



JOSSTED

JOURNAL OF SOCIAL SCIENCES
AND TECHNICAL EDUCATION

Application Geographical Information System in Fire Hydrant and Open Water Sources Management

(Aplikasi GIS Dalam Pengurusan Pili Bomba Dan Sumber Air Terbuka)

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ARTICLE INFO

Article History:
Received 20.06.2023
Accepted 26.07.2023
Published 23.11.2023

Abstract

This paper discusses the application of the Geographical Information System (GIS) in managing fire hydrants and open water sources. The use of GIS in fire hydrant and open water management allows for efficient and effective management of resources. The paper outlines the benefits of GIS, including data visualization, data analysis, and data management. The paper also discusses how GIS can be used to create navigation maps and optimize response times during emergency situations. Furthermore, the paper discusses the challenges and limitations of GIS in this context, such as data accuracy and accessibility. Overall, the paper concludes that GIS is a useful tool for managing fire hydrants and open water sources and recommends its adoption for efficient management of resources in emergency situations.

Keywords: Geographical Information System (GIS), Fire Hydrant and Open Water Sources Management.

INTRODUCTION

Fire hydrant and open water sources management are critical in ensuring the availability of water for firefighting and other emergency response activities. The management of fire hydrants and open water sources involves the maintenance, inspection, and repair of these resources, as well as the identification of risks and the development of strategies to mitigate those risks.

Geographical Information System (GIS) is a technology that can aid in fire hydrant and open water sources management by providing a spatial and temporal understanding of the availability and accessibility of these resources. GIS integrates data from various sources, including remote sensing data, topographic data, and historical data, to create maps and models that can be used to analyse risks and optimize resource allocation.

One of the benefits of GIS is that it can aid in data visualization. By displaying data on a map, it becomes easier to identify the location and accessibility of fire hydrants and open water sources, as well as the areas that require additional resources. Additionally, GIS can be used to develop fire risk maps that identify areas with a high probability of fires, enabling the allocation of resources to these areas.

Another benefit of GIS is that it enables real-time monitoring and analysis of water sources. This is particularly important during emergency situations where access to water sources may be limited, and the availability of real-time data can aid in the decision-making process.

However, there are challenges and limitations associated with the use of GIS in fire hydrant and open water sources management. One of the challenges is data accuracy, as outdated or incomplete data can lead to incorrect conclusions and suboptimal resource allocation. Additionally, data accessibility can be a challenge, as some data sources may be restricted or require a fee to access.

LITERATURE REVIEW

Cheng and Bagnall's (2019) Handbook of Geographical Information Science provides a comprehensive overview of GIS and its various applications, including fire hydrant and open water source management. Longley et al. (2018) similarly offer an in-depth examination of GIS, emphasizing its ability to capture, store, manipulate, and analyse geographic data. Maher's (2014) work focuses specifically on using GIS for emergency preparedness and health risk reduction, while Marsh (2019) examines its use in fire and rescue services. Quattrochi and Goodchild (2016) explore scale issues in remote sensing and GIS, while Rajabifard et al. (2018) discuss the use of spatial data infrastructure in urban regeneration. Sui (2018) highlights the role of GIS in humanitarian emergencies, and Yu (2019) delves into spatial data mining.

Bil and Kucuk's (2018) research analyzes fire station locations and coverage areas using GIS in the city of Adana, Turkey. Feng et al. (2021) use GIS technology to assess the urban fire hydrant network layout. Li et al. (2017) analyze fire hydrant locations in urban areas, and Odeh and Gouda (2015) propose a fire hydrant management system based on GIS and wireless sensor networks. Hines and Conner (2015) use GIS to integrate emergency response in St. John's County, Florida, while Wu et al. (2018) employ GIS and remote sensing to map and analyze fire risk in forest ecosystems. Yang et al. (2020) optimize the selection of urban fire hydrant locations using GIS and multi-criteria decision-making, and Yapici et al. (2015) utilize GIS technology to manage water supply networks in Sinop Province, Turkey.

METHODS

DATA AND SOFTWARE

An existing fire hydrant's locations data was acquired along zone Sarawak in Excel workbook format (.xlsx). These existing data were interpreted into geospatial data to verify or countercheck the accuracy of the location. Besides that, SW Maps apps are also used in field the of data collection to acquire relevant fire hydrant data.

Fire hydrants and open water sources play a pivotal role in emergency response planning. Identifying their locations allows for a better understanding of the coverage areas and potential gaps in the fire protection network. By analyzing the proximity of fire hydrants to open water sources, responders can efficiently allocate resources during firefighting operations, ensuring a timely and effective response.

The relationship between fire hydrants and open water sources helps in optimizing resource allocation. The GIS-based analysis allows for the identification of areas with high fire risk and a lack of sufficient water supply. By strategically placing fire hydrants and open water sources, the study aims to ensure a well-distributed and adequately equipped firefighting infrastructure, thus improving overall response capabilities.

Validating the accuracy of a fire hydrant and open water source locations is critical for a reliable GIS database. Integrating both datasets allow for cross-referencing and verification, ensuring that the information used in the study is precise and up-to-date. Conducting spatial analysis between fire hydrants and open water sources helps in determining the optimal arrangement of these resources to minimize response time and maximize coverage. GIS-based tools enable the identification of potential bottlenecks and areas with inadequate water supply, leading to better decision-making in resource placement.

Understanding the relationships between fire hydrants and open water sources is crucial in achieving effective fire hydrant and water source management. GIS technology allows for data visualization, spatial analysis, and optimization, leading to more informed decisions and enhanced emergency response capabilities.

QGIS is a free and open-source Geographic Information System software that provides a range of features and abilities for spatial data management, analysis, and visualization. It allows users to import, export, and manage spatial data in various formats, provides tools for editing and digitizing spatial data, and supports a range of spatial analysis tools, including geoprocessing, distance calculations, and more. Additionally, QGIS allows users to create maps and other visualizations of spatial data, customize the software with plugins and scripts, collaborate with other users, and integrate with other GIS systems and data sources.

Google My Maps is a web-based mapping platform that allows users to create custom maps for personal or professional use. It provides a range of features and abilities for mapping and data visualization, including the ability to add markers, lines, shapes, and text to the map. Google My Maps also allows users to import and export data in various formats, including KML and CSV, and provides integration with other Google services, such as Google Drive and Google Sheets. Additionally, it provides collaboration features, allowing multiple users to work on the same map simultaneously, and sharing options, allowing maps to be shared publicly or with specific individuals or groups.

Figure 1 shows the flow chart of the application of Geographical Information System (GIS) in managing fire hydrant and open water sources.

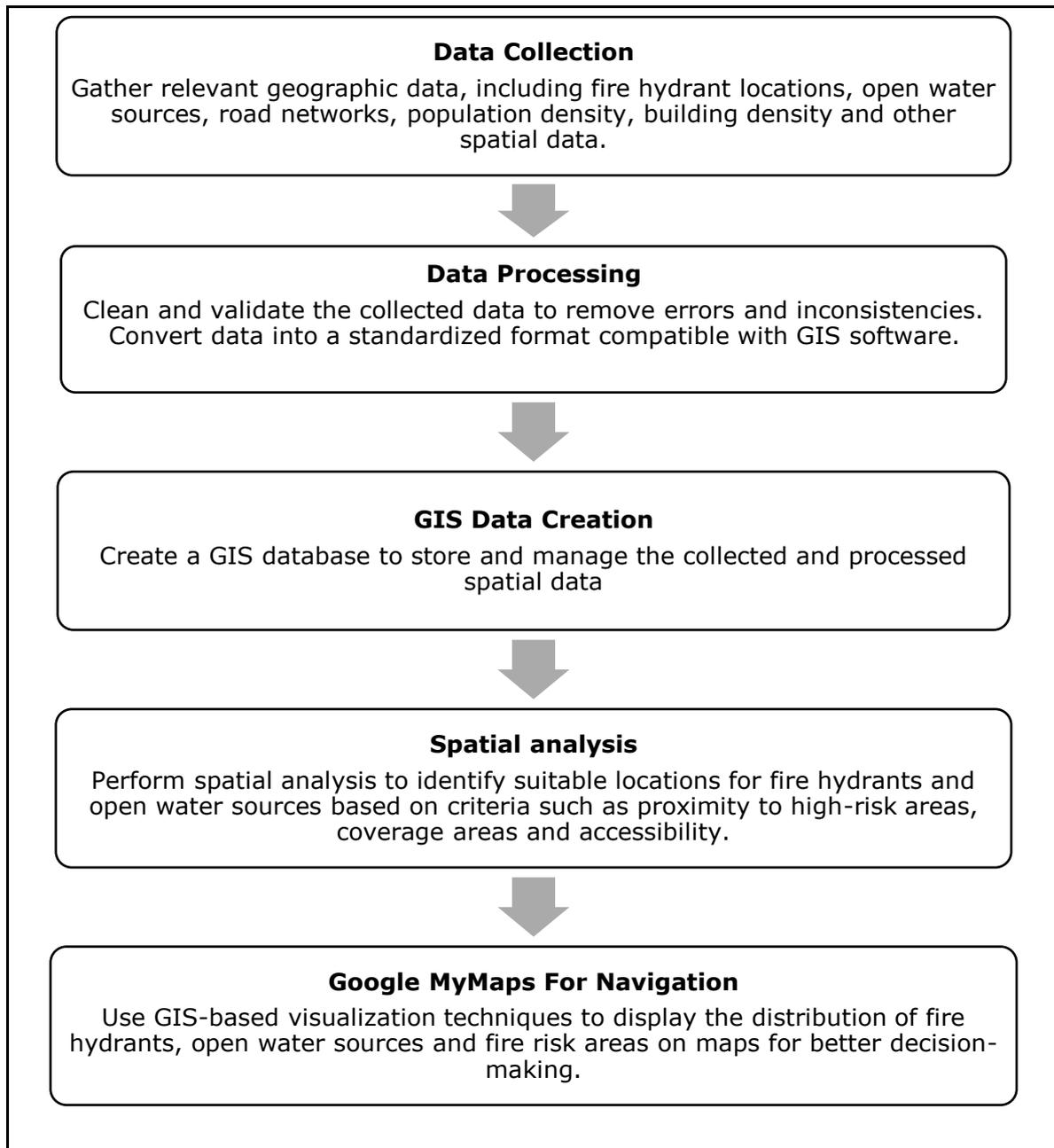
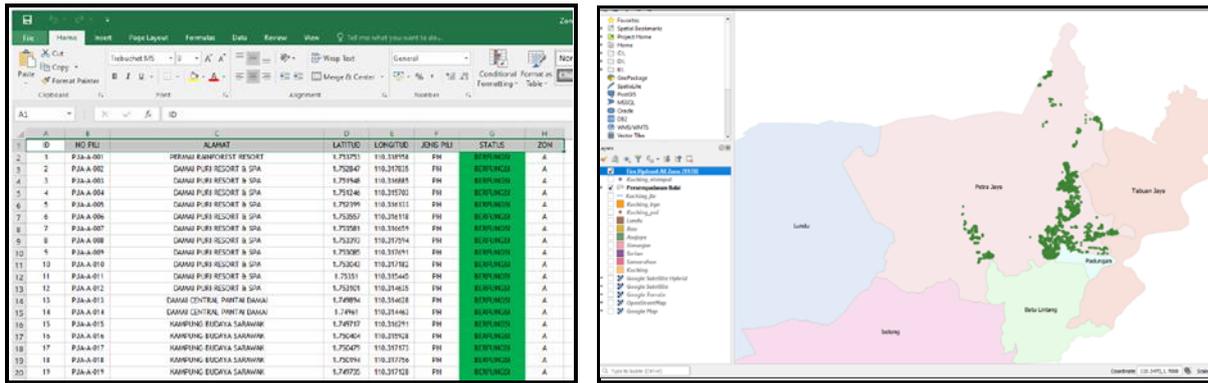


Figure 1. Application of Geographical Information System in managing fire hydrants and open water sources

Data Collection

The first step in any GIS project is to collect data that will be used for analysis. In this case, data on fire hydrant and open water source locations, population density, and existing fire station locations would be relevant. These data can be collected from various sources, including local government agencies, water utilities, and emergency response services. Figure 2 shows the data migration which is data preparation in CSV format dan QGIS data imported. Figure 3 shows the field data collection by using the SW Maps Apps to validated and updated the status of fire hydrants.



(a) Data preparation in CSV format

(b) QGIS Data Imported

Figure 2. Data Migration



Figure 3. SW Maps Apps for Field Data Collection

Data Processing

Once the data has been collected, it needs to be processed in a way that can be used for spatial analysis. QGIS is a popular software for processing spatial data and can be used to create a comprehensive spatial database. Data can be imported into QGIS using various formats such as CSV, shapefiles, and KML. All the existing datasets for each zone, such as hydrant ID, latitude, longitude and hydrant status are merged into one master table. After that, converts an existing Excel format file to Comma Separated Value File (CSV) format. The CSV files were then migrated into QGIS. Determine the correct Geometry Definition and define the coordinate reference system in terms of the World Geodetic System 1984 (WGS 84). Figure 4 shows the setting of the Geometry Definition in this project.

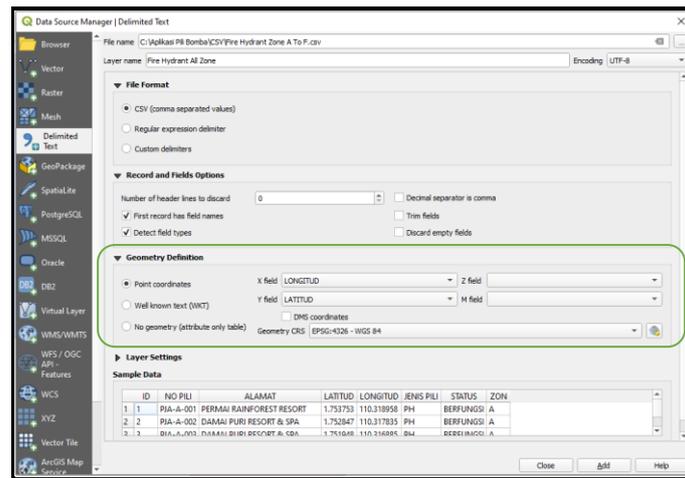


Figure 4. Geometry Definition

The CSV format is then converted to Shapefile (shp) format. GIS software uses the Shapefile format, which is a geospatial vector data format. Before applying the spatial analysis, all the fire hydrant symbols were categorized by their status and clearly displayed on the screen. Figure 5 shows the classification symbol of the fire hydrants.

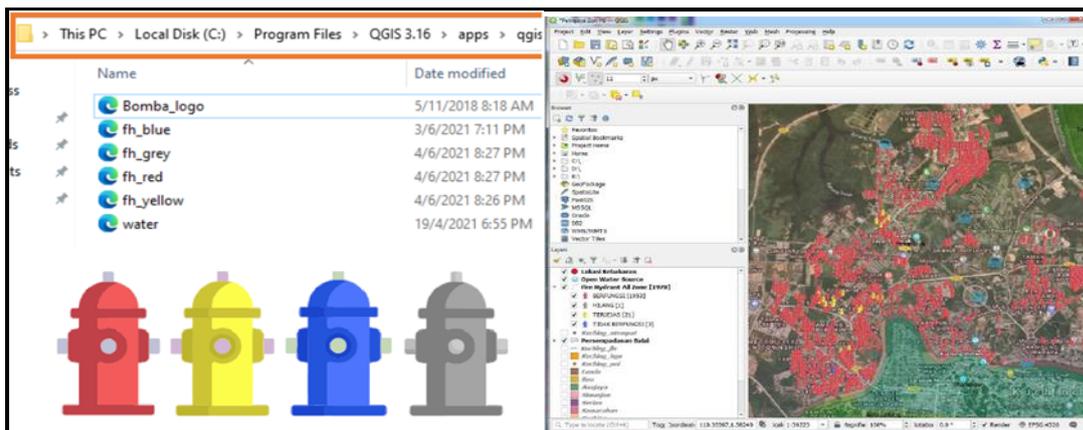


Figure 5. Classification Symbol

Spatial Analysis

With the data processed and organized in a spatial database, QGIS can be used to conduct spatial analysis. This includes proximity analysis to determine the distance between fire hydrants and open water sources and analyzing their distribution across the study area. Spatial analysis tools in QGIS include spatial query, buffer, and distance matrix, among others. Figure 6 shows the spatial analysis for searching the nearby fire hydrants.

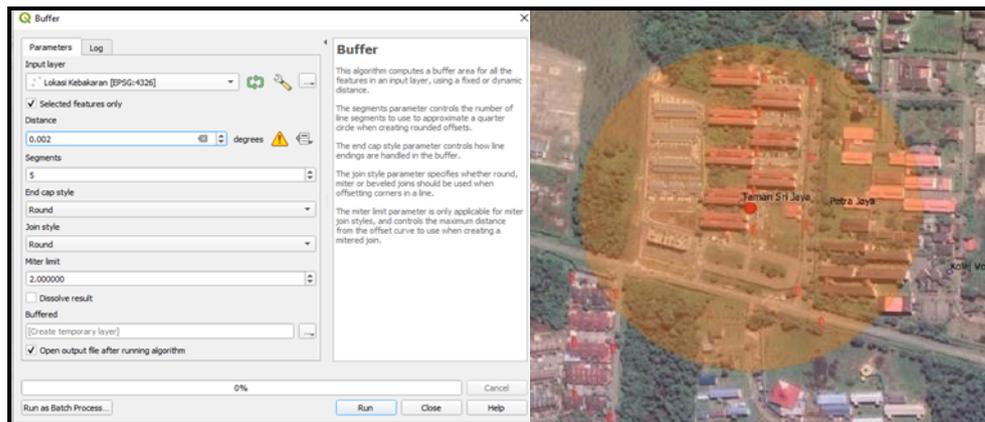


Figure 6. Analyze Nearby Fire Hydrant

Export to My Maps

Once the spatial analysis is complete, QGIS can be used to export maps and other visual representations of the data. Google My Maps platform was chosen to show the distribution of fire hydrants and open water sources across the spot area and create map legends and symbols to help interpret the data with other collaborative users. Figure 7 shows the output view in My Maps and Share the Map.

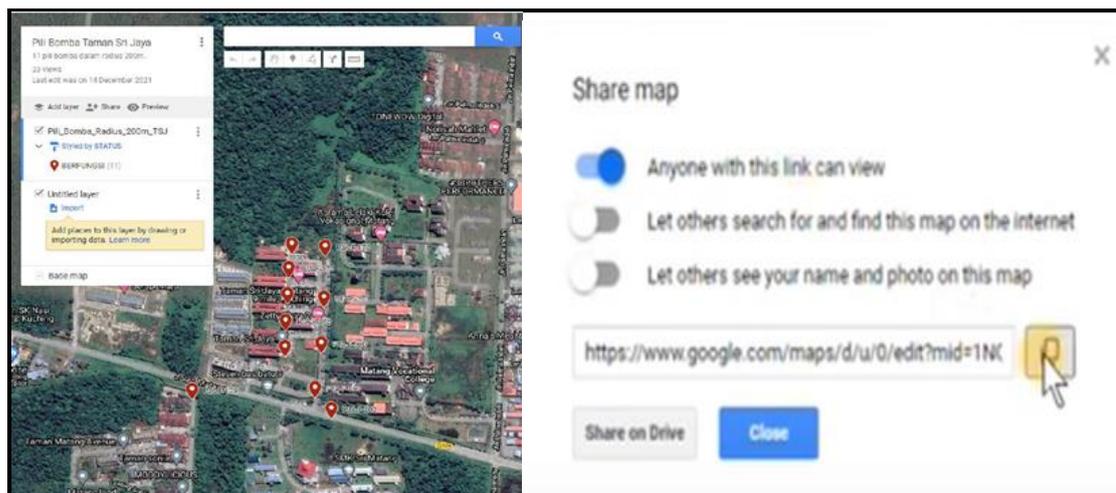


Figure 7. Output View in My Maps and Share the Map

Data Interpretation

With the data analyzed and visualized, it can be interpreted to draw conclusions about the distribution of fire hydrants and open water sources within the buffered area. This includes identifying the functional status of fire hydrants and open water sources.

Navigation with the Google Maps

Figure 8 shows the integration with Google Maps Navigation.

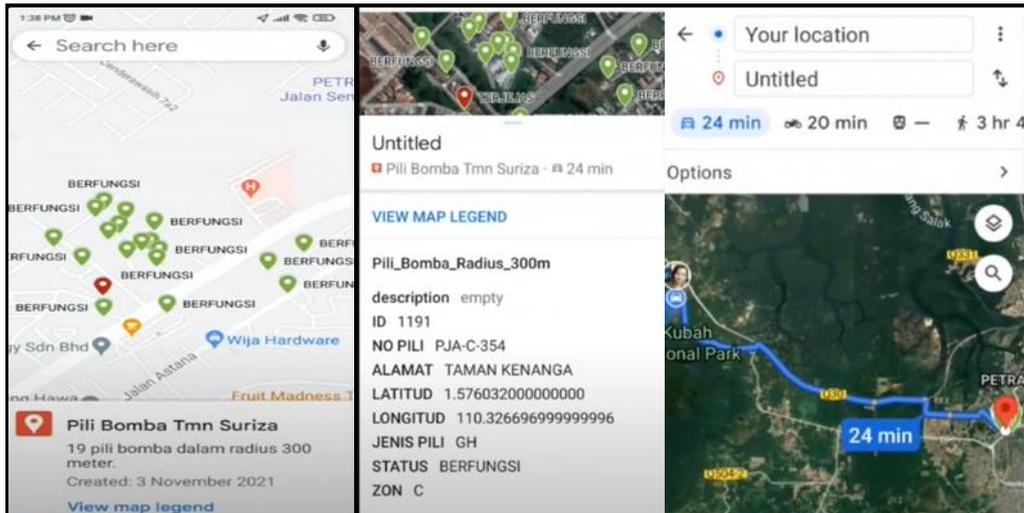


Figure 8. Integrated with Google Maps Navigation

RESULTS AND DISCUSSION

Result

The results of this study show that GIS is a valuable tool in fire hydrant and open water sources management. GIS can provide accurate and reliable data for analysis and decision-making, aiding in the development of effective management strategies. By integrating location-based information with data from various sources such as satellite imagery, aerial photography, and ground-based sensors, GIS can create maps, identify potential risks, and optimize response times during emergency situations.

One of the primary benefits of GIS is its ability to provide real-time monitoring and analysis of water sources. This is crucial in identifying potential risks and developing effective management strategies. GIS can also provide valuable data visualization, making it easier to identify the location of fire hydrants and open water sources and ensure that they are properly maintained and serviced. Furthermore, GIS can be used to create fire risk maps, identify high-risk areas and develop proactive measures to mitigate the risk of fires.

Discussion

The results of this study demonstrate the potential of GIS in fire hydrant and open water sources management. However, it is important to recognize the challenges and limitations associated with the use of GIS in this context. One of the primary challenges is data accuracy. Outdated or incomplete data can lead to incorrect conclusions and suboptimal resource allocation. Furthermore, data accessibility can be a challenge, as some data sources may be restricted or require a fee to access.

Despite these challenges, GIS remains a valuable tool in fire hydrant and open water sources management. Future research should focus on improving data accuracy and accessibility, as well as developing new techniques to analyze and interpret data from various sources. Additionally, research should explore the potential of machine learning and artificial intelligence in fire hydrant and open water source management, which could further optimize response times during emergency situations.

In conclusion, GIS is a valuable tool in fire hydrant and open water sources management, providing benefits such as data visualization, data analysis, and real-time monitoring. While there are challenges and limitations associated with the use of GIS in this context, these can be addressed through further research and development. Ultimately, the

adoption and improvement of GIS can help to ensure public safety and reduce the risk of property damage during emergency situations.

CONCLUSION

In conclusion, this research has demonstrated that the application of Geographical Information Systems (GIS) in fire hydrant and open water sources management is highly valuable. GIS can provide accurate and reliable data for analysis and decision-making, enabling the development of effective management strategies.

The use of GIS can help identify potential risks and optimize response times during emergency situations by integrating location-based information with data from various sources such as satellite imagery, aerial photography, and ground-based sensors. The visualization of data on maps can also facilitate the identification of fire hydrant and open water source locations, ensuring that they are properly maintained and serviced.

However, there are challenges and limitations associated with the use of GIS in fire hydrant and open water sources management. These include data accuracy and accessibility, which can affect the effectiveness of management strategies.

Despite these challenges, the benefits of GIS in fire hydrant and open water sources management are significant. Future research should focus on improving data accuracy and accessibility, as well as developing new techniques to analyze and interpret data from various sources. The potential of machine learning and artificial intelligence in fire hydrant and open water source management should also be explored further. Establish a special mission team to implement a Yearly Action Plan to manage the dataset and its accuracies.

Overall, the adoption and improvement of GIS can help to ensure public safety and reduce the risk of property damage during emergency situations. The findings of this research have practical implications for fire departments, water utilities, and local governments that are responsible for managing and maintaining fire hydrants and open water sources.

ACKNOWLEDGEMENT

Thanks to the Fire and Rescue Department of Malaysia Headquarters, Sarawak State.

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