THE DEVELOPMENT OF MOBILE APPLICATION FOR DENGUE SITE INSPECTION IN JOHOR BAHRU

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Abstract — This study addresses the development of a user-friendly mobile application tailored for dengue site inspections to combat the continued threat of vector-borne diseases in Malaysia. Presently, dengue site inspections predominantly rely on paper-based methods, a system marked by inefficiency, thereby highlighting the need for a digital solution. Existing strategies, such as Destruction of the Breeding Place (*Pemusnahan Tempat Pembiakan*, PTP), are hampered by limited technological resources and informational facilities. This often results in partial eradication efforts, necessitating repeated interventions in previously inspected areas and escalating operational costs. To remedy this, we designed a straightforward, user-friendly mobile application to streamline field data entry, enable precise location tracking, and offer immediate access to inspection data on-site. For efficient site record-keeping, the application leverages the cost-effective open-source platforms QGIS and QField. The goal is to refine the accuracy of PTP activities by harnessing data from the mobile application, subsequently enhancing productivity via in-field direct data entry. This research primarily aimed to define the prerequisites for a dengue inspection mobile application, to create an app with integrated location tracking, and to assess the efficacy and results of the said application. Field testing by health officers indicated robust approval, with 98% concurring that the app considerably improved the inspection process and their workflow. The app, with its intuitive interface, simplified data entry, enabling officers to swiftly input and modify information during inspections. Its location tracking feature also facilitated precise recording of potential breeding site coordinates. Encouraging feedback from health officers underscores the app's potential in elevating the efficiency of dengue site inspections. Furthermore, the application aligns with the Sustainable Development Goal of promoting Good Health and Well-Being. It also dovetails with the digitalization drive of the Fourth Industrial Revolution (Industry 4.0), targeting a reduction in long-term operational expenses.

***Keywords**:* Open-source, QField, QGIS, Field Data Collection, Dengue

I. INTRODUCTION

Dengue fever poses a critical public health challenge in Malaysia, evident by a striking 139% surge in reported cases in 2022 compared to the preceding year [1]. In response, the Malaysia Ministry of Health has spearheaded various measures, notably the introduction of the I-dengue website to bolster awareness [2]. However, the current I-dengue platform falls short in its digitalization objectives, lacking essential features such as geospatial elements, multi-user capabilities, and a robust reporting framework. Moreover, regular site inspections in targeted areas, determined by the influx of reports, persist as a separate endeavor, necessitating the manual intervention of officers. Insights from interviews with site health inspectors reveal that the reporting system of Pusat Kesihatan Daerah Johor Bahru (PKDJB) remains anchored in paper-based data collection, leading to data redundancy following on-site activities [3].

Geographic Information Systems (GIS) have proven to be one of the most useful tools in public health research. It has been used a lot for disease surveillance and monitoring, including coming up with research hypotheses, finding high-risk and at-risk areas [4], putting resources in the right places [5], and keeping track of interventions [6]. GIS embedded on mobile platform has enhance the functionality and the accessibility of GIS. According to [7], Location Based Services (LBS) refers to as application or any service

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that expands GIS capabilities or spatial information process to the end users based on the geographic location, through the wireless and/or networks internet. LBS also can be defined as an information service that can be accessed using mobile devices through the mobile network and could use the function of location in the mobile device [8]. While LBS expands its spatial information processing or GIS capabilities to end users via the Internet and/or wireless network, M-GIS limits that extension to only mobile devices, as to create an abstract "portable GIS" [9]. An application that delivers geographical information (based on location) to a mobile device will be classified as an M-GIS. According to [10], LBS has the ability of positioning the wireless applications and collecting information about the users' current geographical location. Besides that, it also provides useful information to the end users based on their current locations and ability for other functions such as tracking activity [11].

This research focuses on developing mobile applications to be used in dengue site inspection operation. This application is anticipated to become a reference to officer and operational worker on field to identify the area to be eradicated, the buffer boundary as well as job completion monitoring. This application will mainly benefit PKDJB as the stakeholder. In the sense of academic progress, this research explores the potential of open-source software, QGIS and QField in developing scientifically accurate mobile apps with location tracking enablement for epidemiology applications.

II. METHODS

These mobile apps were designed to seamlessly connect on-site activities with data analysts in the office, facilitating real-time updates on the progress of operations and inspections in targeted areas. The process commences with the input of reported cases into the central database on the QGIS platform. A density analysis is then performed on these recent cases to identify hotspots and establish buffer zones for operational areas. The results of this analysis are synchronized with the QField cloud services, providing on-site health officers with a reference point as shown in Figure 1. A detailed representation of the app's workflow can be found in Figure 2.

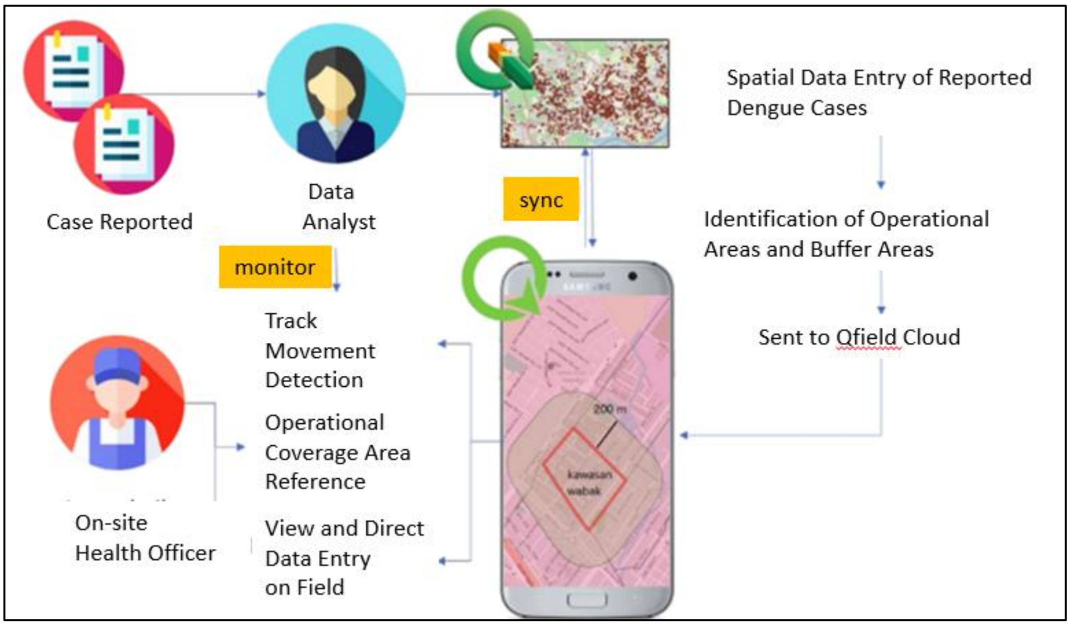

Figure 1. The overall methodology of the developed mobile apps

This study contains four phases to achieve the objectives. Phase 1 is mostly concerned with the initial research, whereas Phase 2 is primarily concerned with data integration, hardware, software preparation and development. Application testing on various devices is part of phase three. The mobile application evaluation is the main emphasis of the final phase (phase 4). Figure 2 illustrates the research workflow.

The phase 1 begins with the problem identification. The user requirement analysis conducted on the focus group discussion attended by the on-site officers and data managers of PKDJB. The discussion addresses the flow of procedure during the inspection and the data record keeping method that currently in practice.

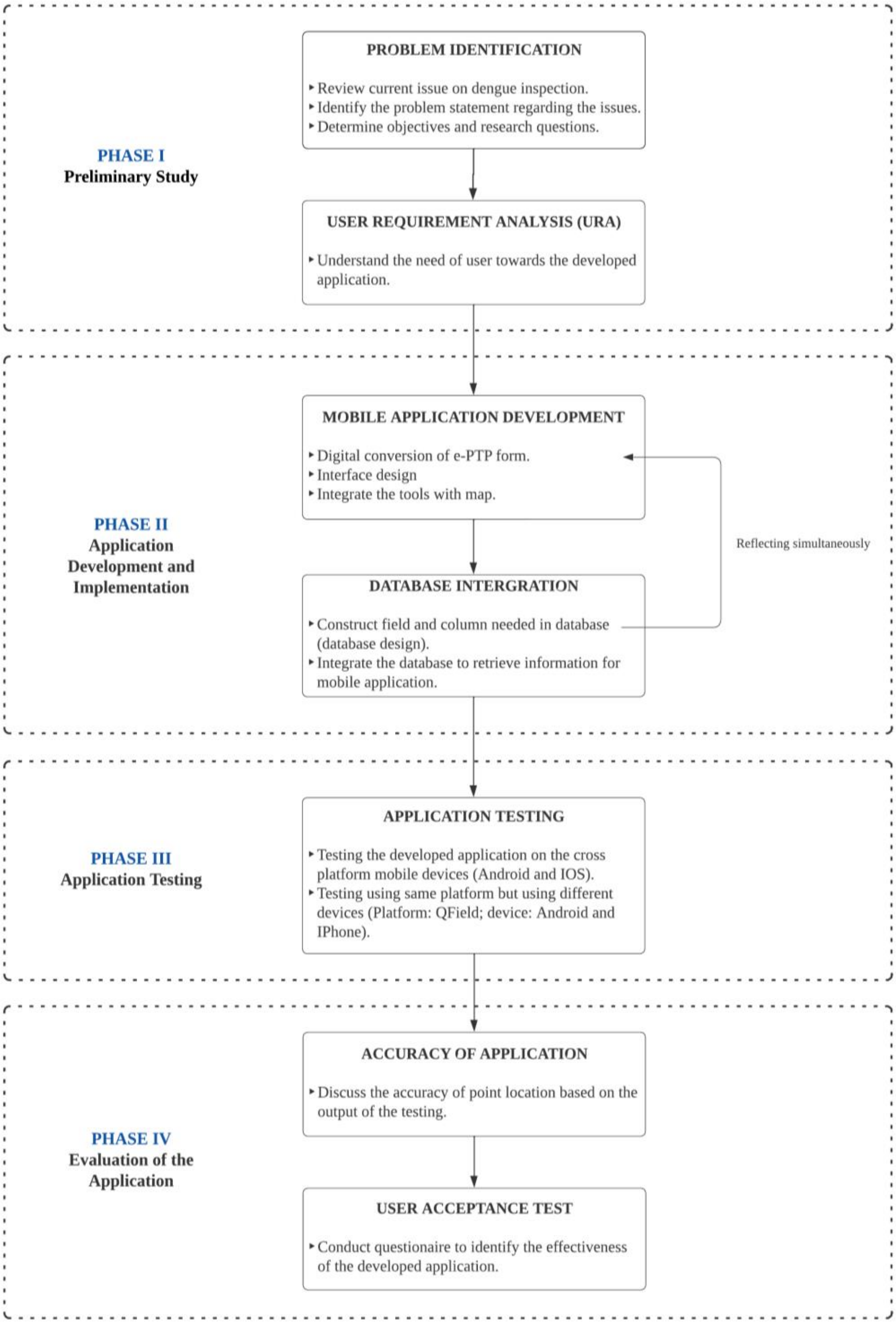

Figure 2. Workflow of Research Methodology

In the second phase, a mobile application was designed and developed specifically for dengue site inspection using the capabilities of QField and QGIS. This involves creating the necessary forms, data fields, and user interfaces within QField to enable efficient data collection and entry in the field. The development of mobile applications involves designing the user interface of the mobile application, ensuring it is intuitive and user-friendly for field workers. The hardcopy form which previously used for site inspection record-keeping were converted into a digital form in the apps, which called as E-PTP form. Next, the necessary forms (e-PTP form), data fields, and functionalities will be implemented using QField and QGIS. The access and interaction of user of this mobile apps were represented by the use case diagram as shown in Figure 3(a), through designed form as shown in Figure 3(b).

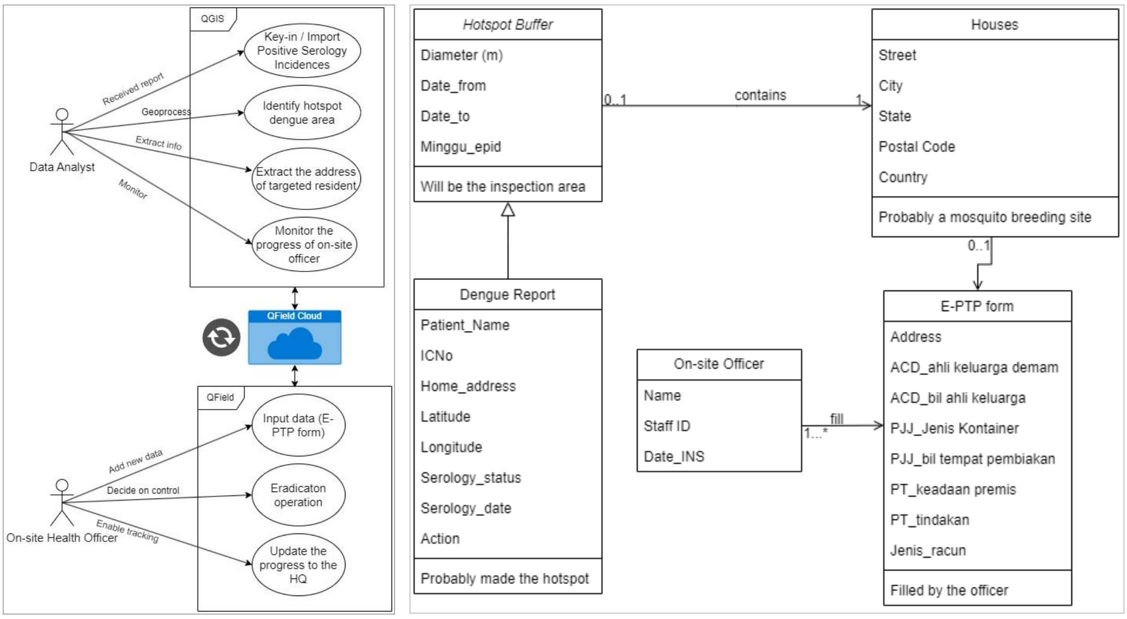

Figure 3. (a) Use Case Diagram for developed mobile applications and **3(b)** The UML diagram for the app's database

In the next phase, field officers will test the developed app on-site to ensure its seamless integration as a replacement for the current method. Eleven (11) officers participated in on-site testing of the app. It was trialed in both terraced residential area and a strata building to evaluate its performance across different types of properties. The field officers were provided with a questionnaire for the User Acceptance Test (UAT) to gather feedback on the app's effectiveness as a replacement for the traditional method of inspection record-keeping.

The UAT evaluation encompassed several aspects, including the app's GPS performance in accurately determining the device's location, user adaptability to the in-app forms, movement tracking, ease of user interface navigation, and more. Additionally, the app was installed on two different mobile operating systems - Android and iOS - to assess variations in positioning accuracy and app responsiveness between the two platforms. These two devices were used simultaneously at the same location to evaluate the accuracy of the location-based system. The specifications of the two phones utilized for testing can be found in Table 1 below.

Table 1. Specifications of the two mobile phones used for app performance testing

No	Specification	Huawei Nova 3	Apple iPhone 11
1	Operating System	Android 8.1 Oreo	IOS 15
2	Positioning	Built-in GPS, GLONASS, BDS Wi-Fi 802.11 a/b/g/n/ac, dual-band, Wi-Fi Direct Cellular	Built-in GPS/GNSS Digital compass Wi-Fi Cellular iBeacon microlocation
3	CPU	Octa-core (4x2.4 GHz Cortex-A73 & 4x1.8 GHz Cortex-A53)	6-core CPU with 2 performance and 4 efficiency cores
4	GPU	Mali-G72 MP12	4-core GPU

III. Results and Discussion

The result of this study is the development of the mobile apps for dengue site inspection which include the interface design, the database design and synchronization of the update on apps with the database. This mobile apps able to add new feature based on the cases found during inspection which includes the capturing of location, attribute insertion to the newly added features and capturing the photo of the inspected situation. Besides that, the function to track the position of the officer in the buffer zone also can be tracked to ensure the inspection process are covering the targeted area.

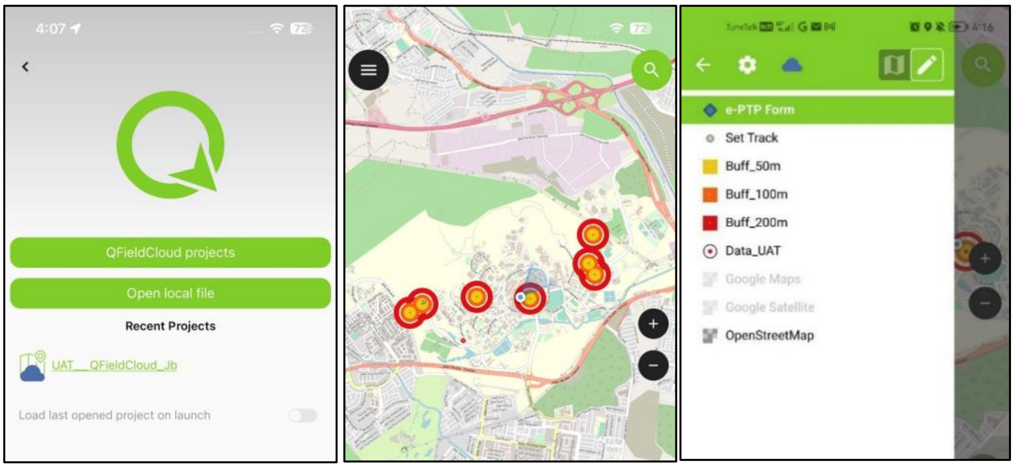

Figure 4. User interface for iOS and Android

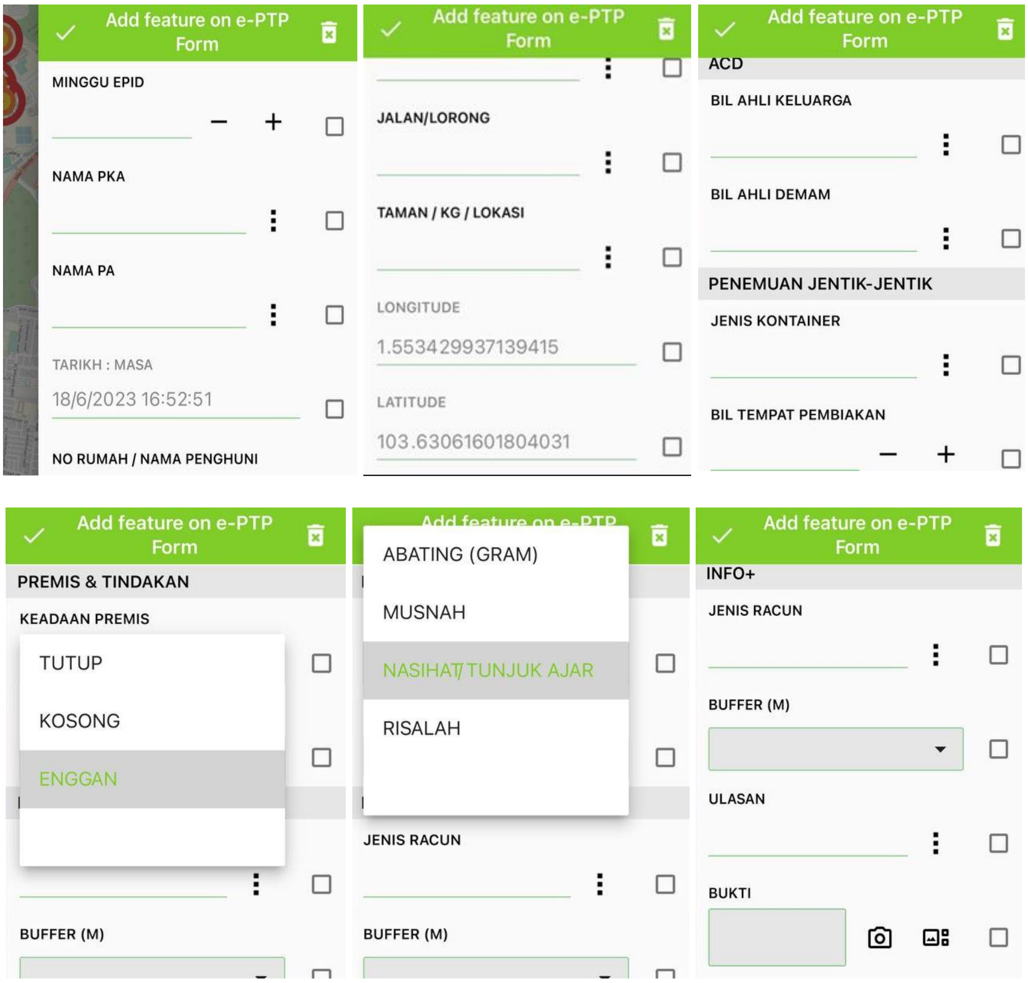

Figure 5. User interface for e-PTP Form

The performance of the developed mobile apps were evaluated through the User Acceptance Test conducted on eleven (11) users which from the PKDJB consisted of eight (8) inspection officers and three (3) public health medical officers. The app underwent testing in two distinct locations. First, in a neighborhood comprising terrace houses located in Taman Universiti, Johor Bahru, and second, in a strata

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building of a residential college within Universiti Teknologi Malaysia. Both sites were recognized as dengue hotspots at the time of data collection. Feedback from users post-testing has been collated and presented in Table 2.

Table 2. The E-PTP mobile apps performance evaluation parameters.

No	Question	Score
1	The types of Smartphones used during the inspection (apps testing).	iOS:81.8% Android:18.2%
2	Telecommunication services provider (TELCO) used.	Maxis:18.2 % Celcom: 18.2% Umobile: 18.2% Digi: 45.5%
3	Generation of mobile networks	5G: 27.3% 4G LTE:36.4% 4G: 36.4%
4	The mobile apps design	Poor: 9.1% Average: 63.6 Excellent :27.3
5	Ease use of the mobile apps	Difficult: 0% Moderate :90.9% Easy: 9.1%
6	The process of data entry using E-PTP form on the mobile apps	Difficult: 0% Moderate :90.9% Easy: 9.1%
7	The mobile apps performance	Unreliable: 0% Satisfactory:72.7% Reliable: 27.3%
8	Integration with existing workflows	Disruptive: 0% Seamless: 63.6% Streamlined: 36.4%
9	The usage of mobile data during data collection	Yes: 100% No: 0%
10	Overall satisfaction	Dissatisfied: 0% Neutral: 45.5% Satisfied: 54.5%
11	Willingness to recommend the E-PTP mobile apps to other public health officer	No: 0% Maybe: 36.4% Yes: 63.6%

Based on the User Acceptance Testing (UAT), 63.6% of respondents agree that the mobile app integrates seamlessly with the existing system, and they would recommend its use to other public health officers. Regarding the app's performance, 27.3% found it reliable, while 72.7% deemed it satisfactory. Additionally, 90.9% of respondents felt that the app's usability and the data entry process through the E-PTP form were moderate, with none finding it challenging. These insights suggest that there may be a need for the development of a Beta version, featuring enhanced user interface design and an improved form flow to simplify the data entry process. The UAT results also indicate that the older generation might require additional training and a familiarization period to effectively utilize the app.

On top of expecting the feedback from users on the user interface of the mobile apps, the accuracy of the positioning on different device were also tested. In QField, the position information is determined by the device's built-in Global Positioning System (GPS) capabilities. When the application is used on a mobile device with GPS functionality, it can access the device's GPS receiver to obtain the latitude and longitude coordinates [12]. The GPS receiver uses signals from satellites to calculate the device's position on the Earth's surface. QField then captures and displays this position information, allowing users to view and record accurate geographic coordinates during field data entry [13]. This ensures that the recorded data is associated with the correct spatial location, providing valuable information for dengue site inspection and analysis. Two devices are used concurrently at the same time and location to assess the precision of the location-based system. [14] conducting research on GPS accuracy using six different devices. He found that the difference is due to the different location technologies used for each device setting. Canvas will follow position and compass direction when the user uses the application and clicks on GPS. To test the accuracy of the positioning on different operating system, two devices are used concurrently at the same time and location to assess the precision of the location-based system. Figure 6 shows the different positioning accuracy on two different operating system – Android and IOS. According to [15] there are a lot of factors determining the accuracy of positioning such as different seasons, times of day, WiFi usage periods and the telecommunication networks usage. In terms of coverage, it is found that the internet coverage for both study areas were satisfactory whereby there is no connection problem to access and to update the cloud from the mobile apps.

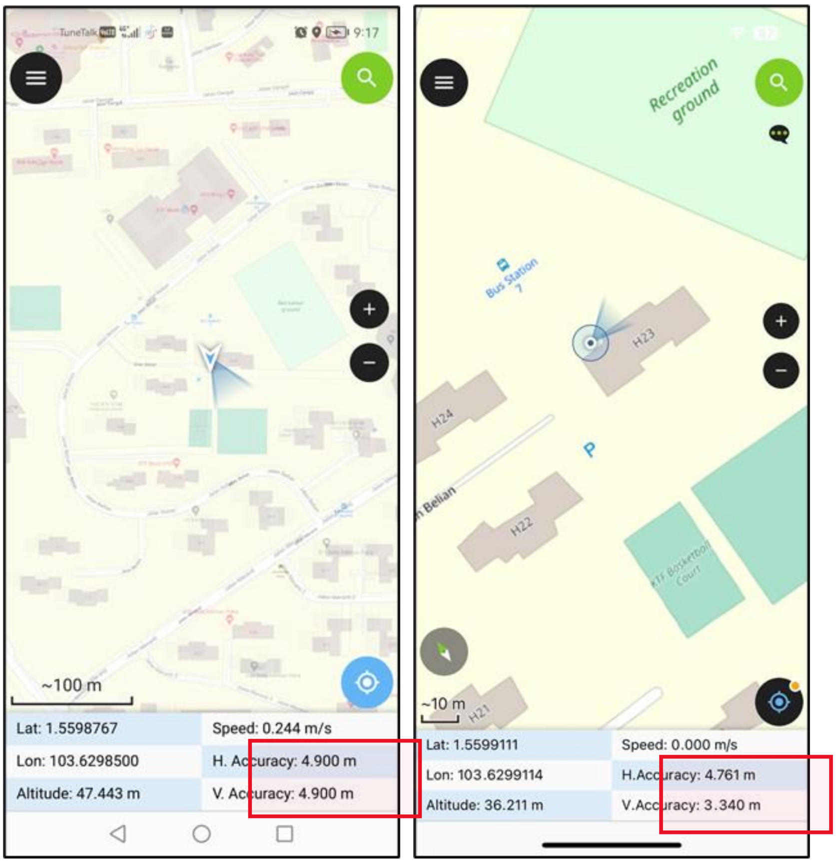

Figure 6. Different devices have different GPS accuracy (left: Android, right: IOS)

IV. CONCLUSION

In conclusion, the research on the development of mobile applications with the utilization of QField and QGIS in dengue site inspection has demonstrated several key findings. Firstly, the integration of these tools has significantly improved the efficiency and accuracy of data collection in the field. The use of a mobile application allows for direct data entry, eliminating the need for manual forms and reducing the risk of errors. Secondly, the spatial analysis capabilities of QGIS have enabled the identification of hotspot areas and related outbreaks, providing valuable insights for targeted intervention and control measures. The real-time data synchronization between QField and QGIS ensures up-to-date information and enhances decision-making processes. Additionally, the cost-effectiveness of the open-source QField and QGIS platforms makes them accessible solutions for organizations involved in dengue control efforts. Overall, this research has demonstrated the effectiveness and advantages of utilizing QField and QGIS in dengue site inspection, offering a comprehensive and integrated approach for improved surveillance, intervention, and prevention of dengue fever.

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