Research Article

QGIS Simulation Using Openstreetmap Data on Pedestrian Routes from Schools to Green Open Spaces

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Received: 30 Nov 2024; Revised from: 24 Mar 2025; Accepted: 22 Apr 2025
Print-ISSN: 2228-9135, Electronic-ISSN: 2258-9194, https://doi.org/10.56261/built.v23.256899

Abstract

Green open spaces play an important role in modern urban development, benefiting both the ecology and the quality of life of city dwellers. Functional pedestrian path is an important element to support the accessibility of green open spaces. Commonly in Indonesia, green open spaces are isolated and disconnected from pedestrian path network. This research used spatial analysis combined with descriptive method to elaborate systematically and factually, regarding the accessibility of the fastest and shortest routes of pedestrian paths from selected schools to Lampung Elephant Park in Bandar Lampung, as the observed green open spaces. Authors suggested that the connection between schools and green open spaces is important in relation to facilitated environmental and physical education. Field observations and software simulation using QGIS based on OpenStreetMap were utilized to analyse the existing pedestrian path and to indicate the shortest routes. The simulation could suggest routes that accommodate comfortable walking times. The findings from this research can serve as valuable recommendations for urban planning, specifically aimed at enhancing pedestrian accessibility to green open spaces. Priority could be given to improving walking infrastructure along the proposed pedestrian pathways by closely addressing any unmet requirements. Future studies will explore advanced simulation techniques to further refine and optimize these recommendations.

Keywords: urban, green open space, pedestrian path, QGIS, shortest route, school.

1. Introduction

The availability of green open spaces plays a vital role in promoting sustainable urban development, as they enhance residents' quality of life and contribute to climate change mitigation. However, ensuring equitable access to these spaces remains a significant global challenge. Ideally, green open spaces should be supported by functional and accessible pedestrian networks. In Indonesia, pedestrian paths often face numerous challenges due to the lack of comprehensive urban planning, resulting in disconnected and isolated pathways that fail to integrate with other urban elements, including green open spaces. Moreover, rapid economic growth, increased population mobility, and intensifying urban social activities have further contributed to the fragmentation of pedestrian infrastructure. Previous studies have highlighted the importance of accessibility, safety, and comfort in pedestrian pathways (Nuzir & Dewancker, 2016; Sasongko et al., 2022) .

In the context of Bandar Lampung City, Indonesia, public green open spaces are notably limited. This scarcity is exacerbated by the ongoing conversion of green areas into built-up spaces to meet the growing demand for urban facilities, such as offices, commercial centers, housing, and shopping malls. Consequently, the extent of public green open spaces in the city continues to decline each year (Christiyandi, 2022). One notable example is Lampung Elephant Park, a centrally located green space frequently utilized by the local community. Due to its expansive area, the park supports a variety of public activities and serves as a venue for nearby schools to conduct outdoor educational and environmental programs.

Figure 1. Lampung Elephant Park.

This research aims to determine the accessibility of the selected green open space, which is the Lampung Elephant Park in Bandar Lampung, by utilizing pedestrian paths and to find the shortest routes, related to time and distance, from the selected schools. Then finding out the physical condition and the availability of facilities of the pedestrian paths is also targeted in this research. It is hoped that the results can support as urban planning recommendations for the development of better pedestrian accessibility to green open spaces that provide safety, health, and comfort especially in Bandar Lampung City.

2. Literature Review

2.1. Importance of Green Open Spaces

The existence of open spaces in densely populated settlements in the city plays a very important role in controlling the environment, microclimate, social community, and economy of the population (Ischak & Burhannudinnur, 2020). Green open spaces are very beneficial for the public who engage in outdoor activities. Green open spaces are also very advantageous for schools as they can be

used for teaching activities or other school events that can take place outside and in green open spaces. Some schools in Bandar Lampung do not have adequate green open spaces for mass outdoor activities. Also, green open spaces are one of the learning elements that might help students improve their academic performance. The green tint of these areas is said to ease monotony during what can seem like boring learning processes. Thus, using green open spaces is likely to increase students' willingness to learn more (Farhana, 2019). In this regard, green open spaces are closely related to schools in terms of education and other school activities. Therefore, green open spaces should be easily accessible from the schools, thus the schools must be equipped with the fastest and shortest routes to the nearest green open spaces. According to the Regulation of the Minister of Public Works of Indonesia No. 5 of 2008, green open space is defined as an area that extends or is a corridor and/or a group of areas that tend to have a more open use, where plants can grow either naturally or through intentional planting. There are three primary types of green open spaces in this context: (1) public open spaces owned by the government and can be accessed directly by the public without a specific time limit, such as town squares and sidewalks; (2) semi-public open spaces include areas such as sports fields owned by schools and gardens within places of worship; and (3) private open spaces involve areas such as gardens at home, private sports facilities, horse racing tracks, agricultural land, and community forests (Afaar, 2015).

2.2 Requirements for Pedestrian Path

The pedestrian path is an area or route specifically designed for use by pedestrians, serving as a place to walk or engage in activities without motorized vehicles. Pedestrian paths are usually located along roads or within urban complexes and are designed to provide safe and comfortable access for pedestrians to various destinations, such as schools, workplaces, shops, parks, or other public facilities. Pedestrian paths are often equipped with sidewalks, traffic signs, crosswalks, street lighting, and other facilities that support pedestrian mobility (Nuzir & Dewancker, 2016b).

The requirements that must be met in the design of appropriate pedestrian paths include the following: surface quality of the path, resting area, ramp dimension, pedestrian path width, lighting and sun shading, maintenance, effective drainage, roadside condition, intersection, warning system, pedestrian crossing, and border wall (Iswanto, 2003). Another study based on content analysis of literatures related to pedestrian studies indicated key-attributes of: spatial planning; walkability; neighborhood livability; traffic safety; pedestrian facilities (hard elements); pedestrian facilities (soft elements); and environmental quality as the components of pedestrian environment (Nuzir & Dewancker, 2015). Every pedestrian path must provide high comfort to accommodate walking activities. Pedestrian paths are very important for appropriate urban planning. Walking is the most basic mode of transportation and does not produce significant carbon emissions, so pedestrian paths must be able to access all places or needs of the community within the urban area (Nuzir & Dewancker, 2016a).

2.3 Walking Time and Distance

A module on sustainable transportation developed by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) mentioned that the average walking speed is 4.7 km/h in general (Petersen, 2004). Meanwhile, the maximum distance that can be traveled by an adult human in general is around 800 meters, with healthy conditions (Brown & Shortell, 2015). Meaning that average people could still enjoy walking at maximum around 0.17 hour or 10.2 minutes. Another study indeed stated that 0.8 km as a walkable distance people with a walking duration of 10–15 minutes continuously (Pooley et al., 2011).

2.4 GIS Applications in Urban Planning

Geographic Information Systems (GIS) are computer-based information systems that process and store geographic data and information (Aronoff, 1989). GIS is an extremely valuable technology for gathering, storing, retrieving, and visualizing spatial data from the actual world (Burrough, 1986). The tools needed for network analysis involve data regarding road networks and utilize Geographic Information System (GIS) software (QGIS) with network analysis extensions. By using this tool, various types of analyses can be conducted, including direct path analysis, optimal route analysis, nearest facility analysis, travel time analysis, and driving directions. In network analysis, impedance is used to determine the best route, and the default impedance value is the length of the line. Users can also utilize other types of impedance, such as travel time estimates, provided that these values are included in the attribute table and specified before the analysis is conducted. One of the extensions found in network analysis is the service area.

QGIS, which supports OpenStreetMap (OSM) data, is free and open-source, like OSM. Users can use QGIS to perform various tasks that are not part of the core software, such as creating, editing, visualizing, and analyzing data from various vector, raster, and database

file formats, including OSM files. This software can also be used on various platforms, such as Windows, Mac, Linux, and BSD, and can be installed directly. There are several QGIS plugins that utilize OSM data as of November 2019, but only two, QuickOSM and OSMDownloader, are intended for downloading that data. Other plugins, such as Pelicas Geocoding and ORS Tools, can query OSM data to extract additional geographic information or offer geocoding services (Ehrig-Page, 2020).

This research employed ORSTools, a program that is directly related to QGIS, in this study. Opernrouteservice, often known as OpenStreetMap (OSM) data contributed by users, is a geodata analysis service created by Heidelberg Institute for Geoinformation Technology (HeiGIT). With the ultimate goal of promoting sustainable mobility and humanitarian help, they have made a number of open location-based services and navigation available, in addition to software, geoinformation, and other techniques. Their suite of algorithms, QGIS, allows the users to download their plugin, ORS Tools. Matrix From Layer and Isochrones From Layer are two algorithms. Route computations, isochrones, and matrices may be performed interactively on the map canvas and from point files inside the processing framework using this toolset. For the output file, wide properties like duration, length, and start/end locations are set (Lindén, 2021).

A previous study used a Geographic Information System (GIS) based on Network Analysis to analyze and sort the most efficient and safest route to the closest evacuation area and also assessed the facilities for the pedestrian pathways (Gunawan et al., 2019). Another study used network analysis techniques with GIS to analyze the evacuation route planning on Ternate Island in the event of Mount Gamalama eruption (Syiko et al., 2013).

2.5 OpenStreetMap

Founded in 2004, the OpenStreetMap (OSM) initiative has lately established itself as the most well-known example of Volunteered Geographic Information (VGI) available online (Arsanjani et al., 2015). OpenStreetMap is a publicly available spatial database to which everyone may contribute geodata and alter the data that is already there. For this reason, it is crucial that software tools be made available to assist contributors in their editing job (Foody et al., 2017).

The core product of OpenStreetMap is a spatial database, but most of OSM's focus is on maps and cartographic products derived from its data. There are many projects, organizations, services, software, and applications that directly use OpenStreetMap data, such as: Data Download and Visualization; Education and Research; Disaster and Humanitarian efforts; Government and Industry; and Data Visualization (Foody et al., 2017). The OpenStreetMap community has created a vast ecosystem of tools and software services. Therefore, it is impossible to provide a comprehensive list of software for visualizing OpenStreetMap data. This section has been divided into three separate parts: OSM data editors, OSM-based routing services, and additional services.

3. Research Method

This research used a descriptive method to explain spatial data systematically and factually by conducting simulations using QGIS software based on OpenStreetMap, which is used to analyze existing pedestrian paths and to indicate the shortest routes from selected schools to green open space, namely Lampung Elephant Park in Bandar Lampung as the case study. The schools were selected based on the criteria of schools with the closest distance from Lampung Elephant Park within the administrative borders of Pelita Subdistrict of Bandar Lampung City. Pelita Subdistrict is one of the area in the city center with most density and lack of access to green open space. Therefore, it is urgent to improve its connectivity to the nearest available green open space, namely Lampung Elephant Park. Then field observations were conducted by exploring the pedestrian paths which connect the selected schools to the green open space. Manual documentation using notes and photographs was implemented during this observation.

3.1 Case Study

This research focuses on 3 (three) schools located nearby Lampung Elephant Park, which is related to the importance of green open spaces for public and learning activities outside of the classrooms.

The first school is SMA YP Unila (YP Unila Senior High School), which is a school located the farthest from Lampung Elephant Park to the north. The second school is SMK Taman Siswa (Taman Siswa Vocational School), which is a vocational high school located in the west side of the park, and the third school is SMP Kartika 2 (Kartika 2 Junior High School), which is a school located closer to the park. Lampung Elephant Park, situated in Bandar Lampung, Indonesia, is a recreational area opened to the public on February 18, 2019. Covering 15,000 square meters, it was established on the main central area of the city of Bandar Lampung. This park offers a green space for the community to partake in diverse activities and outdoor leisure. However, currently the park is

Figure 2. Location of the Case Studies.

undergoing significant changes. The park is now in the process of being dismantled and revitalized. This decision was made to make way for the construction of the Al Bakrie Grand Mosque and the new public plaza around it. As of June 2023, the demolition work is already underway and the entire process is expected to be completed by 2024. However, it is expected that the new public plaza will also function as a green open space for the city of Bandar Lampung.

3.2 Software Simulation

Simulation using QGIS software was developed by entering data obtained from the OpenStreetMap database and complementing it with observation results in order to map the shortest routes which are determined by time and distance. On the OpenStreetMap website, authors extracted maps into shapefile format (.shp), which would later be used in GIS software (QGIS 3.32.3). After the shapefile was extracted and imported into the QGIS 3.32.3 application, the map format was processed and analyzed by utilizing the Open Route Service (ORS) Tools. Authors then implemented one of the ORS services which is the Matrix Endpoint that calculates profile specific distance and time matrices between multiple source and destination positions. By performing this, the map generated by QGIS was able to provide indications of the shortest routes in the form of connected lines of small dots from the starting point to the destination. The routes were automatically generated by QGIS based on the software that analyzed the best route from the schools to Lampung Elephant Park.

3.3 Observation

Data collection was conducted using observation. Observation activities were conducted starting from the gathering points of each selected school and moving along the pedestrian paths, recommended by simulation, towards Lampung Elephant Park. The data obtained at this stage included the availability of the requirements such as: surface quality of the path, resting area, ramp dimension, pedestrian path width, lighting and sun shading, maintenance, effective drainage, roadside condition, intersection, warning system, pedestrian crossing, and border wall.

4. Result

4.1 Simulation

The following are the results of simulation using Geographic Information System (QGIS) software, on the most effective (shortest) routes, in each case study. The simulation recommended the routes based on the best walking time and distance, indicated in green-dotted lines on Figure 3-5 below.

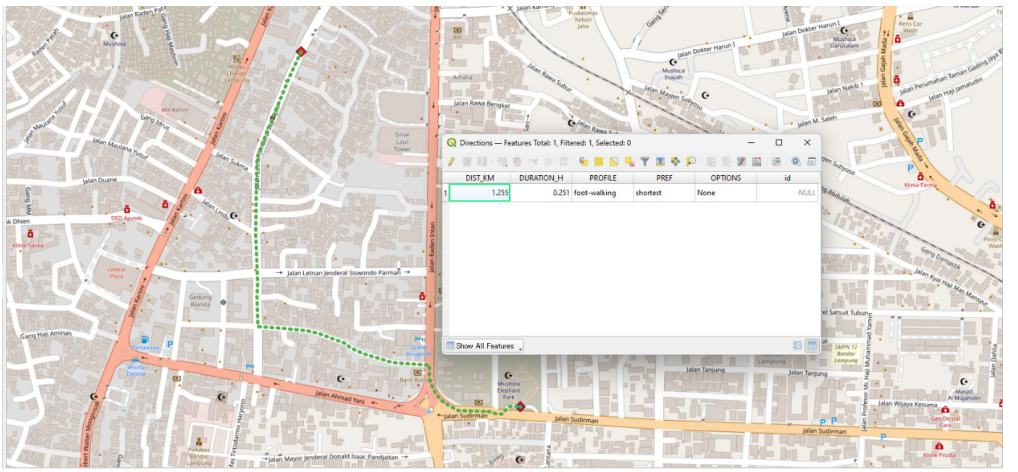

Figure 3. Simulation of the Shortest Route, from SMA YP Unila to Lampung Elephant Park.

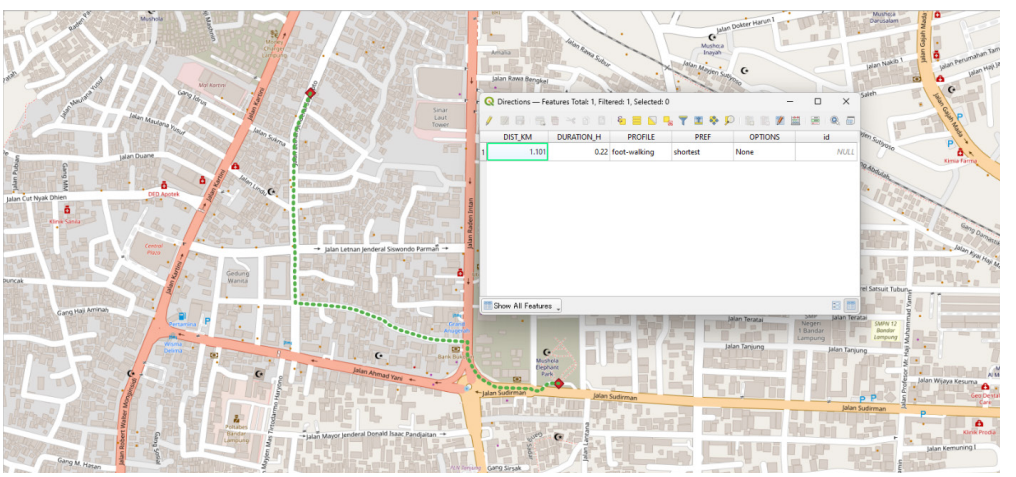

Figure 4. Simulation of the Shortest Route, from SMK Taman Siswa to Lampung Elephant Park.

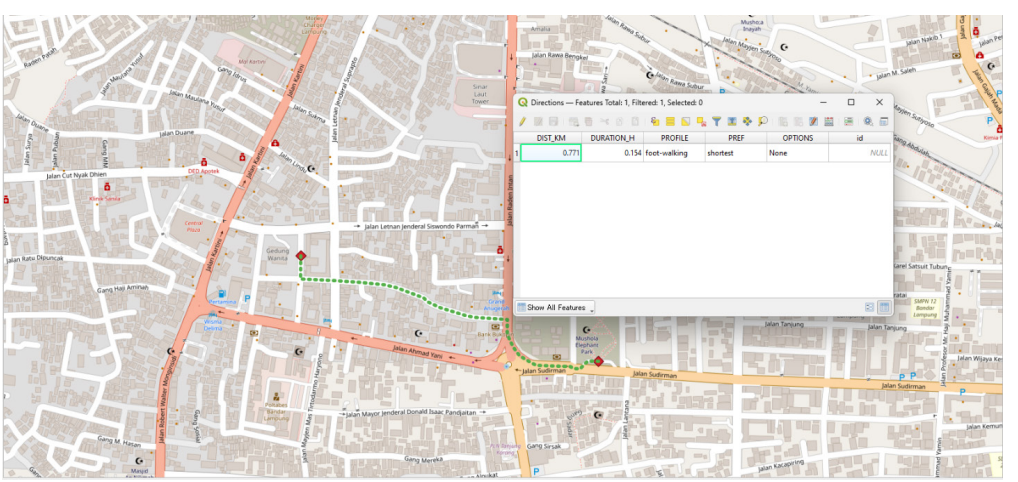

Figure 5. Simulation of the Shortest Route, from SMP Kartika 2 to Lampung Elephant Park.

Figure 6. Documentation of the Shortest Route, from SMA YP Unila to Lampung Elephant Park.

Figure 7. Documentation of the Shortest Route, from SMK Taman Siswa to Lampung Elephant Park.

Figure 8. Documentation of the Shortest Route, from SMP Kartika 2 to Lampung Elephant Park.

Table 1. Simulated time and distance from the shortest routes (source: Author, 2024)

Schools	Time (minutes)	Distance (kilometres)
SMA YP Unila	15.06	1.255
SMK Taman Siswa	13.2	1.101
SMP Kartika 2	9.24	0.771

4.2 Observation

The following figures showed the existing conditions in the form of documentation results obtained by the author when conducting direct field observations on the shortest routes in each case study.

5. Discussion

Based on the simulation, the shortest route from SMA YP UNILA recorded a time of 15.06 minutes or 0.251 hour and a distance of 1.255 km (speed of 5 km/h). Meanwhile the shortest route from SMK Taman Siswa recorded a time of 13.2 minutes or 0.22 hour and a distance of 1.101 km (speed of 5 km/h). Lastly, the shortest route from SMP Kartika 2 recorded a time of 9.24 minutes or 0.154 hour and a distance of 0.771 km (speed of 5 km/h). These records of time and distance indicated that the simulation is able to recommend routes that are meeting the comfortable time for walking yet slightly over the walkable distance for average pedestrian. It was also found that the walking speed used by the simulation is approximately 5 km/h which is similar to the average walking speed of 4.7 km/h (Petersen, 2004). This walking speed seems to be more appropriate to the local context in regard to physical condition and walking infrastructure. Please see Table 1 for the complete records.

In order to complement the results from the simulation with factual condition, direct observations were conducted. Based on the observation to the simulated shortest route from SMA YP Unila to the Lampung Elephant Park, it was seen that the route has a very steep elevation and without any greeneries at all. There is no paving indicating that the path is not designated for pedestrians. Then from the next observation from the other selected school, which is SMK Taman Siswa, it was seen that the path has a very steep elevation with no greeneries as well. There is also no paving indicating that the path is meant for general uses and mixed with

the road space for motorized vehicles. And from the last observed school, SMP Kartika 2, it was seen that the path has a relatively flat elevation but still without any greeneries along the pedestrian path. However, unlike the paths from the other schools, this path is already paved and constructed with appropriate size for walking and indicative markers.

Furthermore, the observation on other requirements showed that the simulated shortest route from SMP Kartika 2 to the Lampung Elephant Park indicated a pedestrian path that meets almost all requirements for appropriate pedestrian path. Meanwhile, the route from SMA YP UNILA indicated a pedestrian path that is less appropriate for walking since some requirements could not be seen, and the routes from SMK Taman Siswa was seen to be the least appropriate path for walking with most of the requirements were missing. The overall observation results are shown in Table 2 below.

Table 2. Result from Observation (source: Author, 2024)

Nr.	Requirements	SMA YP Unila	SMK Taman Siswa	SMP Kartika 2
1	Quality of Path Surface	√	√	√
2	Resting Area	-	-	√
3	Slope (Ramp) Dimension	-	-	-
4	Width of the Sidewalk	√	√	√
5	Shading from the Sun	√	-	√
6	Maintenance	√	-	√
7	Effective Drainage	√	-	-
8	Roadside Condition	√	-	√
9	Intersection of the Road	-	-	√
10	Warning System	-	-	-
11	Pedestrian Crossing	-	√	√
12	Border Wall	-	-	-

The authors suggest that the simulation can recommend routes that are within a comfortable walking time, although they may slightly exceed the average walkable distance. Additionally, the observations help identify pedestrian paths that meet proper standards. Unlike previous studies that focused mainly on emergency routes, this study presents a more comprehensive approach by combining simulations and real-world observations to recommend walkable routes to green open spaces for everyday use.

6. Conclusions

To assess the accessibility of Lampung Elephant Park in Bandar Lampung via pedestrian routes, the authors conducted a simulation of the shortest walking paths from three selected schools to the park. The simulation provided data on both walking time and distance. When compared with reference standards used in this study, the results indicated that the simulated routes offered walking times within a comfortable range but slightly exceeded the average walkable distance for pedestrians. Additionally, the simulation employed a walking speed of approximately 5 km/h, which aligns closely with the global average of 4.7 km/h and appears appropriate for the local context. To validate the simulation outcomes, direct field observations were carried out along the recommended routes. The evaluation of walkability criteria revealed that the shortest route from SMP Kartika 2 to Lampung Elephant Park generally met the standards for a suitable pedestrian path. In contrast, the route from SMA YP UNILA was found to be less adequate, with several walkability requirements unmet. The route from SMK Taman Siswa was identified as the least suitable, with most criteria not fulfilled.

These findings offer valuable insights for urban planning, particularly in enhancing pedestrian access to green open spaces. Improvements to walking infrastructure along the recommended routes should prioritize addressing the specific deficiencies identified in this study. In contrast to previous studies that primarily focused on emergency evacuation routes, this study adopts a more comprehensive approach by integrating simulation data

with field observations to propose walkable routes to green open spaces for everyday use. Future research will explore more advanced simulation techniques to refine route recommendations and further support sustainable urban mobility.

CRediT Authorship Contribution Statement

Daus Maulana: Writing-original draft, Software, Validation, Formal analysis, Investigation, Data curation and editing, and Visualization. Fritz Akhmad
Nuzir: Writing-review and editing, Writing-review Conceptualization, Methodology/Study design, Supervision and Project administration. Muhammad
Fathur Rizki: Resources, Supervision and Project administration.

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