

Green, Green Grass of Home: A GIS-Based Analysis of Greenspace Accessibility in Quezon City

Carl Jason B. Streegan¹, Ariel C. Blanco^{1,2}, Jommer M. Medina^{1,2}

¹ Department of Geodetic Engineering, University of the Philippines, Diliman, Quezon City, Philippines -
streegancarljason@gmail.com, (acblanco, jmmedina)@up.edu.ph

² Training Center for Applied Geodesy and Photogrammetry, University of the Philippines, Diliman, Quezon City, Philippines

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Abstract

Urban greenspace provision in Quezon City is uneven, producing environmental inequities despite the existence of relatively large green areas. Using a GIS-based network analysis aligned with a modified Accessible Natural Greenspace Standard (ANGSt), this study quantifies barangay-level accessibility to three greenspace types according to size [< 2 hectare greenspaces (Type 1 Greenspace), $2 \leq X < 20$ hectare greenspaces (Type 2 Greenspace) and ≥ 20 hectare greenspaces (Type 3 Greenspace)]. OpenStreetMap land use and roads, Project MapABLE tree cover, QCPDAD park points, and NAMRIA boundaries were integrated to create access points (160 meter spacings for open greenspaces or designated entrances) and service area isochrones (560 m, 750 m, 2,000 m) in QGIS 3.32 and intersect service areas with barangay polygons to identify deficits. Results show Type 1 greenspaces appear in 51 barangays, Type 2 in 43, and Type 3 in only 19. Conversely, 25, 56, and 90 barangays lack access to Type 1, Type 2, and Type 3 greenspaces, respectively. Another key revelation is the inadequacy of greenspaces per person in several barangays, indicating potential disparities in greenspace provisions. These nuanced findings emphasize the need for targeted urban planning strategies to address disparities and ensure a more equitable and sustainable greenspace environment, considering both the prevalence and accessibility of different greenspace types within the urban landscape.

1. Introduction

Urban greenspaces are essential for sustainable and equitable cities, aligning with SDG 11, Sustainable Cities & Communities (United Nations, 2015). They provide environmental and health benefits such as improved air quality, stormwater mitigation (Han et al., 2022; Stessens et al., 2016; Gupta et al., 2016), social cohesion (Cetin, 2015), and mental well-being (Ye et al., 2018). Yet, accessibility remains unequal, with some communities exceeding greenspace per capita thresholds while others fall short, reflecting environmental injustice (Gupta et al., 2016; Ye et al., 2018).

Quezon City, originally envisioned as a green and livable capital under the Frost-Arellano Plan and the City Beautiful and Garden City movements (Saloma & Akpedonu, 2021), now suffers from underinvestment in accessible greenspaces. Although 16.25% of its land is allocated to parks and open spaces, 14% is taken up by the La Mesa Dam Reservoir, leaving only 2.25% usable for the public, which is well below global standards. Metro Manila averages just 5 sqm of greenspace per capita, compared to the WHO's 9 sqm recommendation (Palma, 2019). Of the 400 hectares once dedicated to leisure space in the Quezon City Quadrangle, only 19 hectares remain in the Ninoy Aquino Parks and Wildlife Center. Most remaining greenspaces are private subdivision parks, golf courses, or cemeteries, limiting access for the general public. Over time, public parks have declined while exclusive spaces, though nominally open, remain inaccessible due to economic barriers, highlighting persistent inequities (Saloma, 2021).

Despite its historical vision, Quezon City's greenspace distribution is highly uneven. Some barangays enjoy a surplus, while many fall below international standards, deepening environmental disparities (Saloma & Akpedonu, 2021). Unlike global studies that use GIS to assess greenspace accessibility, no equivalent analysis has been conducted for

Quezon City. This study addresses that gap by using GIS-based network analysis, a modified ANGSt framework, and the 3-30-300 rule to map greenspace distribution, assess walkable service areas, and identify underserved barangays. By adapting global frameworks to a local context, it provides practical contributions for planners and policymakers to improve zoning, allocate budgets, and expand greening initiatives, ensuring equitable access across barangays.

2. Review of Related Literature

2.1 Defining Greenspaces and Related Concepts and Policies

Greenspaces have gained prominence for their environmental and health benefits, from ecosystem services to enhanced well-being (Han et al., 2022; Stessens et al., 2016; Gupta et al., 2016; Ye et al., 2018; Cetin, 2015). Stessens et al. (2016) describe them as the "missing link" between ecosystems and human health. While definitions vary, they generally refer to urban vegetated areas such as parks and gardens for recreation and public use (Han et al., 2022; Saloma & Akpedonu, 2021; Vilcea & Şoşea, 2020).

For this study, greenspaces are defined as vegetated land, forests, parks, meadows, and recreation grounds, with at least 30% tree cover (Lachowycz & Jones, 2013; MacKerron & Mourato, 2013; Nieuwenhuijsen et al., 2022). This threshold reflects evidence that 30–40% canopy cover promotes health and reduces heat-related deaths (Wang & Hess, 2023) and aligns with the "3-30-300 rule," which requires visibility of three trees from one's home, 30% canopy cover in neighborhoods, and proximity within 300 meters to the nearest greenspace (Nieuwenhuijsen et al., 2022). Service areas were assessed using the Accessible Natural Greenspace Standard (ANGSt), a framework that sets minimum distances to the nearest greenspace and is widely applied in prior studies (Comber, Brunson & Green, 2008; Kmail & Onyango, 2020;

Koliotsis & Papadopoulou, 2020; Gelan, 2021). This study tests ANGSt within the context of Quezon City.

In NCR, LGU-driven initiatives and DENR-NCR's Enhanced National Greening Program expanded greenspaces by 47% between 2021 and 2024 (Paunan, 2024). However, these programs have yet to fully address equitable access, underscoring the importance of examining spatial distribution across communities.

2.2 Accessibility and Equity of Greenspaces

Accessibility refers to the ease with which residents can reach greenspaces, shaped by spatial, temporal, and cost constraints (Huang et al., 2023; Kmail & Onyango, 2020). It indicates whether greenspaces are adequately distributed to meet community needs and strongly influences actual use (Gupta et al., 2016; Ye et al., 2018).

Quezon City, like much of Metro Manila, has limited public greenspaces. Metro Manila provides only 5 sqm of greenspace per person, far below the WHO's 9 sqm standard and global benchmarks such as Singapore (47%), Rio de Janeiro (29%), and New York (14%) (Asian Green City Index, 2011; Palma, 2019; Siemens AG, 2012). Manila itself records just 0.03% greenspace. Comparative studies show Metro Manila and Jakarta lost nearly half their greenspaces between 1989 and 2014, leading to fragmentation and uneven distribution, while Kuala Lumpur's greenspace remained stable (Muhammad Nor et al., 2021). These patterns underscore how rapid urbanization and high population density intensify greenspace inequities (Gupta et al., 2016).

Beyond physical presence, barriers also restrict greenspace use. These include transportation challenges, unsafe roads, and inaccessible facilities for persons with disabilities or parents with strollers. Psychological barriers, such as safety concerns, particularly affect women, youth, and minority groups. Social and cultural exclusion, financial constraints, lack of time, and limited information about available greenspaces further reduce accessibility (Weldon & Bailey, 2007; Forest Research, n.d.).

2.3 Methods for Accessibility Evaluation

GIS is a central tool for evaluating greenspace accessibility, supported by advances like the ArcGIS Network Analyst (Unal, Uslu, & Cilek, 2016; La Rosa, 2014). Two common methods are Euclidean buffers and network analysis. Buffers are simple for area-to-population ratios but assume straight-line movement, uniform access, and regular boundaries, often misrepresenting real travel distances (Gupta et al., 2016; Unal, Uslu, & Cilek, 2016). Network analysis overcomes these limits by using actual road networks, entry points, and irregular shapes, yielding more realistic service areas (Nicholls, 2010; Kmail & Onyango, 2020). It has been widely applied beyond greenspaces in water, traffic, and transport studies (Oh & Jeong, 2007; Chen & Chang, 2015). This study applies service area analysis with isochrones to better capture walkable accessibility than simple buffers.

3. Methodology

3.1 Study Area

Quezon City, the largest city in Metro Manila with a land area of 16,112.58 hectares and a population of 2,960,048 (Philippine Statistics Authority, 2020; Quezon City Government, n.d.), served as the study area. It is bordered by

Caloocan, Manila, Marikina, San Juan, and Mandaluyong, and divided into 142 barangays.

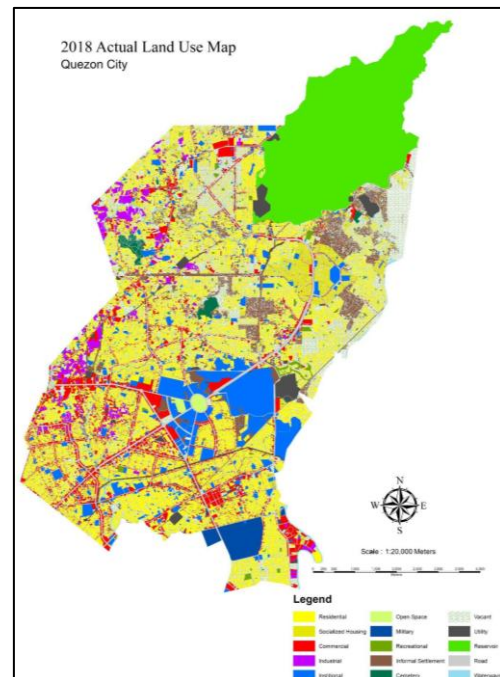


Figure 1. 2018 Actual Land Use Map of Quezon City (Quezon City Planning and Development Office, 2018)

Greenspaces are scarce, as shown in Figure 1. The 2,659-hectare La Mesa Watershed dominates the city's green cover but is largely inaccessible to the public since it is a protected area (SMEC, 2022). Excluding La Mesa, only 43 barangays meet the city's 9.5 sqm per capita standard, underscoring inequities in greenspace distribution (Estoque et al., 2018).

Moreover, many areas classified as "parks" by QCPDAD (n.d.) are not true greenspaces, as they include courts or subdivision parks with little vegetation. Using a 30% vegetation threshold, only a subset of these qualified, requiring further filtering in this study (Ranada, 2020).

3.2 Datasets Used

This study used multiple geospatial datasets to identify and assess greenspaces in Quezon City. Barangay boundaries from NAMRIA (2016) delineated the study area, while OpenStreetMap land use classifications were filtered to include only forests, meadows, parks, and recreation grounds. Cemeteries, commercial zones, schools, golf courses, and the La Mesa Natural Reserve were excluded due to inaccessibility.

As shown in Figure 2, the methodology involved three main steps: (1) data collection, (2) creation of service areas, and (3) accessibility analysis. Access points were identified through manual digitization, centroids, intersections of roads and barangay borders, and perimeter-based points (So, 2016). Service areas (isochrones) were generated in QGIS Desktop 3.32.2 using the "Service area (from layer)" tool under the Network Analysis toolbox. The "Minimum Bounding Geometry" tool was then applied to define isochrone boundaries. Finally, the "Intersection" tool was used to determine which barangays had access to greenspaces.

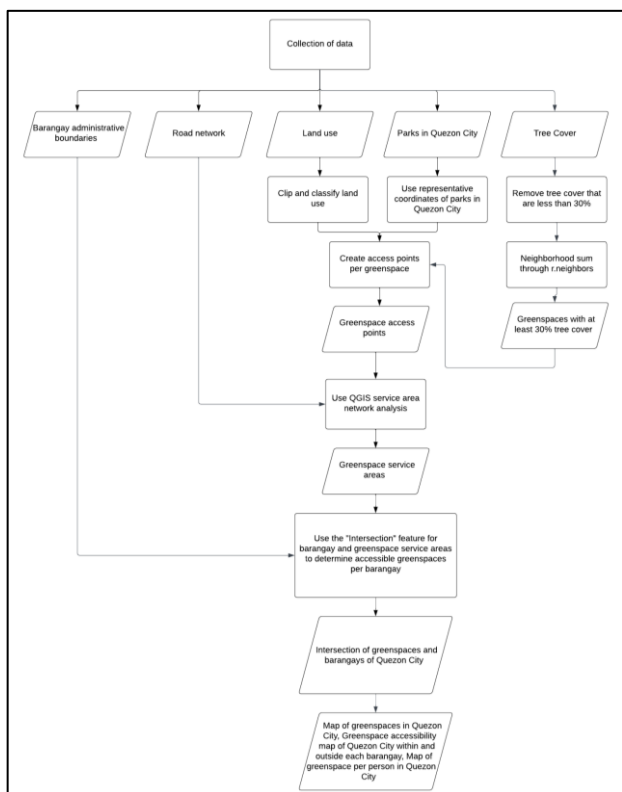


Figure 2. Flowchart of Methodology

3.3 Greenspace Definition and Classification

Greenspaces were defined as vegetated areas with at least 30% tree canopy cover, forests, parks, meadows, and recreation grounds, following the 3-30-300 rule (Nieuwenhuijsen et al., 2022) and earlier definitions (Lachowycz & Jones, 2013; MacKerron & Mourato, 2013). The 30% canopy threshold was applied using the *r.neighbors* function in QGIS GRASS. Land classification, tree cover, and Quezon City Parks Development and Administration Department data were combined to create the final greenspace layer (Figure 3).

Table 1 shows greenspaces classified by size based on ANGSt standards: Type 1 (<2 ha), Type 2 (2–20 ha), and Type 3 (≥20 ha). Corresponding isochrones were set at 560 m, 750 m, and 2000 m, respectively, to represent accessibility ranges (ESRI, 2023).

Greenspace Type	Size Range	Isochrones (m)
Type 1 Greenspace	Less than 2 hectares	560 and 750
Type 2 Greenspace	2 to less than 20 hectares	560 and 750
Type 3 Greenspace	20 hectares or larger	2000

Table 1. Greenspace Classification by Size (Modified Accessible Natural Greenspace Standard, 2003)

A modified ANGSt is used for this research. The modifications were be the following:

1. No individual should reside over 560 and 750 meters away from a green space spanning at least 2 hectares.
2. Within a 2-kilometer radius of residential areas, there must exist at least one accessible site measuring 20 hectares.

3. Within a 5-kilometer radius, there should be an accessible site of 100 hectares.
4. Within a 10-kilometer radius, there should be an accessible site of 500 hectares.

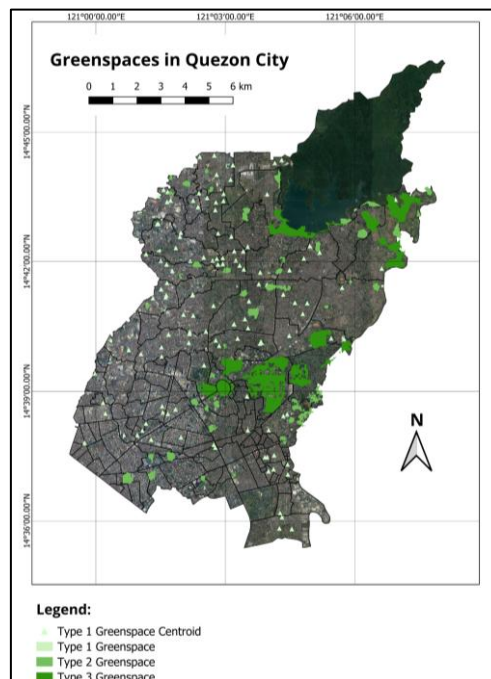


Figure 3. Greenspaces in Quezon City (OSM, 2023; Quezon City Planning and Development Office, 2018)

Walking distances of 560 m and 750 m were adopted based on Tolentino & Sigua (2022), who found recreational trips typically range from 555–746 m (7.85–10.57 minutes at 70.62 m/min or 4.24 km/h). Accordingly, this study assumes greenspaces within a barangay are accessible to its residents. Isochrone thresholds (560 m, 750 m, 2000 m) were adapted from a modified ANGSt framework, widely applied in accessibility studies (Gelan, 2021; Kmail & Onyango, 2020; Koliotsis & Papadopoulou, 2020; Comber et al., 2008). The 560–750 m range reflects typical walkable distances, while the 2000 m threshold captures access to larger greenspaces.

3.4 Accessibility and Isochrone Generation

Network analysis has various applications, including route, service area, and location-allocation analysis (ESRI, n.d.). This study used service area analysis, which generates isochrones to represent walkable coverage. Unlike simple buffers, isochrones incorporate road networks and physical barriers, offering more realistic accessibility estimates (Kmail & Onyango, 2020; Nicholls, 2010; Oh & Jeong, 2007; ESRI, 2023). In GIS, facilities are typically placed at park access points, often at street intersections, so each greenspace can generate multiple isochrones that together define its accessible area (Iraegui, Augusto, & Cabral, 2020). Accessibility was modeled in QGIS Desktop 3.32.2 by converting greenspaces from polygons to access points using the “Points Along Geometry” function at 160 m intervals (Spangler et al., 2023). For enclosed sites, entrances were manually digitized. Isochrones were then generated with the “Service Area” tool using the “Shortest Path” algorithm, excluding non-pedestrian roads. Final polygons were merged with the “Minimum Bounding Geometry” tool to define service areas.

3.5 Accessibility Evaluation

Accessibility was assessed by calculating the spatial intersection between greenspace service areas and barangay boundaries. The proportion of each barangay's land area covered by isochrones was computed using QGIS's "Field Calculator," with higher overlap indicating greater accessibility. This approach enabled the identification of underserved barangays with limited access to greenspaces. While this analysis provides a spatial measure of accessibility, it does not account for quality of amenities, or barriers such as safety and maintenance. These factors, while important, were beyond the scope of this study and are identified as areas for further research.

4. Results and Discussion

4.1 Greenspace Distribution Across Barangays

Results showed that greenspace accessibility is uneven across barangays, with some lacking access altogether (see Table 2). Type 1 Greenspaces were the most common, present in 51 barangays, followed by Type 2 in 43 and Type 3 in 19. This hierarchy shapes accessibility, with Type 1 being the most widespread, while Type 3, though fewer, cover the largest areas due to their size and 2000 m service radius. However, their benefits are concentrated around nearby barangays. In contrast, the smaller service areas of Type 1 and 2 are offset by their greater numbers, providing more localized access.

Additionally, Figure 1 shows that the actual land use of many barangays in Quezon City is not primarily designated for greenspaces, with recreational areas occupying only a very small share. In contrast, Barangay U.P. Campus includes land uses such as parks, meadows, and forests, but its greenspace is largely supported by extensive tree cover. On the other hand, barangays like Bahay Toro and Tandang Sora, despite their large areas, lack significant greenspace-designated land use. Their provision relies mainly on small parks, which, while locally accessible, remain insufficient to meet WHO standards.

This imbalance between quantity and size reflects a fragmented greenspace system: many barangays rely on small patches for daily use, while only a few enjoy large recreational areas. Such fragmentation and uneven distribution mirror trends in Jakarta and Metro Manila, where rapid urbanization has intensified greenspace inequities (Muhammad Nor et al., 2021; Gupta et al., 2016).

Greenspace Type	Barangays with No Access	Partial Access (1–49%)	Moderate Access (50–89%)	Full Access (90–100%)
Type 1 (560 m)	35	63	38	6
Type 1 (750 m)	18	54	40	30
Type 2 (560 m)	63	56	20	3
Type 2 (750 m)	50	53	19	20
Type 3 (2000 m)	90	18	8	26

Table 2. Area of Greenspace Service Area within Barangays (Service Area Coverage)

Table 2 shows that several barangays fail to meet the modified ANGSt criteria, which require residents to live within 300 m of a 2-hectare greenspace and within 2 km of a 20-hectare site.

Rules 3 and 4 of ANGSt were unmet entirely, as no greenspaces of 100 or 500 hectares exist within the 5–10 km buffer zones of Quezon City. This absence underscores a structural weakness in city planning: while small parks exist, large urban parks that can serve citywide populations are lacking.

Analysis of the three greenspace types further reveals uneven distribution. For example, Paligsahan has 7.83% coverage of Type 1, Loyola Heights 13.79% of Type 2, and U.P. Campus 66.07% of Type 3. These disparities highlight the need to evaluate both quantity and size in assessing greenspace provision. The identification of barangays without greenspaces underscores the urgency for targeted development. Moreover, considering the type and size of greenspaces is crucial, as these factors shape their ecological and social impact.

4.2 Greenspace Service Area and Accessibility

Figure 4 shows that Type 1 Greenspaces are often located within or near residential neighborhoods, making them easily accessible to many barangays. Their small size allows for wider distribution and integration into urban areas, providing localized benefits and community-focused design. Because they require less land, even small plots (e.g., 150 sqm parks in Villa Arca Subdivision and Kingspoint I Subdivision) can serve as functional greenspaces

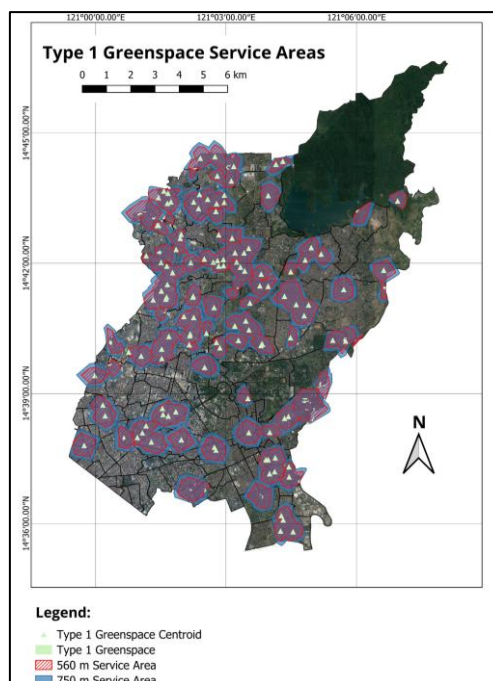


Figure 4. Type 1 Greenspace Service Areas in Quezon City

In Figure 5, it can be seen that Type 2 Greenspaces present intermediate accessibility due to their size. Their size is limiting their distribution across barangays. Although offering varied recreational amenities, they may not attract as broad a range of users as larger greenspaces, and their design might not be as community-centric.

Figure 6 shows that Type 3 Greenspaces, though fewer, serve citywide functions by attracting residents from multiple barangays to centralized hubs. These large areas often host regional facilities such as sports fields or nature reserves and can also act as green corridors, linking different parts of the

city. While fewer barangays have direct access, their broader scale provides regional benefits.

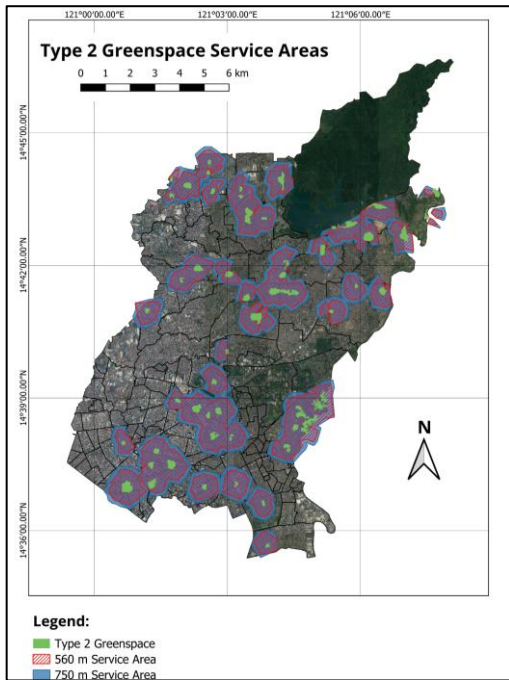


Figure 5. Type 2 Greenspace Service Areas in Quezon City

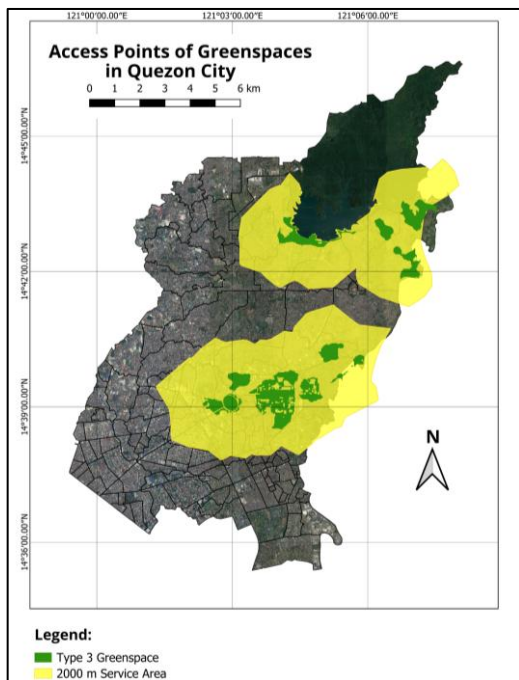


Figure 6. Type 3 Greenspace Service Areas in Quezon City

4.3 Greenspace per Capita and Environmental Inequity

Figure 7 illustrates greenspace per person in Quezon City, measured in square meters to align with WHO standards. Within Type 1 Greenspaces, Barangay Sikatuna Village has the lowest per capita greenspace at 0.03 sqm, while Paligsahan records the highest at 13.01 sqm. Only Paligsahan and Damar meet the WHO's 9 sqm standard (Palma, 2019; Siemens AG, 2012). Paligsahan's high per capita greenspace stems not only from listed parks like Amoranto Stadium and Roces Circle

(QCPDAD, n.d.) but also from its extensive vegetated areas with at least 30% tree cover.

For Type 2 Greenspaces, Tatalon records the lowest per capita greenspace at 0.03 sqm, while Kristong Hari reports the highest at 16.02 sqm. Several barangays, including Kalusugan, Paligsahan, Phil-Am, Doña Imelda, Loyola Heights and Kristong Hari, meet WHO standards. Although Kristong Hari is not listed as having official greenspaces by QCPDAD (n.d.), its higher coverage suggests the presence of vegetated open spaces with substantial tree cover.

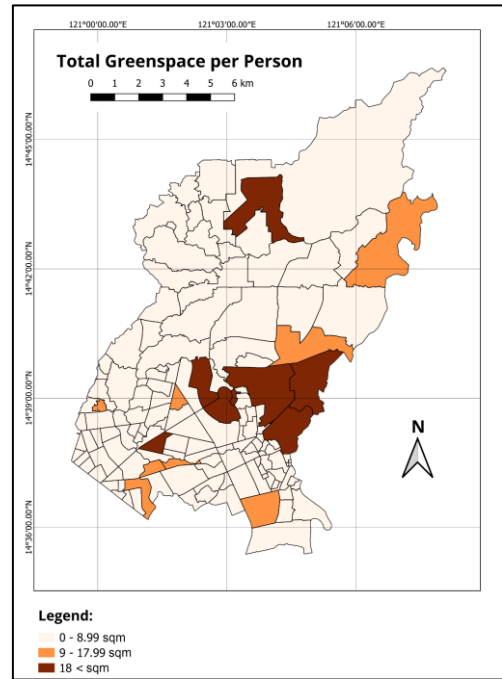


Figure 7. Total Greenspace per Capita (sqm)

For Type 3 Greenspaces, Commonwealth shows the lowest per capita greenspace at 0.07 sqm, while U.P. Campus leads with 61.73 sqm. Barangays meeting WHO standards include Matandang Balara, Bagang Silangan, Central, Loyola Heights, Greater Lagro, Project 6, Pansol, Old Capitol Site, and U.P. Campus.

Greenspace Type	GAPP (sq.m.)				
	0	< 1	1–5	5–10	> 10
Type 1	65.49%	21.83%	10.56%	1.41%	0.70%
Type 2	70.42%	9.15%	11.97%	4.93%	3.52%
Type 3	87.32%	2.82%	3.52%	0.70%	5.63%

Table 3. Distribution of Barangays per Greenspace Type and Greenspace Area Per Person (GAPP, sqm)

Table 3 highlights disparities in greenspace provision, with many barangays lacking adequate greenspace per person (Palma, 2019). While higher tree cover often correlates with greater availability, this pattern is not consistent across all areas. Zoning density helps explain greenspace disparities in Quezon City. Low residential density barangays like Phil-Am and Loyola Heights, which meet WHO standards, do not have to accompany more people within their area, though not all low-density areas achieve this standard. Medium residential

density barangays such as Kristong Hari, Quirino 2-C, and Batasan Hills show mixed outcomes, with some retaining tree cover while others lose space to development. In contrast, high residential density barangays like Sauyo and Commonwealth face the greatest lack of greenspace due to dense housing and high population pressure. Overall, lower-density areas generally maintain more greenspace, while higher-density zones struggle to provide adequate access (Quezon City Government, 2017).

In 2020, Quezon City's population reached 2,960,048 (Philippine Statistics Authority, 2021). Its total greenspace area of 12,661,926.68 sqm provides only 4.28 sqm per person, less than half of the WHO's 9 sqm standard (Palma, 2019; Siemens AG, 2012). This gap underscores the insufficiency of greenspaces to meet the city's recreational and health needs. Findings also reveal that greenspaces extend beyond formal parks and gardens to include vegetated open areas with substantial tree cover. Recognizing these spaces in planning is crucial, as they significantly contribute to accessibility and should be integrated into strategies to improve urban livability.

4.4 Policy and Planning Implementation

The findings highlight the need to consider not only the total greenspace area but also its equitable distribution across barangays. Addressing these disparities requires targeted interventions to improve both accessibility and quality. Policymakers must align strategies with WHO standards and adapt plans as the city's population grows. These inequalities reflect environmental injustice, as population-dense barangays remain deprived of greenspace, limiting both recreation and critical health benefits. Similar to patterns across Southeast Asia, these disparities stem from governance, policy decisions, and socioeconomic pressures (Muhammad Nor et al., 2021).

The decline of greenspaces in Quezon City can be traced to rapid residential development after the Asian financial crisis, when vacant lands were converted into housing projects. Although laws required developers to allocate 3.5 to 9% of their projects as open space, many avoided compliance by subdividing land below one hectare to bypass requirements. As a result, open space declined instead of increasing between 2003 and 2009 (Quezon City Government, n.d.).

Although recent NCR initiatives increased greenspace by 47% between 2021 and 2024 (Paunan, 2024), they focus on total area rather than equitable distribution. Without prioritizing underserved barangays, exclusion will persist. Two strategies are key: expand and protect Type 1 greenspaces in dense areas for walkable access, and develop and connect larger Type 2 and 3 greenspaces to provide broader ecological and recreational benefits. Together, these measures can ensure social interaction, psychological relief, and the link between ecosystem and well-being that greenspaces provide (Stessens et al., 2016; Cetin, 2015; Ye et al., 2018).

5. Conclusion and Recommendations

5.1 Conclusion

The analysis of greenspace allocation and accessibility in Quezon City reveals clear evidence of environmental injustice. Greenspaces are unevenly distributed, with some barangays enjoying substantial provision while many fall short of the World Health Organization's 9 sqm per capita standard. Defining greenspaces through tree cover provides a

more accurate measure of usable areas than traditional land-use classifications, underscoring the gaps in both availability and accessibility. Addressing these inequities requires more than increasing greenspace quantity. Policymakers must also ensure accessibility, safety, and quality so that all communities benefit. A more equitable distribution of greenspaces is essential to improving public well-being and advancing Quezon City's environmental sustainability.

5.2 Recommendations

Future studies should integrate additional factors such as safety, maintenance, cultural norms, and financial barriers that influence actual use. Expanding greenspace definitions to include private vegetated areas, along with datasets like NDVI and updated land cover, will offer a more comprehensive assessment. Spatial statistical tools (e.g., clustering, autocorrelation) can further strengthen evidence of environmental inequity.

Methodologically, future research may expand coverage to nearby greenspaces beyond city borders, and test models incorporating transport modes, traffic, and pedestrian dynamics. Assigning weighted distances per barangay could also refine results.

For policymakers, greenspace planning should be embedded in zoning regulations, budgeting, and greening initiatives. Prioritizing new sites near dense residential areas, coupled with community participation and recognition of past planning shortcomings, will be vital to building a fairer and more sustainable greenspace system.

References

- Cetin, M., 2015: Using GIS analysis to assess urban green space in terms of accessibility: case study in Kutahya. *International Journal of Sustainable Development & World Ecology*, 22(5), 420-424. doi:10.1080/13504509.2015.1061066
- Chen, J., Chang, Z., 2015: Rethinking urban green space accessibility: Evaluating and optimizing public transportation system through social network analysis in megacities. *Landscape and Urban Planning*, 143, 150–159. doi:10.1016/j.landurbplan.2015.07.007
- Comber, A., Brunson, C., Green, E., 2008: Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups. *Landscape and Urban Planning*, 86(1), 103-114. doi:10.1016/j.landurbplan.2008.01.002
- ESRI, 2023. Service areas. developers.arcgis.com/documentation/mapping-apis-and-services/routing/service-areas/ (15 October 2025).
- Estoque, R. C., Murayama, Y., Lasco, R. D., Myint, S. W., Pulhin, F. B., Wang, C., Ooba, M., Hijioka, Y., 2018: Changes in the landscape pattern of the La Mesa Watershed – The last ecological frontier of Metro Manila, Philippines. *Forest Ecology and Management*, 430, 280–290. doi:10.1016/j.foreco.2018.08.023
- Forest Research, n.d. Access and accessibility. forestresearch.gov.uk/tools-and-resources/fthr/urban-regeneration-and-greenspace-partnership/greenspace-in-practice/benefits-of-greenspace/access-and-accessibility

- Gelan, E., 2021: GIS-based multi-criteria analysis for sustainable urban green spaces planning in emerging towns of Ethiopia: the case of Sululta town. *Environmental Systems Research*, 10, 13. doi.org/10.1186/s40068-021-00220-w
- Gupta, K., Roy, A., Luthra, K., Maithani, S., Mahavir., 2016: GIS based analysis for assessing the accessibility at hierarchical levels of urban green spaces. *Urban Forestry & Urban Greening*, 18, 198-211. doi:10.1016/j.ufug.2016.06.005
- Han, Y., He, J., Liu, D., Zhao, H., Huang, J., 2022: Inequality in Urban Green Provision: A Comparative Study of Large Cities Throughout the World. *Sustainable Cities and Society*, 89. doi.org/10.2139/ssrn.4133473
- Huang, B., Li, W., Ma, W., Xiao, H., 2023: Space Accessibility and Equity of Urban Green Space. *Land*, 12(4), 766. doi.org/10.3390/land12040766
- Iraegui, E., Augusto, G., Cabral, P., 2020: Assessing Equity in the Accessibility to Urban Green Spaces According to Different Functional Levels. *ISPRS International Journal of Geo-Information*, 9(5), 308. doi:10.3390/ijgi9050308
- Kmail, A. B., Onyango, V., 2020: A GIS-based assessment of green space accessibility: case study of Dundee. *Applied Geomatics*, 12(1993). doi:10.1007/s12518-020-00314-7
- Koliotsis, P. A., Papadopoulou, M. P., 2020: Spatial Analysis of the Accessibility of Urban Greenspace at the City Level. *European Journal of Environmental Sciences*, 10(1). doi.org/10.14712/23361964.2020.3
- Lachowycz, K., Jones, A. P., 2013: Towards a better understanding of the relationship between greenspace and health: Development of a theoretical framework. *Landscape and Urban Planning*, 118, 62–69. doi.org/10.1016/j.landurbplan.2012.10.012
- La Rosa, D., 2014: Accessibility to greenspaces: GIS based indicators for sustainable planning in a dense urban context. *Ecological Indicators*, 42, 122–134. doi:10.1016/j.ecolind.2013.11.011
- MacKerron, G., Mourato, S., 2013: Happiness is greater in natural environments. *Global Environmental Change-Human and Policy Dimensions*, 23(5), 992–1000. doi.org/10.1016/j.gloenvcha.2013.03.010
- Muhamad Nor, A. N., Abdul Aziz, H., Nawawi, S. A., Muhammad Jamil, R., Abas, M. A., Hambali, K. A., Yusoff, A. H., Ibrahim, N., Rafeai, N. H., Corstanje, R., Harris, J., Grafius, D., Perotto-Baldovieso, H. L., 2021: Evolution of Green Space under Rapid Urban Expansion in Southeast Asian Cities. *Sustainability*, 13(21). doi.org/10.3390/su132112024
- Nicholls, S., 2001: Measuring the accessibility and equity of public parks: a case study using GIS. *Managing Leisure*, 6(4), 201-219. doi.org/10.1080/13606710110084651
- Nieuwenhuijsen, M. J., Dadvand, P., Marquez, S., Bartoll, X., Barboza, E. P., Cirach, M., Borrell, C., Zijlema, W. L., 2022: The evaluation of the 3-30-300 green space rule and mental health. *Environmental Research*, 215(2). doi.org/10.1016/j.envres.2022.114387
- Oh, K., Jeong, S., 2007: Assessing the spatial distribution of urban parks using GIS. *Landscape and Urban Planning*, 82(1), 25–32. doi:10.1016/j.landurbplan.2007.01
- Palma, R. A., 2019. Metro Manila needs more public parks and green spaces. Here's why. CNN Philippines. cnnphilippines.com/life/culture/2019/8/20/public-green-spaces-manila.html (15 October 2025).
- Paunan, J. C., 2024. NCR's green space cover expands 47% to mitigate climate change, bring other benefits. Philippine Information Agency. pia.gov.ph/ncrs-green-space-cover-expands-47-to-mitigate-climate-change-bring-other-benefits/ (15 October 2025).
- Philippine Statistics Authority, 2020. Quezon City. psa.gov.ph/classification/psgc/barangays/1381300000 (15 October 2025).
- QGIS, 2023. 27.1.9. Network analysis. docs.qgis.org/3.28/en/docs/user_manual/processing_algs/qgis/networkanalysis.html (15 October 2025).
- Quezon City Government, n.d. History. quezoncity.gov.ph/about-the-city-government/history/ (15 October 2025).
- Quezon City Government, n.d. 2011-2030 Comprehensive Land Use Plan. quezoncity.gov.ph/wp-content/uploads/2020/12/CLUP-2011-2025-Final-Version.pdf (15 October 2025).
- Quezon City Government, 2017. Comprehensive Zoning Ordinance of 2016. quezoncity.gov.ph/wp-content/uploads/2021/01/Quezon-City-Zoning-Ordinance-2016.pdf (15 October 2025).
- Ranada, P., 2020. Parks will save us: Pandemic highlights lack of Metro Manila green, open spaces. Rappler. rappler.com/newsbreak/in-depth/covid-19-pandemic-highlights-lack-metro-manila-green-open-spaces/ (15 October 2025).
- Saloma, C., Akpedonu, E., 2021: Parks, plans, and human needs: Metro Manila's unrealised urban plans and accidental public green spaces. *International Journal of Urban Sustainable Development*, 13(3), 715-727. doi.org/10.1080/19463138.2021.2021418
- Siemens, A. G., 2011. Asian Green City Index. w1.siemens.com.cn/userfiles/AGCI%20Report_EN.pdf (15 October 2025).
- SMEC, 2022. SMEC caps year with tree planting at La Mesa Watershed Reservation, Philippines. smec.com/general/smec-caps-year-with-tree-planting-at-la-mesa-watershed-reservation-philippines/ (15 October 2025).
- Spangler, K. R., Brochu, P., Nori-Sarma, A., Milechin, D., Rickles, M., Davis, B., Dukes, K. A., Lane, K. J., 2023: Calculating access to parks and other polygonal resources: A description of open-source methodologies. *Spatial and Spatio-Temporal Epidemiology*, 47. doi.org/10.1016/j.sste.2023.100606
- So, S. W., 2016. Urban Green Space Accessibility and Environmental Justice: A GIS-Based Analysis in the City of Phoenix, Arizona. spatial.usc.edu/wp-content/uploads/2016/07/So-Shuk-Wai.pdf (15 October 2025).

2025).

Stessens, P., Khan, A. Z., Huysmans, M., Canters, F., 2017: Analysing urban green space accessibility and quality: A GIS-based model as spatial decision support for urban ecosystem services in Brussels. *Ecosystem Services*, 28, 328-340. doi:10.1016/j.ecoser.2017.10.016

Tolentino, N. J. Y., Sigua, R. G., 2022 Characteristics of Walking and Cycling in Metro Manila, Philippines. *Philippine Transportation Journal* Vol. 5, No. 1. ncts.upd.edu.ph/tssp/wp-content/uploads/2022/12/TSSP2022_Vol5-No1_02-Tolentino-and-Sigua.pdf (15 October 2025).

Unal, M., Uslu, C., Cilek, A., 2016: GIS-Based Accessibility Analysis for Neighbourhood Parks: The Case of Cukurova District. *Journal of Digital Landscape Architecture*, 1, 46-56. doi:10.14627/537612006

United Nations, 2015. Goal 11 Sustainable Cities and Communities. globalgoals.org/goals/11-sustainable-cities-and-communities/ (15 October 2025).

Vilcea, C., Şoşea, C., 2020: A GIS-based analysis of the urban green space accessibility in Craiova city, Romania. *Geografisk Tidsskrift-Danish Journal of Geography*, 120(1), 19-34. doi:10.1080/00167223.2020.1766365

Wang, BA., Hess, J.J., 2023. Tree Cover and Greenspace. Risk Reduction Guidance. climatesmarthealth.org/articles/increased-tree-cover.pdf (15 October 2025).

Weldon, S., Bailey, C., 2007. New Pathways to health and Well-being: Summary of research to understand and overcome barriers to accessing woodland. cdn.forestresearch.gov.uk/2007/11/new_pathways_to_health_summary.pdf (15 October 2025).

Ye, C., Hu, L., Min, L., 2018: Urban green space accessibility changes in a high-density city: A case study of Macau from 2010 to 2015. *Journal of Transport Geography*, 66, 106-115. doi.org/10.1016/j.jtrangeo.2017.11.009