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Electrical substations mapping for possible communication technologies using QGIS and Google Earth Pro

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ABSTRACT

The visualization of mapping has aided researchers in gaining a better understanding and studying a specific area in a variety of professions. One of the well-known visualization software for mapping is the Geographic Information System (GIS). This work demonstrates the integration between an open-source GIS technology, named QGIS, and the Google Earth Pro programme in the mapping and analysis of electrical distribution substations. This integration shows the electrical substation data, the possible communication technology ranking, and a map that can be displayed and visualized based on the demographics. The QGIS in this study is used to reclassify the demographics into three main demographics: urban, suburban, and rural areas. On the other hand, the Google Earth Pro programme is used to map and visualize the overall electrical distribution substations alongside the communication technology ranking, based on the three main demographics. A case study using QGIS and Google Earth Pro was carried out in Area X, Malaysia for this investigation. Substation locations in Area X are mapped using Google Earth Pro, and the area's demographics are categorized as part of the process. The features also enable the technology ranking to be displayed upon clicking the respective color-coded areas, where red represents urban area, yellow represents suburban and green represents rural This integration deems beneficial for future references on electrical distribution substations alongside the possible communication technologies.

Keywords: Electrical Substations; Mapping; Google Earth Pro; QGIS; Communication Technologies; Energy

INTRODUCTION

Mapping software programmes have been known to assist researchers, professionals, and users to visualize geospatial data more effectively. With the use of GIS, all forms of geographical data can be captured, stored, manipulated, analyzed, managed, and presented (Erdin & Akbas 2019). One of the most widely use GIS software that are widely use is ArcGIS developed by ESRI (Ogli and Murodilov 2023). However, ArcGIS can be expensive for researchers due to the subscription nature of the license and every extension of the software are add-on to the basic software. The rise of open-source GIS software has been useful for users as they offer almost similar capabilities to the closed source software. Some of the best-known open-source mapping software programmes are FlowMap, GDAL (Appel et al. 2018), QGIS (QGIS.org, n.d.) , and Google Earth Pro (Google, n.d.; Yin et al. 2023; Pereira et al. 2022), where each software provides different application and analysis of the geospatial data.

In this work, QGIS has been used alongside Google Earth Pro. QGIS (short for "Quantum GIS") was developed by the QGIS Development Team in 2002 as a free, open-source GIS programme (Flenniken, Stuglik, & Iannone 2020). QGIS is a volunteer-run project, and users can help by writing code, making tools, reporting bugs and fixing them, writing documentation, and promoting or supporting the project. The benefits of open-source software come from the worldwide contributions of professionals and users, which allow all users to access and verify code and procedural algorithms.

On the other hand, Google Earth Pro also enables users to create, visualise, evaluate, and overlay geospatial data. This resource is frequently a useful intermediary for learners who are interested in learning more about GIS but wish to begin with more fundamental processes and tools (Duplain 2022). In addition to viewing Google's high-resolution satellite imagery, Google Earth Pro can be used to upload or download geospatial data in Google's own interoperable file format namely Keyhole Markup Language (.kml) and to search for specific locations (e.g., for simple geocoding). In this work, QGIS and Google Earth Pro are used to map electrical distribution substations alongside with communication technologies ranking.

ISSUES IN THE ELECTRICAL DISTRIBUTION

In this study, QGIS and Google Earth Pro are employed to create maps of electrical distribution substations, including a ranking of communication technologies. The significance of electrical distribution substations is underscored due to their critical role in supporting end-user applications. Challenges arise as a consequence of the expanding consumer base within these applications, leading to heightened demand, potential compatibility concerns, considerations for security, and resource utilization. Thus, having many distribution substations makes accessing the information of each substation tedious and time-consuming. By visualising the electrical distributions substation placemark, one may easily access electrical distribution substation information. With the current emerging of future end user applications, these substations are undergoing upgrades to accommodate the smart grid paradigm, thus, needing of bidirectional communications (Azmi et al. 2022). In this work, not only it maps the placemark of the electrical distribution substations, but also includes the recommended communication technologies based on the demographics.

The main issues in viewing the electrical substation is that, these electrical substation placement is visualised in term of a set of data. The recent studies on electrical substation placement have been done in Mohd Azmi et al. *(*Mohd Azmi et al. 2022) conducted recent research on the placement of electrical substations. In their study, the authors employed the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to determine the most suitable communication technology solutions for electrical distribution substations. In a separate study conducted by Trivedi et al. in 2023, (Trivedi et al. 2023) they utilised the Analytic Hierarchy Process (AHP) and TOPSIS to provide a framework for choosing the appropriate substation technology in an electrical power distribution network.

Based on prior research, it has been observed that the placement of electrical substations or the selection of communication technology is frequently associated with a methodology that incorporates a series of criteria and often present in a set of data. When presented in this manner, it is difficult for the utility company Tenaga Nasional Berhad (TNB) to analyze the appropriate communication technologies based on demographics.

In order to assist them, our work entails creating a better visualization in which not only the placemark indicates the ranking of communication technology, but also the substation information is incorporated for convenience.

The purpose of this research is to utilize GIS technologies along with Google Earth Pro in order to map and analyze electrical distribution substations. In order to achieve these aims we identify the needing of bidirectional communications for the electrical distribution substations and we want to visualise the placement of the electrical distribution substations in n different demographics, which includes a ranking of communication technologies. The primary contribution of this study lies in its emphasis on the visualization of electrical distribution substations, encompassing comprehensive information pertaining to each substation, alongside a ranking of suitable communication technology for diverse demographic contexts.

In this paper, Section 2 shows different applications of GIS or open-source GIS in various fields, while Section 3 discusses the methodology of this work, Section 4 elaborates on the mapping of a case study in Malaysia, Section 5 on discussion and Section 6 concludes this research.

LITERATURE REVIEW

The integration of both open-source GIS and Google Earth Pro are not widely implemented as some tasks can be completed with only one primary software. This study has identified two studies that integrates GIS with Google Earth as to visualize terrain (Martinenko 2021) and manage rural waterbone (Rasam et al, 2014). There are also several studies on integrating GIS with others technique, which is on QGIS training (Idrizi et al, 2021), substation expansion planning (Vahedi, Banejad, & Assili 2021), impact of electric vehicle (EV) (Viganò et al. 2021), planning of EV charging station locations (Zhang, Teoh, & Zhang 2022), assessing PV potential (Massano et al. 2022) and planning base station placements (Mustafa et al, 2022).

Idrizi et al. (Idrizi, Pashova, and Nikolli 2021) promote a lifelong training programme on QGIS for earth observation sciences in South-East Europe. The work aims to present and promote adequate training on QGIS to improve QGIS research, development, and knowledge of the open-source GIS software. According to the authors, the South-East European Research Institute on Geo Sciences (GEO-SEE Institute) started professional training courses consisting of three levels: elementary, intermediate, and advanced. Through teaching, training, and learning the open-source software, the GEO-SEE Institute's objective is to continuously raise the competence and qualification of geocommunity specialists (Idrizi, Pashova, and Nikolli 2021).

Martinenko and Obradović (Martinenko and Obradović 2021) conducted a study to visualise terrain changes produced by natural disasters such as landslides over an observed time period. The research mainly focuses on the Umka territory in Belgrade, Serbia. The authors claimed that employing this integration saves time and provides various advantages, such as low cost, easy implementation, and the availability of open-source and free software compared to traditional methods. In addition, this methodology helps professionals gain better insights into natural disaster-affected areas, which is crucial for companies wishing to invest (Martinenko and Obradović 2021).

Rasam *et al.* (Rasam et al. 2014) integrated QGIS with Google Earth to manage rural waterborne outbreaks in Kota Kinabalu, Malaysia. The primary goal of this integration is to map and analyse the cholera disease in the area. In order to analyse the spatial-temporal pattern of the cholera outbreak in the high-risk areas, QGIS was combined with Google Earth to create a geodatabase and map of the disease's distribution. From 2005-2011, the researchers tracked the spread of cholera and found that 258 cases occurred within 100 m of a coast or river. Only 29 cholera cases occurred in coastal and river buffering over 100 m.

This paper (Vahedi, Banejad, and Assili 2021) presents a novel methodology that utilizes GIS to analyze a raster map in order to facilitate the planning of substation growth in a significantly large real network. This methodology offers a novel strategy to partition the planning area into irregular miniregions, enabling the effective management of large-scale real network growth planning. The system comprises a total of 44 subtransmission substations, operating at voltages of 132 kV and 63 kV. These substations currently possess a combined capacity of around 2550 MW. Compared to prior systems, the proposed irregular planning miniregions (IPMR) have more function and better solutions. The IPMR's flexibility may make it suitable for large-scale problems. In addition, a clustering technique has been utilized to present the optimal substation autoplacement (OSAP), which is particularly suitable for GIS research. Using a rasterized map, this method takes into account geographical, economic, and technical criteria to provide an evaluation of the planning region independent on specific candidate locations.

In this paper, the analysis' goal is to create a methodology for investigating the impact of future EV penetration on MV networks (Viganò et al. 2021). The approach is then used to analyze Brescia as a case study. Geolocation of electrical assets enables better integration with external databases, such as parking area data, for more realistic network evolution studies. Using the QGIS plugin QuickOSM (QGIS.org, n.d.) parking data can be retrieved. This tool imports OpenStreetMap data on Brescia a city in Northern Italy, parking areas into QGIS. The data consists of two datasets : contains polygons representing the surface of parking areas, and the other contains points representing attributes of unknown parking places, such as underground or covered parking. Using preexisting algorithms and tools, the MV network is simulated while assuming various scenarios. It has been demonstrated that EVs can have a significant impact on MV distribution networks, particularly MV/LV transformers. Fast charging stations are a common source of MV line violations and MV/LV transformer failures because of their high nominal power. In addition, slow charging stations can detect violations, particularly when the secondary substation supplies a high number. The network would benefit greatly from having the recharge occur during off-peak hours.

Another research that integrates GIS with EV can be seen in (Zhang, Teoh, & Zhang 2022) where, long-term sustainable urban growth is aided by careful planning of EV charging station locations. To address the location selection challenge for EVs, this research provides a novel method that combines GIS and Bayesian Network (BN). Capturing spatial and geographical data with a GIS allows for the acquisition of dynamic and visually appealing data while choosing charging locations while BN is used to analyze criteria and show the impact of alternate site choices. By employing a GIS based BN approach, authors examine the optimal site selection issue from the viewpoints of the economy, society, and infrastructure. Raw data serves as the geographic database for GIS technology, which then transfers the data and converts it into rasters and layers for visual analysis. A BN model is constructed to depict the causal links and facilitate the updating of probability.

GIS can also be used in renewable energy sources (RESs) since the RESs, such as photovoltaic (PV) systems, and a distributed generation (DG) model of energy production have become increasingly popular as people become more aware of environmental concerns and as more RESs become available. This study introduces a methodology that combines procedures for assessing PV potential using GIS with models for estimating energy generation and consumption patterns (Massano et al. 2022). In a GIS environment, the proposed solution integrates open data and models with various urban geometric characteristics (e.g., census data and real weather parameters). In this study, the methodology was implemented and evaluated in an authentic urban setting, specifically in the city of Turin, Italy. Simulations were conducted for both home domestic loads and rooftop PV production over the entire municipality.

GIS can also be integrated with other techniques as demonstrated by Mustafa *et al.* (Mustafa et al. 2022), who developed a GIS-based methodology for planning base station placements in Cameron Highland, Malaysia. This work integrates GIS with fuzzy membership and MCDM method, including Analytical Hierarchy Process and Weight Linear Combination. Appropriate base station placement is required to ensure a continuous and steady communication network for transmission line slope monitoring. From the study, seven potential base station placement sites were selected. Table 1 shows the summary work on the usage of GIS or Google Earth.

TABLE 1. Summary of previous work on the usage of GIS or Google Earth

Authors	Method	Goal
Idrizi et al. (2021)	QGIS	Aims to present and promote adequate training on QGIS
Martinenko and Obradović (2021)	Google Earth Pro QGIS	Visualise terrain changes produced by natural disasters
Rasam et al. (2014)	Google Earth QGIS	Manage rural waterborne outbreaks
Vahedi et al. (2021)	IPMR OSAP GIS	Substation expansion planning
Viganò et al. (2021)	QGIS OpenStreetMap	Evaluate the effects of EVs on electrical distribution networks
Zhang et al. (2022)	Bayesian Network GIS	Planning of EV charging station locations
Massano et al. (2022)	GIS-based distributed software infrastructure	Estimate energy generation and consumption profiles.
Mustafa et al. (2022)	GIS Fuzzy Membership Analytical Hierarchy Process Weight Linear Combination	Planning base station placements

ADVANTAGES AND DISADVANTAGES OF QGIS

The simplicity of operation and open source/free design of QGIS are among its main benefits. The drawbacks of QGIS have been addressed in newer versions based on its previous limitations. A 2014 study from the University of Vienna compared QGIS and ArcGIS (Flenniken, Stuglik, and Iannone 2020; Friedrich 2014). The comparison found that ArcGIS offered more features, such as 3D data, animations, and advanced network analysis, than QGIS did at the time. Now, QGIS provides functionality in these domains (Flenniken, Stuglik, and Iannone 2020). The key benefit is being able to add externally generated programmes known as QGIS plugins and modify the software codes as needed (Idrizi, Pashova, and Nikolli 2021).

ADVANTAGES AND DISADVANTAGES OF GOOGLE EARTH PRO

One of the most attractive aspects of Google Earth Pro is its extensive set of features. It has useful measuring tools, professional-only data layers, high-resolution printing, GIS import, and spreadsheet import. Another advantage of

Google Earth Pro is that it helps with the visualisation of the overall overview of urban, suburban, and rural areas. In contrast, QGIS require higher performance hardware compared to Google Earth Pro. However, if the Google Earth Pro slowed down, this is because Google Earth Pro is less efficient to conduct heavier processing.

ADVANTAGES AND DISADVANTAGES OF INTEGRATING GOOGLE EARTH PRO AND QGIS

By overlaying QGIS data onto Googles base maps, which include satellite imagery and street maps we can enhance our project, with real world context. This integration helps us gain an understanding of the relationship between electrical distribution data and the surrounding environment. Google Earth Pro offers exceptional 3D visualization capabilities along with a user-friendly interface that enables us to create visually captivating and interactive maps. This feature proves valuable when presenting the data to individuals without expertise. In contrast, while Google Earth Pro excels, in visualization capabilities it doesn't provide the spatial analysis functionality that QGIS offers. Apart from that, since Google Earth Pro has some KML file size limitations, the data exported from QGIS suffered from reduced resolution. Google Earth Pro and QGIS consumed high computational resources since we required both software for this project.

METHODOLOGY

Information can be effectively communicated to a range of audiences through visual presentation and mapping is one of the most common types of visual data. GIS and open-source software such as GeoDa, QGIS, and Google Earth Pro can be used to visualise data mapping. In this work, the mapping is integrated with QGIS and Google Earth Pro. The data format provided by Land Use Map is a raster file (GeoTIFF). GeoTIFF is based on the TIFF format and used to describe and store geographical information (Kearney et al. 2020). Using both QGIS and Google Earth Pro is significant because QGIS can support and convert files since KMZ and KML are the default spatial data in Google Earth Pro. Hence, QGIS converts files from GeoTIFF and XSL to KMZ files before exporting the files to Google Earth Pro. As mentioned in previous section, Google Earth Pro offers the visual representation of the mapping. Figure 1 shows the overall process in this study.

The general stages employed in this research included: the preliminary stage, the QGIS processing stage and Google Earth Pro processing stage. The preliminary stage consists of obtaining data from Land Use Map and reclassification of demographics which is based on Eurostat and PLANMalaysia. The Land Use Map classes data obtained that will be used in the QGIS stage. In the QGIS stage, the *tif* file is imported to reclassify the classes to three main demographics; Urban, suburban and rural. The *.xslx* file that contains relevant substation details is also imported in QGIS. The *.xslx* file in QGIS is converted to *.kmz* file for the data to be compatible with Google Earth Pro. The final steps in the QGIS stage involve: 1) converting the raster data (*.tif*) from the preliminary stage to a *.kmz* file; and 2) subsequently exporting the *.kmz* files into Google Earth Pro. In the Google Earth Pro stage, the QGIS data is imported into the programme. Additionally, the communication technology rankings for the substations are also included in the mapping. Section 4 will explain in detail the process of integrating QGIS and Google Earth Pro.

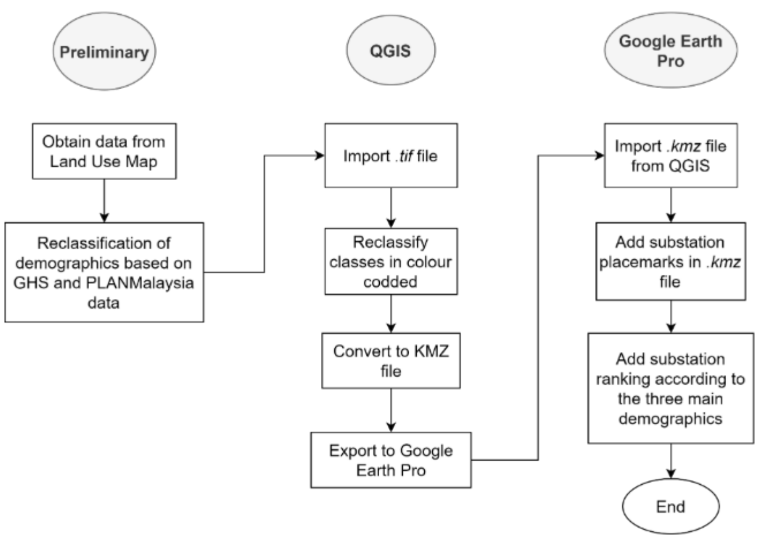

FIGURE 1. The overall process of the study

In order to enhance the credibility and reliability of our research outcomes, we implemented a peer-review procedure among our research team and industry specialists, specifically Tenaga Nasional Berhad which aim to detect and address any inconsistencies or inaccuracies present in the gathered data. The inclusion of feedback and insights from participants enhanced the legitimacy of our study by validating our research procedures and conclusions. This iterative cross-validation process not only ensured the accuracy of our research findings, but also enhanced the practical applicability of our recommendations to real-world situations.

RESULTS

In this section, discusses in details the process of mapping the placemark of the electrical distribution substation and the communication technology ranking based on demographics The classification is performed based on the “A Land Use Map of Peninsular Malaysia for the Year 2018 (25m Grid)” documentation (Kaelin A. & Miller 2021) and the accompanying raster file (GeoTIFF). The Land Use Map is a product of merging Climate Change Initiative Land Cover (CCI LC), Global Human Settlement Layer Urban Centre Database (GHS-UCDB R2019A), state polygon data from PLANMalaysia and paddy fields as illustrated in Figure 2.

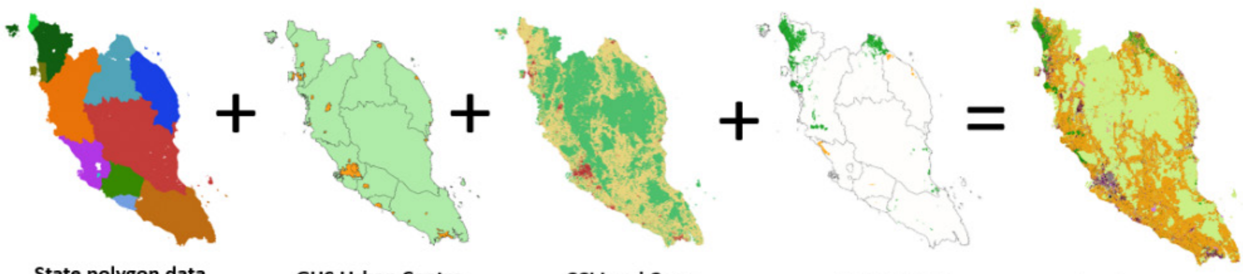

FIGURE 2. Mosaic Land Use Map (Kaelin A. & Miller 2021)

GOOGLE EARTH PRO MAPPING OF ELECTRICAL DISTRIBUTION SUBSTATIONS AND DEMOGRAPHICS CLASSIFICATION

The gridded land use map of Peninsular Malaysia data (GeoTIFF) sourced from (Kaelin A.;Miller 2021) is uploaded into QGIS. The reclassification is based on Eurostat and PLANMalaysia. For this study the data is reclassified to urban, suburban, and rural as shown in Table 2. Table 3 shows the reclassification of polygon classes. The degree of urbanisation classification, according to Eurostat (Eurostat 2021), can be classified as follows:

1. Urban Centre (High Density Cluster) - consists of contiguous grid cells (4-connectivity cluster) with a density of at least 1,500 inhabitants per km² of permanent land or with a built-up surface share on permanent land greater than 0.5, and has at least 50,000 inhabitants in the cluster with smoothed boundaries.
2. Urban Cluster (Moderate Density Cluster) - consists of contiguous grid cells (4-connectivity cluster) with a density of at least 300 inhabitants per km² of permanent land, a built-up surface share on permanent land greater than 0.03 and has at least 5,000 inhabitants in the cluster plus all contiguous (4-connectivity cluster) Urban Centres.
3. Rural grid cells (Mostly Low-Density Cells) - all the other cells that do not belong to an Urban Cluster. Most of these will have a density below 300 inhabitants per km² (grid cell). Some Rural grid cells may have a higher density, but they are not part of cluster with sufficient population to be classified as an Urban Cluster.

TABLE 2. New demographic classifications and the residence density (Eurostat 2021; “DPF Desa Negara 2030” 2011)

Old Demographic Classifications	New Demographic Classifications	Residence Density/km²
Urban Centre (High Density Cluster)	Urban	More than 1,500 per km²
Urban Cluster (Moderate Density Cluster)	Suburban	300 – 1,500 per km²
Rural grid cells (Mostly Low-Density Cells)	Rural	less than 300 per km²

TABLE 3. Polygon classes and their reclassifications

Polygon class	Reclassification
Agriculture (non-paddy)	
Paddy fields	
Residential	
Recreation and stranded land	
Bare land	Rural
Beach	
Water bodies	
Forest	
Mixed development	
Commercial	
Institutions and Facilities	Suburban
Industrial	
Infrastructure and utilities	
Mixed development	Urban
Residential	
Roads	Roads

QGIS FILE CONVERSION

The GeoTIFF file provided is in a single band color with different shades based on the polygon classes. Figure 3 shows the peninsular Malaysia map in a single band color.

The reclassified polygons are summarised and color-coded into the three main demographics: red for urban areas, yellow for suburban areas, and green for rural areas. The classification of the color of each demographic is performed in QGIS, as shown in Figure 4.

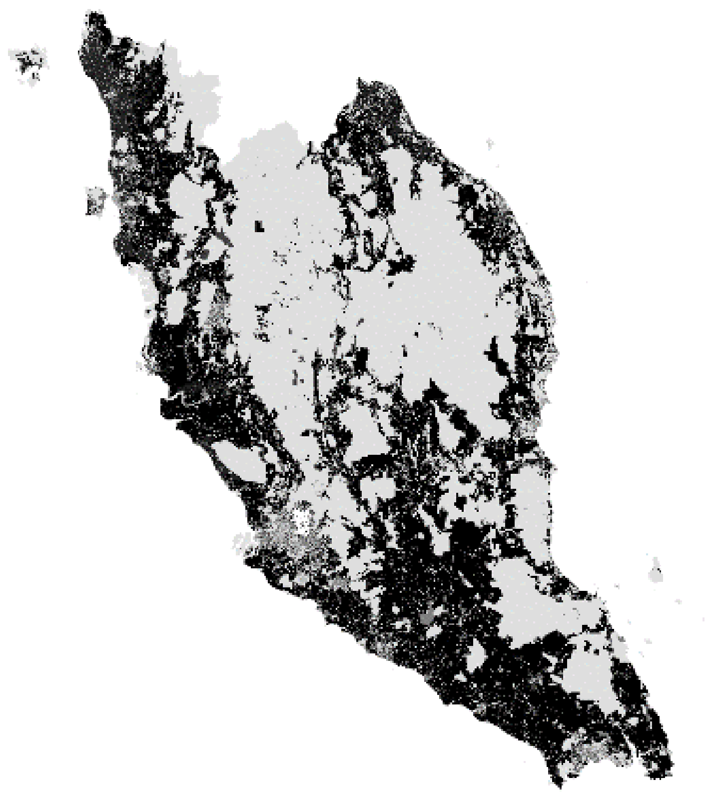

FIGURE 3. Peninsular Malaysia Map with a single band color (Kaelin A.;Miller 2021).

FIGURE 4. Reclassified Demographic Map of Peninsular Malaysia with color-coded

QGIS INTEGRATE WITH GOOGLE EARTH PRO

The file is then exported as uncompressed high resolution georeferenced raster image as *.geotiff* file extension and imported to Google Earth Pro as shown Figure 5. The coordinates of the electrical distribution substations are imported into QGIS for file conversion from an XSL to a KMZ file. Next, the electrical distribution substations' KMZ file is exported to Google Earth Pro as a placemark file. The placemarks indicate each electrical distribution substation that exists in the area and contain details of the substations, such as their coordinates, distribution voltage, operational area, and substation types. Figure 6 shows an example of the available substation placemark details. Additionally, the technology ranking details appear when the color-coded areas are clicked.

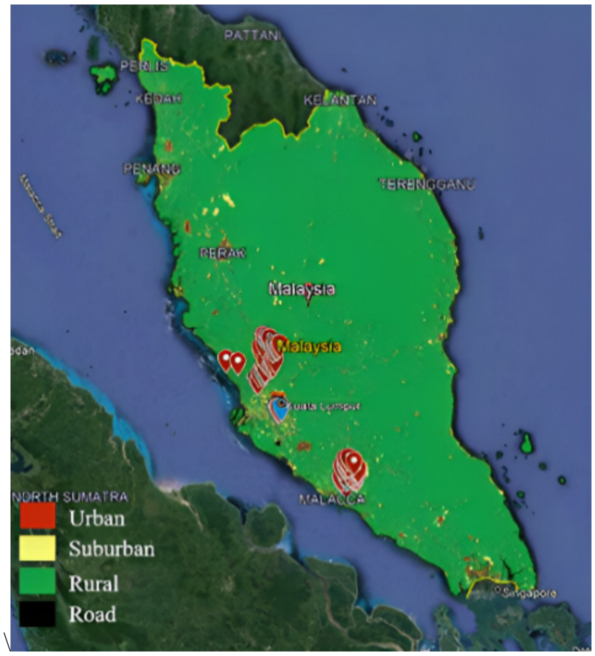

FIGURE 5. Reclassified Demographic Map Peninsular Malaysia overlain on satellite image in Google Earth Pro

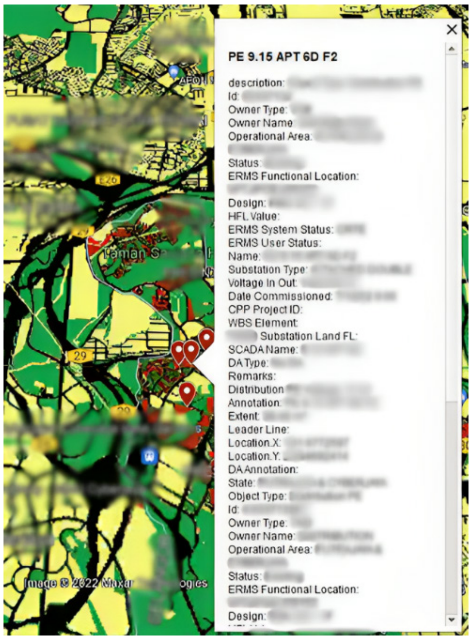

FIGURE 6. A snapshot of placemark details for a substation located in an urban area in Malaysia (sensitive information is redacted)

For this study, a case study in Area X is selected. Area X is a federal territory of Malaysia that functions as the administrative and judicial capital of Malaysia. This area was chosen because it has a wide range of demographics, from densely populated urban areas to rural areas with lower population densities. The electrical distribution substations in Area X are located in urban, suburban, and rural areas. Figure 7 shows the zoomed-in map of Area X.

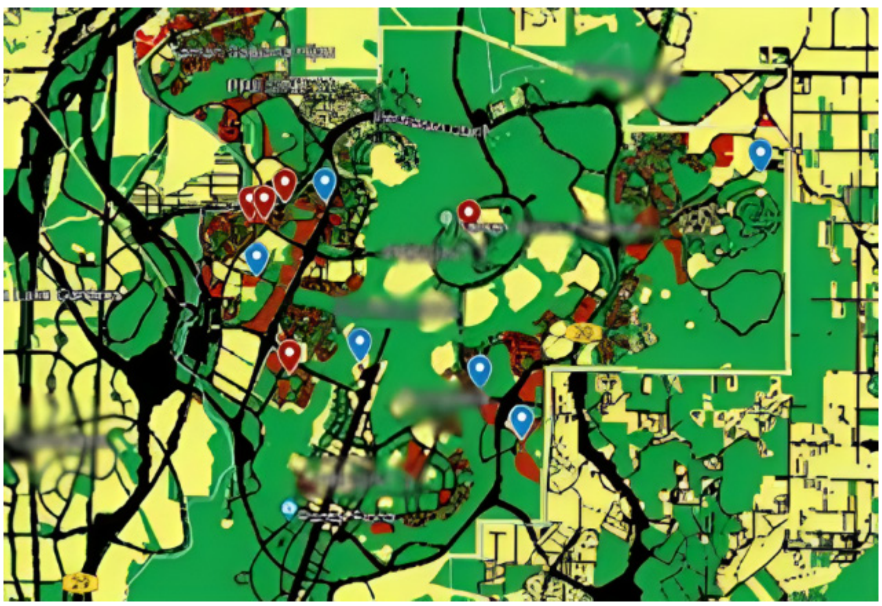

FIGURE 7. Zoomed-in map of Area X

Area X's population was estimated to be around 30,000 people in 2007, with the majority of residents being government employees. As of 17th of May 2022, based on the population clock by state provided by the Department of Statistic Malaysia, the population had increased to 119,492 (Department of Statistics Malaysia 2021). Figure

8 shows the technology ranking for the electrical distribution substations in Area X. The ranking of possible communication technologies will appear when we click the color-coded area.

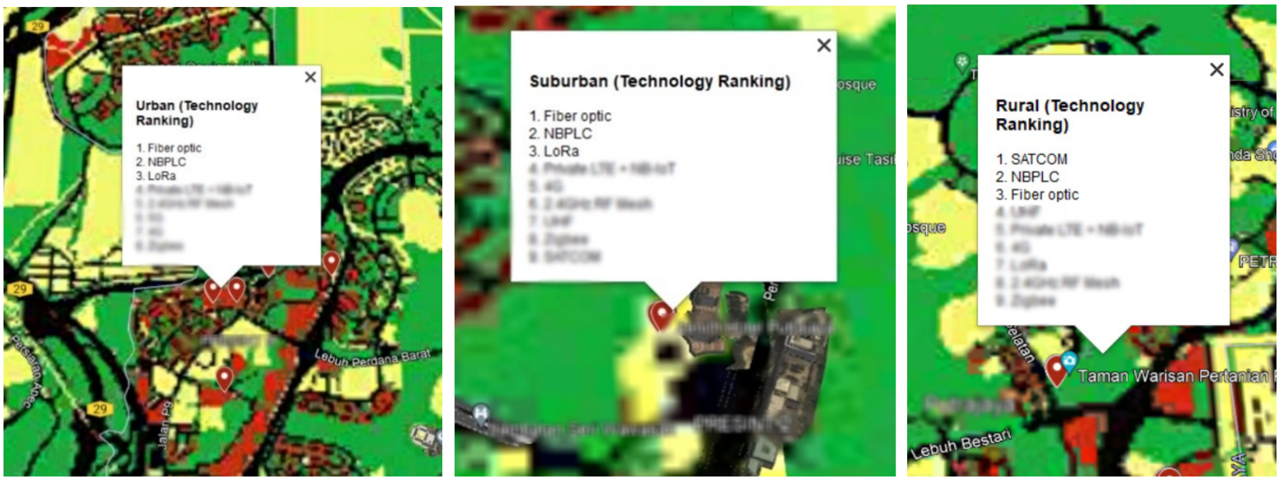

FIGURE 8. Communication technology ranking for urban, suburban, and rural areas in Area X

DISCUSSION

This study has achieved as an act of visualisation tool to have better visual on the ranking that has been provided. As our society witnesses a surge in end-user applications, ranging from smart homes and electric vehicles to energy storage systems and smart meters, the significance of our mapped visualization extends beyond immediate utility. The application of this visualization is crucial not just for present utility needs but also for future scenarios where demand is expected to increase proportionally. The mapped visualization serves as a valuable tool for utility companies, assisting in the identification of suitable communication technologies that will accommodate the anticipated rise in demand. Moreover, it aids in strategically locating additional 11kV substations for specific areas, providing a graphical perspective that complements raw data.

Graphical representations offer enhanced comprehension, presenting a clear understanding of optimal substation placement. This visual approach allows stakeholders to intuitively grasp spatial considerations, facilitating more informed decisions beyond traditional reliance on numerical data. The color-coded classification not only visualizes demographic nuances but also serves as a practical guide for determining suitable locations for additional substations.

Recognizing the diverse communication requirements across demographic groups, we underscore the importance of considering factors such as line of sight, terrain conditions, and bandwidth. Our mapping approach, with its categorized color-coding, streamlines the identification of specific areas with unique communication needs. This comprehensive understanding, derived from both communication technology ranking and color-coded regions, expedites decision-making processes and informs strategic planning.

In essence, our study is crafted with a focus on clarity for non-technical stakeholders. We aim to unravel the intricacies of the communication system associated with 11kV substations in specific areas using accessible, layman terms. This ensures that a wider audience can engage with and comprehend the complexities of our findings.

The limitation of the study is that, we need to specify each area by using one of the Google Earth Pro tools called Polygon. This tool allows us to our desired area so that when we click on that area, a ranking will be appeared based on the demographics. Another drawback of using QGIS is the necessity to rendered the image based on the available documentation and export it to Google Earth Pro. This entire process demands significant resources, resulting in occasional lagging.

Further studies, is to find another efficient way to specify each area, so that, this can reduce time consuming to visualize the ranking obtained.

CONCLUSION

The rising utility of QGIS as a tool for geographical visualisation and analysis makes it a competitive option to other commercial GIS software programmes. QGIS is an open-source software package that benefits from the contributions of professionals and users from all over the world. Due to this, QGIS's open-source nature and online data's growing availability allow people to learn and use GIS technology in various field. The Google Earth Pro on the other hand, is able to give the overall view of the Earth and this is beneficial when it comes to mapping.

This study presents information regarding electrical substation data, a ranking of potential communication technologies, and a map that may be utilized to illustrate demographic patterns. In this research, QGIS is utilized to categorize the population into urban, suburban, and rural regions. On the other hand, Google Earth Pro maps and visualizes electrical distribution substations and communication technology rankings based on demographic.

This research incorporates a case study conducted in Area X, Malaysia, employing the combination of QGIS and Google Earth Pro. A placement marking for the electrical distribution substations at the area X are performed using Google Earth Pro mapping and it includes with the demographic classification. The mapping is categorised into three demographics: urban, suburban, and rural.

The features also allow that, the details of the technology ranking to be displayed when the color-coded sections are clicked. However, a downside of this approach is that each area must be manually specified using one of the tools available in Google Earth Pro. Additionally, the entire process of merging both software applications consume a significant amount of computational resources. This integration deems beneficial for future references on the electrical distribution substation alongside the possible communication technologies. Further research is necessary to identify alternative methods for accurately delineating specific areas. This would result in a reduction of the time required to visualize the generated rankings.

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DECLARATION OF COMPETING INTEREST

None

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