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VISUALISATION OF URBAN SPRAWL WITHIN THE CITY USING TABLEAU

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Abstract:

The urban sprawl still happening today is causing an imbalance in development between urban and rural areas. Issues such as non-optimal land use, land use development dispersal, land use conversion to municipal use, and reducing forest and agricultural areas need help in effective governance and enforcement. Furthermore, the condition of the village-in-the-city is increasingly threatened due to the urban sprawl. Currently, the existing visualisations are limited to only categorising the city and village boundaries. It cannot show the boundaries of a village-in-the-city area. The vague boundary categorisation caused by the village boundary area in the city cannot be determined clearly when the existing data provide only the city boundary and the village boundary. This study introduced a structured visualisation of village boundaries in the city using TABLEAU to assist agencies in making decisions in formulating development plans, especially for rural areas in the city. Focus Group Discussions (FGD) among the stakeholders are then used to evaluate the effectiveness of the developed visualisation. The visualisation will be based on dashboard development using Tableau software, including statistical information and urban, rural and village-in-the-city boundary information. The existing raw data in shapefiles, excel, and comma-separated values (CSV) formats are processed and integrated before the dashboard can be developed. This paper presented a pilot study for only two states: Negeri Sembilan and Melaka. The results of this study have been able to prove the existence of village-in-the-city visually, which previously could not be confirmed in the form of graphic maps. In addition, the results from the FGD can be concluded that the developed visualisations are promising and could provide the necessary information. Besides helping the agency management make better and more accurate decisions, this study will also benefit the public living within the city's village boundary area. On the other hand, from a scientific point of view, this

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study can be further explored to visualise the urban sprawl and apply predictive analysis to determine the needs of educational and health facilities in the area.

Keywords:

Urban Sprawl, Information Visualisation, Dashboard Visualisation, Tableau

Introduction

Urban sprawl occurs when a city does not have clear boundaries. Several issues have risen, such as non-optimal use of land, disparity distribution of land development, conversion of land use to municipal usage, and reduction of forest and agricultural areas. In addition, this will also cause difficulties in effective governance and enforcement in determining the catchment area for the provision of facilities, infrastructure and utilities to the community, as well as increasing costs due to this scattered development.

With the explosion of information caused by Big Data technology, it has become a driving force for the growth of innovations while also opening up opportunities for government agencies to implement Big Data Analytics. The Big Data Analytics implemented uses Big Data for analytical purposes in producing visualisations and applications that will provide benefits and can be leveraged when making plans and decisions. The production of good data visualisation has become a necessity when there is an increase in the amount (volume) and complexity of data (Yusuf, 2019). Visualisation supports the human ability to draw better perceptual conclusions when working with large amounts of structured or unstructured data (Yusuf, 2019).

One of the visualisation methods often used in implementing Big Data Analytics is the development of a dashboard. According to Eigner (2013), dashboards allow a person to make decisions quickly with available information. The dashboard is often seen as a visual data display aid to monitor the situation or facilitate understanding with infographic elements or narrative visualisation. Accordingly, a dashboard visualisation approach is implemented to see the existence of urban sprawl against village boundaries.

One of the software used in developing visualisation is Tableau software. Tableau uses integration innovations such as JavaScript APIs and Single Sign-On applications to consistently incorporate Tableau analytics into underlying business applications. Tableau is also able to create a variety of visualisations that are sufficient to present data interactively. In addition, Tableau allows the compilation of data (data drill down) and seeing its effects in a visual format that facilitates individual understanding. Tableau is seen as an end-to-end analysis platform that is the most robust, secure and flexible concerning information, so much so that it is felt to be able to increase the power of data to users (Akhtar, N. et al., 2020).

This paper discusses the development of the visualisation of urban sprawl through a dashboard using Tableau. The developed dashboard has visually proven the existence of villages within the city, which had never been confirmed in the form of a graphic map before. In addition, the display of the boundaries of identified villages within the city allows research to be done on the issue of urban sprawl that occurs, causing the needs of villages within the city to be fulfilled. Overall, the research carried out has a positive impact on the related government agency in

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particular and the public in general, especially in implementing the physical development planning of villages-in-the-city.

Literature Review

Malaysia Urban Planning Issues

Referring to Core 1 in the 3rd National Physical Plan Policy states that Urban and Rural Dynamic Growth is critical in achieving the status of a developed and high-income country (Malaysia, 2017, Malaysia 2016). This core is seen to strengthen the city's role as the primary catalyst and further help improve the ability and competitiveness of rural areas in developing the country's economy. Cities are the heart of the country's development because they have a high population and are the centre of economic activity. Therefore, emphasis is placed on urban areas to stimulate good urban economic growth. In rural areas, the focus is on providing infrastructure and utilities, including roads, water, electricity, education and health facilities, and social facilities to improve residents' quality of life and rural economic performance. The development strategy for these two areas aims to balance economic growth and bridge the gap between urban and rural development.

The Second National Urban Policy (DPN2) was drafted to ensure that urban development could be planned harmoniously (Malaysia, 2017). At the same time, the National Rural Physical Planning Policy was prepared as a holistic plan for rural development. These two policies become a source of reference in development planning within the scope of their respective borders. However, according to Karakayaci (2016), the trend of urban sprawl is continuing in Malaysia, especially in the Metropolitan area. The issue of urban sprawl has affected the development pattern of the surrounding area to the point of threatening its sustainability (Yasin et al., 2020).

According to DPF Desa Negara 2030, a village is "a traditional settlement in a rural area, consisting of a group of houses and having high traditional characteristics in terms of socio-cultural and physical". The total number of villages identified in Peninsular Malaysia and Labuan Region with a (spatial) location is 15,091.

Also, in the DPF Desa Negara 2030, the definition of rural is "other than urban areas where the population is less than 10,000 people, characterised by agriculture and rich in natural resources". In addition, the population density is low, and the primary economic basis for the population is related to agriculture, rural industry and natural resources. Villages will maintain village social and cultural activities, including village organisations or committees, family institutions, and social and cultural activities.

The Second National Urban Policy (DPN2) has defined a city as "a gazetted area and a built-up area bordering it and the combination of these two areas has a population of 10,000 people or more; or particular development area or district administrative centre even if the population is less than 10,000 people and at least 60% of the population is 15 years old and above engaged in non-agricultural activities.

However, a review of spatial data obtained from the National Rural Physical Planning Policy Unit, PLANMalaysia, found that there are traditional settlement areas (kampung) within the boundaries of urban areas. This will probably be caused by the effects of urban sprawl, better

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known as "urban sprawl", where land use activities are dispersed. This urban sprawl occurs beyond the established city boundaries. Karakayaci (2016) states that urban sprawl is part of urbanisation and development.

Among the identified reasons for the spread of the city still occurring is the need for coordination between related agencies and the lack of monitoring for implementing policies that have been outlined (Naeema, 2016). This statement is reinforced when it is found that the determination of Urban Boundary Limits has already been identified and outlined in the Second National Urban Policy (DPN2), which includes Urban Growth Boundary (UGB) and Urban Containment Boundary (UCB), which are developed to address the issue of urban sprawl in Malaysia while avoiding the waste of resources.

The agencies involved have also conducted studies determining the city and village boundaries that various interested agencies can use as standard official boundaries in planning and development. From the studies, data and related information are stored in their respective data warehouses because two different unit entities carry out the two studies. Difficulties occurred when demarcations for villages within the city needed to be displayed in the same dashboard. Accordingly, the data from these two studies need to be integrated. Data visualisation methods can display information related to cities, villages or villages within the city.

Information Visualisation

Information visualisation uses computer-supported interactive visual representations of numerical and non-numerical abstract data sets to enhance human cognition. Information visualisation is an art form of presenting data that is easy to understand and manipulate simultaneously, which can help understand information and make it useful in life (Keim, 2002). Information visualisation is also communicating abstract data through an interactive visual interface. Graphics such as histograms, trend graphs, flow charts, and tree diagrams are examples of information visualisation, and these graphic designs transform abstract concepts into visual information.

Currently, in the related agencies, the existing visualisation can display city and village boundaries only. Furthermore, these two visualisations can only be accessed separately. This situation makes it difficult for the management to identify the existence of village boundaries within the city in a state. In addition, more visualisations have yet to be developed by the related agencies that combine urban and rural statistics and mapping for a state. Accordingly, a visualisation combining these elements and areas is essential to assist various agencies in making accurate and quick decisions.

Tableau Software is among the tools that are increasingly discussed and has become the choice of many in implementing data visualisation. Tableau is visualisation software that can help users explore and understand data by producing interactive visualisations (Akhtar et al., 2020). Tableau is also used to perform data analysis that can be connected to various data sources. It also enables data blending and real-time reporting. Furthermore, Tableau can use extensive data sets to be analysed, visualised and shared (Ahmed and Mohamed, 2019). In addition to its ability to translate data into purposeful visual dashboards, it becomes software of the choice of many (Ben, 2014)

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Various studies use Tableau software to produce different types of data visualisation. Among them is the development of a dashboard for landslide locations in Indonesia (Darman, 2018), Tableau: Big Data visualisation tool in higher education institutes for Sustainable Development Goals (Ahmed and Mohamed, 2019), data analytics and visualisation using Tableau for COVID -19 (Coronavirus) (Akhtar et al., 2020).

The main factor that Tableau is increasingly becoming the choice of users is because Tableau is easy to use and can produce excellent visualisations. Furthermore, Tableau's 'drag and drop' facility is very convenient for users. According to Gartner's Magic Quadrant, more than 70% of Tableau users choose to use it because it is easy to use, and the basics of Tableau can be easily understood quickly.

In addition, researchers agree that using Tableau can design dashboards quickly, easily and accurately. Tableau can also be connected to various data sources and accommodate large data sets to implement the required design process. Moreover, data visualisation provides a clear interpretation and picture of the data. It can help agencies make quick and accurate decisions in dealing with urban sprawl issues that significantly impact village areas, especially for village areas in the city. This visualisation not only proves the existence of villages in the city in terms of mapping but can also help with development planning and providing appropriate facilities to the villagers.

It cannot be denied that a suitable data visualisation needs to have a combination of data sources, such as a combination of data and images so that the visual produced is more meaningful and easy to understand. Presentation using visuals will be more accessible to attract attention than displaying numbers and alphabets only, as it is closely related to human thinking and natural skills.

Tableau Software has become familiar as one of the tools used to visualise data that is currently so large and diverse. The advantages and facilities of this Tableau software make it the primary choice in realising data visualisation that can impact the public and decision-makers. One of the approaches used is the development of a dashboard, which can give a clearer picture in just one display, but the information presented can be easily understood. Therefore, this study will use Tableau software with a dashboard development approach to determine the position of village areas within the city. So, related agencies can use this dashboard as a source of information in decision-making associated with the area's development.

Methodology

The development of the visualisation of the urban sprawl in Negeri Sembilan and Melaka is based on the Cross Industry Standard Process Model for Data Mining or CRISP-DM. CRISP-DM approach was adopted in this work as it provides facilities for the phases to be iterated for improvements (Piatetsky, 2014). Four phases are involved: Data Sourcing and understanding, Data preparation and Dashboard development and Dashboard validation.

Phase1: Data Sourcing & Understanding

Phase 1 begins with collecting data according to the objectives and requirements of the project, conducting research on the data to understand it, identifying the existence of problems and issues in the data, and searching and finding meaning through the data based on hidden information from the data. This phase will also involve the identification of data quality from

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data collected from various sources, with the project's objective as a guide to understanding the data. Data understanding consists of several activities: data acquisition, identifying data issues, data exploration, and further understanding of the data. The data is then prepared in a process that aims to produce the final data set. The activities in this process are selecting appropriate data, data cleaning, data generation and data set integration. The data obtained from the National Physical Planning Division, PLANMalaysia, is the raw data that will be used in the study consisting of various formats.

Phase 2: Data Preparation

Data Preparation in phase 2 involves two steps, namely data cleaning and data integration. The first step is to select the data to be analysed by looking at uniformity, feasibility and consistency. Then, in the second step, pre-processing, the data is examined based on the suitability of the data to be included or excluded from the primary data to be analysed. This process is called data cleansing or purification. After that, the cleaned data will be entered into the database. Rapidminer software integrates the data used for the dashboard development in this phase.

Step 1: Data cleaning

The data obtained from the National Physical Planning Division, PLANMalaysia, is the raw data that will be used in the study consisting of various formats. The number of cities, villages, and population data is in .xls, .xlsx and .csv format. However, in this study, the data will be converted to one format only: the .csv format. Therefore, for the data, Microsoft Excel software has been used for that purpose. In addition, the city and village boundary data received is in .shp format. Although this .shp format data is used as a mapping visual, there is a need where these .shp data needs to be combined in shapfiles format and also processed to .csv format to facilitate its use during Tableau and Rapidminer development. QGIS software is used to change the format of the boundary data. The QGIS software is an open-source software supports displaying and editing spatial data. The three spatial data processes involved are combining and exporting village information for the two states studied, purifying and exporting city information, and identifying the intersection between the village and the city.

Step2: Data integration

For this study, data in shapefiles format that has been translated to .csv format will be uploaded and processed in Rapidminer to produce a connector that will hold key attributes for villages-in-the-city. This processed data is updated into a Hive table to be used in the Tableau software to design the dashboard. Figure 1 shows the data flow process adopted for designing the dashboard. Rapidminer is a data science platform that can provide an environment for business analytics, data mining (data mining) and machine learning. In this study, Rapidminer was used in the data preparation process to be used during dashboard development. Overall, three processes occur in Rapidminer: receiving .csv data, preparing and storing data.

Figure 1: Data Flow Process

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Phase 3: Dashboard development

In this phase, Tableau software will be used for modelling and visualisation. Among the advantages of using Tableau software for data modelling is the ability to handle large data sets and easier integration. In addition, Tableau can perform various tasks and make the process easy and accurate for the next phase of data evaluation, where it can connect, consolidate, complete, and organise data according to the needs of the study. In developing a dashboard using Tableau software, three basic things need to be known, which are data connection (data connection), data visualisation (data visualisation) and data sharing (data sharing). Data relationship means connecting the data available and required for dashboard display, while data visualisation is where the data is analysed and displayed in various forms such as bar charts, pie charts, statistics and mapping. Then, after the data is displayed as a dashboard, it should be shared with the management or the implementation team to make relevant decisions more accurately. The result of the development of this dashboard will be able to display the demarcation of cities and villages in the form of a state demarcation map.

Phase 4: Validation through FGD

In this fourth phase, the results of the dashboard display will be reviewed, where the demarcation of villages within the city can be identified. Finally, discussions and conclusions will be made based on the results that have been obtained. A discussion session with a Focus Group Discussion (FGD) was held to obtain confirmation of the demarcation of villages within the city that had been generated in the dashboard. This exercise ensures that the agency's needs can be met and guarantees the accuracy of the data displayed. The stakeholders consist of officers from various government departments that are directly involved in physical planning for urban and rural areas. The User Acceptance Test (UAT) and Final Acceptance Test (FAT) are also adopted to ensure the developed dashboard meets the user requirements. The FGD comprises five Planning Officers from PLANMalaysia (Town and Country Planning Department), which consists of several units such as the National Physical Planning Unit, the National Urban Policy Unit and the National Rural Physical Planning Policy Unit. The five officers are directly involved in physical planning for urban and rural areas. Apart from the implementation of tests such as the User Acceptance Test and Final Acceptance Test, the FGD has also discussed the direction of development of the dashboard and the possibilities for other states to adopt this dashboard development (Laporan UAT, 2020 and Laporan FAT, 2020).

Results and Discussion

Dashboard Visualisation

Developing a dashboard using Tableau software can produce an exciting and interactive display. In this study, the dashboard display can be categorised as a strategic dashboard that provides the related agencies' data with values. This dashboard display assists the agencies, especially in implementing the country's physical planning involving towns and villages' development. Nowadays, data analysis has to take a long time due to the difference in the existing data format, causing the decision-making process to be made after some time. However, with the presence of this dashboard display, it can speed up the process.

This developed dashboard display will contain statistical and visual mapping elements for Melaka and Negeri Sembilan. This dashboard display generally has two main sectors: mapping boundaries and statistics for the two study states. The mapping boundary sector includes

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boundary maps for states, cities, villages and inner-city villages. In contrast, the statistics sector includes information on the number of cities, villages, inner-city villages and residents.

This paper's result focuses on the dashboard display for the state of Melaka only. Figure 2 shows the dashboard display of the overall statistics of the study for the selected state of Melaka. There are two display categories; on the right is a statistical display of the identified number of cities, villages and villages-in-the-city. While on the left side, a geographical map of the position of the city, village within the city and village outside the city is displayed. In general, users can see 114 identified villages in the city. When the user moves the mouse to the City bar chart, the number of Villages-in-the-City will be displayed, as shown in Figure 3. Figure 3 shows four villages within the city identified in Ayer Keroh.

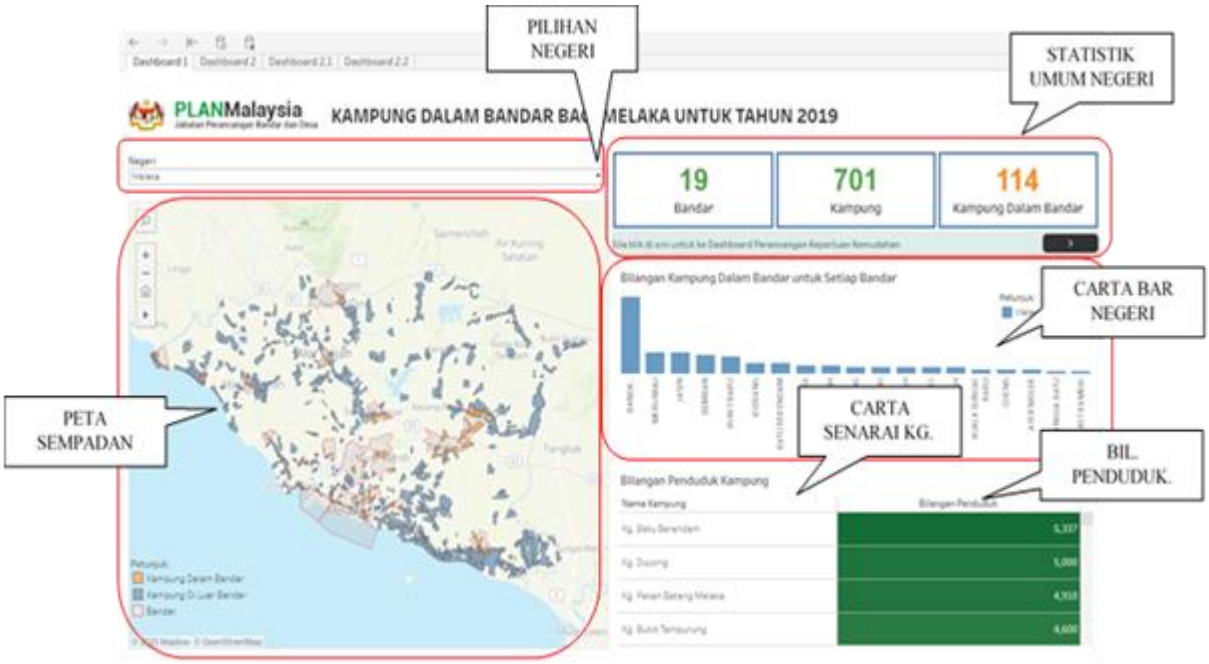

Figure 2: Dashboard Visualisation for Melaka

When the user moves the cursor to the City bar chart, the number of Villages-in-the-City will be displayed, as shown in Figure 3. Figure 3 shows that there are four villages-in-the-city identified in Ayer Keroh.

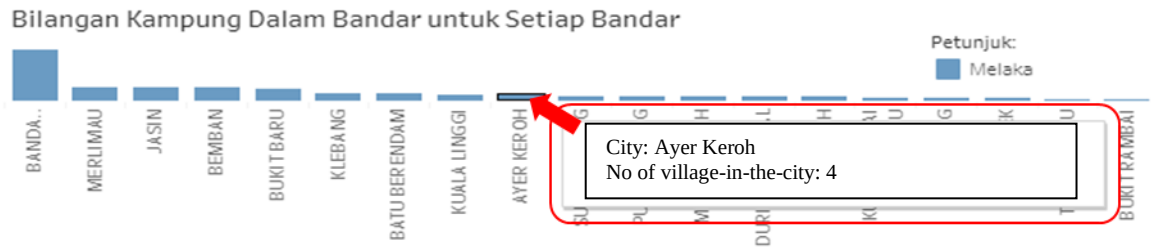

Figure 3: Number of Villages in Ayer Keroh City

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Next, when the user clicks at the city, the dashboard will highlight the map of the city and the number of residents in each of the village-in-the city identified as in Figure 4.

Figure 4: Visualisation of the Selected City (Ayer Keroh)

Figure 5 shows the Ayer Keroh city boundary map, highlighted in black. Village-in-the-city are identified with orange colour while villages outside the city are recognised with blue.

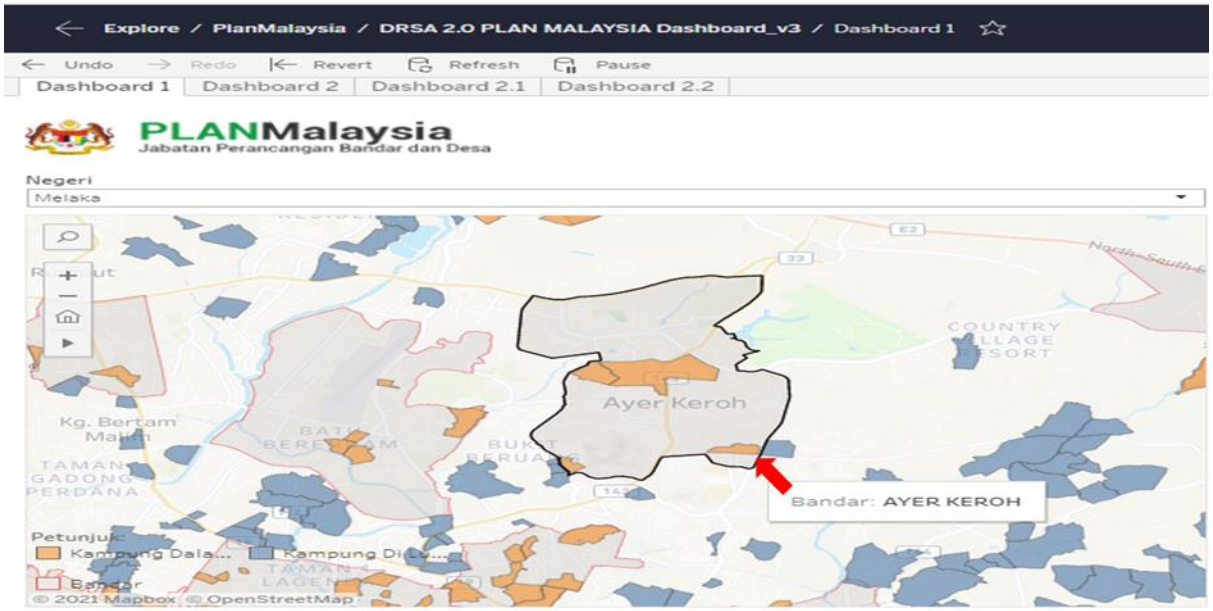

Figure 5: Map for Ayer Keroh City Boundary

From this visualisation, it can be identified that within the boundaries of Bandar Ayer Keroh, there are four villages which are:

- Kampung Ayer Keroh
- Kampung Tun Razak Village
- Kampung Baru Ayer Keroh
- Kampung Bukit Beruang Jaya

In order to view the information of each village-in-the-city, the user needs to move the cursor on the map to get the location of that village-in-the-city of Ayer Keroh.

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Kampung Ayer Keroh

Figure 6 shows *Kampung Ayer Keroh*, which is located in the middle of Ayer Keroh city and is identified as the largest village-in-the-city in Ayer Keroh. The information of that particular village is provided in the visualisation.

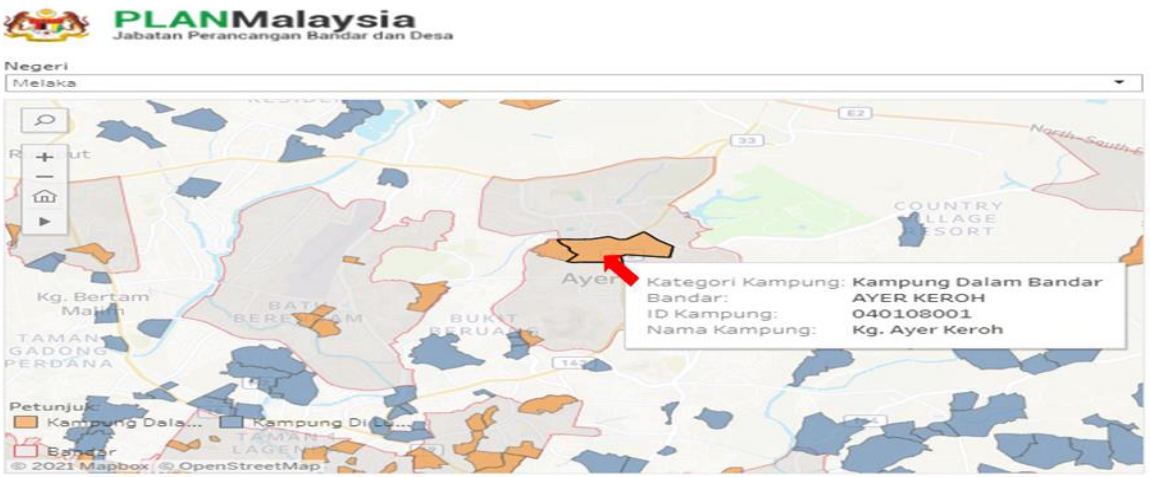

Figure 6: Map Visualisation for Kampung Ayer Keroh

Kampung Tun Razak

Figure 7 shows the location of *Kampung Tun Razak* which is one of the village-in-the-city identified in Ayer Keroh. This village is recognised as the second smallest village-in-the-city of Ayer Keroh.

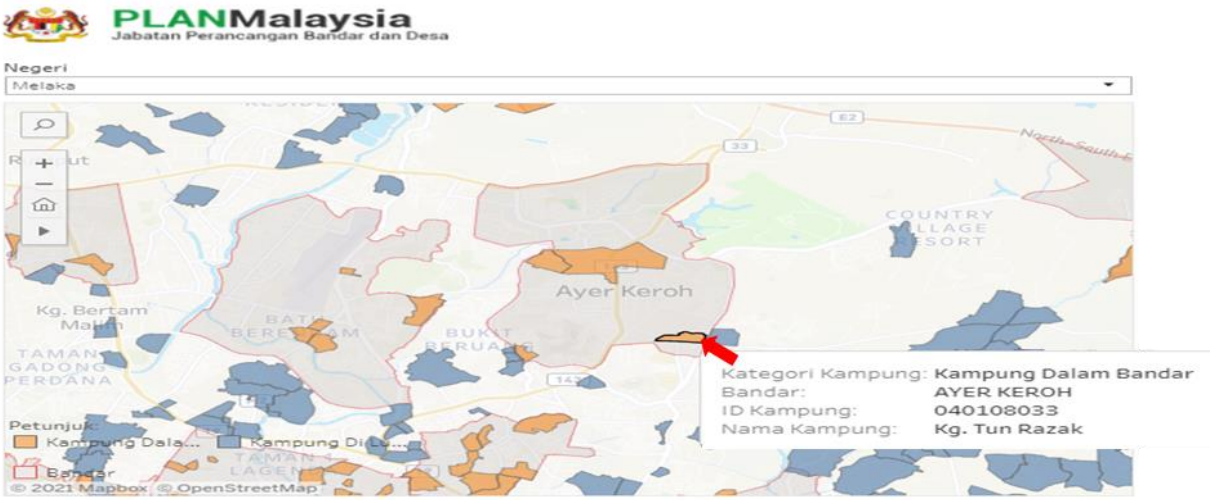

Figure 7. Map visualisation for Kampung Tun Razak

Kampung Ayer Keroh Baru

In Ayer Keroh City, there is another village-in-the-city that has been identified. Kampung Baru Ayer Keroh is next to Kampung Ayer Keroh, as shown in Figure 8.

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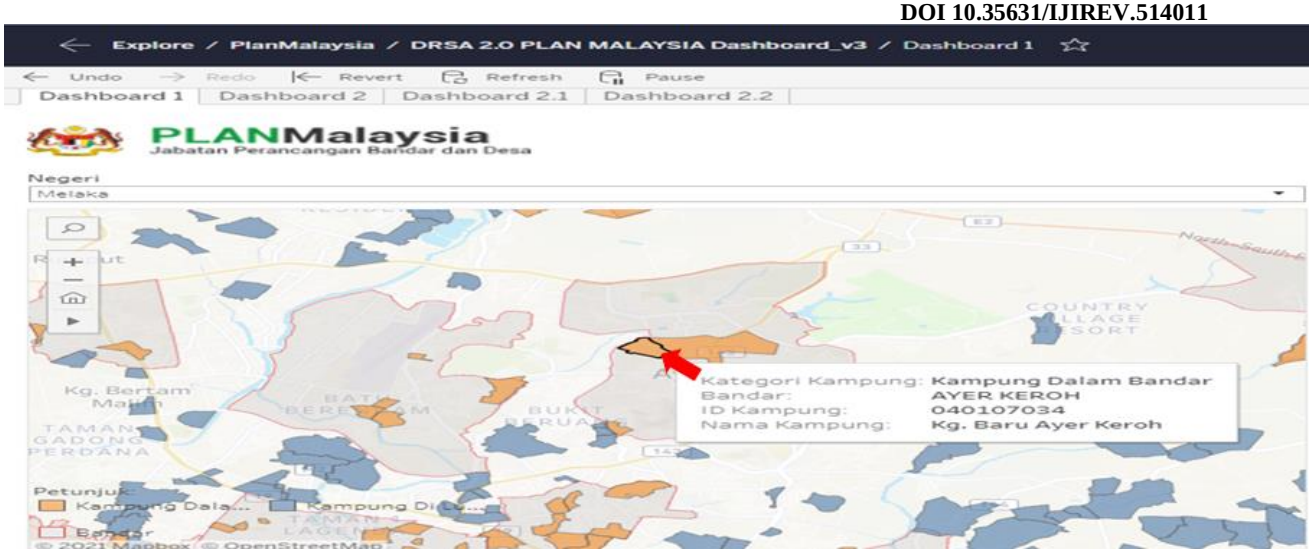

Figure 8: Map visualisation for Kg Baru Ayer Keroh

Kampung Bukit Beruang Jaya

Figure 9 shows that Kampung Bukit Beruang Jaya is within the boundaries of Ayer Keroh city and is identified as the smallest village-in-the-city compared to the other three villages-in-the-city mentioned before.

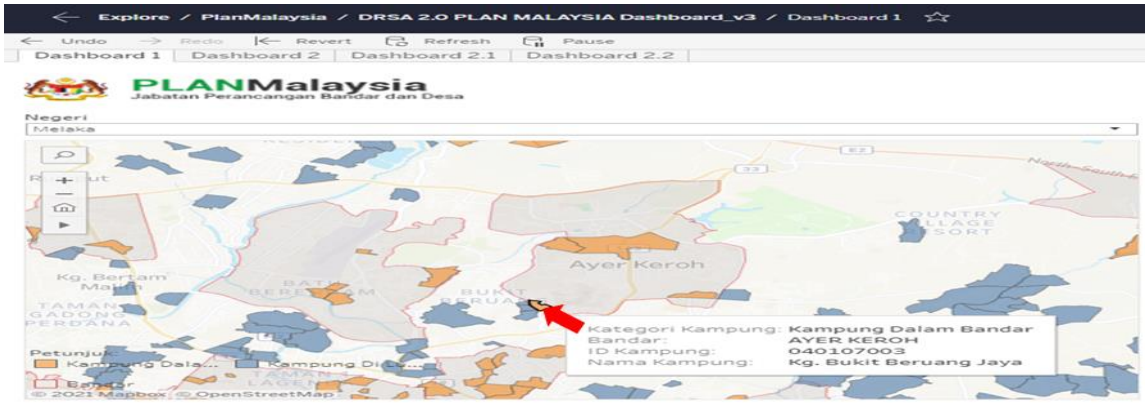

Figure 9: Map Visualisation for Kg Bukit Beruang Jaya

Users can also see the number of residents in the four villages-in-the-city that have been identified by the display on the bottom right of the dashboard as in Figure 10.

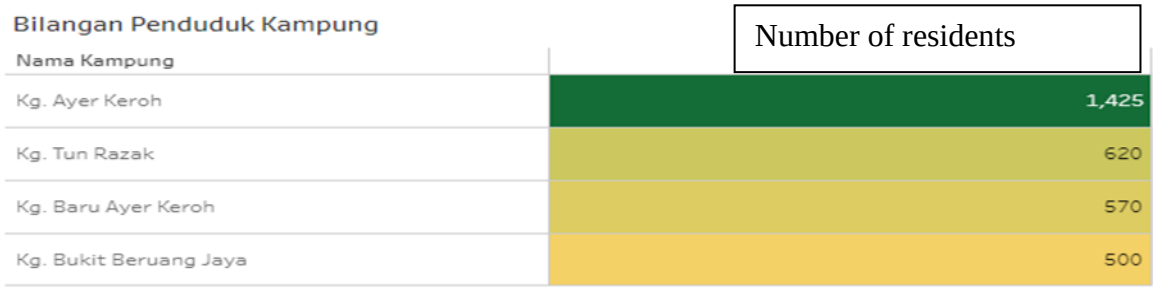

Figure 10: Number of Villagers in Ayer Keroh city

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Analysis from Dashboard Development

The results of the dashboard development can provide a clear visual representation of the existence of village-in-the-city for the states in this study. Tableau Software, a business intelligence application that can obtain information from statistical or graphics data, can be utilised to visualise the data precisely, easily and clearly. Integrating information from various visual, graphics and statistical sources permits the boundaries to be mapped and visualised. The map visualisation allows not just plotting the boundaries between the city and villages but also shows the boundaries of identified village-in-the-city. Figure 11 shows the plots of boundaries for cities, villages and village-in-the-city that can be identified in Melaka, where blue indicates the village, orange indicates village-in-the-city, and grey represents the city.

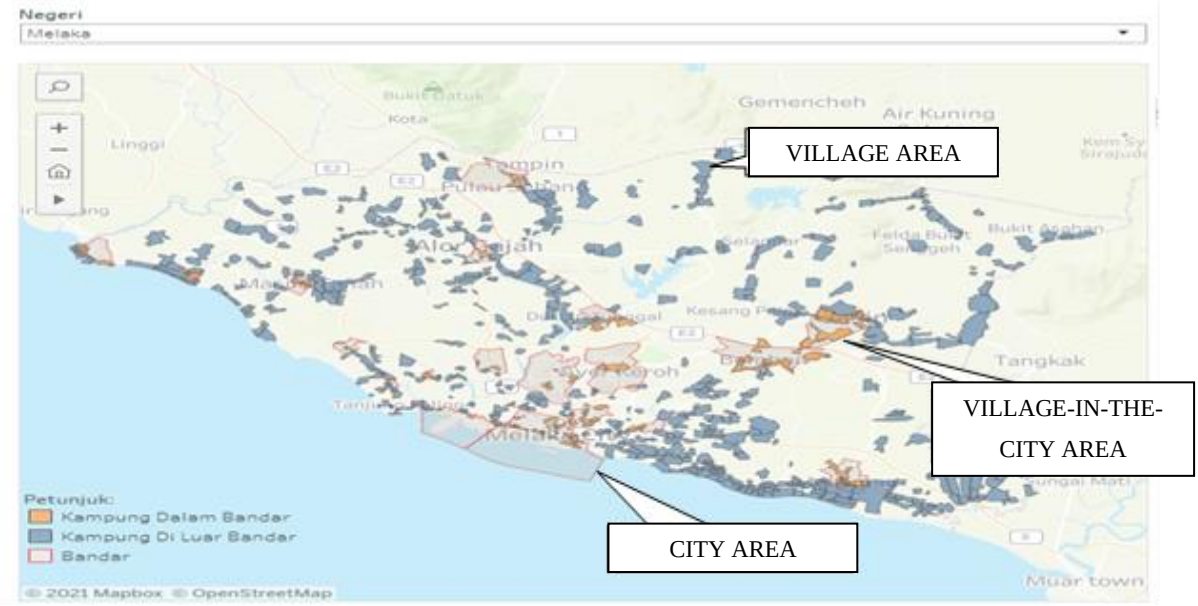

Figure 11: Boundaries Village, City and Village-in-the-city in Melaka

In addition, it was found that there are 152 village-in-the-city in Negeri Sembilan, compared to 114 in Melaka, even though the number of city in Negeri Sembilan is less than Melaka. This is seen to be caused by the spread of the city to the village areas in Negeri Sembilan that are close to the existing city boundaries. The statistics of this comparison can be seen as in Table 1 below.

Table 1: Comparison of the Number of Village-in-the-city

No	State	No. of City	No. of Village	No of Village-in-the-city
1.	Melaka	19	701	114
2.	Negeri Sembilan	14	1324	152

Based on Table 1, it can also be seen that the percentage ratio between the number of village-in-the-city and the total number of villages in Melaka is higher at 16.26% compared to Negeri Sembilan at 11.88%. These differences give an impression of the occurrence of urban sprawl in Melaka, and it is higher than the urban sprawl that occurs in Negeri Sembilan.

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Analysis from FGD

The final FGD with the stakeholders is carried out to discuss and review essential elements on the developed dashboard. Furthermore, the data displayed are also validated by the stakeholders to ensure the preciseness of the demarcation mapping information. Discussions with the FGD of the Agency directly involved, namely the National Physical Planning Division, PLANMalaysia (Urban and Rural Planning Department) at the management and implementing levels, have been carried out. This discussion and review are essential because all questions and concerns related to the study can be discussed directly. This also ensures that the data displayed in the developed dashboard is valid and can be used in addition to more accurate demarcation mapping. A series of questions were presented to the FGD based on three elements (Dashboard design, Dashboard Interaction and data validation). FGD agrees with the layout of the statistical display, bar charts and graphic maps provided. However, there are changes to the titles used and the colour scheme on the map. FGD with a colour view on the map must be differentiated and not in the same colour group. FGD has done testing and found that the dashboard can respond well when one option change is made. The 'zoom in' and 'zoom out' functions on the map section are highly emphasised because they clearly show the location and extent of demarcation.

Overall, the FGD agreed with the statistics displayed on the developed dashboard. This is because the result of the FGD review with the existing data used is the same as the data displayed in the dashboard. According to the Agency's FGD, this developed dashboard can help the agency identify the existence of villages in the city more quickly and easily. So far, the agency has yet to have a clear picture of mapping the demarcation of villages within the city, primarily when urban sprawl occurs. This is because the current mapping data only involves city and village boundaries. In addition, the agency has been forced to use two different platforms, namely QGIS and Excel, to obtain relevant statistical data.

Finally, for the data validation, the stakeholders confirmed the correctness and preciseness of the statistics displayed. In conclusion, the stakeholders agreed that the developed dashboard assists the related agencies in identifying precisely the existence of village-in-the-city more quickly and easily. Previously, the agency has yet to clearly understand the demarcation of village-in-the-city, primarily when urban sprawl occurs because the data used involved only mapping of city and village boundaries. The dashboard development using Tableau provides facilities to build good statistics and mapping; it can even be a reference, especially for the management implementing the development plan.

Conclusion

Overall, the research carried out has a positive impact on the selected agency in particular and the public in general, especially in implementing the physical development planning of village-in-the-city. The developed dashboard has visually proven the existence of village-in-the-city, which had never been confirmed in the form of a graphic map before. In addition, the display of the boundaries of identified village-in-the-city allows research to be done on the issue of urban sprawl that occurs, causing the needs of the residents to be fulfilled. Furthermore, with this dashboard, it is seen that the related agencies' management can make decisions related to the physical planning of the village-in-the-city earlier than usual because it is no longer necessary to wait for separate data analysis that needs to be produced manually. Indirectly, this dashboard has saved time and energy in addition to being able to carry out better, detailed and relevant research. At the same time, the developed dashboard can act as the agency's 'strategic

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dashboard' in analysing future development planning. If seen in the context of the benefits that the general public will receive, that is, residents living in village-in-the-city areas, the need for infrastructure and health facilities such as schools, transport, and health clinics can be planned to be implemented precisely. The impact of urban spread to the village area's border can be reduced. Errors in planning the needs of these facilities can be avoided when elements such as the population and the radius of the facility can be identified. Indeed, this will ensure adequate allocations in the physical development of the village itself. Therefore, the advantages of using this dashboard have been brought into the discussion at the highest management level of the agency to expand its use to other states in Malaysia. The agency has planned to use this dashboard approach to monitor municipal issues, including urban data management including smart cities at the national level.

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