Water Loss Meter Tracking GIS Mobile Application

Muhammad Faiz Osman Zaini, Abdul Rauf Abdul Rasam

Abstract*: *One of the most challenging tasks in providing water services is proportion of water loss or known as non-revenue water (NRW). NRW is water supplied to the consumer, but it is lost before it reaches the consumer. The losses of NRW is related with water billing and water produced by local agencies such as Air Selangor. One of the ways to overcome NRW is by changing inaccurate or malfunctioned water meter, but the local department's water meter still uses the manual method. An innovative geospatial mobile application for water loss meter tracking system was developed at AIR Selangor s, Shah Alam. The main stages used in this study were identifying the problem, designing the app, developing the app and lastly evaluating the app's performance. Selected officers and contractors of the department agreed with the recommendation made by the authors to develop a digitized system based on the current system. The app has technical capabilities to improve the current system which uses pen and paper to manage water loss via meter system at the site. This geographical information system (GIS)-based application could also update and locate all the coordinates of water meters efficiently so that the contractor can easily find the malfunctioned water meters. The respondents agreed that the design and practical functions developed in the app are relevant in dealing with the water problem.

Keywords* : *Geospatial mobile apps, GIS, Non-revenue water (NRW), Water loss tracking meter,

I. INTRODUCTION

In the recent years, the population is increasing in Malaysia and the government need to expand more on their service area based on the population to keep clean water for consumer. One of the major challenges in providing service and supplying water to consumer is the proportion of water loss or known as non-revenue water (NRW). NRW is water that has been supplied to consumer, but it is lost before it reaches the consumer. NRW is divided into two categories which are apparent losses and real losses. Apparent losses are unauthorized consumption and metering inaccuracies while real losses refer to leakage on transmission or distribution mains or utility's storage tank [8]. Fig. 1 shows examples of water meter inaccuracies.

Financial sustainability of the water sectors in the country will be affected because of NRW. Water meter malfunction needs to be traced immediately because of unbilled water consumption. In addition, another effect for real losses is it

Fig. 1. Water Meter inaccuracies or malfunction [11]

could lead to flooding, the formation of sinkholes and the contamination of portable water systems [6]. The costing faced by the government will also increase if the water problem is not solved effectively. This is because the cost of operation and maintenance to repair the infrastructure is high as well. Besides this, billions of cubic meters of treated water and water utilities will continue to cause wastage and to lose a substantial amount of revenues respectively [3].

NRW are losses costing up to RM400 million a year, the Selangor government is finally putting in place its plan to cut down the total losses in treated water from 35% at present to 25% by 2025. Therefore, there are solutions to overcome this problem. First of all, it is crucial to understand the reasons for water losses and the factors which influence NRW [7]. Water losses can occur in all distribution system. There is similarity between water losses and NRW, so it is important to understand the relative significance between water losses and NRW (water losses = water produced - water bill or consumed). This relative significance is also known as unaccounted-for water (UFW). However, there is also a difference between water losses and leakage with relative significance: (water loss = real losses + apparent losses) [7]. Therefore, it is vital to ensure that there are differences between water losses for apparent losses and water losses for real losses.

In Malaysia, the common solution to overcome NRW for apparent losses is by changing the inaccuracies or malfunction water meters. It is a practical and cost-effective approach. Alternatively, the government can also use advanced technologies to detect leakage in underground piping. However, this method is costly even though it is an effective solution for NRW. Air Selangor or SYABAS Projects and NRW Executive Director, Yusof Badawi (2014) said that by using the new technology (SMARTBALL),

Revised Manuscript Received on 20 October, 2019.
***** Correspondence Author

Muhammad Faiz Osman Zaini, Centre of Studies for Surveying Sciences and Geomatics, Faculty of Architecture Planning and Surveying. Universiti Teknologi MARA, Selangor, Malaysia, faizzaini94@gmail.com.

Abdul Rauf Abdul Rasam*, Centre of Studies for Surveying Sciences and Geomatics, Faculty of Architecture, Planning and Surveying. Universiti Teknologi MARA, Selangor, Malaysia, rauf@uitm.edu.my

2,400km of pipes will be examined using the system over a two-year period. SMARTBALL is a new technology. The effectiveness of the new technology can reduce NRW in Selangor from 33.8% to 30.75%. By considering the current issues of NRW and the cost factor, this study proposes an alternative and effective way by developing a mobile GIS application for managing water loss in Shah Alam, Selangor.

Mobile application (app) is designed to run on smartphone platforms [1]. Developers of mobile app have to undertake a number of decisions, including target platform and the development technology to utilize. With this mobile app, the management system of the department can be made smoothly and paperless. The number identification of new water meters can also be capture by using smart mobile phones. Intelligent system [12], especially application of Internet of Things [14] and GIS [5], [15], [16] can manage effectively secondary water supply and space facility system.

II. DATA AND METHODS

Fig. 2 shows the general methodology of this study, i.e. preliminary study, exploration of the apps, development of the apps, data evaluation and processing and finally, the execution of the apps. Project planning is the most important stage that must be given priority before the development of prototype water meter tracking. The planning stage was planned very well to ensure smooth workflow of the development of water meter tracking prototype.

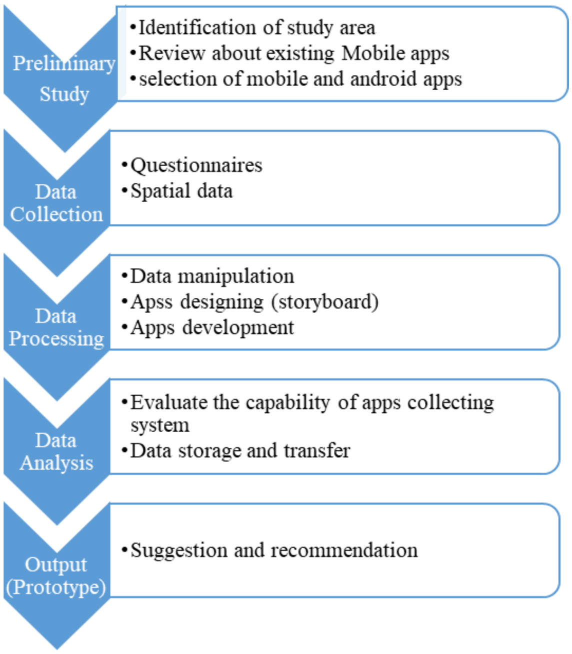


Fig. 2. Research methodology

This study only covered Sections17, 18, and 19 in Shah Alam because it was easier for data collection. Furthermore, this area encompasses both urban and rural settings thus, making it suitable for the testing or evaluation of the prototype. The main data source was collected from UiTM and Jabatan Bandar and Desa Selangor, while the tools used were handheld GPS, ArcGIS 10 and Android Studio. Android Studio was selected this study because this software is flexible, and it does not need to be purchased to develop the prototype. The mobile platform used to conduct this system was Samsung Galaxy V Plus. This hardware was selected because it fulfils the requirement of the apps selection.

Questionnaire survey was carried out on the contractors and officers of the department to obtain all the information needed in the development of a water meter tracking prototype. It was not an easy task to conduct the questionnaire survey because not all the users know about GIS that can be used in managing water meter. In developing a new GIS application for AIR Selangor, finding and utilizing the suitable data that related to the application that we want to develop, including Google Maps, Fulcrum apps. air Selangor and MBSA, PhpMyAdmin, XAMPP. When all the prototype has been finished build, the questionnaire to get feedback about the prototype also need to be done. By doing this, performance of the prototype can be known either it satisfied or not.

Application design was also conducted to initiate a design that could satisfy the application requirements. In this phase, the application that was selected from the analysis phase will be constructed and codified. Then, the application developed from the logical design phase was transformed into a digital coding version in which technology details were implemented with the aid of specified tools to form a physical design phase. After that, AI (Adobe Illustrator) was used to re-sketch the design to make the interface more user-friendly.

The final step is evaluating the prototype to assess the developed prototype from a group of selected respondents. It is important to ensure that the product will work accordingly or to identify any need for improvement. The execution phase is defined as the testing of prototype which allows the designer and client to assess the viability of the design of the application. Users will be given the opportunity to test the mobile application that has been developed by the authors. The evaluation, comment, and recommendation received from respondents are useful for the improvement of this mobile application in the future.

III. RESULTS AND ANALYSES

A. GIS User Need Assessment on the Proposed Apps

This result is based on the survey conducted among 11 respondents in the water meter's unit/department. Table I shows the respondents' position information. The responsibility of the water meter officer is to handle the data of water meter malfunction, while f contractor is responsible to change the malfunctioned water meter to a new one based on the address given by water meter's officer. Majority of the respondents have experience in managing water meter system. Therefore, the officers or contractors know the advantages and disadvantages of the existing system.

The result shows that 90% of the existing system use both manual and digital (semi-digital) methods. Notably, 72.7% of the respondents were not satisfied with the existing system. Therefore, the current system needs to be improved for a better implementation. Maybe the current system is not friendly with user or difficult to handle. Table II shows about This question is about opinion from the all staff either they agree or not to develop a new apps to manage existing water meter system. Evidently, all opinion from the staff agreed (100%) with the new or proposed apps for a more efficient management of the water meter. The respondents do not hesitate to try new prototype of water meter tracking.

Table-I: Respondents' Position Information

Subject	Type	Number of Respondents	Percentage (%)
Position	Water Meter Officer	6	54.5
	Water Meter Contractor	5	45.5

Table-II: Respondents' Satisfaction on Existing System Information

Subject	Opinion	Number of respondents	Percentage (%)
Satisfaction	Very satisfied	0	0
	Satisfied	3	27.3
	Not Satisfied	8	72.7

An additional question was also asked in the questionnaire to obtain more information and feedback about the new apps and the respondents answered by suggesting several features to be included in the proposed apps for example, maps, database, dates, upload/download function, info update and the use of QR Code. Majority of the officers and contractors strongly agreed with the suggestions because these features are indeed useful for efficient water meter management

B. Apps Functions and Capabilities

The capabilities of the apps were customized and developed to improve the existing system that are generally using pen and paper during the management of the water meter system and the process of updating all the coordinates of water meters. With this App's capabilities, the process becomes more efficient as it can reduce the time taken to search for the water meter. The location of the water meter can be searched immediately via Internet connection. All the database collected from water meters will be sent to officers for official applications. For example, the contractor can easily find the geoinformation of the water meter on the sites. Fig. 3 presents a flowchart of the prototype system.

C. Coordinates of Water Meters

The data of water meters' coordinates were collected for this prototype. Two instruments used for data collection were Fulcrum application and a handheld GPS, Trimble Juno 3B. Collecting water meters' coordinates by using Fulcrum apps is very easy and the data are kept in the Fulcrum apps. By using our own smartphones, we can easily install the Fulcrum apps and the coordinates are ready for c collect the coordinate. The accuracy by using this instrument can also be improved because it uses GPS from smartphone with high accuracy. All the coordinates of water meters for every single address in Sections 17,18 and 19 are stored inside the Fulcrum apps.

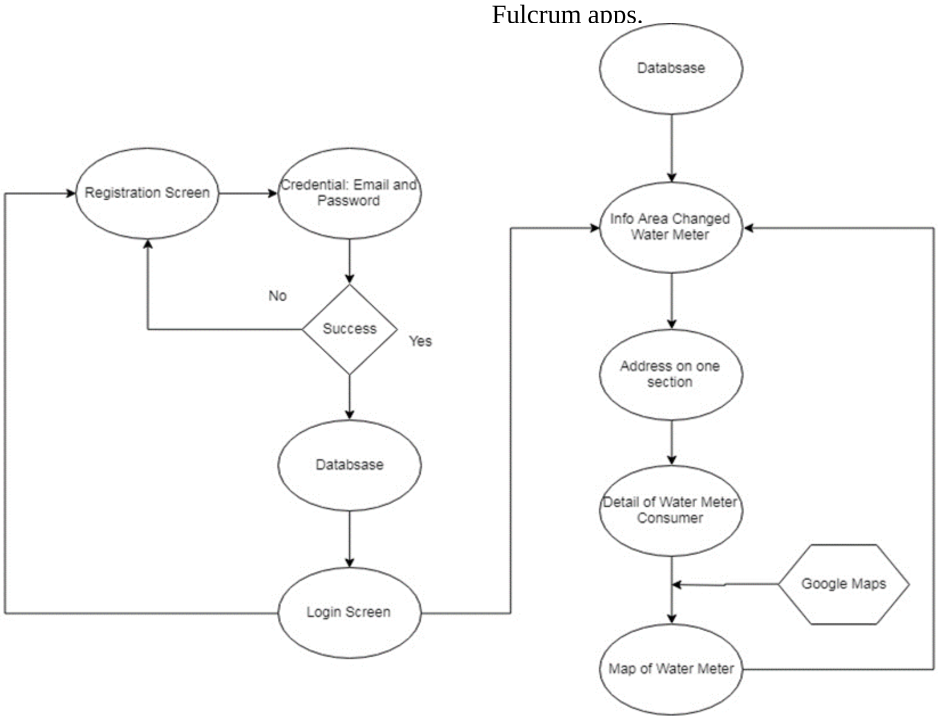


Fig. 3. A flowchart of the prototype apps

All the addresses of malfunctioned water meters were obtained from AIR Selangor. The coordinates of the addresses are then quickly detected in the particular location by using smartphone. Fulcrum apps is used to snap a picture of the water meter as proof that the water meter's coordinate has been taken. Moreover, the prototype also used Google Maps as a base for the map and location for water meter. For handheld GPS, Trimble Juno 3B also offers good performance for data collection.

There are no different with Fulcrum apps. Both of the instrument is really helpful to finish collection of the data. Fig. 4 presents the data collected with handheld GPS. The method of using this handheld GPS is the same as the data collection method using the Fulcrum apps. After all the coordinates have been collected, they were then stored in Excel. Next, all data was transferred to the database. PhpMyAdmin was used to store all data and these data are synchronized directly to the apps.

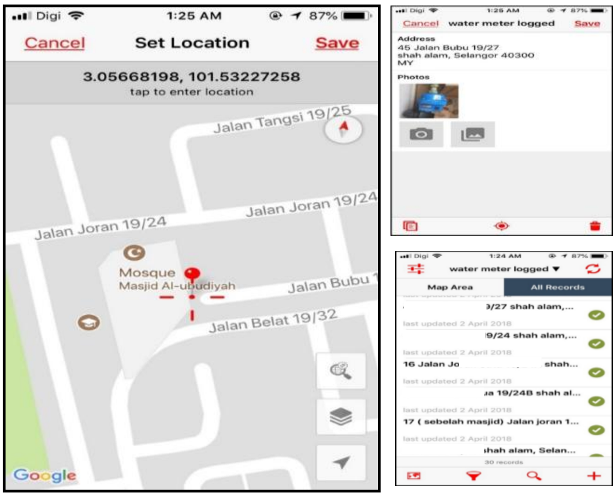


Fig. 4. The coordinate and address of water meter

D. App Design, Development and Applications

After collecting all the water meters' coordinates, the design needs to be sketched based on the need assessment. First, the design needs to be sketched roughly on paper so that it can be adjusted accordingly. The design is important because coding of the apps is based on the design. Once the design is complete, coding can be continued. After done roughly sketch on paper, Adobe Illustrator is used to sketch the design. Fig. 5 shows the sketch on Adobe Illustrator Android Studio that were used for coding the apps. All the designs were coded separately based on the sketches.

Login activity is first layout for this apps. Contractors of water meter need to login with their identification details that have been registered before they can start using the apps. All the data for identification of the users are stored in a database known as phpMyAdmin. This activity is for the new registration for contractors of water meters. Water meter officers can monitor all the registrations of contractors on the database. The second layout shows the total number of water meters needed to be changed according to address. The total number is updated daily on the database. The third layout displays all the addresses of water meter malfunctions based on the selected sections. For example, when the user selects Section 17 on the second layout, then on the third layout, all the addresses of water meter malfunctions are displayed, as shown Fig. 6

In the fourth layout, it displays the request for collection of the identification of water meters. The most important aspect of collecting the identification of water meter is the identification number, date of work and the last reading of water meter before the malfunction. Button navigation and scanning barcode used in this application. After the collection of the details of the water meter was complete, the changing work was then continuing to another water meter.

E. Map and Database of Water Meter Changed

This prototype also includes Google Map platform for users to use in their daily work. So, when they want to find the water meter, users have to just click the button on the apps, and it will display the route to the water meter that needs to be changed. All the coordinates in the database are accurate and precise because the prototype has been tested and it is convenient for contractors to search for the water meters. The

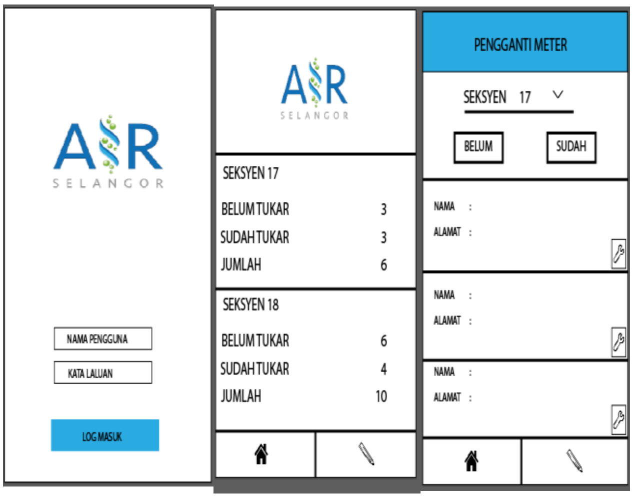


Fig. 5.Apps sketch using Adobe Illustrator

button to use Google Maps is displayed in the interface's 'customer information' on the right of the top of the interface. Every work of contractor has a date and number identification of water meter. The identification is important as a reference for next input updating work of the meter as illustrated Fig. 7.

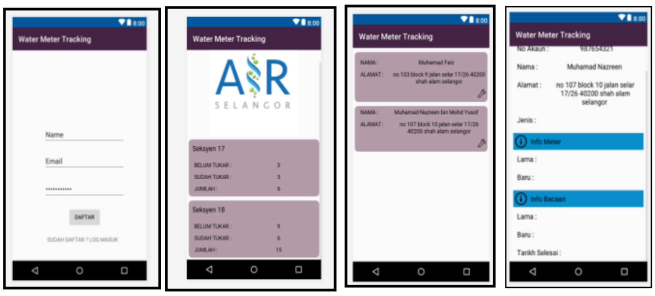


Fig. 6. Registration activity, second activity and third activity in the apps

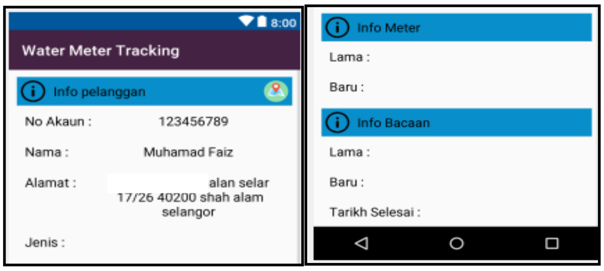
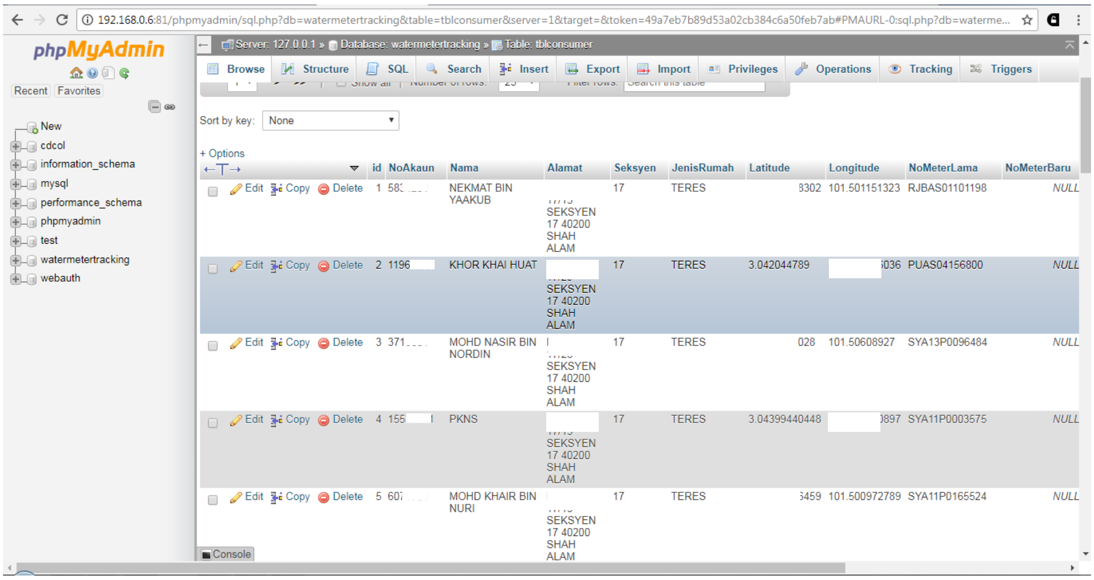


Fig. 7. Button maps of water meter and the space to write the details.

Database is vital to store the data obtained from the app. The data need to be stored separately from the apps because the apps could not run smoothly if there is an overload of stored data. The database from phpMyAdmin manage, store and update the data that have been entered by the officers as shown in fig. 8 shows.



F. Performance of the Mobile Apps

This application needs to be tested to ascertain its performance through the feedback from the staff at water meter's department. There are few questions about all the function in this prototype. The questionnaire consists of a few questions on the functions of the prototype and this is important because it will provide significant feedback in terms of the performance of the apps so as to identify and predict all possible problems. Based on the responses, all respondents were satisfied with the button functions of this apps. All buttons can be used, and their functionalities are in good condition and are able to run smoothly without any problem.

GIS databases are important because they are used to relate to each of the features enabling the system to complete complex analysis and queries. Maintenance of data is also completed on the databases in order to keep up with the demand of the data. The shift from paper-based database in this facility to the digital world is in line with the country's aim to be more efficient and sustainable and consequently, this will save time and money in the long run. Moreover, web-based applications and maps can shape the management of database in ways that have not yet been documented. This is a new phenomenon that relies heavily on the data behind the facility application.

IV. CONCLUSION

A prototype of water loss meter tracking mobile apps was successfully developed in Shah Alam. Selangor. The respondents of Air Selangor authorities also agreed that the apps can help the staff to change water meter with better accuracy and efficiency. The apps can reduce users' time and space due to paperless application. Moreover, human error in identifying the number of the water meters can be avoided by using barcode scan in the apps. The number identification of water meter is important because it represents the housing address. Furthermore, water meter locations are easy to find and update because of the functions of coordinate tracking that is available in the apps. In the future, the prototype can add more features such as Optical Capturing Reading (OCR) for easier identification task of the water meters as suggested by [9].

ACKNOWLEDGMENT

The authors would like to thank AIR Selangor for providing useful input in this study. The management of the FSPU is also appreciated to support this academic study.

REFERENCES

1. C.H. Wong, C.W.Khong and K.Chu, "Interface design practice and education towards mobile apps development," *Procedia - Social and Behavioral Sciences.*, vol. 51, 2012, pp. 698 – 702.
2. E. Pellini, "Design implementation and evaluation of a mobile application for sustainable water consumption," *Poltecno Di Milano Indrustial and Information Engineering.*, vol. 70, 2015.
3. F. Rudolf and R. Liemberger, "The Issues and Challenges of Reducing Non-Revenue Water," *Asian Development Bank*, 2010.
4. J.Kotwal, S. Pawar, S. Pansare, S. Khopade, M., and

Mahalunkar, P," Android Apps for Meter Reading," *International Journal of Engineering and Computer Science*, 2015, pp. 9853-9857.
5. M. A. Ali, "Improving Utility Operation and Maintenance Through The Use of GIS," *Utilities and waste management.*, 2004, pp. 1-5.
6. M. Chikwanda. "The Importance of Minimising Non-revenue Water" *Water Sector edigest.*, vol. 6. 2011.
7. M. Farley, "Non-revenue Water- International Best Practice For Assessment, Monitoring and Control," 2003. pp. 1-18.
8. M. Vermersch, A. and Rizzo. "Designing an Action Plan to Control Non-Revenue Water." 2008, pp. 1-5.
9. R. Dayama, A. Chatla, H. Shaikh, H., and M. Kulkarni, "Android Based Meter Reading Using OCR," *International Journal of Computer Science and Mobile Computing*, vol. 3, no. 2014, pp. 536-539.
10. S. Nizam, Staff of Air Selangor, private communication, 13 November 2107.
11. Seah, J, *Syabas water meters runs even on air/angin!*[Motion Picture], 2015
12. W.M. Fuller, "Improvement in Water Meter" *United States Patent Office* 138 697, May 6, 1873.
13. Wikipedia. (2018, February 25) *Syarikat Bekalan Air Selangor*. Retrieved from Wikipedia Ensiklopedia Bebas. [Online]. Available: from https://ms.wikipedia.org/wiki/Syarikat_Bekalan_Air_Selangor.
14. X.Liu, S.Shu. K.Yang, T. Wang and B.Geng, "Intelligent Management of Secondary Water Supply Systems in Downtown Shanghai," *Procedia Computer Science*., vol. 154, 2019, pp. 206–209.
15. A. R. Abdul Rasam, F. A. Hanif, A. M. Samad and R. A. Hadi. "Spatial information management system for building energy consumption," *2013 IEEE 3rd International Conference on System Engineering and Technology*, 2013, pp. 295-299.
16. A. R. Abdul Rasam, A. H. Azlin and N. M. Saraf. "Mobile Apps and Web GIS-Based Accessible Health and Social Care System for People with Disabilities," *2018 IEEE 8th International Conference on System Engineering and Technology (ICSET)*, 2018, pp. 85-90.

AUTHORS' PROFILES

Muhamad Faiz Osman Zaini graduated from Universiti Teknologi MARA (UiTM) in Bachelor of Surveying Sciences and Geomatics (Honours). He is currently working in hydrographic surveying field. His team was awarded a Silver Medal in the International Research Innovation Invention Solution and Exposition (iRISE 2018) in University of Malaya (UM), Malaysia. His research interest focuses on GIS and water and hydrographic management system.

Sr Dr. Abdul Rauf Abdul Rasam is a senior lecturer and researcher in the Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA (UiTM) Shah Alam, Selangor, Malaysia. He obtained his PhD from Universiti Sains Malaysia (USM) in GIS (Geospatial Modelling and Geovisualisation). He has published a number of indexed papers in various topics on geospatial and geomatics such as GIS, Cartography, Mapping, Remote Sensing and related fields of computer sciences, social and environmental studies. In addition, he has received innovation awards from national and international organizations. He also has several active intellectual properties (IP) such as MyCholeraRiskIndex, E-City of Shah Alam, MyGeoHealth Model, MyGeoTBIS and so on. Currently, his team is developing a new generation model of infectious disease using geospatial big data analytics.