Information System (IGIS) and the Asset Management Information System (AMIS) to ensure the smooth process of the company in their daily work and facilitate access of information that is needed. Using the AMIS, the user can access the related information with LRKA and SPPA such as the asset number, location name, street name, an information of design for Population Equivalent (PE), total connected PE of current development, the plant type, developer name, reference file, an information of sewer line, lot number, land area, land owner and others. While using the IGIS, the user can view the location of LRKA and SPPA on the ground.

1.1 Operation and Maintenance Department (OMD)

OMD has faced a lot of problem in their daily works because of an increasing number of LRKA and SPPA every year. With the high catchment maintenance and limited staff, the operation and maintenance work are very difficult to be done properly. Based on the existing procedure, the LRKA need to be monitored at least twice per month where the frequency is depended on the design PE of LRKA. This existing procedure is called ‘Plant Maintenance Frequency’ (PMF). The main purpose of this monitoring is to ensure the LRKA in a good condition and complied with all requirement stated in Malaysia Sewerage Industries Guidelines (MSIG).

Another issue faced by OMD is conducting a maintenance for all unused or rationalized LRKA. Based on January 2019 database, 101 LRKA site has been rationalized in state of Penang and the company has spent a million ringgit to do operation and maintenance works such as to demolished the structure, grass cutting, filling up the ponds, security and others. As a national sewerage company, the LRKA is synonymous with IWK even the former sewerage sites had been handed over to Sewerage Services Department (JPP). Referring to local news reports, about 1,000 residents in Taman Seri Marina Phase 1, Kuala Kedah in state of Kedah had to smell a stench form the 5-year-olds idle LRKA [9].

1.2 Planning, Land and Asset Management Section (PLAMS)

One of the main problems faced by Asset or GIS unit under PLAMS is an outstanding documentation received from related Certifying Agency Unit (CA). Due to this problem, the latest information of development that has been connected to existing LRKA or SPPA can’t be capture and updated into IGIS and AMIS system. This incomplete information has led to mistake either made by a planning engineer (EP), GIS executive (GE) or Asset executive (AE) during given an information related to LRKA or SPPA to properties developer. On current practice, before the property developer submitted the form of Planning Approval (PDC1) to CA, they will lease with GE and AE in getting the related information of LRKA. Usually, the property developer will check the location of their new development with the information in IGIS application such as location of existing sewer line but there are a few cases the sewer line is not updated into the system due to an outstanding documentation issue. Updated information from the property developer is based on real situation on the ground. Form this problem, it means that the information provided by Asset and GIS unit is not accurate and may cause to an overloaded issue if not check properly. After this PDC1 has been submitted, the related CA will forward this PDC1 to EP for their detail comment. Then, the EP will give their comment based on current status related to selected STP either it has any project involved such as to be upgraded by another property’s developer and others. As non-profitable company, PLAMS has taken an initiative to reduce the increasing number of STP with giving the comments or advised to the properties developer to upgrade an existing LRKA unto new design PE.

1.3 Certifying Agency and Development Control Section (CADCS)
CADCS is one of the service sections under Planning and Engineering Department (PED). The main function of CADCS is this section has entrusted to deal directly with the properties developer from PDC1 stage, design approval for built a new STP or upgrading existing STP (PDC2) until this STP will took over by IWK as a public STP. Another function of CADCS is this section has responsibility to control the number of increasing STP in order to assist the company to reduce their operation and maintenance cost every year. Unfortunately, it is not happened due to a certain reason. One of the reasons is, if the development is located far from existing sewer line or LRKA, the properties developer has an option either to build a new STP or built a septic tank, commonly known as Individual Septic Tank (IST). There also have a few cases which the properties developer has built a private STP but in a few years ahead this STP had handed over to IWK company due to not properly maintain or public complaint issue.

1.4 Customer, Billing and Collection Department (CBCD)
CBCD is one of the departments in IWK company that has a responsibility to in-charge all the related matter with customers, billings and collection of payment IWK bills. With an accretion number of STP taken over by IWK, it is mean the collection amount will increase. IWK company has taken an initiative to overcome this issue with collaboration between PLAMS and CBCD in identifying the customers who failed to paid their sewerage bills using IGIS application. This action called ‘Non-Revenue Customers’ (NRC) and lead by PLAMS. Through this exercise, CBCD will provide the list of unpaid customers from their billing records to PLAMS in purpose to rechecking the related information with IGIS application. This joint NRC initiative also focusing on customers that who have received IWK services but the data of this customers is not captured in the billing database. However, this action is not 100% successful because the information of IGIS application is not updated due to an outstanding documentation form CADCS.

1.5 Finance Department (FD)
The cost operation and maintenance incurred by IWK company was increased every year because of an accretion number of LRKA. With the lower sewerage tariff charges to the customers, it is seen too difficult for the IWK to cover up this increasing cost every year. At present, IWK company has charges household an average of RM8 per month for their sewerage services despite the company incurring operating costs between RM18 to RM20 [10]. Furthermore, IWK company also need to spend an extra cost for the operation and maintenance for unused or rationalized LRKA before it fully surrendered to the Federal Land Commissioner (FLC) or State Authority (SA) as a land guardian. In addition, another cost incurred by IWK company besides the operation and maintenance cost refurbishment cost for problematic LRKA such as structure defects and mechanical equipment damage and summons received form DOE and others.

2. Research Methodology
A requirement is defined as a statement that identifiers a necessary attribute, capability, characteristic or quality of a system in order for it to have value and utility to a user [2][3]. Successful systems and products begin with an understanding of the needs and requirements of the users [4]. The benefits can include increased productivity, enhanced quality of work, reductions in support and training costs, and improved user satisfaction.
Information gathering may have involved identification of the users or stakeholders, analyzing published sources such as reports or any publishes materials, identification the purposed use of the system through methods such as field study, observation methods and context of use analysis. User needs identification can be implemented through various methods such as user surveys, focus groups discussions, interviewing, case study, workshops and evaluating an existing or competitor system. While envisioning and evaluation phase is important to get user feedback and their validation to the developed system. The final process is the requirements specification that include identification of the range of relevant users and other stakeholders, a clear statement of design goals, the requirements with an indication their priority levels, measurable benchmarks, evidence of acceptance of the requirements by the stakeholders, acknowledgment of statutory or legislative requirements, e.g. for health and safety. It is also important to manage changing requirements as the system develops [4].

This study was performed using the approach as shown in Figure 2 above. It starts by reviewing existing IGIS application, data inventory and related technical reports. Subsequently, user requirements are identified where the agencies and stakeholders involved in the management, operation and maintenance of the STP and sewer line were interviewed to determine the suitability of the new added data with the functions of the section or department. It is for the purpose of ascertaining the extent to which these data additions assist them in making decisions in managing and maintaining STP. The content analysis method has been used to collect and analyze the data that needs to be added into the IGIS application. It is done by updating the required attribute data into IGIS application and removing unrelated attributes data.
3. Result and Discussion

This section is discussing the result from an improvement of IGIS application after all the spatial information had been added in the new IGIS version. The findings discuss the new capabilities of IGIS application to be used in managing sewerage facilities and to control an increasing number of STP. Currently, IGIS application also has been used by another department in IWK company such as by OMD, CADCS, PLAMS and CBCD in helping them in their daily works after launched on December 2018. Few spatial data analysis that can be used on new IGIS application is stated as below:

3.1 An Analysis for Nearest Location of STP or NPS

On current practice, before the developer or consultant submitted their application for planning development to Certifying Agency Unit (CA) on purpose of planning approval, the first stage is they will check the nearest STP or Network Pump Station (NPS) that are located in their new development with GIS Unit. Then, after the nearest STP or NPS was determined, the available current PE for related STP or NPS will be given to the developer or consultant for their planning purpose. With an improvement of spatial data including an information of land and sewerage information stated in PDC1 into the IGIS application, it will help GIS Unit to searching the location easily using a lot number or by street name and can provide the precise information and indirectly help the company to avoid any an overloaded issue. It is because all the information of current PE and connected PE planned to be connected to related STP or NPS was capture early. Previously, there are a few cases, STP or NPS was upgraded twice by developer due to wrong information given. The new IGIS application also request the CA to update a PDC1 information online for all the development PE for planning application because the development PE below than 150PE has not capture before.

An additional, the sewerage land information also can help the planning engineer in giving their comment on PDC1 if it need the existing STP or NPS to be upgraded. It is because, to upgrade the old design PE to a new design PE, it need to meet the requirement stated in MSIG. Using the information from this analysis, the planning engineer also can give their advice to the property developer either to connect their development PE to an existing STP without upgrading, to build a new STP or to upgrading an existing STP. As a result, using this analysis it can help the IWK company to control the increasing number of STP.

3.2 An Analysis for Nearest Sewer Line Location

Incomplete information of sewer line in IGIS application become a big problem to GIS Unit. It is because when the developer or consultant searching the existing sewer line nearest their new development, it is too difficult for the GIS Unit to provide the related information. There a few reason why the information of sewer line is not updated into IGIS application, and one of the reason is the information of certain area is not available due to this existing sewer line is taken over from the LA. In order to ensure all the information in IGIS application is completed, the ‘Asset Verification’ exercise (PEV) has been carried out by planning technician. Through this exercise, planning technician with the network section team will conduct investigation on the ground. Then, all the information getting from PEV will updated into new IGIS application. Thus, the new information of spatial data such as pipe material, pipe size, the date of taken over, the manhole depth, sewer length and others will be added or replace with previous record.

The benefit getting from new IGIS application is it can help the PLAMS when there has a new project for properties connection. Using this IGIS application, the EP can view and proposed all the government premises, residential and commercial lots that are potential to be connected to nearest sewer line before all the incoming flow connected to Regional Sewerage Treatment Plant (RSTP). Updating spatial data for sewer line will help developers or consultant in planning, construction and excavation work that need the information of manhole depth.
3.3 Planning Analysis for RSTP Proposal

One of the main factors contributing to an increasing cost of operation and maintenance is the accretion of the number of STP or NPS taken over by IWK every year. Currently, the PE design for new STP or NPS designed by the developer is only to cater for PE from their own development. Thus, new STP or NPS designed with a small PE design and the size of sewerage land is also limited. With a small design PE, the new development located nearest the existing STP or NPS has requested the new developer to upgrade the existing STP or to build a new STP. The problem faced by the developer is if this existing STP needs to be upgraded, they need to meet the requirement that has been stated in MSIG especially for a land size. The updated information for PDC1, a location of private plant and IST, as an additional information in this IGIS application, will help the PLAMS to do a proper planning process in their proposal to build a new RSTP.

With the capabilities of this IGIS application that linked with the ‘Google Earth’ application, PLAMS will get a clear depiction on the ground and select the potential LRKA to be rationalized also to find a suitable location for this new RSTP. In addition, updated land information into IGIS application will help the IWK company to recognize the land owner for the land acquisition process and also give an estimation land acquisition cost to the government based on the information of land size.

3.4 An Analysis for Rationalization Program

Every year IWK company needs to spend an extra cost for doing their operation and maintenance on daily work. It is because the number of LRKA maintained by IWK company was increasing every year. With the lower tariff charged to the customers, it seems IWK company consistently losing their profit. Thus, IWK company through OMD had taken an initiative to reduce the cost of operation and maintenance with the implementation of the program called ‘rationalization program’. Under this program, every operation unit will select the small and unprofitable LRKA to be rationalized. Unprofitable LRKA means the cost of operation and maintenance bigger than the total amount of billing has been collected. Using this new IGIS application, they can view all the potential LRKA in every catchment also can choose the nearest existing sewer line to connect all the incoming flow from the proposed rationalized STP or NPS and select the suitable LRKA with bigger design PE to cater this rationalized PE.

3.5 An Analysis for Future Planning Purpose

An improvement of attribute data for sewer line with an additional information of pipe material, pipe size and the date of taken over also can be used in the future planning purpose. For the example, the sewer line rehabilitates or replacement, this new information will help the PLAMS to determine and do a selection for a critical sewer line. It is can be done using this new IGIS application with selected a difference sewer line layer based on the date of taken over. With this new information of sewer line, the IWK company also can calculate an estimated budget if they want to do a rehabilitate or replacement sewer line work based on information of pipe material, pipe size and sewer length. Now, OMD can do an updating work automatically for any critical sewer line into this IGIS application. So, from this latest information, OMD or PLAMS can request an extra budget from the management through FD if it is need to do a sewer line rehabilitate or replacement based on current situation on the ground.

3.6 An Analysis for the Public Complaint

One of the benefit getting from online updating using this IGIS application is the related operation unit can do an analysis for the problem arising through public complaint. An example is the public complaint for the missing manhole cover, an overflow and blockage issues, the respective operation unit can do a fast feedback using referring all the related information on to this system. Using this IGIS application, they only need to select the location or manhole ID and then print out the layout plan as their reference before going to the site. Previously, the operation unit need to take an extra time to do a searching of
location using as-built network drawing and need to determine which the exactly location on the ground. Thus, IGIS application will help the IWK company to decrease a number of public complaint. Through this system, the respective operation unit can update the number of public complaint into system such as a frequency received for the missing manhole cover.

3.7 An Analysis for the Illegal Discharge

One of the major issues faced by IWK today is an illegal discharge received from the industries or food court. Due to this problem, IWK has received a lot of summon received from DOE. Usually, an illegal discharge is effected the result of sampling and the mechanical equipment. For the example, under MSIG requirement, any food court that are connected to an existing sewer line they are requested to install the equipment called ‘grease trap’ to filter the grease before discharge it sludge to the sewerage sewer line. Currently, IWK company have spent a hundred thousand Malaysia Ringgit to replace the failure equipment at their treatment plant. This illegal discharge happened when the premises is located nearest to IWK sewer line.

Now, based on new information getting from IGIS application, this issue can be resolved by IWK company. During the site investigation and updating record into IGIS application, the development that are connected to an existing sewerage sewer line also can be identified. Besides that, from the record of private plant and IST updated into the IGIS application, the IWK company also can recognize which one of the development are submitted their planning application for the monitoring purpose. Thus, it will help the IWK company to observe an illegal connection and to monitor the new development that has not recorded into IGIS application besides the result getting from PEV exercise.

3.8 An Analysis for Outstanding Bill

An outstanding bill is one of the main issues faced by IWK company since the company was establish in year 1994. With the lower tariff that has been charged to the customer, it is seen that the company cannot cover the increase of operation and maintenance cost every year. Due to that reason, this company is consistently losing their profit. One of the initiative taken by the company to avoid this issue is all the information of the property buyer will be updated into new IGIS application. This information getting from the complete documentation for new takeover development submit by CA to PLAMS and this form called ‘Purchaser List’. GIS unit will update all the related information then this record will share and link with the BRAINS database under Customer, Billing and Collection Department (CBCD). The meaning of BRAINS is ‘Billing and Revenue Information System’. Now, using this new IGIS application the CBCD staff can monitor, check and get the information of outstanding bills for every customer also can take a future action to resolve this matter such as send a reminder letter to alert a customer about their outstanding bill.

4. Conclusion

The GIS system is an application related to the IT currently used by various organization especially by the government departments and private companies. This is because of its ability to an access information quickly and help its users to analyze the information. In conformity with the GIS concept as 'Enabling Technology', this IGIS application can be integrated with a various technology especially related to spatial data such as Remote Sensing, Global Positioning System (GPS) and others. Looking at the lack of information supplied by the GIS unit to the system users, especially properties developers and consultants, a process of improvement on the IGIS application in this IWK company needs to be done. The enhancement of the IGIS application is intended to ensure that all information is needed to be updated. Looking at the results of the analysis obtained in enhancing the IGIS application, it will help the IWK company to manage this sewerage system more efficiently and control the increasing number.
of STP. An improvement of the IGIS application is also seen to assist related departments in IWK company to solve their current problems such as to monitor unpaid customer’s sewerage bills.

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