Spatial Accessibility Analysis of Public Facilities in Hamilton City

Question: Which residential areas in Hamilton City are currently underserved by public facilities?

1. Introduction：

Ensuring access to key public services—such as healthcare, education, and green space—is important for all residents, especially for those with limited mobility, like seniors. In Hamilton City, the uneven distribution of hospitals, schools, and parks may lead to differences in accessibility across residential areas, which can affect quality of life and fairness in urban services.

This project uses spatial analysis to assess how well public facilities serve different parts of the city, applying both Buffer and Network-based methods. It focuses on identifying areas with limited or no service coverage, aiming to answer the key question:
Which residential areas in Hamilton City are underserved by public facilities?

The results can support more equitable urban planning and help identify priorities for future development.

2. Literature Review

Some studies in the review found that access to health services, cultural facilities, and social or public spaces contributed positively to urban residents' quality of life. For example, Wood et al. (2025) found through survey data analysis that accessibility to health services, cultural facilities, and public spaces was significantly associated with life satisfaction among urban residents, while Lotfi and Koohsari (2009) further argued that spatial accessibility is an important objective indicator for assessing urban quality of life.

In addition, Nicoletti et al.'s (2022) study on 54 cities highlighted that vulnerable groups often suffer from limited accessibility to urban infrastructure, which further deepens social inequality. Overall, the accessibility of public facilities is seen as a key factor in **promoting equitable urban services and enhancing residents' well-being.**

In terms of the research methods of accessibility analysis, Yhee et al. (2021) proposed a GIS-based evaluation method to assess the accessibility of social infrastructure facilities, including education, healthcare, and recreational services. Their study used Euclidean buffer analysis combined with **spatial overlay** to identify infrastructure gap areas—locations with high population density but insufficient service coverage.

While the method does not reflect actual road networks, travel patterns, or physical barriers, it was considered a practical and efficient tool for preliminary accessibility assessment, especially in contexts where detailed transport data is unavailable. This provides a strong theoretical foundation for the **Buffer + Union + Select** method adopted in this project.
Several studies have highlighted the advantages of **network-based accessibility methods**,

particularly in urban contexts where the actual travel experience is influenced by the road network, barriers, and route hierarchy. For instance, a study by *Chen et al. (2022)* in Xiamen combined walking and public transport access to assess **accessibility equity**, demonstrating the capability of network analysis to reflect nuanced spatial disparities. Similarly, research on access to **urban green spaces** confirmed that network path analysis more accurately captures real-world travel behavior compared to simple Euclidean distances. These findings provide a strong theoretical basis for adopting **Network Analyst tools** in this study. In contrast to buffer-based methods, which tend to overestimate service areas, network-based approaches yield more conservative but realistic representations of urban accessibility. Therefore, the integration of the **Network Analyst method** into my project allows for a more reliable evaluation of public facility accessibility from the perspective of actual travel constraints.

In summary, existing studies show that both buffer-based and network-based methods have clear strengths in accessibility analysis. Buffer analysis is simple and effective for identifying general service gaps, while network-based methods provide more realistic results by considering actual travel conditions. Based on this, my project applies and compares both approaches to better understand the accessibility of public facilities in Hamilton City and to ensure the analysis is both practical and grounded in established research.

3. Research Methodology

To evaluate spatial accessibility, two methods were applied:

Method 1: Buffer + Union + Select
Method 2: Network Analysis (using ArcGIS Network Analyst tools)

3.1 Schools, hospitals, and parks (reserves) were selected as destination facilities.

3.2 A 500-meter distance threshold was used to define service areas for each facility type. Both methods were applied separately to generate accessibility zones:

Method 1: Created 500m buffers for each facility type, then used Union and Select operations to derive overlapping service areas.

Method 2: Used the Service Area tool in Network Analyst to generate network-based 500m reachable zones.

3.3 The resulting service areas from each method were used to clip the residential area layer, identifying zones with varying levels of facility accessibility (low, moderate, and high).

3.4 The outputs of the two approaches were compared based on the area covered under each accessibility category.

3.5 Conclusions were drawn by interpreting differences between the two methods, focusing on accessibility coverage and spatial distribution.

4. Research Process

4.1 Downloading and Preparing Datasets

(1) The *Hamilton City boundary dataset* was used to define the study area.

(2) *School, hospital, and reserve datasets* were selected as destination facilities for accessibility analysis.

(3) A *residential dataset* was used to represent areas of residential land use.
For hospital data, location information for *Private Hospitals*, *GP Practices*, and *Public Hospitals* was manually collected from **Healthpoint** and compiled into an Excel table. This table was geocoded into a point feature layer using the **Geocode Addresses** tool.

Picture 1. Sample of hospital attribute data

Name	Address	Type
Anglesea Hospital	9077/19 Knox Street, Hamilton Central, Hamilton 3204	Private Hospitals
Southern Cross Hamilton Hospital	21 Puutikitiki Street, Hamilton East, Hamilton 3216	Private Hospitals
Bridgewater Day Surgery	130 Grantham Street, Hamilton Central, Hamilton 3204	Private Hospitals
Waikato Hospital	183 Pembroke Street, Waikato Hospital, Hamilton 3204	Public Hospital
Tui Medical - Parkwood	6 Gordonton Road, Huntington, Hamilton 3210	GP Practices
Raukura Hauora O Tainui - Te Rengarenga	2/41 Whatawhata Road, Dinsdale, Hamilton 3204	GP Practices
Dinsdale Medical Centre	21 Whatawhata Road, Dinsdale, Hamilton 3204	GP Practices
Hamilton Lake Clinic Westend	38 Tuhikaramea Road, Dinsdale, Hamilton 3204	GP Practices
Raukura Hauora O Tainui - Te Papanui Whare Haumanu	274 Peachgrove Road, Fairfield, Hamilton 3214	GP Practices
Fairfield Medical Centre	1021 Heaphy Terrace, Fairfield, Hamilton 3214	GP Practices
Rata Health - Five Cross Roads	284 Peachgrove Road, Enderley, Hamilton 3214	GP Practices
Tui Medical - Davies Corner	31 Hukanui Road, Chartwell, Hamilton 3210	GP Practices
Flagstaff Medical Centre	2 Endeavour Avenue, Flagstaff, Hamilton 3210	GP Practices
Tui Medical - Borman	Borman Road, Flagstaff, Hamilton 3210	GP Practices

Note: Use a **green** border to highlight "**Private Hospital**"; use a **red** border to highlight "**Public Hospital**"; use a **blue** border to highlight "**GP Practices**"

Detailed sources of all datasets are listed in **Appendix 1: Data Source Summary**.

4.2 Preprocessing Spatial Layers

(1) The precise Hamilton City boundary was extracted from the original administrative layer using **Select by Attributes** and **Export Features**.

(2) All destination facility layers (schools, hospitals, reserves) and the residential layer were **clipped** to the Hamilton City boundary.

(3) Since Network Analysis only supports point inputs, **Polygon to Point** was applied to convert school and reserve layers into point features for consistency across both analysis methods.

4.3 Accessibility Analysis 1 – Buffer Method

(1) A **500-meter buffer** was generated around each destination facility layer (schools, reserves, and hospitals).

(2) Indicator fields (e.g., "School1", "Park1", "Medical1") were added and assigned a value of 1 using **Add Field** and **Calculate Field**.

(3) The buffer layers were combined using the **Union** tool to create overlapping zones.
Select by Attributes was used to classify areas into *low*, *moderate*, and *high* accessibility categories based on the number of overlapping facilities.

(4) The results were **clipped to the residential layer**, and attribute data for accessibility level, facility combination type, and area size was extracted for comparison.

4.4 Accessibility Analysis 2 – Network Method

(1) The **Make Service Area Analysis Layer** tool was used to create walking-based service areas (with a **500-meter travel distance threshold**) for each facility type.

(2) **Add Locations** was used to assign the respective facility points to their service layers.

(3) **Solve** was executed to generate the reachable areas.

(4) Use the **Union** tool to create overlapping zones. **Select by Attributes** was used to classify areas into *low*, *moderate*, and *high* accessibility categories based on the number of overlapping facilities.

(5) The results were **clipped to the residential layer**, and relevant data (accessibility level, facility combination, and area) was extracted for analysis.

4.5 Comparing Results

The extracted results from both methods were compared in terms of area coverage and spatial distribution across accessibility levels and facility combinations.

4.6 Produce visualization maps

5. Result and discussion

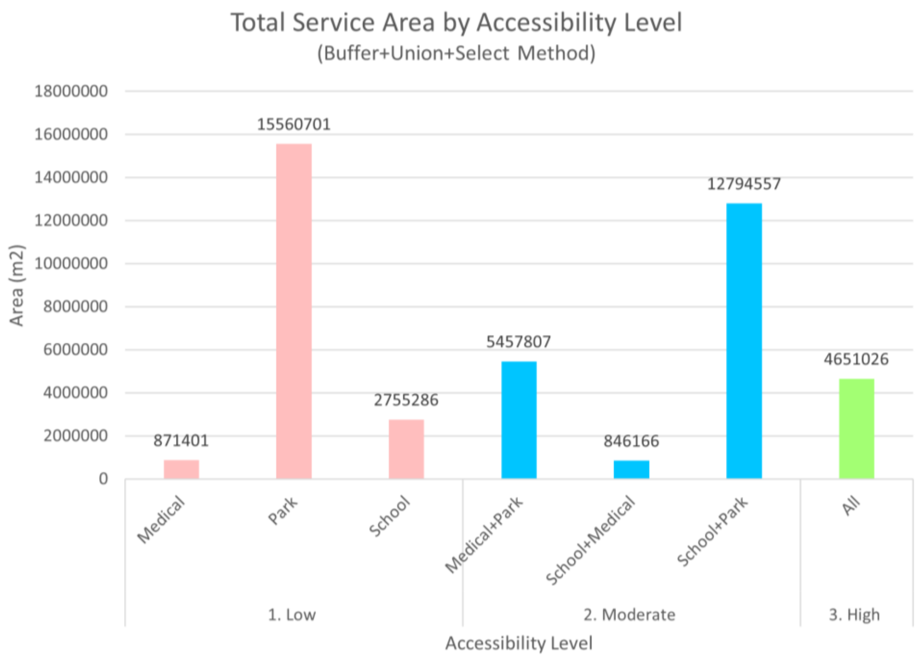
5.1 Accessibility Analysis 1 (Buffer Method)

Table 1. Total Service Area by Accessibility Level (Buffer + Union + Select Method)

Accessibility	Category	Area (m²)
Low	School	2,755,286
	Medical	871,401
	Park	15,560,701
Moderate	School + Medical	846,166
	School + Park	12,794,557
	Medical + Park	5,457,807
High	All	4,651,026

Note: Low indicates areas covered by **only one** type of facility; **Moderate** refers to areas covered by **two** types of facilities; **High** represents areas covered by **all three** types of facilities.

Figure 1. Total Service Area by Accessibility Level (Buffer+Union+Select Method)



The buffer-based accessibility analysis shows clear differences in the coverage of different types of facilities. Areas with only one accessible facility (low accessibility) cover the largest space—parks have the widest reach (around 15.56 million m²), followed by schools (about 2.76 million m²), and medical facilities (around 870,000 m²). In medium-accessibility areas with access to two facility types, the school + park combination covers the most area (around 12.79 million m²), while medical + park and school + medical combinations cover about 5.46 million m² and 0.85 million m², respectively. High-accessibility areas, where all three facility types are accessible, total just 4.65 million m². This suggests that residential areas in Hamilton City with fully comprehensive public service access remain relatively limited.

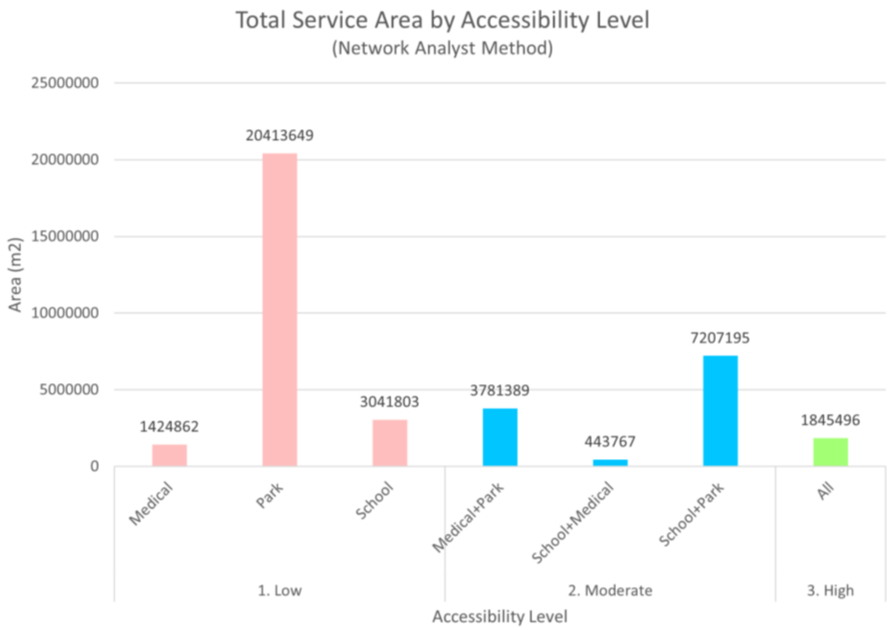
5.2 Accessibility Analysis 2 (Network Method)

Table 2. Total Service Area by Accessibility Level (Network Analyst Method)

Accessibility	Category	Area (m²)
Low	School	3041803
	Medical	1424862
	Park	20413649
Moderate	School + Medical	443767
	School + Park	7207195
	Medical + Park	3781389
High	All	1845496

Note: Low indicates areas covered by **only one** type of facility; **Moderate** refers to areas covered by **two** types of facilities; **High** represents areas covered by **all three** types of facilities.

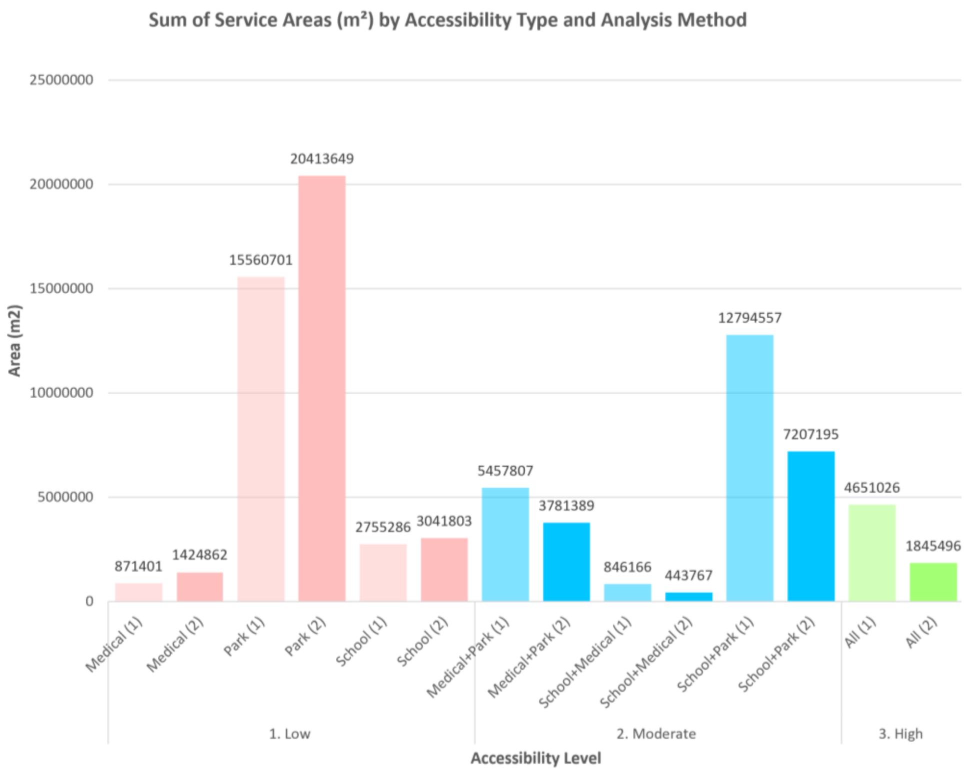
Figure 2. Total Service Area by Accessibility Level (Network Analyst Method)



The accessibility analysis using the Network method also reveals differences in the coverage of various types of facilities. In low-accessibility areas, parks have the widest coverage, with around 20.41 million m², which is significantly higher than schools (about 3.04 million m²) and medical facilities (about 1.42 million m²). For medium-accessibility areas, the school + park combination still covers the largest area (around 7.21 million m²), while medical + park and school + medical combinations are relatively smaller, at approximately 3.78 million m² and 0.44 million m², respectively. The high-accessibility area, where all three facilities can be reached, is only about 1.85 million m²—smaller than the result from the Buffer method. This suggests that when real travel paths are considered, the service coverage becomes more limited, further highlighting the shortage of truly comprehensive service areas in Hamilton City.

5.3 Comparative Analysis of Accessibility Methods (Buffer vs. Network)

Figure 3. Sum of Service Areas (m²) by Accessibility Type and Analysis Method



Note: *(1) represents Buffer analysis; (2) represents Network Analyst method.*

By comparing the results of the Buffer and Network methods, it's clear that the two approaches produce different outcomes across various levels of accessibility. Specifically:
In **low-accessibility areas**, all three facility types (parks, schools, and medical facilities) show larger coverage under the Buffer method. For instance, the park service area is about 15.56 million m² using the Buffer method, while it increases to 20.41 million m² with the Network method. This difference may be due to the Network method accounting for real travel paths and barriers, which leads to a more limited service range.

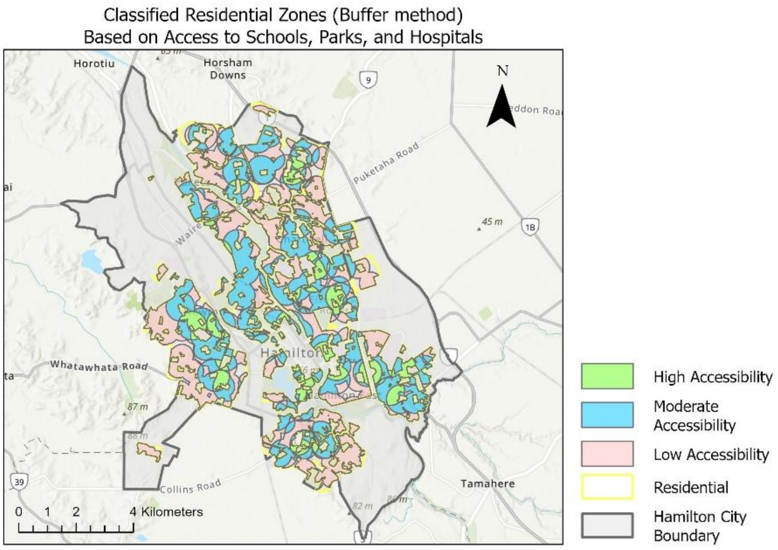
In **medium-accessibility areas**, the differences become more noticeable. The School + Park combination covers around 12.79 million m² in the Buffer method, significantly higher than the 7.21 million m² under the Network method. Other combinations like Medical + Park and School + Medical show similar patterns. This suggests that the road network reduces the spatial overlap of accessibility for multiple facilities to some extent.

For **high-accessibility areas**, where all three types of facilities are reachable, the Buffer method shows 4.65 million m², whereas the Network method only covers 1.85 million m²—a decrease of over 60%. This indicates that, under real travel conditions, only a small portion of residential areas in Hamilton can access schools, hospitals, and parks at the same time.

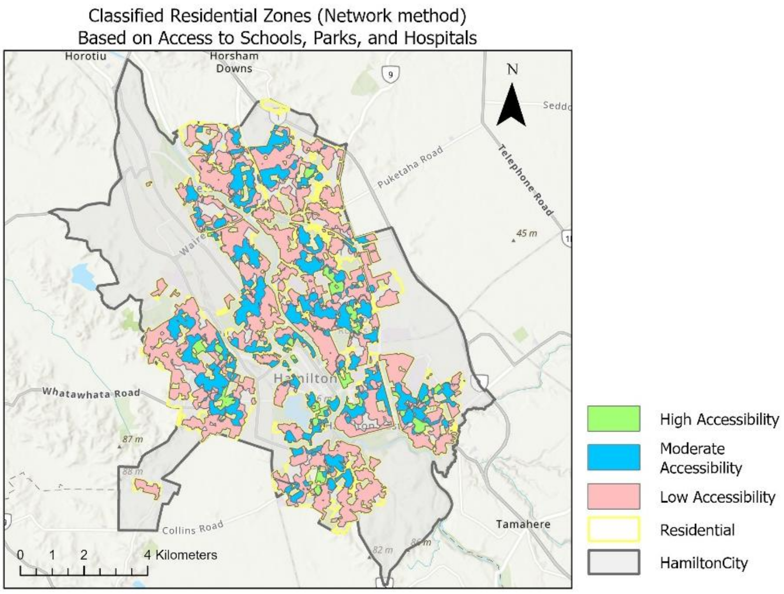
In summary, the Buffer method is more suitable for assessing ideal or potential service coverage, while the Network method reflects actual accessibility based on real travel conditions. Using both methods together provides a more comprehensive understanding of facility distribution and can offer stronger support for urban planning and resource allocation.

5.4 visualization of maps

Map 1. Classified Residential Zones (Buffer method)



Map 2. Classified Residential Zones (Network method)



6. Limitations

Although this project systematically analyzes the spatial accessibility of residential areas in Hamilton City to three types of facilities—schools, medical services, and parks—using both the Buffer and Network methods, there are still some limitations:

(1) **Lack of population and demand considerations**: The analysis is based purely on spatial distance, without taking into account population distribution or residents' actual needs. As a result, it may not fully reflect service pressure or equity in facility access.

(2) **Network analysis doesn't include travel time or traffic conditions**: While the

Network Analyst tool was used, the analysis relies on default path distances and does not factor in real travel time, peak-hour traffic, or road hierarchy, which limits the accuracy and realism of the results.

(3) **Facility classification is too general**: Only three broad categories—schools, hospitals, and parks—are included. No distinction is made between different levels (e.g., primary vs. secondary schools, clinics vs. hospitals, or small parks vs. large green spaces), which may reduce the precision of the analysis.

(4) **Boundary effects not addressed**: Some edge areas may not be fully analyzed due to falling outside administrative boundaries, leading to potential boundary effect issues in the results.

7. Future Work

Based on the identified limitations, future work could be carried out in the following ways:

(1) Introduce population grid data or a resident distribution model to assess how much of the population actually benefits from the service areas.

(2) Use **Travel Time analysis** instead of simple distance, and incorporate peak-hour traffic or public transport networks to improve the realism and timeliness of the results.

(3) Expand facility types and refine classification levels to better capture the accessibility characteristics of different service categories.

(4) Combine accessibility outcomes with urban planning or land use data to help identify areas that may lack adequate public services.

8. Conclusion

This project has conducted a comprehensive spatial analysis to evaluate the accessibility of schools, medical facilities, and parks from residential areas within Hamilton City, using both buffer-based and network-based methods. The results show that while a large portion of residential areas can access at least one type of facility, the number of areas that enjoy comprehensive access to all three types is relatively limited—especially when realistic travel constraints are considered.

The buffer method revealed broader service coverage, providing an idealized picture of accessibility. In contrast, the network analysis presented a more conservative yet realistic perspective by incorporating the road network, which led to smaller areas of overlap and highlighted gaps in integrated service access.

Through the comparison of these two methods, it becomes clear that a dual-approach analysis provides stronger support for understanding spatial disparities in public service provision. It also reveals the critical importance of accounting for travel constraints in urban accessibility studies.

Appendix 1: Data Source Summary

Index	Name	Source	URL
1	Hamilton City Boundary	Stats NZ Geographic Data Service	https://datafinder.stats.govt.nz/layer/120963-territorial-authority-2025/
2	School	LINZ Data Service	https://data.linz.govt.nz/layer/105588-nz-facilities/
3	Residential	LINZ Data Service	https://data.linz.govt.nz/layer/50325-nz-residential-area-polygons-topo-150k/
4	Hospital	Healthpoint	https://www.healthpoint.co.nz/
5	Reserve	Waikato Open Data Hub	https://data-waikatolass.opendata.arcgis.com/datasets/60f870473c8a4b119a71a032f80c848a_0/explore?location=-37.792665%2C175.299834%2C13.53

Reference:

Wood, S. M., Page, K., Baker, E., Beks, H., Binder, M. J., Blake, M., Versace, V. L., & Coffee, N. T. (2025). *Essential service accessibility and contribution to quality of life: A systematic review.* **BMC Public Health, 25**, Article 1608. https://doi.org/10.1186/s12889-025-22858-2

Lotfi, S., & Koohsari, M. J. (2009). *Analyzing accessibility dimension of urban quality of life: Where urban designers face duality between subjective and objective reading of place*. Social Indicators Research, 94(3), 417–435. https://doi.org/10.1007/s11205-009-9438-5

Nicoletti, L., Sirenko, M., & Verma, T. (2022). Disadvantaged communities have lower access to urban infrastructure. *Environment and Planning B: Urban Analytics and City Science, 50*(3), 831–849. https://doi.org/10.1177/23998083221131044

Yhee, H., Kim, S., & Kang, S. (2021). *GIS-Based Evaluation Method for Accessibility of Social Infrastructure Facilities*. *Applied Sciences, 11*(12), Article 5581. https://doi.org/10.3390/app11125581

Chen, X., Xu, L., Zhang, F., & Zhou, Y. (2022). Accessibility equity of urban public service facilities in Xiamen: A multi-scenario analysis based on multi-mode transport. *Spatial Information Research, 30*(6), 875–891. https://doi.org/10.1007/s12061-021-09387-2