Developing a Geospatial Framework for Calculating a 15-Minute City Index (FMCI): The Case of Quezon City

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Abstract: The 15-minute city concept is a measure of the quality of urban life based on proximity, sustainability, and sociality. This study proposes a geospatial framework for calculating the 15-minute city index (FMCI) aimed to measure the accessibility of its residents to six social functions, which include living, working, supplying, caring, learning, and enjoying. Quezon City, Philippines, was chosen for its urban characteristics that aligned with this vision and served as the study area. To account for pedestrian needs, age-based weights were assigned to the social functions, and service areas were mapped using a uniform walking speed. FMCI values were calculated based on weighted social functions and barangay population distribution by age group. Results revealed that 39% of Quezon City's barangays achieved a perfect FMCI score of one, indicating access to all six functions within a 15-minute walk. Positive spatial autocorrelation indicated the clustering of barangays with similar FMCI values, with hot spots in the southern and cold spots in the northern parts of the city. These findings offer insights for policymakers in improving urban life quality. The adaptable FMCI framework can be applied to other urban areas to assess service accessibility, considering residents' needs.

1 INTRODUCTION

The 15-minute city is a population-oriented urban development concept that has gained popularity in recent years. Its primary idea is that the accessibility to essential services of the residents should be within a 15-minute radius of their homes, whether by walking, biking, or utilizing public transportation (Poorthuis & Zook, 2023). It is a multi-reformative urban model that addresses the decentralization of a city, reduction of carbon footprint, and social and economic integration (ArchDaily, 2024). The COVID-19 pandemic brought renewed focus to this pedestrian-centered idea, as lockdowns underscored the need for easily accessible amenities amid limitations on mobility and public transportation (Akrami et al., 2024).

Moreno et al. (2021) claim that the ability of residents to access six essential urban social functions (SF), which include (a) living, (b) working, (c) supplying, (d) caring, (e) learning, and (f) enjoying, in a 15-minute space-time frame is linked to a higher quality of life. This concept connects the proximity and integration of the six essential functions to the enhancement of well-being, sociality, and sustainability, which emphasizes the purpose and significance of the 15-minute city to offer a high-quality urban life to the residents.

For the practical and effective implementation of the 15-minute city, each societal function should be broken down into subcategories and linked to corresponding specific uses, activities, and facilities (Moreno et al., 2023). Table 1 provides a summary of the elements and facilities associated with six SFs.

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Considerably, population distribution per age distribution of a city is an important demographic characteristic to be considered in assessing a 15-minute city (Moreno et al., 2023). For instance, a child must have access to learning or enjoying SFs, while the elderly must have access to the caring SF. Assessment of accessibility within the neighborhood requires incorporation of the origins of mobility needs, which the population distribution represents. This ensures that services are located close to the people who are the users of these services (Caselli, 2021). Thus, this research project will incorporate population data to facilitate the assessment.

Table 1: Elements and facilities are integrated into the six SFs.

Social Function	Subcategories
Living	Housing Energy Waste Management Transportation Services Infrastructure
Working	Environment Access Diversity Services
Getting Supplies	Food Non-food-related consumption Public services
Enjoying	Holidays Culture Leisure Association
Learning	Access Availability Performance Guide
Caring/Being Healthy	Access to care Prevention Emergency Living environment Wellness Sport Pollution

Over the past few years, the 15-minute city concept has gained significant support from various countries due to its urban planning benefits. Cities such as Barcelona, Oxford, and Paris have embraced this model (Vaughn, 2023). In China, the government has prioritized the development of walkable neighborhoods, ensuring that essential public services are accessible within a 15-minute walk. This initiative not only promotes walking behaviors and enhances overall health but also highlights the critical role of such neighborhoods in reducing the risk of obesity and non-communicable diseases (NCDs) among residents (Weng et al., 2019).

Scholarly research demonstrates varying approaches to measuring accessibility in urban contexts, with some studies favoring network distances (Birkenfeld et al., 2023; Fazio et al., 2023; Gorrini et al., 2023; Knap et al., 2023) while others employ Euclidean distances, largely due to the computational challenges posed by road network data (Gaglione, 2022; S. Zhang et al., 2022). Network distances are generally preferred as they provide more realistic and precise results by reflecting the actual paths residents travel to access urban amenities (Papadopoulos et al., 2023). In contrast, Euclidean distances are deemed inadequate for spatial analyses within road networks, as they fail to account for critical factors such as road length and travel time, leading to underestimation (Shahid et al., 2009).

A variety of indicators have been used to evaluate the principles underlying the 15-minute city concept. For example, Starrico (2022) assessed service accessibility by calculating the percentage of the population with access to at least one amenity of the same type within a 15-minute walking radius, highlighting the need to consider population coverage. The selected metrics aid in optimizing the balance between service count, spatial distribution, and area coverage relative to user locations. Starrico's findings revealed significant disparities, with certain areas over-supplied with amenities while others lacked sufficient services despite being populated.

Similarly, Gaglione et al. (2022) examined accessibility by analyzing population density in conjunction with urban amenities. By overlaying population density data onto service area polygons generated through urban amenity analysis, they identified the proportion of the population served or underserved within a 15-minute walking distance. These reinforce the utility of population distribution as a key metric for evaluating the "density" dimension of the 15-minute city, which is the number of residents who can access available resources, infrastructure, and spaces (Moreno et al., 2021).

In the Philippines, the Quezon City government is actively considering the adoption of the "15-minute city" concept as an important part of its efforts to foster a livable, environmentally conscious, and sustainable community for its residents. This endeavor of the local government unit aims to stimulate the economy locally through the decentralization of conventional urban services and their increased accessibility within local neighborhoods (Mateo, 2023). This study aims to develop a geospatial data-based method for evaluating the "15-minute city" concept in the case of Quezon City's urban setting.

This study aims to create a 15-Minute City Index (FMCI) that quantifies how closely a region or area approaches the ideal of 15-minute walking accessibility to six key SFs: living, working, caring, supplying, learning, and enjoying. The research focuses specifically on walking as the mode of transportation, using a walking speed tailored to Metro Manila, Philippines, with a case study in Quezon City. The index calculation, based on the barangay, the smallest administrative unit in the Philippines, incorporates barangay-level population distribution data by age group and the weighted needs specific to each group.

The FMCI is scored between 0 and 1, where a score of 0 represents no accessibility to any of the six SFs, and a score of 1 signifies full access to all six functions within a 15-minute walking distance, meeting the age-specific needs of the population. With this, the paper aims to perform service area network analysis or isochrone analysis for the six SFs, to develop a geospatial framework for the 15-minute city, define the FMCI and model its dependence on age-group-specific population distribution, calculate the FMCI for each barangay, the smallest administrative unit in the Philippines, and to examine spatial autocorrelation to identify clustering patterns of FMCI values.

2 METHODOLOGY

2.1 Geospatial Framework

Figure 1 presents the geospatial framework for developing the 15-minute city index in the selected case study area of Quezon City. This displays the interplay and relation of the five key components of the FMCI, which include age group classification, pedestrian network, population distribution, the six SFs, and walking speed, based on literature. This paper adopts the six SFs defined by Moreno et al. (2021) to identify urban amenities offering various services, which will be referred to as 'points of interest' in this study.

Network analysis, in particular service area analysis, is employed to assess the proximity of services with time as the cost (ESRI, n.d.). Consequently, this required the incorporation of road network data. To emphasize the pedestrian-centric principle of the 15-minute city, walking was chosen as the transportation mode. The selected walking speed was utilized to generate service areas around the points of interest.

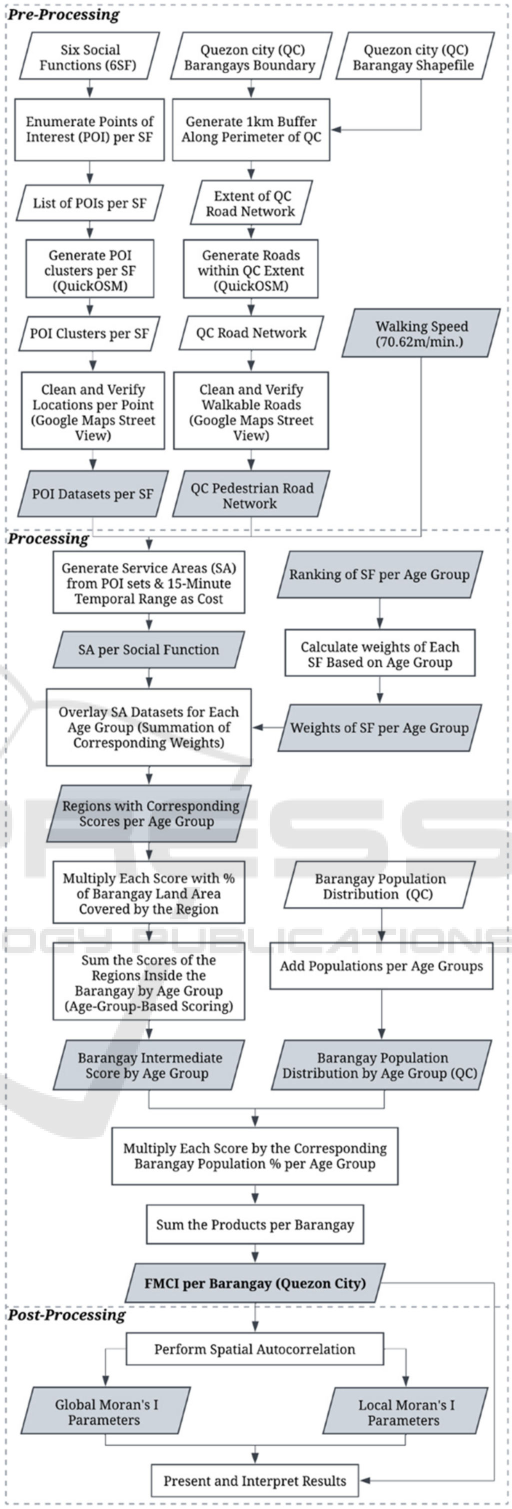

Figure 1: Geospatial framework for calculating FMCI.

Moreover, while many existing studies utilized population household locations as starting points, this research took on a different approach inspired by

Gaglione et al. (2022), wherein the origins of proximity analysis were points of interest. As such, the regions reached within 15 minutes from the points of interest delineate the population household locations within the service area. The calculation of the 15-minute city index depended on the age-based weight of SFs and population distribution of the age classification with respect to the six SFs, while the analysis of results involved spatial statistics. These will be discussed further in the subsequent sections. It is important to note that this framework was applied in the case of Quezon City, Philippines.

2.2 Data Gathering

2.2.1 Age Group Classification

The age group classification in this study is based on the common age structure used for population distribution in the Philippines (Philippines Age Structure - Demographics, 2020), which is 0 - 14 years, 15 - 34 years, 35 - 54 years, 55 - 64 years and 65 - years and above. Given the focus on walking as the mode of transport for assessing the 15-Minute City Index (FMCI) in Quezon City, the first age group has been adjusted to 7–14 years. This modification aligns with the onset of independent mobility among children, which typically begins around age seven (Schoeppe et al., 2015). This adjustment is crucial for the assessment, as it ensures the evaluation considers the accessibility of services for children capable of independent walking. By doing so, the study ensures that points of interest (POIs) are realistically reachable within a 15-minute walk for this demographic.

Moreover, considering the median marrying age in Quezon City, which is around 29 to 30 years (PSA, 2023), the classification has been further adjusted to better categorize and address the specific needs of those below and above these ages. Below is the revised and final age group classification which will be used in this study:

- 7- 14 years
- 15 - 29 years
- 30 - 54 years
- 55 - 64 years
- 65 years and above

2.2.2 Road Data and Land Use

Road data for Quezon City was acquired using the QuickOSM plugin in QGIS, which enables the retrieval of freely available OpenStreetMap (OSM) data (QGIS Documentation v: 3.34, n.d.), which is completely available for the area. To properly account for facilities outside the study area that may be within the proximity of areas that are near said boundaries, a one-kilometer buffer was applied, allowing the inclusion of routes extending beyond Quezon City's immediate boundaries. Figure 2 illustrates the raw road data prior to data cleaning and network establishment.

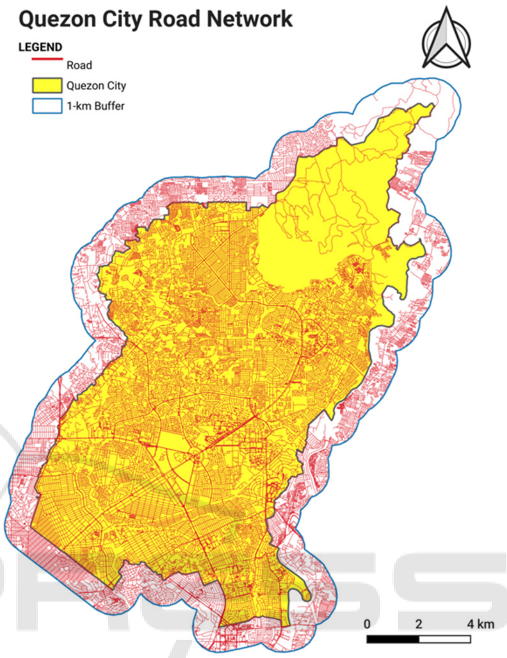

Figure 2: Quezon City's Road network is extended by a one-kilometer buffer.

2.2.3 Population Distribution

The population data utilized in this study originates from the 2020 Barangay Census of Quezon City, sourced from the Humanitarian Data Exchange platform and managed by the Office for the Coordination of Humanitarian Affairs (OCHA) Philippines. It includes information on the total population as well as population breakdowns by age and sex for each barangay in Quezon City.

2.2.4 Points of Interest

In this paper, POIs from the open dataset are classified into the six SFs defined by Moreno et al. (2023). These functions represent key aspects of daily life and urban needs, with each category encompassing specific amenities that serve these roles. This paper adopts this methodology by focusing on the available facilities related to the set of terms and concepts specifying each SF, based on

Table 1. Table 2 presents the POIs categorized under each SF and their respective formats and sources.

Table 2: Information on the POIs.

Social Function	Points of Interest	Data Format	Data Source
Living	LRT1 & 2, MRT3 Train Stations	Point	Land Transportation Office
	QC Bus Stations	Point	Quezon City Government
	EDSA Carousel Bus Stations	Point	Edsa Busway
	Barangay Halls & Quezon City Hall	Point	OpenStreetMap
Working	Commercial, Industrial, & Institutional areas	Polygon	Quezon City Government
Supplying	General shops Supermarket Convenience Stores Public Market		
Caring	Hospitals Pharmacies Health Centers		
Learning	K-12 Public Schools		
Enjoying	Museum Picnic sites/ Park Theme park, Water park Zoo Amusement Arcade Garden Playground Swimming Areas Malls	Point	OpenStreetMap

2.2.5 Walking Speed

In a walkability study by Gerilla (1995), a mean walking speed of 70.62 meters per minute, or approximately 4.23 kph, was determined for Metro Manila. This speed was established by estimating walking distance in the region and has since been used in other walkability studies in the Philippines and Asia to reflect the walking speed in Metro Manila (Mateo-Babiano & Ieda, 2007; Tolentino & Sigua, 2022). This speed was uniformly used to create service areas from sets of POIs.

2.3 Data Preparation

2.3.1 Getting Points for the Working Social Function

Figure 3 shows the land use (LU) classification of Quezon City obtained from the city government. Based on local regulations, one location can only be classified into one LU. Based on this, commercial, industrial, and institutional areas within Quezon City are designated as the working areas within the city to simplify the identification of the places of work. This assumes that people working from home or those with no fixed places of work (delivery workers, etc.) are not considered.

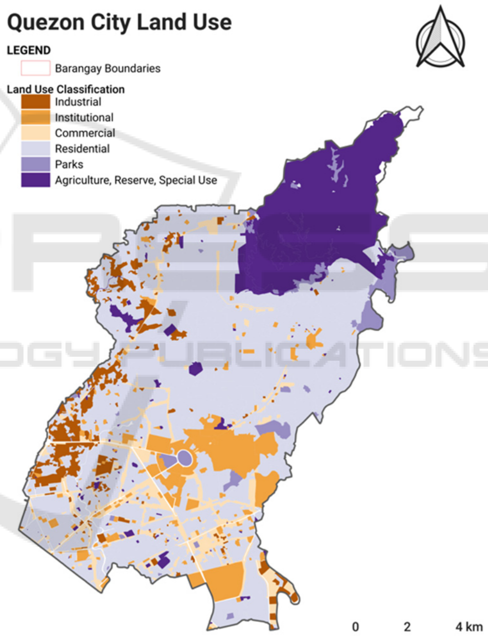

Figure 3: Land use classification of Quezon City.

These areas are converted into points of interest for the working SF by generating points along the boundary of the polygon features. Apart from the boundary points serving as entry points to these areas, centroids were not used to avoid over-generalization of the POI. The interval of the generated points is based on the maximum distance reached in 15 minutes using our assumed walking speed based on Equation 1.

$$Max. Distance = walking\ speed \times time\ cost \quad (1)$$

where:

$$\text{walking speed} = 70.62\ [\text{m/min}]$$
$$\text{time cost} = 15\ [\text{min}]$$

As a result, points along the working area boundary were generated at 1059.3-meter intervals to reflect the 15-minute temporal distance between each adjacent point.

2.3.2 Calculating the Age Group-Based Population per Barangay

The population for ages 0-6 was subtracted from the total population, consistent with the adopted age ranges. Given that the raw population data is aggregated at ranges finer than what is adapted in this study, the population for each age group was obtained by summing the population data within the specified range. The ratio of each age group relative to the new total population per barangay was also calculated.

2.3.3 Weighting of Social Functions

Pedestrian characteristics are important in studies involving walkability (Gorrini et al., 2023). Therefore, in this study, a set of weights for each SF was established for each group. To accomplish this, seven experts in various fields relevant to the study, including sociology, geography, geomatics, and urban planning, are consulted to characterize the population for each age group. The experts were requested to rank each SF based on its importance for each age group. Table 3 shows the resulting average rank for the SFs per age group.

Table 3: Average rank of SFs per age group.

Social	Ranking for each age group				
Function	7-14	15-29	30-54	55-64	≥ 65
Living	3	2	1	1	2
Working	6	5	2	2	6
Supplying	5	6	3	5	4
Caring	4	4	3	3	1
Learning	1	1	6	6	5
Enjoying	2	3	3	4	3

Then, the weight of each rank was calculated through Equation 2. Table 4 shows the computation of the weights for each rank based on using values from Table 3 in this equation.

$$W_i = \frac{1}{m}\sum_{k=n}^{m}\frac{1}{k} \tag{2}$$

where:

W_i = weight of SF i
m = total number of SFs
n = rank of SF i

Table 4: Calculation of weight per rank.

Rank	Calculation	Weight
1	$\frac{1}{6}\times\left(1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right)$	0.4083
2	$\frac{1}{6}\times\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right)$	0.2417
3	$\frac{1}{6}\times\left(\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right)$	0.1583
4	$\frac{1}{6}\times\left(\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right)$	0.1028
5	$\frac{1}{6}\times\left(\frac{1}{5}+\frac{1}{6}\right)$	0.0611
6	$\frac{1}{6}\times\left(\frac{1}{6}\right)$	0.0278

Based on these results, the final weights of each SF for each age group are established. It is important to note that from Table 3, experts ranked supplying, caring, and enjoying SFs equally for the age group 30-54 years old, thus having the same weight. Since the 3 SFs are tied in ranking, the weights for ranks 3-5 were added and divided by 3 and assigned to the three SFs to make sure the sum of weights is still 1. The results are presented in Table 5.

Table 5: Weights of SFs per age group.

Social	Weights for age group				
Function	7-14	15-29	30-54	55-64	≥ 65
Living	0.1583	0.2417	0.4083	0.4083	0.2417
Working	0.0278	0.0611	0.2417	0.2417	0.0278
Supplying	0.0611	0.0278	0.1074	0.0611	0.1028
Caring	0.1028	0.1028	0.1074	0.1583	0.4083
Learning	0.4083	0.4083	0.0278	0.0278	0.0611
Enjoying	0.2417	0.1583	0.1074	0.1028	0.1583
Sum	1.00	1.00	1.00	1.00	1.00

2.3.4 Preparation of Network Dataset

To generate the pedestrian road data from the raw road dataset from OSM, features that are accessible to pedestrians are retained. Hence, the network data included pedestrian lanes, footbridges, and paths. Primary and trunk roads were also still utilized, but only in the areas where there were walkable paths, such as exterior lanes. Google Maps and Google Streetview were used to verify walkable paths across the road network. Roads accessible to vehicles only are removed, with motorways like expressways, skyways, and U-turn slots removed from the network. Road features that were not in the raw OSM network were added and properly referenced. Extensive intersections were checked for proper pedestrian routes. Residential roads were included in the road network, along with some service roads that access residential areas. Service roads that go into institutional areas like schools and hospitals were removed from the network.

2.4 Network Analysis

Service areas (SA) from each of the six sets of POIs were generated via the Network Analyst tool of ArcGIS using the 15-minute walking time cost as the impedance on the finalized pedestrian network dataset. The direction was set away from the facilities, which were set to be the POIs.

2.5 Calculating the 15-Minute City Index

2.5.1 Generation of Regions and Age Group-Based Scoring

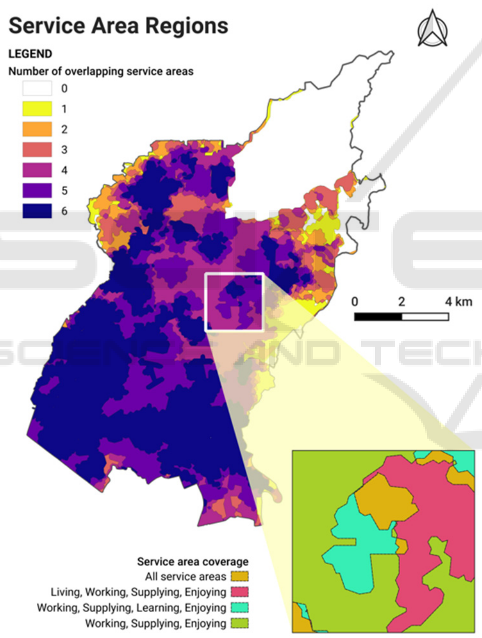

Figure 4: Resulting regions from combining service areas.

Each service area generated from 2.4 is assigned a score of 1 for the SF it represents and a score of 0 for the other SFs. In the context of this study, we define a region as an area covered by a unique set of service areas. To generate the overlapping regions of the service area polygons, the six service areas are combined. Figure 4 visualizes the combination of the service areas, where the colors of the features in the larger map show the number of service areas that cover said location.

This map, however, does not illustrate the regions themselves. For example, two areas valued "3" on the map may not be the same region since each may include different sets of 3 service areas. In contrast, the colors in the inset map visualize the unique set of service areas that cover the location. Since each region combines a set of service areas, it has five binary scores, each containing 1 (for an SA present in the region) or 0 (for an SA not in the region). These binary scores can be transformed into age-based scores by multiplying them by the scores in Table 5 to obtain age group-based (AGB) scores per region.

2.5.2 Transforming Region Scores to Scores per Barangay

An area-based overlay operation is used to re-organize the AGB scores per region into the barangays. We can compute the percentage of barangay areas that each region covers by dividing the region within the barangay's area by the barangay's area. The region's five AGB scores are multiplied by the percentage of barangay area that the region covers. Then, the intermediate scores of each barangay are derived by summing all the corresponding AGB of the regions belonging to that barangay. At the end of this step, the barangay has a set of five intermediate scores corresponding to the five age groups.

According to Section 2.3.2, each barangay has an attribute for the population per age group. The intermediate scores were multiplied by the corresponding age group percentages. Finally, the 15-minute city index is obtained from the sum of these weighted scores.

2.5.3 Clustering Analysis

To further support the FMCI generated per barangay, its global and local spatial autocorrelation was assessed through Moran's I statistics. Similar parameters were applied for both global and local spatial autocorrelation. In the analysis, the Conceptualization of Spatial Relationships was set to be inverse distance, which imposes a larger influence on closer features compared to farther features. Concerning the distance method, Euclidean distance was applied since, at this point, solely the FMCI are considered among barangays without regard to roads and borders, thus only requiring a simple distance between barangays. Moreover, the standardization parameter was set as 'row,' which is appropriate for polygon data, and for aggregated data, which applies to barangays' FMCIs.

3 RESULTS AND DISCUSSION

3.1 Service Areas

Six maps representing the coverage area of the six SFs discussed were made, with a 100-meter tolerance distance for the network analysis. The generated maps are in Figure 5. It can be observed that the location of services is heavily concentrated in the southern part of the city. Notably, La Mesa Dam, a watershed area, is in the northern part of Quezon City. The presence of this watershed reservation explains the lack of points of interest and, consequently, low coverage of service areas, as displayed by the large space in the northern area.

3.2 Scoring Regions and Barangays

As discussed in Section 2.5.1, regions were generated from overlaying service area datasets, and AGB scores were obtained by summing corresponding weights. Intermediate scores were determined following the methodology detailed in Section 3.5.2. Higher intermediate scores suggest a closer proximity to achieving a high 15-minute city index. Similar to scored regions, the specific needs of different age groups are considered in this part through the weights of SF.

The complete results of the intermediate score for each barangay, categorized by age group, are shown in Figure 6. Darker areas imply a higher number of overlapping service area datasets, as AGB scores are from the summation of weights. However, it is important to note that this does not necessarily indicate a higher population served in darker areas, as the population distribution of each age group has not yet been taken into consideration. Higher intermediate scores suggest a closer proximity to achieving a high 15-minute city index. These scores illustrate the specific needs of different age groups, which are considered in this part through the weights of the SFs.

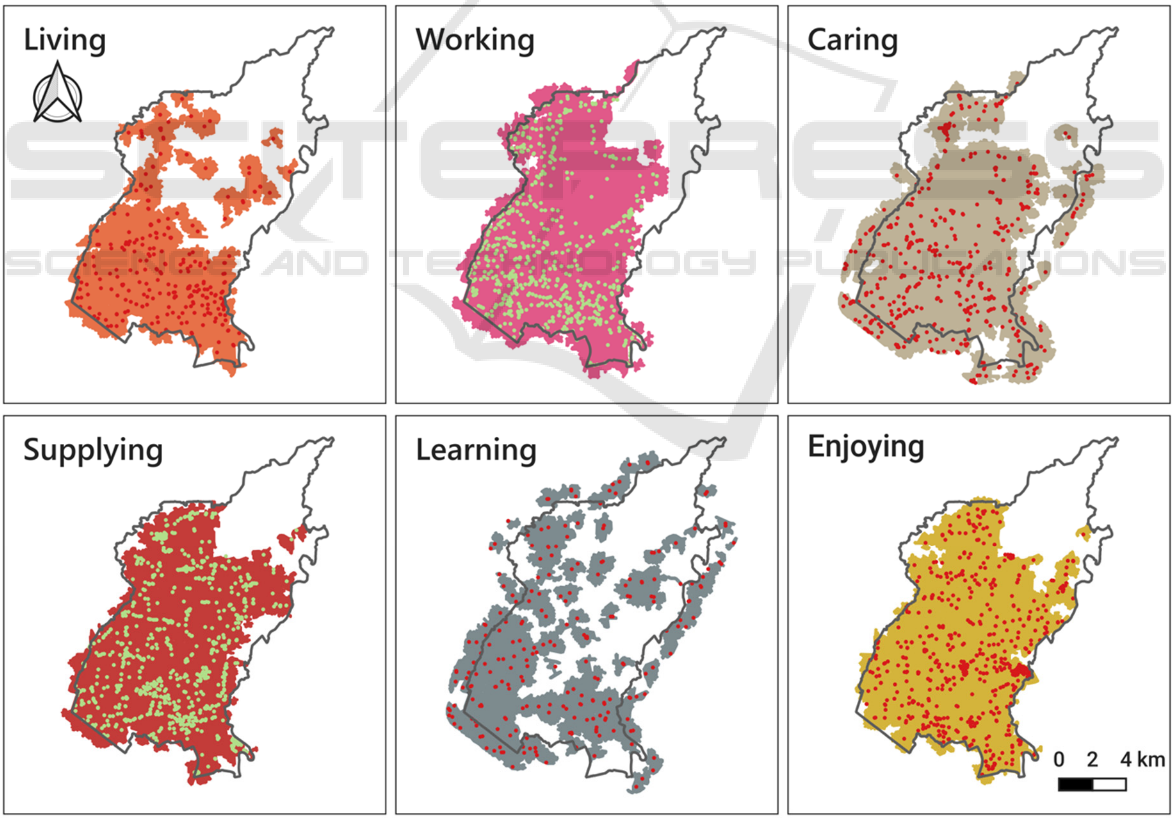

Figure 5: Generated service areas and points of interest for each of the six SFs. Each dot represents a POI.

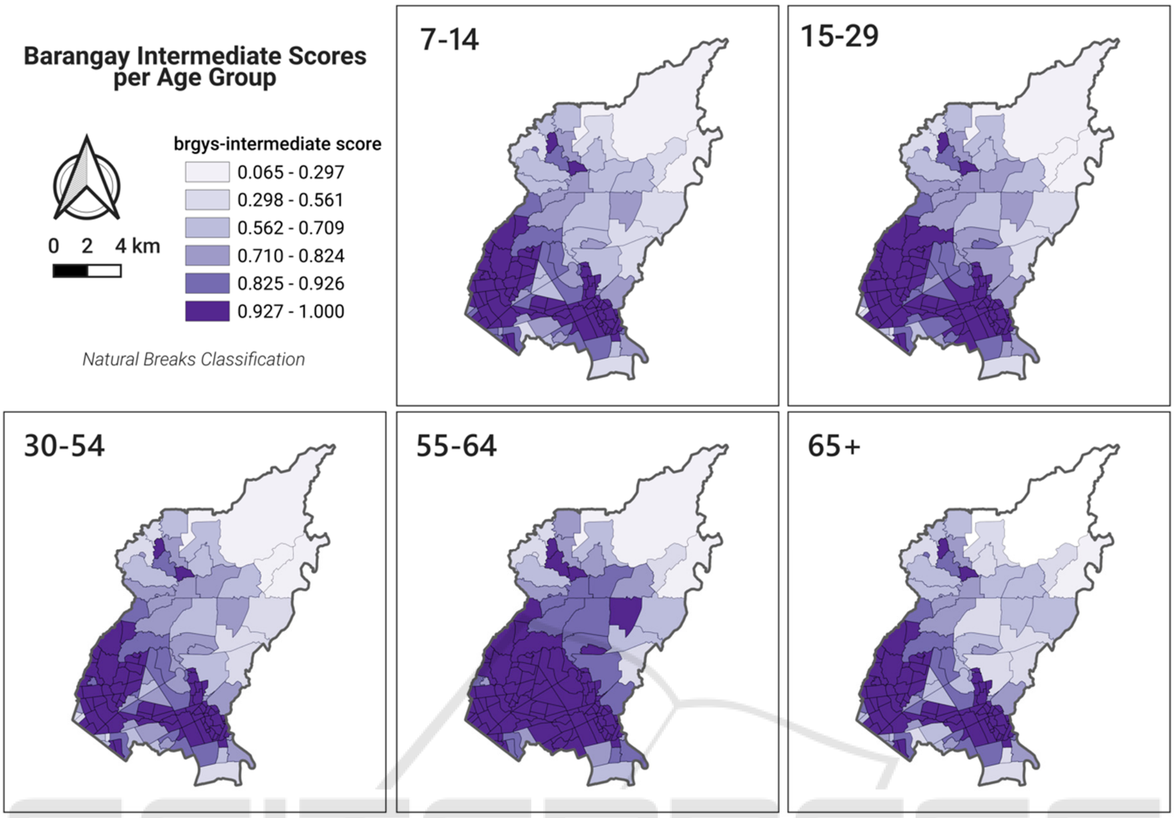

Figure 6: Age-Group-Based Scores per barangay.

3.3 15-Minute City Index

After summing up the products of each calculated intermediate score by the corresponding barangay population percentage for each age group, the 15-minute city index (FMCI) of each barangay is generated. Figure 8 shows the distribution of barangays categorized by FMCI ranges. These ranges are established through the division of the entire FMCI spectrum into five equal intervals, from the minimum to the maximum value.

Out of 142 barangays, 56 achieved a perfect FMCI of one, representing 40% of the total barangays in Quezon City. This indicates that residents of all age groups of these barangays have access to the six SFs within a 15-minute walk. Conversely, the lowest FMCI of 0.066 was recorded for Pasong Putik. Situated in the northern part of Quezon City near the Sierra Madre Mountain Range and La Mesa Dam, the low FMCI of Pasong Putik implies that this area has low accessibility to the services defined by the six SFs. Table 6 shows the complete list of barangays that achieved a perfect FMCI and those that recorded the three lowest FMCIs in Quezon City.

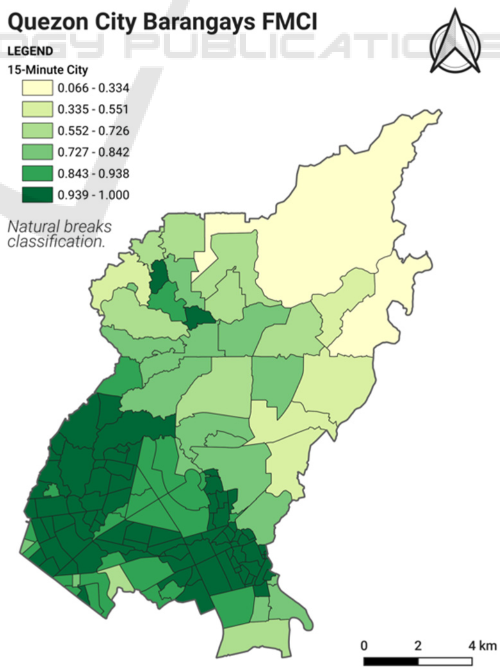

Figure 7: FMCI for each barangay in Quezon City.

Table 6: Barangays with the highest and three lowest FMCI.

FMCI	Barangay Names
1 (highest)	Alicia, Amihan, Bagumbuhay, Balong Bato, Bayanihan, Blue Ridge B, Bungad, Claro, Damayan, Del Monte, Dioquino Zobel, Duyan-duyan, E. Rodriguez, East Kamias, Escopa I, Escopa II, Escopa III, Escopa IV, Kamuning, Katipunan, Krus Na Ligas, Lourdes, Maharlika, Malaya, Mariblo, Marilag, Masagana, Masambong, Milagrosa, Obrero, Paraiso, Pinagkaisahan, Quirino 2-A, Quirino 2-B, Quirino 2-C, Quirino 3-A, Ramon Magsaysay, Roxas, Sacred Heart, Saint Peter, San Antonio, San Martin De Porres, San Roque, San Vicente, Santa Teresita, Santo Domingo (Matalahib), Sienna, Sikatuna Village, Silangan, Tagumpay, Talayan, Tatalon, Teachers Village East, Veterans Village, Villa Maria Clara, West Kamias
0.333	Payatas
0.243	Bagong Silangan
0.066 (lowest)	Pasong Putik Proper

3.4 Global and Local Cluster Analysis

With the FMCI already defined for each administrative division, this section explores significant geospatial patterns to identify relationships concerning the index. The spatial variation of the FMCI across barangays was examined using spatial autocorrelation techniques. As shown in Figure 8, the Global Moran's I statistic of 0.485244 indicates positive spatial autocorrelation, suggesting a clustered distribution of FMCI values among barangays. The statistical significance of this result, supported by a z-score of 18.46 and a p-value near zero, confirms a less than 1% likelihood that the observed clustering occurred randomly. These patterns are also visually evident in the FMCI distribution map in Figure 7.

The positive spatial autocorrelation indicated by the Global Moran's I suggests that FMCI values are not randomly distributed across barangays but rather tend to cluster. This implies that areas with similar levels of access to SFs are geographically proximate, reflecting spatial dependencies due to factors like urban infrastructure, socioeconomic conditions, and geographic location. The significance of this result reinforces the reliability of the clustering patterns and provides a robust foundation for understanding spatial disparities.

Local Moran's I provided more granular insights, identifying barangays as hot spots (High-High or HH), cold spots (Low-Low or LL), or outliers (High-Low or HL and Low-High or LH). Figure 9 illustrates these patterns. Among the 142 barangays, 77 in the southern part of Quezon City form HH clusters with high FMCI values, reflecting greater access to the six SFs. Conversely, 13 northern barangays form LL clusters. Outliers include 13 LH barangays with open spaces and 2 HL barangays near the watershed. Notably, the remaining 37 of 142 barangays are not statistically significant. Thus, results from the extensive FMCI hot spots suggest that the 15-minute city concept is consistently realized throughout most of the study area.

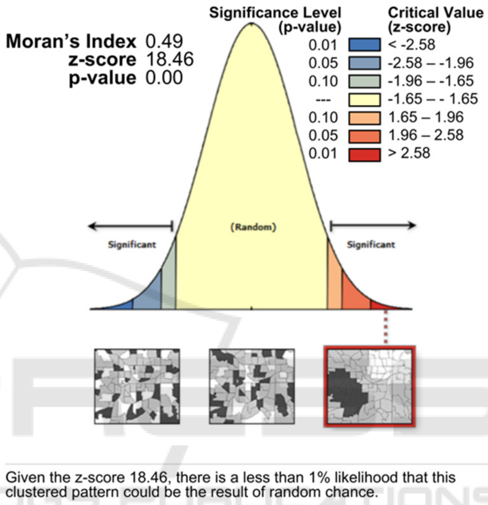

Figure 8: Global Moran's I spatial autocorrelation report of FMCI in Quezon City.

The Local Moran's I analysis provides a deeper understanding of the spatial dynamics within Quezon City. The 77 HH barangays suggest that these areas benefit from better urban infrastructure, higher population density, and improved access to essential SFs. On the other hand, the 13 LL barangays indicate that natural features such as open spaces and the La Mesa Watershed limit access to these functions, creating spatial disparities in service provision. The outliers suggest that factors like land use (e.g., parks and cemeteries) and proximity to natural features play an important role in shaping access to social services in these areas and highlight the complexity of spatial patterns and the need for context-specific interventions to address inequities. The observed clustering supports the Global Moran's I results, emphasizing positive spatial autocorrelation among barangays. These findings highlight disparities in accessibility, with southern barangays benefiting from proximity to Metro Manila's urban core, while northern barangays face limitations due to geographic and land use constraints.

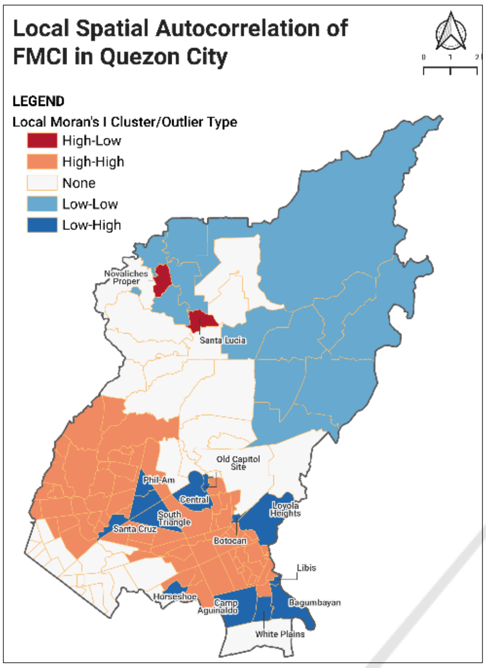

Figure 9: Cluster/Outlier Map based on Local Moran's I spatial autocorrelation of FMCI in Quezon City.

4 CONCLUSIONS

This study explores the 15-minute city concept, emphasizing the importance of providing residents with accessible essential services within a 15-minute radius, thereby enhancing urban quality of life. In Quezon City, service areas for these functions were generated using points of interest (POIs), producing maps that revealed a concentration of accessibility in the city's southern regions. To contextualize these findings, a 15-minute city index (FMCI) was developed, integrating geospatial and demographic data, including population and age distribution. The FMCI evaluates how well areas achieve ideal accessibility to the six SFs.

Analysis showed that 57 of 142 barangays, predominantly in the south, achieved an FMCI of 1, signifying access to all six functions. In contrast, northern barangays like Pasong Putik scored the lowest (0.066) due to geographical and land use constraints. Spatial autocorrelation using Moran's I confirmed clustering patterns of FMCI values, identifying significant hot spots in the south and cold spots in the north.

The FMCI, grounded in a geospatial framework, provides valuable insights for policymakers to enhance urban life by addressing proximity, sustainability, and social equity while aligning with the 15-minute city concept (Moreno, 2019). To improve future implementations, service area generation can be refined by incorporating walkability in paths and adjusting walking speeds per age group. Additionally, the 1-km buffer can be implemented as network buffer, not a Euclidean buffer. Sensitivity analysis should also be performed for the expert-given weights to reinforce its reliability. To overcome boundary effects, tessellation-based calculation can be performed instead of calculating the FMCI per barangay, as calculating FMCI at a finer spatial resolution, such as the household level, may reveal more nuanced spatial patterns. Lastly, incorporating service prioritization within each SF can improve the ranking, tailoring scores more effectively for different age groups.

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