Evaluating the pedestrian accessibility to public services using open-source geospatial data and QGIS software

Alba KUCUKALI, Rejdi PJETERNIKAJ, Egin ZEKA, Artan HYSA*

Epoka University, Department of Architecture, Rruga Tirane-Rinas, Tirana, Albania; ahysa@epoka.edu.al (*corresponding author)

Abstract

This study brings a rapid method to utilize the available open-source geospatial data in assessing the pedestrian accessibility to key public services/facilities. At this stage, we are testing the method in the case of Tirana, the capital city of Albania. Yet, the method is reproducible to other metropolitan areas around the world. Open street map (OSM) data and reference layers from Albanian National authority for geospatial information (ASIG geoportal) have been used as the raw material of the study. While the geospatial visualization, refinement, and analysis rely on the usage of QGIS software and the related plugins. QNEAT is the plugin that was used to generate the isochrones which indicate the spatial coverage of a certain service referring to the existing urban transportation/circulation network. The plugin enables the definition of different distance ranges. Our results show that certain public services serve to various amounts of the building stock at a gradient of walking distances. For example, more than 25% of the existing building stock has pedestrian access to cafés and pharmacies within a walking distance of 250 m. The same services serve to almost 90% of the same building stock within 1 km walking distance. However, services like banks are accessible only by 12.6% of the existing buildings within a walking distance of 250 m, and 67% at 1 km walking distance. The accuracy of the available geospatial data resulted to be vital for the reliability of the results. We conclude by highlighting the importance and utility of GIS-based methods of urban analysis in the processes of planning new public services in the city.

Keywords: accessibility; QNEAT; QGIS; problem-oriented research; Tirana

Introduction

The distribution of services is an integral part of city planning theories and has been a significant factor for land use planning policies in existing cities. One of the pioneering works that deals with this problem is the ‘central place theory’ developed by the German geographer Walter Christaller (1933). Although, its main concern is about the hierarchical distribution of settlements, their size and number (Briney, 2020), the theory tries to explain that the location of certain economic services and their accessibility is strongly related to the arrangement of settlements (Altaweel, 2020). Christaller’s theory has been very influential in later studies on
settlements’ geography (Michel, 2016) but its rigid and static and schematic approach has been criticized for not being able to explain the dynamic factors that might define the settlements’ pattern and the location of various services in cities.

Another interesting work, which is not directly related to the distribution of services, but rather a model for neighbourhood planning, is the ‘Neighborhood Unit’ of Clarence Perry (1929). Perry’s model, a reaction to the automobile-based city, tries to define the principles of a good, human-scale neighbourhood (LeGates and Stout, 2011). Even though the model focuses on the neighbourhood scale, it has some relevancies to the issue of service distribution since it defines the type of facilities that should be in the vicinity of a community. The primary school is the central function that defines the neighbourhood. Besides that, other facilities and services like small business district, market square, retail functions, religious buildings, open spaces, and playgrounds are important components of the neighbourhood unit (Perry, 1929).

The model presented by the ‘Neighbourhood Unit’ has influenced significantly other movements of neighbourhood planning (Sharifi, 2016) but it has been also widely criticized for having a physical deterministic nature, not being self-sufficient, neglecting the complexity of city and prompting urban sprawl (Jacobs, 1961; Silver, 1985; Brody, 2009; McHaffey et al., 2015). Other movements such as: New Urbanism, Transit-oriented development, smart growth and eco-urbanism tries to employ sustainability principles (Sharifi, 2016) with a focus on compact settlements that provide easy access to mixed use functions through walkable places and integrated transportation infrastructures.

A similar approach, widespread recently, by recycling many of above-mentioned principles is the concept of 15-minute city. Although presented as a kind of new concept, the issue of walkable distances in cities and neighbourhoods is elaborated before in many works (Jacobs, 1961; Alexander, 1977; Gehl, 2010). The ‘15-minute city’ model was developed by Moreno (2016) but became more popular on the time of COVID-19 pandemic. The approach is based on the idea that certain facilities of daily activity are positioned in easily accessible distances (Allam et al., 2022).

“The ‘15-minute city’ may be defined as an ideal geography where most human needs and many desires are located within a travel distance of 15 minutes. While automobiles may be accommodated in the 15-minute city, they cannot determine its scale or urban form. Based on automobile travel, most metropolitan areas may be 15-minute cities” (Duany and Steuteville, 2021).

All these approaches look very attractive and promising in the theoretical dimension, but they have a common feature, failing to fit in the complex urban realities. Except some successful cases, many cities in the world still have many deficiencies in providing walkable neighbourhoods and equal distribution of public services. For instance, a study done on China show that certain groups do not have equal opportunities to access public facilities such as education and health services (Li et al., 2021). In another research, results show that there are many areas that do not have a good accessibility to health facilities in the city of Jeddah (Murad, 2018).

Studies show that a good access to public services has the potential to increase the social and economic equality (Verbist et al., 2012). A good accessibility to basic public facilities such as education and healthcare can contribute to have a better impact on the socio-economic dimension and equality (Lee and Miller, 2018; Kelobonye et al., 2019). According to a study, a good access to public facilities can decrease the inequality by around 20 % in OECD countries and close to that in some Latin American countries (Seery, 2014). This percentage could be higher in other less developed countries like Albania, and especially in metropolitan zones like Tirana.

In this context, this study aims to bring an overview of the urban accessibility to different public services in Tirana. We hypothesize that certain public services are not evenly distributed in space. Thus, there might be significant neighbourhoods that are not covered by a specific public service area. Furthermore, we foresee that some neighbourhoods may be close in distance to certain public services locations, but due to the fragmented transportation network they are uncovered by the specific service area. Both hypotheses may inform future decision-making processes about (i) planning new public services for better coverage and (ii) identifying key fragmented nodes within the transportation network.
Materials and Methods

This article reports the research activity as experienced within the graduate course Arch463- GIS Applications for Planners, in the Department of Architecture, at Epoka University. The participating students had no background information about GIS technologies. First, they were trained about the utility of GIS technologies through short thematic exercises. The main approach of the course was to rely on open-source software and geospatial data. Thus, we used QGIS software as an open-source platform. Similarly, students were demonstrated how to search for and access open-source geospatial data.

Study area

The study area of this work is the capital city of Albania, Tirana. Albania is a post-socialist country located in the western Balkans, while its capital metropole (Tirana) is positioned in the central part of the country as shown in Figure 1. Albanian territory has experienced unprecedented urban and rural spatial transformations during the post-socialist period, that result in various challenges at both landscape and planning levels (Pojani, 2009; Hysa et al., 2021). Informal urban development and lack of integrated mobility planning has resulted in emerging adverse concepts like transportation poverty in Tirana (Pojani et al., 2017).

Analytical workflow and Software

QGIS software is selected in order to promote the open-source culture among young professionals. Furthermore, commercial GIS application can be expensive and unaffordable by the education community. However, QGIS is a collaborative open-source software which is continuously improved by a wide community of volunteers and much more advantageous than the commercial GIS which are served as “black boxes” to the users’ community (Flenniken et al., 2020). We used QGIS 3.16 version in during the process. QGIS software is continuously fed by thematic plugins which brings novel analytical workflows dealing with specific geospatial themes.

QNEAT is a Python-based QGIS plugin that is integrated in the QGIS3 Processing Framework. Via QNEAT3 we could perform advanced network analysis algorithms that range from simple shortest path solving to more complex tasks like Isochrone polygons as service area & Origin-Destination-Matrix calculation (Raffler, 2022). QNEAT is previously used as a routing software (Vettermann et al., 2021). The main two inputs of the workflow are the point layer of public service locations, and the polyline features of the road network shapefile. The plugin first calculates a raster image heatmap based on graph analysis. Later it prepares contour polygons to define coverage areas (isochrones) as polygon shapefile.
Materials

In this study we utilize different types of open-source data. Databases like Open Street Map, Urban Atlas (Copernicus), and ASIG (Albanian State Authority for Geospatial Information), etc. served to provide the necessary geospatial information about the study area (Tirana). First, we accessed OSM data of Albania via Geofabrik portal (www.geofabrik.de). OSM data enabled data for both key inputs of the workflow, being the services location (points of interest layer) and circulation network (road polyline layer). Other QGIS plugins like QuickOSM, can be more practical tool for individual and well trained researchers, as the retrieve of filtered necessary layer is possible within a specific study area.

Results and Discussion

Isochrones Analysis of Accessibility to Multiple Public Services in Tirana

We performed the isochrones analysis based on the available transportation network and the identified services locations. OSM data provides a variety of service types within the points of interest layer. QNEAT plugin generated the isochrones based on four distances thresholds between 0 and 1000 m from the service location. We selected five public facilities like pharmacies, banks & ATMs, restaurants, supermarkets, cafes, and hairdresser. The following sections deliver the gained results. Then we shortly discuss our findings in relation to city level accessibility in Tirana.

Pharmacies

The results shown in Figure 2 deliver the analysis of the pharmacy coverage in Tirana city. In overall these results were generally expected, since it has the biggest overall coverage compared to other services with 88.8% for the radius between 750-1000 m. This is due to the nature of the service, since it is a necessity for everyone. The results that were generated are more insightful since the service typology is general not specific like in the case of the banks. Even in other distances the coverage percentages remain high with 75.8% coverage for 500-750 m radius, 56.7% coverage for the distance 250-500 which are also the highest coverage percentages for the selected services and the lowest one 0-250 m radius has a coverage of 27.9%.

Figure 2. The location of Pharmacies, their service area isochrones, and the percentage of served buildings in Tirana
Even though the coverage of the service is relatively high, it is worth noted that pharmacies are a service targeted generally by elderly citizens and families with kids. Thus, the coverage for the 0-250 m radius should be the focus, in order to accommodate their needs. Another concerning factor is that the remaining percentage that is left uncovered is at the edges of the city: near Paskuqan, Kombinat and Shkoze neighbourhoods making the life of the residents in these areas more difficult and in sometimes even in danger.

*Banks and Automated Teller Machine (ATMs)*

The study of banks and ATMs was done on a general level without getting into details about the specificity of each bank company. The fact that one individual, despite having a certain bank or ATM near him may have to travel a long distance either way since the bank of his account doesn’t have a wide range of coverage is another problem which is overseen, as the aim of this research is analysing the coverage on a macro level.

According to the results shown in Figure 3, the coverage of this service fails to live up to the most desirable standards. For the upper bound of distance range (750 - 1000 m) the coverage is above average with a percentage of 67%. As the ratio decreases obviously so does the coverage, with 51% for the radius in between 500 - 750 m walk, 36% for the radius in between 250 - 500 m, and finally for the ratio of 0-250 m the coverage stands at roughly 13%.

While judging this percentage as an isolated factor, the number is disturbingly low. It is worth mentioning that there are few other factors to be considered. With the digitalization of society on a massive scale, many functions of banks have been digitized as well. In order to avoid gatherings, queues, and wasted time spent in the waiting area, a lot of services that go through banks are now done electronically. However, there is, and will be for a long time, a significant demographic category which is not comfortable using technology and prefers face to face interaction to handle daily tasks. In this way, that category, too, should be adequately represented and have a comfortable experience in Tirana’s city structure.

![Banks and Automated Teller Machine (ATMs)](image)

*Figure 3. The location of Bank services, their service area isochrones, and the percentage of served buildings in Tirana*

*Supermarkets*

The next service type that we analysed is “supermarket”. Supermarkets are among the key public services that the community at each neighbourhood need to access frequently. That is why it is among the service with the highest service area coverage scoring about 81% coverage at 1 km distance. At the same time, more than 25% of building stock are located within 250 m serving distance to supermarkets. The in-between walking
distances of 500 m and 750 m isochrones cover respectively 50% and 67% of the building stock. Referring to Figure 4, it is visible that the existing supermarkets distribution is not even. Most of them are located close to each other around central part of the city. Yet here we do not differentiate among supermarkets, neither by brand nor by products. However, both the former and the later are crucial criteria for supermarket preferences by the users and may directly affect the behaviour of pedestrians. Thus, future studies can even consider detailing the method by introducing other filtering criteria like supermarket brand, available products, etc.

**Figure 4.** The location of Supermarkets, their service area isochrones, and the percentage of served buildings in Tirana.

**Restaurants and Caffes**

Furthermore, we have selected Restaurants and Caffes since they are accepted to be among the key services of civic life. They provide spaces of leisure and social interaction. Restaurants represent the gastronomical culture of a city serving both traditional and international recipes. Yet, there are differences among both services in relation to daily life of the city. Referring to Figure 5, the maximum service coverage of restaurants within 1 km is 77%, while caffes serve to almost 84% of the building stock in Tirana. A similar trend belongs to the service area within 250 m walking distance that records 21% coverage for restaurants and above 28% for caffes. The reason behind this break may rely on the fact that Albanian families are still traditionally lunching or dinning at home, while widely prefer to have a coffee drink at the nearest coffee shop. Most restaurants within the core urban area of Tirana are frequented for business social events or tourists. Yet, most inhabitants prefer to visit by the rural restaurants located within Tirana’s hinterland during weekends or holidays.

Again, here we could not go further in detail regarding the restaurant brand, type of dishes and recipes, menu content, etc. These variations between restaurant type may have a direct impact on clients’ preferences and the pedestrian mobility within the study area. On the other hand, in the case of caffes the preference of the clients depends on the brand of the coffee, the comfort & the attractiveness of the interior design of the coffee shop. Future studies may consider integrating these details to properly guide investments’ decision making for new facilities like restaurants and caffes.
A final service type that we bring in this study is “hairdresser”. According to Figure 6, hairdressing service is among the ones that have the least service coverage, marking less than 19% coverage for 250 m walking distance and 76% for 1000 m distance. Hairdressing is a customized service unlike supermarkets and pharmacies which in general provides very similar service to the community. We decided to include this typology to expand the discussion about different service types of civic life and their relation to the user accessibility. Future studies must integrate other research methods like users’ survey and behavioural observation to reveal the user preferences and the reasons behind this low percentage of service coverage for hairdressing and similar other customizable services.
**Discussion of the results in the scope of pedestrian accessibility in Tirana and further improvement of the method**

Despite several drawbacks that the transportation network has on rural and urban landscapes connectivity in Albania (Hasa et al., 2021), it is vital for a comfortable accessibility for the community to certain public services at a gradient of spatial scales. This comfortability of access may differ according to the user profile and their walkability status. Thus, the walking distances could vary for different citizens’ profile. We suggest that future studies rely more on the existing literature about walkability profile of users and their proximity demand to certain public services. This may feed the method with meaningful distances thresholds in terms of distance to the closest public service type.

According to our results, there are several neighbourhoods that even though are closer than the threshold distance to the service location, they are not served due to the unavailability of transportation network. Similar cases are present in all maps represented in figures above. Local authorities like the Municipality of Tirana must focus on these areas to enhance the circulation schemes for an improved accessibility to public services by the citizens.

Another drawback of our study is related with the accuracy of the used data. OSM data are a very valuable open-source data that has already boosted the valuable research on object-based urban analysis. However, the accuracy level of OSM data differs in different regions in the world. This is mainly due to the professionalism and correctness by volunteering contributors around the globe. The accuracy level is aligned with the development level of region.

In Albania, as a developing country, the accuracy level of OSM data is to be improved. Previous studies have shown that the accuracy of the building stock provided by OSM data is needs improvement (Hysa, 2021). Future studies must quest for the reliability of the available data. A safer approach is to perform a data update phase within the research workflow. Information gained from site visits to add public services that are not mapped in the current OSM data must be added. This will enable more reliable findings to inform proper decision-making processes in urban accessibility in Tirana.
Conclusions

This study presented the pedestrian accessibility to selected public service types in Tirana, Albania. We used open-source GIS software (QGIS) and geospatial data (Open Street map – OSM). OSM data supplied with information about the point location of selected public facilities, the circulation network, and the existing building stock. Isochrones was generated via QNEAT plugin in QGIS3, and defined service area coverage in four consecutive walking distances: 250 m, 500 m, 750 m, and 1 km. At this stage we presented the pedestrian accessibility to pharmacies, banks & ATMs, supermarkets, restaurants & cafes, and hairdresser within the urbanized core of Tirana. Our results show that certain public facilities are fairly distributed among neighbourhoods serving to almost 90% of the existing building stock. However, while considering the 250 m walking distance which is a vital threshold for users with special needs like elderly and children, the service area coverage is not exceeding 30%. Future studies must focus on specific target groups in relation to specific public service type, by integrating qualitative research methods like questionnaire. Our findings may motivate and guide thoughtful decision-making about public services accessibility at municipal level.

Authors’ Contributions

Conceptualization (AH); Data curation (AH, AK, RP); Formal analysis (AH); Methodology (AH); Project administration (AH); Resources (AH, AK, RP); Supervision (AH); Visualization (AH, AK, RP); Writing - original draft (AH, EZ, AK, RP); Writing - review and editing (AH, EZ). All authors read and approved the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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