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Assessing Service Imbalances as Contributing Factors to Mobility Issues in the Metropolitan District of Quito, Ecuador

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Abstract: This article analyzes the service distribution imbalance within the Metropolitan District of Quito (DMQ) and its impact on urban mobility, aiming to propose strategies for more equitable territorial planning. The data were gathered from sources such as the National Institute of Statistics and Census (INEC), the Ministry of Health, the Ministry of Education, and OpenStreetMap. These data were integrated with GIS tools to model patterns of accessibility and mobility. Through a comprehensive approach, the study assessed education, banking services, employment, and healthcare, identifying how inequitable access to these services drives increased travel demand, especially in rural and peri-urban areas. In the education field, over 500 neighborhoods faced a shortage of institutions, compelling students to commute to other neighborhoods. For financial services, only 67% of neighborhoods had adequate access, with disparities across different socioeconomic zones. Additionally, employment-related mobility posed another challenge, with 88% of workers commuting outside their residential parish. Finally, access to healthcare was also unequal across the DMQ, particularly in peripheral areas where residents must travel long distances. In this context, it can be concluded that more efficient urban planning in the Metropolitan District of Quito (DMQ) is crucial to address imbalances in the distribution of services and enhance quality of life. Proposed strategies include establishing a land reserve, decentralizing services to underserved areas, integrating smart technologies, and promoting incentives for remote work, sustainable mobility, and public transport. These actions aim to foster greater territorial equity and accessibility.

Keywords: mobility; GIS; imbalances; spatial distribution; displacement; urban planning

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1. Introduction

Mobility is a quantitative measure reflecting the frequency and scale of individual travel within a specific geographic area over a set time interval (e.g., trips per day, passengers per kilometer per day, average travel time) and can be analyzed through spatiotemporal patterns [1,2]. Globally, high mobility is a defining characteristic of modern society [3].

In Latin America, mobility challenges are compounded by road accidents, traffic congestion, environmental pollution, and security concerns. These challenges are closely linked to the increasing reliance on private transportation and the corresponding decline in public transit use [1,4].

The challenges faced by various population groups are closely tied to inequities in physical and economic access to urban spaces, services, infrastructure, safety, environmental quality, comfort, and convenience [5]. Ethnic and racial minorities as well as low-income individuals often reside far from employment opportunities, goods, and essential services, relying on public transportation systems that frequently fail to provide adequate access [6].

Studies in Western countries have shown that mobility inequalities disproportionately impact low-income populations, restricting their access to transportation systems and daily activities [7]. These disparities heighten the risk of social exclusion and underscore the uneven effects of transportation policies on groups with differing economic, geographic, and environmental conditions.

To tackle these challenges, equity-based principles offer valuable guidance: horizontal equity calls for the equal treatment of all users; spatial equity seeks a fair distribution of infrastructure and services; and vertical equity prioritizes accessible and affordable transportation for low-income communities, promoting a more inclusive and just mobility system [7].

Ecuador's social landscape, particularly in major cities like the DMQ, shares common challenges with other Latin American regions, where the lack of public spaces, insecurity, social exclusion, and urban disorder are prevalent issues [8]. The DMQ's urban structure is strongly shaped by geographic constraints and vulnerability to natural hazards, making it particularly susceptible to everyday challenges and episodic disruptions in urban mobility. These issues hinder the city's functionality and can constrain its development [9].

Research on daily mobility and its associated challenges has mainly utilized census data and origin–destination surveys to determine travel purposes and time allocation [9–13].

Currently, Ecuador lacks statistical data on spatial mobility between populated areas, limiting insight into the interactions between these regions [14].

Urban mobility is a cornerstone for the effective functioning of modern cities, and in Quito, its efficiency is deeply connected to the distribution of essential services such as education, healthcare, employment, financial institutions, religious centers, and recreational facilities. An unequal distribution of these services forces residents to make longer commutes, leading to increased congestion, decreased efficiency of the urban transport system, and widening accessibility gaps that negatively impact the quality of life and limit opportunities for the city's inhabitants.

This study aimed to identify and analyze disparities in the availability of key services including education, banking, employment, and healthcare that contribute to mobility challenges within the DMQ. A smart-system-based methodology was developed to pinpoint the factors driving forced travel and propose solutions to optimize the urban distribution of services. The analysis was conducted at the neighborhood or sector level, as these territorial units provide a detailed and accurate view of mobility patterns and service distribution in the urban context.

This research holds significant relevance not only for Quito, but for other Latin American cities facing similar challenges. The findings have the potential to shape urban planning and inform public policy, encouraging a more equitable distribution of services, improving accessibility, increasing transport efficiency, and ultimately enhancing the residents' quality of life.

The rest of this article is organized as follows. Section 2 includes a literature review to contextualize the research within existing academic discussions. Section 3 focuses on describing the study area and the methodology established for analyzing variables—education, banking systems, healthcare, and employment. Notably, the methodology used here can be replicated in other locations. Section 4 presents the results obtained, Section 5 discusses these results, and Section 6 offers the overall conclusions of the research.

2. Literature Review

Urban mobility and accessibility are fundamental concepts in analyzing travel patterns within cities. According to Ref. [15], mobility is a quantitative measure of movement

volume, whereas accessibility is a qualitative concept, focusing on the ease of overcoming distances to fulfill essential needs. In alignment with this, Ref. [16] emphasizes that accessibility is key to enabling the exercise of citizens' rights.

The concept of urban mobility expands when considering the social practice of movement, which is not only individual but also collective and based on empirical research. This broader perspective allows for more comprehensive explanations that go beyond simply describing specific travel situations [2] and is integrated with traditional transportation analysis, which focuses on the origins and destinations of travel while also considering the dynamics of daily interactions.

During the past few decades, a significant body of literature has contributed to quantifying urban accessibility. A majority of these approaches have agreed on measuring accessibility based on two main components. These two components are: (1) locations and the attractiveness of urban opportunities (benefit side), and (2) the impedances of travelling to these locations from residential areas in the network (cost side). Based on these definitions, more accessible areas are those that have lower impedances for travelling to attractive locations [17].

The literature on accessibility categorizes its dimensions into three measures: count-based opportunity measures, gravity indices, and utility-based measures. Opportunity measures focus on the proximity of users to stations, often measured in time or distance. Gravity indices measure accessibility using a distance or time decay function, often alongside equity indicators such as the Gini, Theil, and Atkinson coefficients. Utility-based measures assess the travelers' choices based on various factors, providing a more comprehensive analysis than gravity indices. Studies have applied these methods to evaluate transportation systems, highlighting the importance of equity in accessibility [18].

A significant challenge in studying urban mobility is understanding the movement patterns related to education, healthcare, employment, and leisure, requiring tools like origin–destination surveys [19]. These surveys, which collect data on transportation modes, travel motivations, and traveler characteristics, are essential for effective urban mobility planning [20,21].

Recent studies have also explored walkability, highlighting the importance of proximity to key services such as healthcare, education, and public transport [22]. Research shows that people are generally willing to walk five to ten minutes to access these services [23,24]. This time frame is crucial for urban planning, as it contributes to creating more walkable cities with less reliance on automobiles [25,26].

In major cities in developing countries, urban mobility issues are closely linked to large populations and increasing motorization, while road infrastructure struggles to keep pace. As a result, travel times are typically long and continue to rise [27].

In Latin America, urban mobility and accessibility are particularly challenged by rapid urban growth, socioeconomic inequalities, and insufficient infrastructure. The rapid expansion of cities has overwhelmed the capacity of public and road transportation systems, resulting in congestion and extended travel times. Cities like Bogotá, Mexico City, and São Paulo have experienced urbanization and an increase in motor vehicles, which has limited access to essential services such as healthcare, education, and employment [28].

In Ecuador, particularly in Quito, the city's rugged topography and sprawl toward the peripheries exacerbate connectivity issues, particularly for vulnerable groups. A study in Cuenca, Ecuador, using geographic information systems (GIS), modeled the accessibility to educational centers in four parishes and demonstrated how travel costs and times hindered access to education for those living in more distant areas from the urban core [29].

Bank locations follow similar patterns, with institutions considering both demand and strategic positioning to ensure accessibility, thus maximizing profitability. As a result, financial services tend to cluster in well-connected areas with strong transportation infrastructure [30,31]. Access to healthcare also remains a key issue, as, despite progress toward universal health coverage, inequalities persist in less connected areas, creating gaps in healthcare quality and availability [32,33].

The literature concludes that urban mobility and accessibility are essential components in designing sustainable cities. Such cities must not only ensure equitable access to services, but also foster a healthy and accessible environment for all residents.

3. Materials and Methods

3.1. Study Area

This study was conducted in the Metropolitan District of Quito (DMQ), located in Pichincha Province, Ecuador. The DMQ covers an area of 4235 km^2 and houses 15.5% of the country's population (Figure 1). It is made up of 32 urban parishes and 33 rural and suburban parishes [34–37], encompassing 1269 neighborhoods or sectors. The district's territorial structure is heavily influenced by its geology and geomorphology, which have historically shaped the city's development. Quito is situated on an intermediate terrace at an altitude of about 2800 m, formed by tectonic activity between the Western Cordillera and the Tumbaco Basin, with visible meridional faults along the Quito–Tumbaco route [38,39]. This terrace, suspended over steep slopes with an elevation difference of 400 to 500 m and sporadic vegetation cover, is now undergoing urbanization, which has reduced the visibility of surface outcrops [40,41].

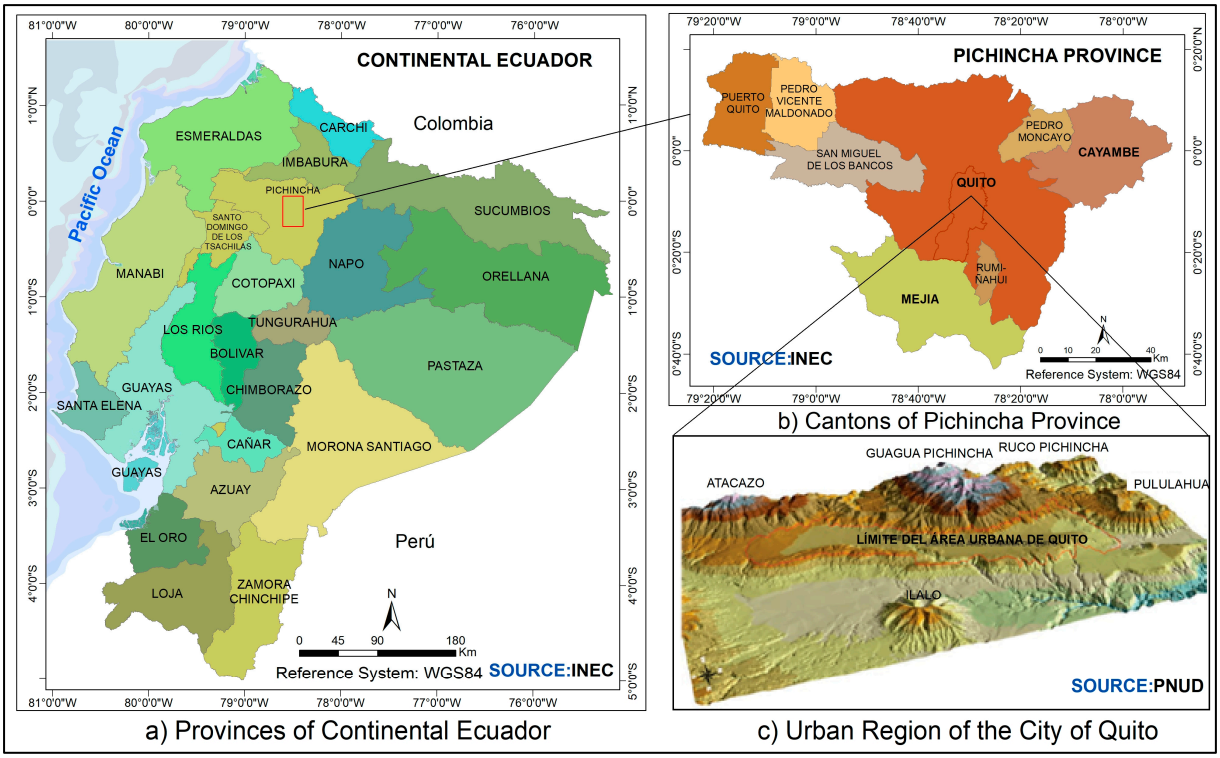


Figure 1. Study area location map. Cartographic source: [42].

From a territorial perspective, Quito, the capital of Ecuador and one of the country's largest and most populous cities, serves as the hub of an urban network that integrates various economic and productive activities including industry, mining, forestry, and agriculture [34]. Its strategic location and demographic dynamics, shaped by migration to peripheral areas, establish it as a key urban reference point.

The Metropolitan District of Quito (DMQ) was selected as a case study due to its relevance in addressing the urban mobility challenges faced by developing cities. Its mountainous geography, linear urban expansion, and unequal access to transportation infrastructure exemplify issues commonly encountered across Latin America. Additionally, the high volume of daily commuting reflects a decentralized urban model, highlighting the urgent need for integrated mobility solutions.

3.2. Data Collection

To commence this study, geographical and other relevant data were gathered from various institutions concerning resource imbalances impacting daily mobility within the city. Table 1 provides an overview of the data utilized.

Table 1. Inputs for the analysis of service imbalances affecting people's mobility in the DMQ. Source: Own elaboration.

Service Imbalance	Material	Format	Delivery or Download Date	Source	Scale/ Resolution
All imbalances	Administrative boundaries of the DMQ (urban and rural parishes)	*.shp	2019	DMQ Open Government	1:5000
	Neighborhood/sector	*.shp	2019	DMQ Open Government	1:5000
	Census sectors, housing units	*.shp	2022	National Institute of Statistics and Censuses (INEC)	1:5000
	DMQ orthophoto	*.tiff	2019	Military Geographic Institute (IGM)	1:5000
	DMQ road system	*.shp	2021	DMQ Open Government	1:5000
Education	Educational institutions	*.shp	2019	DMQ Open Government	1:5000
	Master File of Educational Institutions (AMIE)	*.xlsx	2019	Ministry of Education of Ecuador	1:5000
Banking system	Banking systems (banks, cooperatives, and ATMs)	*.xlsx	2021	Superintendency of Banks (SB)	1:5000
		*.shp	2021	Open Street Map (OSM)	1:5000
Employment	Origin/destination survey	*.xls	2021	Not applicable	No applicable
Health	Public and private health facilities	*.shp	2020	Ministry of Health	1:5000
	Influence zones of health facilities	*.pdf	2024	Secretariat of Habitat and Territorial Planning (SHOT)	1:5000

3.3. Methodology

Modern society relies heavily on mobility, and a significant portion of movement can often be attributed to uneven service distribution. These imbalances can be assessed against an ideal structure for equitable service distribution. Excessive travel, known as "forced population movements", could be minimized with more balanced service provision.

This section examines the imbalances in education, banking services, employment, and healthcare services to determine whether they contribute to service disparities across neighborhoods and sectors within the DMQ. The scale of analysis was defined at the neighborhood or sector level, as these territorial units are representative for accurately assessing mobility patterns and the distribution of services within the urban context.

The analysis of service distribution imbalances was initially conducted independently, utilizing the available data and geographic layers for each corresponding year. However, an integrated analysis of disparities in the education, healthcare, and banking sectors was

subsequently performed. This comprehensive approach is essential to understand the interplay between these sectors, as their interactions can influence one another. A holistic perspective was therefore required to address inequalities and their impact on service distribution within the Metropolitan District of Quito (DMQ).

Figure 2 presents the flow diagram illustrating the methodology applied in this research.

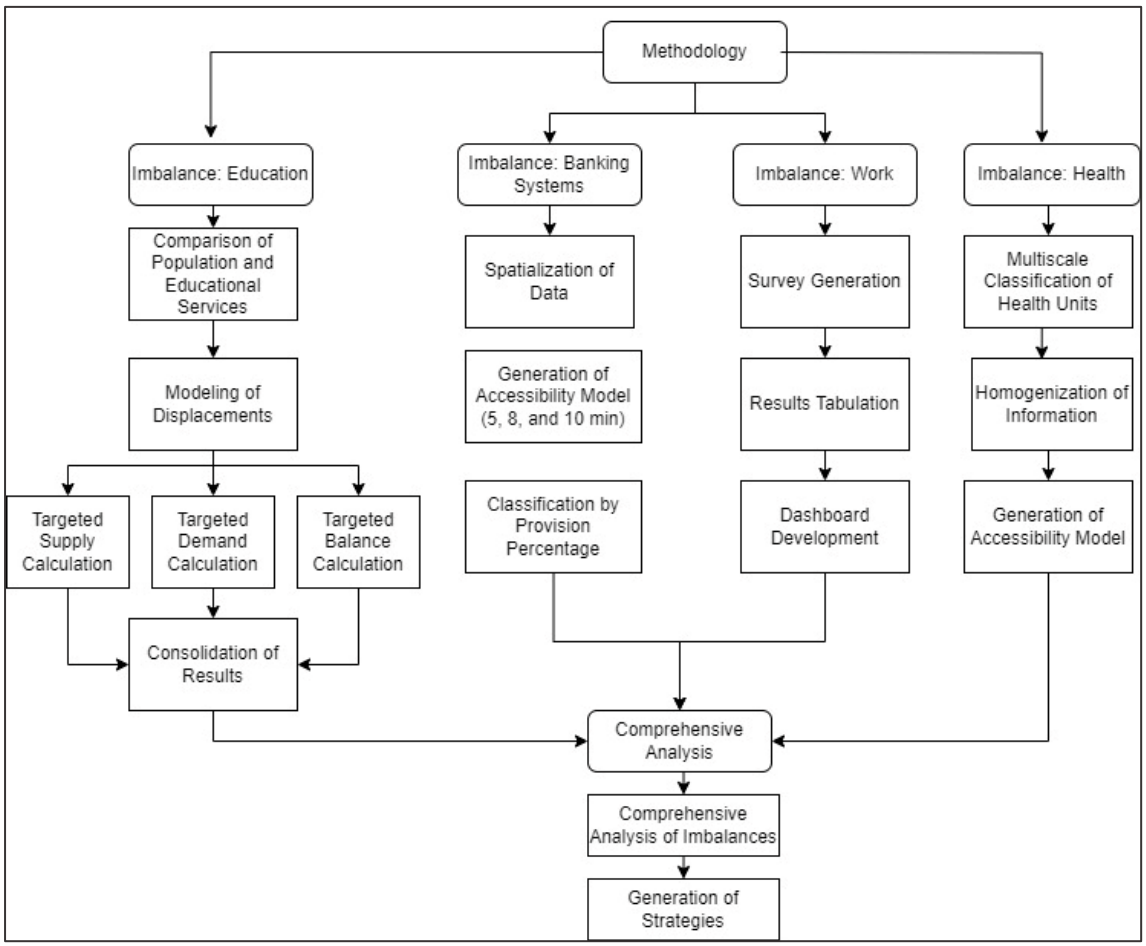


Figure 2. Flow diagram of the methodology employed in this research.

3.3.1. Service Imbalance Analysis: Education

The methodology applied to analyzing educational resources in the DMQ included two phases. The first phase involved data processing, while the second employed algorithms to conduct spatial analysis. The objective was to reconcile the availability of school seats with the corresponding demand, a challenge compounded by the fact that service data are organized by neighborhood-sector units, whereas population data are structured according to census units, which do not consistently align spatially.

In the initial phase, the distribution of the school-aged population was compared with the distribution of educational facilities. Basic and secondary education levels were assessed separately to identify imbalances in school seat availability. Facilities lacking geographic coordinates were geolocated. This comparison was performed within neighborhood-sector units, adjusting census data so that census units were assigned to a single neighborhood sector based on the largest area of overlap.

The issue emerged in very small neighborhood sectors, where there were insufficient data on the enrolled student population. To address this, resources from these smaller sectors were combined with those of larger neighboring sectors, which slightly reduced the granularity of the analysis. The selected measure of imbalance was the difference between

the number of enrolled students and the available school seats, omitting occupancy rates to avoid distortions in areas experiencing "forced" student movements.

The second phase utilized a Python (3.8.2) algorithm to model movement between neighborhood sectors and iteratively balance the supply and demand of school seats. First, "directed demand" was defined as assigning any excess demand from one neighborhood sector to adjacent areas with available seats, distributing the excess proportionally among neighboring sectors.

Simultaneously, the "directed supply" was calculated, distributing surplus seats from sectors with availability to adjacent sectors experiencing excess demand. The supply was allocated in proportion to the demand pressure from neighboring sectors, thereby creating a balance between supply and demand.

The "directed balance" was calculated between units with surplus supply and demand, resulting in three possible outcomes: unmet demand, surplus supply, or a balance of zero when the supply aligns with demand. These balances were then used to reallocate resources between adjacent units.

This iterative process continues until neither surplus supply nor demand remains. The result is a map displaying areas with a balance of school placements as well as those with excesses of supply or demand. This analysis helps pinpoint regions where student commuting could be reduced by better aligning school placements with local demand.

3.3.2. Service Imbalance Analysis: Banking Systems

Banking institutions have strategically positioned themselves in cities over time, based on a shared market logic [30], considering that that their market—comprising branches, clients, and competitors—is unevenly spread across a territory [31]. Their objective is to identify areas where the population needs financial services including neighborhoods lacking access or showing an uneven distribution. Consequently, they develop a location strategy focused on three interrelated aspects: (1) customer accessibility to services, (2) the sale of banking products, and (3) overall firm profits [43].

This study assessed the availability and spatial distribution of financial systems in the DMQ to evaluate access and determine whether this access disparity contributed to an uneven distribution of financial services across the city. A detailed analysis was conducted to identify areas with limited access, providing insights and solutions to improve equity in service distribution.

In Ecuador, particularly in the DMQ, a comprehensive geographical database for spatial analysis of financial systems is unavailable. While the SB offers a list of financial institutions and addresses, it excludes specific data on ATMs, limiting the scope for a thorough analysis on accessibility and distribution—crucial for advancing financial inclusion.

Furthermore, Ecuador lacks national standards for measuring accessibility to financial systems, which impedes the identification of areas with low service coverage and implementing effective strategies. Although digital banking facilitates online transactions, accessible ATMs and bank branches remain necessary due to limitations in electronic payment methods.

This research focused on banks, ATMs, and cooperatives within the DMQ, using OpenStreetMap and QuickMapServices in QGIS 3.24 to collect location data, and ArcGIS 10.5 Network Analyst to evaluate accessibility. This approach enabled the identification of areas with low financial service availability and guided the design of interventions to improve equitable service distribution. The analysis considered walking distances of 5, 8, and 10 min, as people are generally willing to walk within this time range to access these services [23,24].

Finally, four weighting ranges were defined to assess the provision of financial services within the urban areas of the DMQ: none (0–5%), low (6–30%), medium (31–75%), and high (>76%). These ranges enable the classification and quantification of financial service distribution, facilitating the identification of areas with varying levels of access and contributing to more equitable and sustainable urban planning. This study offers a robust

methodology for improving urban planning and fostering financial inclusion, promoting more equitable, sustainable access to essential financial services.

3.3.3. Service Imbalance Analysis: Employment

Urban employment-related travel significantly impacts city mobility, driven by the need to access economic opportunities. Such commuting, concentrated during similar hours, is a major contributor to urban congestion, affecting both public and private transportation [44]. The geographic dispersion of jobs and residences, along with significant distances between homes and workplaces, exacerbates this issue. While the COVID-19 pandemic temporarily boosted remote work, reducing commuting, the structural causes of urban mobility remain.

The unequal distribution of employment opportunities and deficiencies in public transportation infrastructure are critical factors affecting mobility. Inadequate public transportation services lead many workers to rely on private vehicles, exacerbating congestion. This underscores the need for more efficient urban planning that addresses job location, road infrastructure, and traffic management in cities like Quito to improve mobility and reduce the negative impacts of employment-related travel.

According to a 1998 origin–destination survey by the DMQ's Mobility Secretariat, 41.4% of respondents commuted daily for work [9]. However, COVID-19 has changed mobility patterns, prompting this research to examine these changes.

In Ecuador, origin–destination surveys are not conducted annually due to high costs, the time demand, and labor requirements. Although Ecuador's 2010 and 2022 Population and Housing Census provided valuable demographic data, it did not include questions on daily commuting or time invested. Including such questions in future censuses is crucial for a clearer understanding of urban mobility. Additionally, periodic studies by entities like the Ministry of Transport and DMQ Mobility Secretariat would improve the data interpretation, enabling more effective mobility policy design.

The analysis of work-related commutes in the DMQ faces significant challenges due to the lack of updated origin–destination surveys to determine the reasons and durations of these trips. To address this limitation, a targeted survey was conducted in 2021 among the employed population, within the post-pandemic context. The sample size was calculated using data from Ecuador's 2010 Population and Housing Census. It is important to note that the results of the 2022 census were not utilized, as the survey was designed and implemented in 2021, prior to the availability of this more recent data.

The 2010 Census data indicate that the DMQ has a total of 806,983 employed inhabitants, which is reflective of the high economic dynamism of the city. The city is home to the largest labor activity in the country due to its status as the capital and administrative center of the country [42]. Statistical data indicate that the economically active population (EAP) has exhibited fluctuations in response to a range of economic and social factors including the impact of the COVID-19 pandemic, which has transformed the labor market through the introduction of remote work arrangements and significant shifts in the composition of productive sectors. The primary sectors of employment in the DMQ are commerce, services, manufacturing, and public administration.

Based on the employed population of 806,983 residents in the DMQ, a statistical sample with a 95% confidence level and a 5% margin of error was established, determining a representative sample of 385 residents. The survey was conducted using ArcGIS Survey Connect within the ArcGIS Online platform, with a dashboard created to monitor and analyze results in real-time, thereby streamlining the data processing.

Challenges arose in ensuring that only employed individuals responded to the survey. To address this issue, the survey was disseminated via social media, which proved effective in increasing the rate of valid responses. However, it is important to acknowledge the limitations of this approach. Since the survey was distributed via social media, it was restricted to individuals with access to these platforms and the willingness to engage with them, introducing a sampling bias. As a result, groups such as older adults or individuals

with limited resources may have been excluded, potentially affecting the representativeness of the results and limiting their generalizability to the entire population.

The primary objectives were to identify whether individuals traveled for work, the transportation mode used, and the time spent commuting as well as assess the mobility patterns and perceptions of transportation modes. Specific questions were designed to gather key data for analyzing work-related mobility in the DMQ. The insights gained from this analysis then informed recommendations for urban mobility and transportation planning in the city.

Following the collection of the survey data, an in-depth analysis was conducted, enabling the drawing of conclusions regarding mobility patterns, the residents' perceptions of transportation, and the primary challenges faced by the DMQ residents in their daily commutes.

Finally, through the generated dashboard, feedback was provided to the participants with the results obtained. The link to this information was sent to each participant and was also made available on the DMQ municipality's website and social media platforms. It is important to note that a pilot study was conducted with 15 individuals to ensure the clarity and objectivity of the questions. Based on the results of this pilot, adjustments were made to the survey

3.3.4. Service Imbalance Analysis: Health

From a geographic perspective, the provision of healthcare services in a territory and the analysis of inequities in service provision have long been areas of interest, particularly given the existence of spatial patterns in the location, quantity, and characteristics of such services, which create unequal access opportunities for residents [32].

This research aimed to determine whether access to health services contributed to service imbalance in Quito, focusing on urban land areas. Additionally, we sought to assess how the spatial distribution of these services may impact city mobility issues.

The study examined the distribution of medical services across neighborhoods in the DMQ, analyzing the travel distances required to access them. For this purpose, cartographic data from Ecuador's Ministry of Health were utilized including information on public and private health facilities and integrated health care teams, classified by care levels.

Moreover, the technical architecture and urban planning rules developed by SHOT were taken into consideration, as the Ministry of Health data lack information regarding service coverage radii. These regulations are designed to guarantee that new facilities promote accessibility, environmental sustainability, and quality of life [45]. Coverage radii for various facility types were defined, delineating the geographical area that each establishment must guarantee reasonable access to health services.

The coverage radii have remained unchanged over time, prompting the need to re-evaluate them considering DMQ's population growth and territorial changes. This calls for studies that assess the effectiveness of these radii and update them to reflect contemporary urban dynamics.

The data provided by the Ministry of Health, organized by facility level, were matched with the influence radii defined by the technical architecture and urbanism rules. This process presented several challenges, primarily due to the large number of healthcare facilities and the lack of coordination in data presentation between the governmental and municipal entities.

Following the harmonization of the data, the coverage radii were calculated at the neighborhood (800 m), sectoral (1500 m), and zonal (2000 m) levels. This was achieved by employing variables such as slope, cost, road network, and urban structure, with the assistance of the Network Analyst tool. Furthermore, the walking time to health facilities was evaluated, incorporating housing data from the census to demonstrate accessibility at the housing unit level.

The objective of this study was to evaluate the efficacy of current regulations in ensuring access to health services, identify deficiencies in service provision, and assess the

integration of these findings into territorial planning tools. While the number of public facilities is significantly lower, future studies should prioritize these facilities, as they are instrumental in guaranteeing universal health access.

3.3.5. Comprehensive Analysis of Service Imbalances

After completing the separate analyses of each service imbalance affecting DMQ mobility, an integrated study was conducted to determine whether limited access to services in certain neighborhoods or sectors represents a temporary issue or a sustained trend of unequal distribution. This comprehensive analysis revealed significant patterns, providing support for strategies and public policies aimed at enhancing access to essential services and improving urban mobility.

The analysis began by assessing the imbalance in education services, identifying neighborhoods and sectors lacking this service. The same procedure was applied to the other variables studied. Subsequently, all graphical and alphanumeric data were cross-referenced, facilitating the identification of areas with and without service provision.

The analysis of imbalances in education, healthcare, banking systems, and employment was conducted using data from the relevant censuses for each area and year, ensuring the reliability of the results within their specific context. For imbalances in education, employment, and banking systems, data from the 2010 census were used, while for healthcare, the most recent data from the 2022 census were employed. However, when integrating the results from the different analyses into a comprehensive analysis, data from both the 2010 and 2022 censuses were combined. This may introduce limitations in reliability, particularly in housing units, due to potential differences in the methodology and coverage between the two censuses. This should be taken into account when interpreting the results of the comprehensive analysis.

Finally, a decision-support tool was developed to visualize and analyze service imbalances that generated mobility issues in the DMQ and propose actions to mitigate these challenges. This tool not only provided a clear visualization of service imbalances in the DMQ, but also allowed for detailed inquiries about deficiencies in different neighborhoods.

The results obtained through this platform provide a solid foundation for informed decision-making by the public, academia, and authorities. The primary objective was to facilitate territorial planning and management, ensuring that services are distributed equitably and efficiently.

Additionally, this tool is essential for developing land use and development plans (PDOT) that respond to the population's real needs. It facilitates a more inclusive and coherent approach to urban growth challenges and ensures that all districts possess the requisite services to enhance the quality of life for residents.

4. Results

This section presents the findings of the research, which are aligned with the methodological approach described earlier. The analysis focused on identifying key patterns and trends in service behavior, intending to enable well-founded conclusions to be drawn. Based on these results, strategies and policies were proposed to optimize service delivery, with an emphasis on spatial distribution to streamline people's commutes and reduce unnecessary travel.

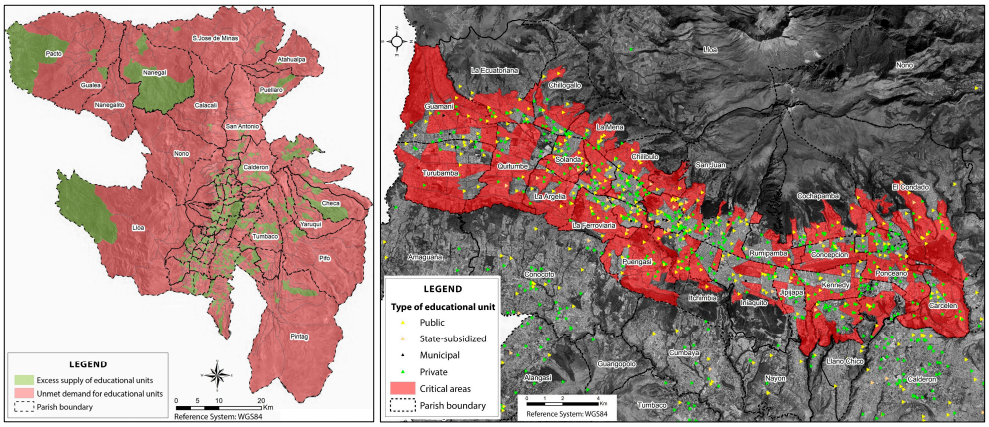
These proposals aim to increase service efficiency and the accessibility of services, thereby better aligning them with the needs of users. Together, the findings provide a solid foundation for policy formulation and evidence-based decision-making to enhance the citizens' quality of life and support a more efficient management of available resources.

4.1. Service Imbalance Results: Education

The initial analysis revealed that within the DMQ, 698 neighborhoods lacked primary and secondary educational facilities, requiring students to travel to nearby or distant

neighborhoods to access these services. This often involved the use of public or private transportation.

Based on the imbalance indicator obtained by comparing educational and population data at the neighborhood-sector level, 881 neighborhoods across the DMQ and 349 in the urban area were identified as critical areas. In these areas, there is a high demand from the school-age population, but an insufficient supply of educational facilities to meet the students' needs. Figure 3a depicts the critical areas across the DMQ, while Figure 3b focuses on Quito's urban area, without factoring in the compensations of neighboring areas.



(**a**) (**b**)

Figure 3. (**a**) Map indicating neighborhoods with educational unit supply and demand relative to population level. (**b**) Map highlighting critical neighborhoods in Quito's urban area (without adjustments from adjacent neighborhoods).

It is important to acknowledge the prevalence of high-demand areas (in red), which can be attributed to a straightforward supply–demand analysis of school places by neighborhood-sector spatial units. This prevalence presents a significant challenge in terms of implementing effective interventions.

The application of a refined algorithm that permits student transfers between neighboring sectors without categorizing such movements as additional mobility issues yielded considerably more precise results. These results offer a more detailed representation of the problem, indicating approximately 582 neighborhoods with unmet demand and 215 within the DMQ's urban area, as illustrated in Table 2.

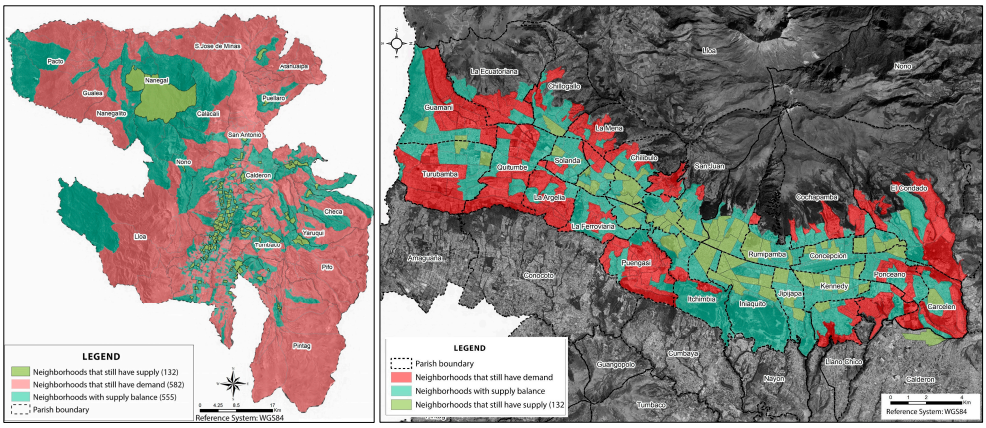
Table 2. Results obtained after the iterations carried out. Source: Own elaboration.

	Neighborhoods	
Description	**DMQ**	**Urban Areas Within DMQ**
Balanced	555	226
Neighborhoods with unmet demand	582	215
Neighborhoods with excess supply	132	77
Total	**1269**	**518**

The methodology applied serves to identify neighborhoods that could achieve a balanced provision of educational services, thereby reducing the need for school-aged residents to travel long distances, as they could access nearby neighborhoods instead.

Figure 4a shows that neighborhoods with a persistent need for educational facilities are mainly located in the rural and peri-urban areas of the DMQ. Figure 4b shows that within the urban areas, neighborhoods in the south of Quito (Guamaní, La Ecuatoriana, Chillogallo, La Argelia, La Mená, Solanda, Nueva Aurora, Lucha de los Pobres, Pueblo Unido, La Ferroviaria Alta, Turubamba de Monjas, etc.) as well as peri-urban areas (Chiribulo, Libertad, San Fernando, Alma Lojana, San Juan, Puengasí, Atucucho, Santa Rosa Singuna,

Pisulí, La Josefina, Carcelén, El Condado, Comité del Pueblo, Jaime Roldós, Cochapamba Sur, etc.) still face a shortage of educational facilities. Government intervention is crucial to enhance the availability of services in these areas, thereby minimizing the need for residents to travel considerable distances to access services located in far-flung neighborhoods, often situated at opposite ends of the city. Meanwhile, the hyper-center of Quito has an overabundance of educational institutions, which requires appropriate regulation and oversight to prevent over-concentration.



(a) **(b)**

Figure 4. (**a**) Final map displaying the results of the compensation process applied across the DMQ. (**b**) Final map showing the outcomes of the compensation process applied specifically within Quito's urban area.

It is important to mention that the term hyper-center is considered the main hub for economic, administrative, cultural, and commercial activities in Quito, Ecuador. It is characterized by its high density of infrastructure, services, and transient population and plays a key role as a central axis of connectivity and urban accessibility.

4.2. Service Imbalance Results: Banking Systems

This study provides an in-depth analysis of access to financial services in the DMQ, examining the distribution of banks, ATMs, and cooperatives. Identifying both well-served and underserved areas is essential for creating strategies that promote equitable access and financial inclusion citywide.

Out of the 842 neighborhoods and sectors in the DMQ's urban area, only 298 had financial services, meaning 64.7% lacked direct access. However, demand for these services also varied by population size and housing density, as not all neighborhoods require the same level of financial infrastructure (see Figure 5).

Using a methodology that assesses access to financial services within 5, 8, and 10 min of travel, the study found that 37% of neighborhoods had access to banking services. These services were mainly concentrated in the hyper-center and southern areas such as La Villaflora and El Recreo, while coverage in the northern and peripheral areas remains sparse.

In the context of the DMQ, peripheral areas refer to regions located on the urban fringes, typically far from the city center and areas with a high concentration of economic and administrative activities. These zones are characterized by lower population density, less developed urban infrastructure, and limited access to both public and private services. In many cases, the peripheral areas of the DMQ include low-cost residential neighborhoods, sectors with rural characteristics, or are in the process of urbanization as well as informal settlements..

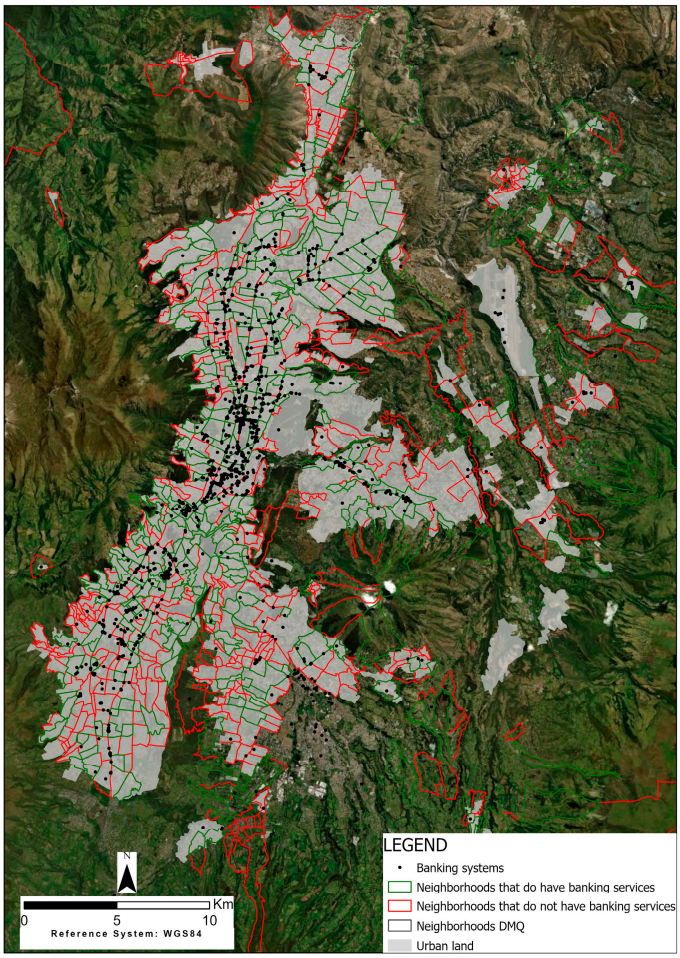


Figure 5. Concentration of banking systems in the urban area of DMQ.

Regarding ATMs, 562 neighborhoods were within the specified time ranges. However, since ATMs are often limited to cash withdrawals, users must frequently travel to banks for other transactions. Peripheral neighborhoods face a significant shortage of ATMs.

Savings and credit cooperatives are currently available in 279 neighborhoods and are often preferred by users because of their competitive interest rates and loan terms. Nevertheless, their distribution remains uneven, with a higher concentration in the southern DMQ.

Compared with previous findings that only 37% of neighborhoods had access to banking services, this analysis, using updated accessibility metrics, showed an increase of 30% and now shows that 67% of neighborhoods have balanced access to these services (see Figure 6).

Figure 7a shows that within a 5-min walking range, only the Iñaquito and Cipreces neighborhoods achieved a financial service coverage of 76–100%. Other neighborhoods closer to the city center, such as El Inca and La Carolina, reached 31–75% coverage. In contrast, neighborhoods like La Merced and La Gasca had only 6–30% coverage, and a substantial 87% of neighborhoods (733 in total) had less than 5% banking coverage, leaving only 13% of urban neighborhoods within a 5-min walk of banking services.

As shown in Figure 7b, when expanding the walking distance to 5 min, only 3.7% of neighborhoods in the hyper-center and select areas in the south achieved a banking service coverage of 76–100%, with 76.1% of neighborhoods still lacking adequate access. Within a 10-min range, 8.8% of neighborhoods had 76–100% coverage, while 71% remain without banking services, as shown in Figure 7c.

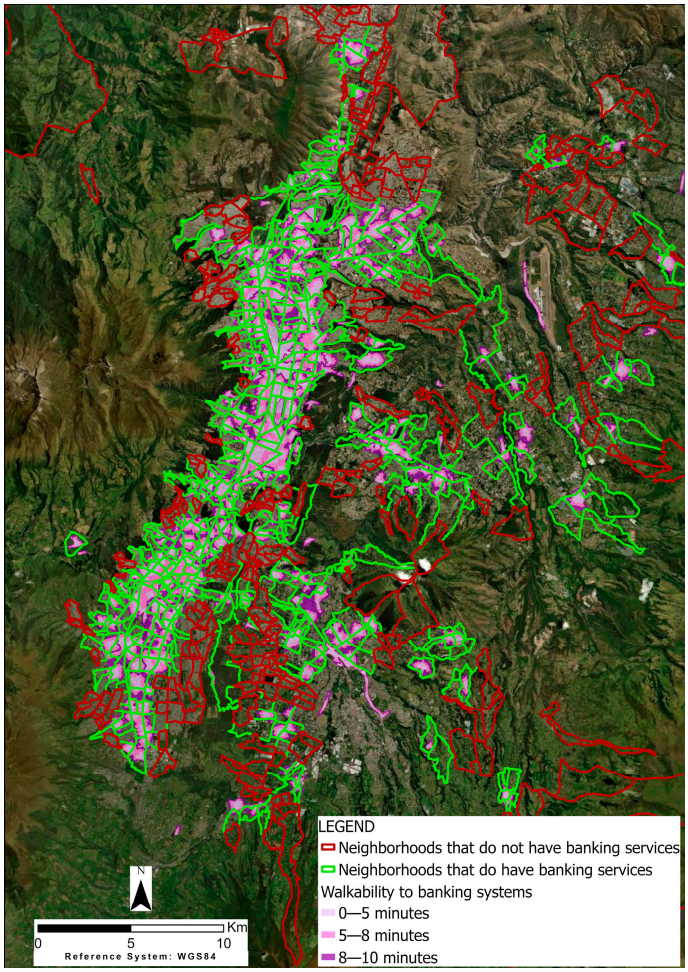
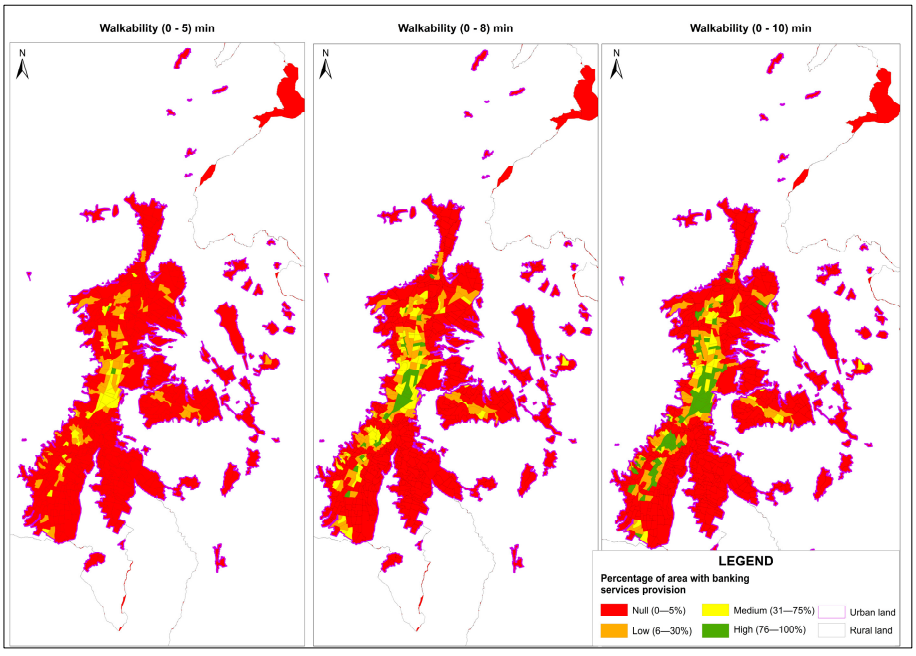


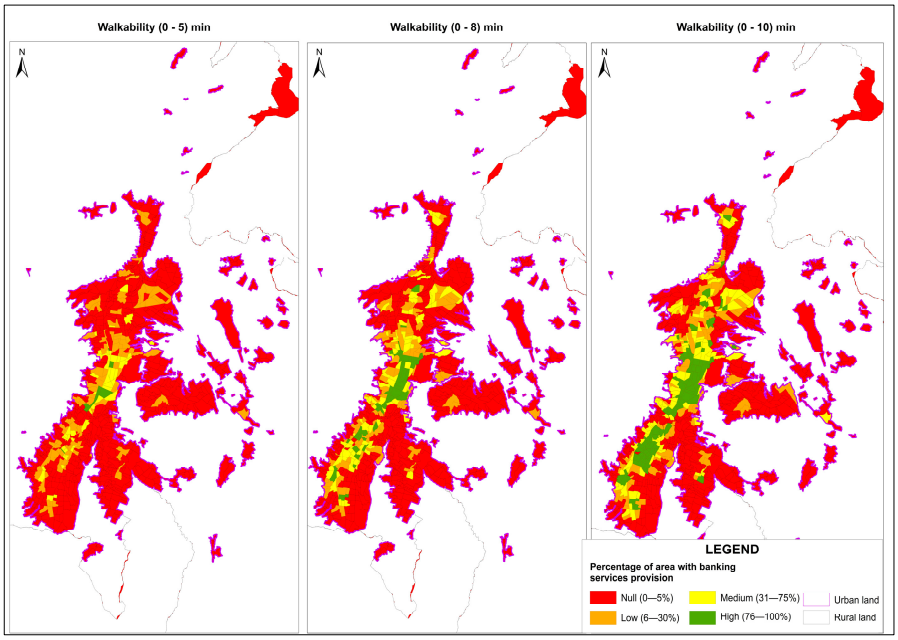
Figure 6. Neighborhood-sector map, with and without accessibility to financial systems.



(**a**) (**b**) (**c**)

Figure 7. Analysis of bank facilities at the neighborhood-sector level. Walkability: (**a**) 5 min; (**b**) 8 min; (**c**) 10 min.

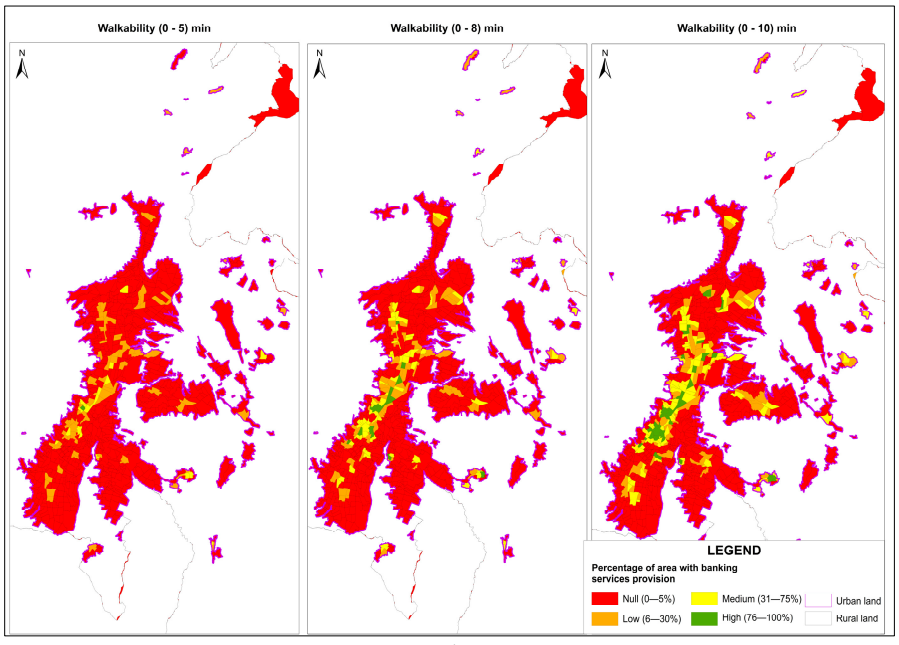
The analysis of ATM coverage (Figure 8) indicates that within a 10-min walking distance, 13.2% of neighborhoods had ATM coverage between 76 and 100%. However, access remains insufficient, especially in peripheral areas, emphasizing the need to improve financial service infrastructure across the city.



(**a**) (**b**) (**c**)

Figure 8. Analysis of ATM provision at the neighborhood-sector level. Walkability: (**a**) 5 min; (**b**) 8 min; (**c**) 10 min.

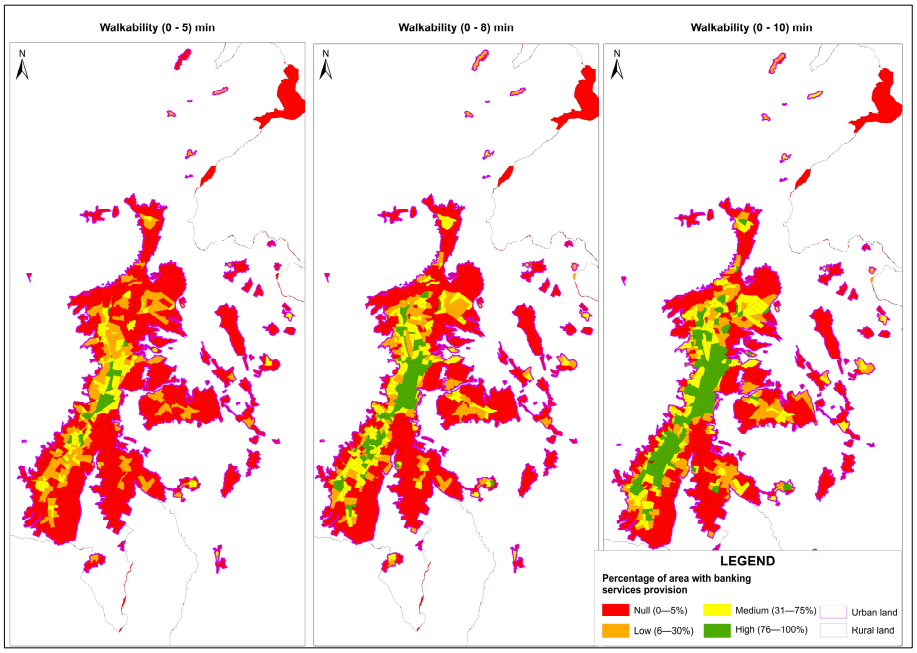
For cooperatives (Figure 9), only 5% of neighborhoods enjoyed 76–100% coverage, with services heavily concentrated in the city center. A significant 73.9% of neighborhoods lacked cooperative access, underscoring the need for expanded cooperative services.



(**a**) (**b**) (**c**)

Figure 9. Analysis of the provision of cooperatives at the neighborhood-sector level. Walkability: (**a**) 5 min; (**b**) 8 min; (**c**) 10 min.

Finally, within a 10-min walkability range (Figure 10), 20.3% of neighborhoods achieved financial service coverage between 76% and 100% For cooperatives (Figure 9), only 5% of neighborhoods enjoyed 76–100% coverage. This uneven distribution highlights fragmented access to services. Additionally, higher-income households are more likely to have convenient access to financial services, while lower-income households experience significant service gaps.



(**a**) (**b**) (**c**)

Figure 10. Analysis of financial system facilities (banks, ATMs, and cooperatives) at the neighborhood-sector level. Walkability: (**a**) 5 min; (**b**) 8 min; (**c**) 10 min.

The comprehensive analysis of financial service distribution in urban neighborhoods across the DMQ revealed that 50.4% of neighborhoods had some level of financial service access. However, when this was compared with the walkability data, which showed that 67% of neighborhoods had a balanced service provision, the figure dropped to 16.6%, indicating a notable fragmentation in service distribution. This finding highlights the need to improve accessibility and expand service coverage to promote more equitable access to essential financial resources.

The analysis of accessibility to financial systems in the DMQ revealed a marked imbalance between areas with higher and lower socioeconomic levels. Households in high and upper-middle socioeconomic levels had broad access to banking services, with coverage ranging from 76% to 100% in central areas such as La Carolina, Iñaquito, and Bellavista. However, households in lower socioeconomic levels, located in peripheral and peri-urban areas such as Turubamba, Guamaní, Calderón, and Nueva Aurora, faced a severe shortage of these services, with banking coverage below 5%.

This imbalance was reflected in the unequal distribution of banks, ATMs, and cooperatives, which were concentrated mainly in higher-income areas. Although there have been improvements in the provision of financial services in some zones of the city's south and north, over 70% of peripheral neighborhoods still lack adequate access. This situation not only restricts access to formal financial services, but also exacerbates the economic and social barriers faced by the most vulnerable communities. The absence of basic infrastructure, combined with the scarcity of financial options, limits their economic integration, perpetuating cycles of poverty and structural inequality in the DMQ.

4.3. Service Imbalance Results: Employment

The data collected from the surveys enabled an in-depth analysis of the mobility patterns and public perceptions of transport within the DMQ. This analysis provided important insights into commute times, preferred modes, satisfaction levels, and reasons for work-related travel. Clear distinctions emerged between travel motives and constraints affecting the residents' quality of life.

The geographic distribution of respondents, shown in Figure 11, encompassed both urban residents and those in peripheral areas, ensuring a representative sample that highlights disparities in transportation access and mobility patterns. Including participants from peripheral areas was essential to identifying inequalities in accessibility and connectivity—key factors for formulating public policies aimed at improving urban mobility and reducing travel barriers.

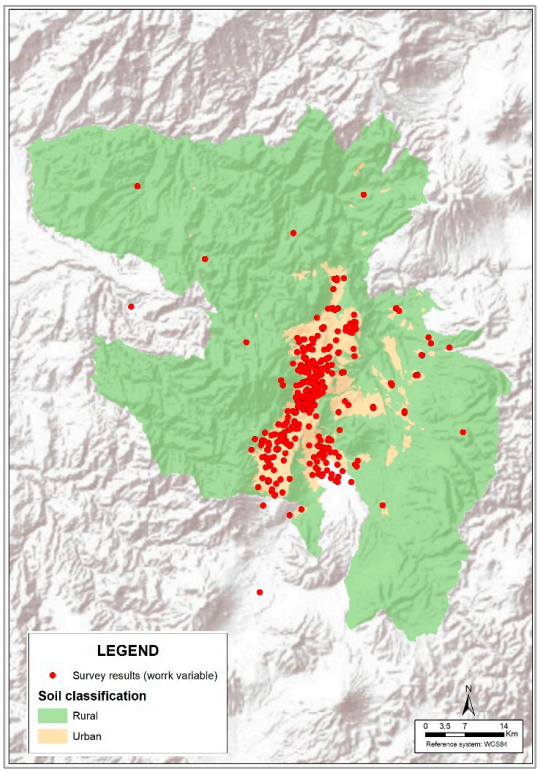


Figure 11. Distribution map of the people surveyed.

Survey results indicate that 88% of respondents worked outside their residential parish, highlighting an imbalance in the DMQ's urban development, where residential areas often do not meet all of the residents' needs. This imbalance leads to a disconnect among residential, employment, and service zones, compelling people to undertake lengthy commutes. Furthermore, 68% of respondents spent over 30 min commuting to work, which challenges the "15-min city" ideal [46], where essential services are reachable within a 15-min walk or bike ride from home (Figure 12). These findings underscore the DMQ's lack of integration between residential and work areas, which increases commute times and lowers the overall quality of life.

In terms of transport modes, 56% of respondents relied on private vehicles, contributing to traffic congestion and environmental pollution (Figure 13). While 33% used public transport—a figure that has increased with the recent opening of the Quito Metro—connectivity with peripheral areas remains limited. Alternative mobility options, such as cycling (16%) and walking (6%), remain low due to the dispersion of services and insufficient cycling and pedestrian infrastructure.

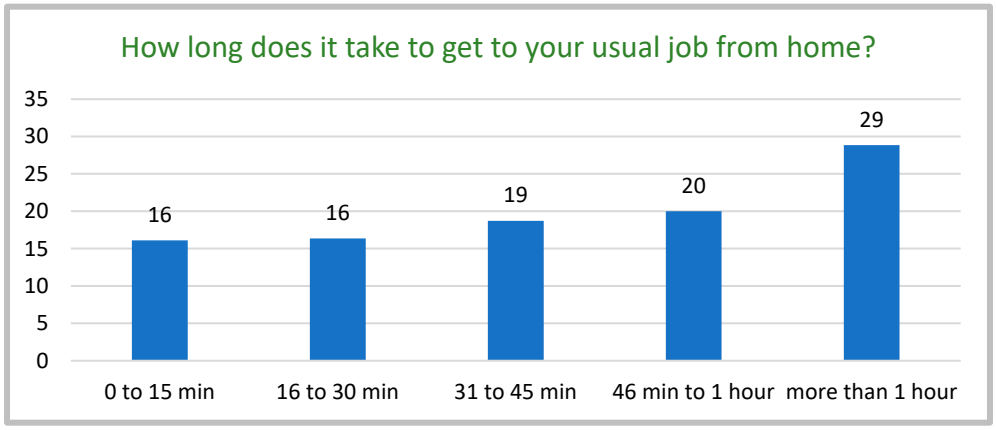


Figure 12. Results of the question: How long does it take to get to your job from home?

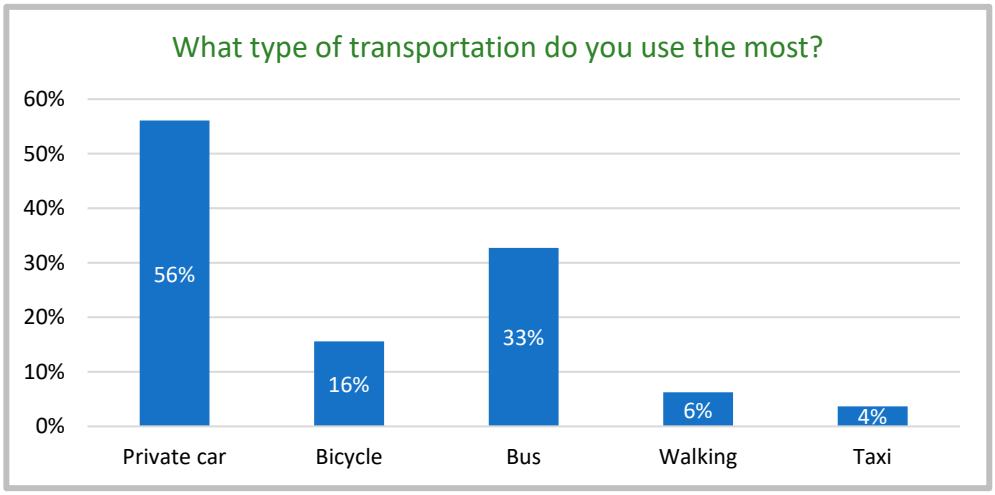


Figure 13. Most commonly used modes of transportation.

Additionally, 51% of respondents commuted daily for work, despite the anticipated reduction in commuting after the COVID-19 pandemic. These findings highlight the need for improved territorial integration in the DMQ, promoting urban development that brings residential areas closer to employment centers, reducing the dependence on long commutes, and enhancing access to job opportunities. The survey results can be viewed on the dashboard (link to the dashboard with the results of the analysis on labor distribution imbalances can be found at: https://upmarcgis.maps.arcgis.com/apps/dashboards/a4208877a0c84b9283675f9ffcc81e46 (accessed on 1 January 2024)).

Finally, the sampling bias introduced by distributing the survey through social media may have led to an overestimation of certain behaviors and characteristics such as the use of digital technologies or work patterns associated with youth and familiarity with technology. Additionally, the results may not accurately reflect the labor realities of underrepresented groups on these platforms such as older adults or individuals with low income. This limits the representativeness of the results, as they do not adequately reflect the entire population, affecting the accuracy of the analysis regarding employment variables.

4.4. Service Imbalance Results: Healthcare

The analysis revealed that, according to data provided by the Ministry of Health, the DMQ has 5566 healthcare facilities, of which 452 are public and 5114 are private. The latter category represents most facilities. These establishments are primarily concentrated in the city's central areas including neighborhoods such as La Mariscal Sucre, Belisario Quevedo, Rumipamba, and La Carolina. This uneven distribution of healthcare facilities favors

wealthier residents in these areas, while those in the southern and peripheral zones must travel considerable distances, often requiring motorized transport, thereby highlighting disparities in healthcare access.

The classification of facilities according to care levels (I, II, and III) revealed that level I, comprising primary care centers, was the most prevalent, with 3175 facilities, the majority of which were private. Level II, which encompasses general hospitals, had 2016 facilities, of which only 32 were public. Finally, level III, which includes specialized hospitals, had 375 facilities, with only 22 publicly accessible.

The analysis across neighborhood, sector, zonal, and metropolitan scales showed a significant deficit at the neighborhood level. In this area, there were only 1069 facilities (public and private) that served large populations, which left 338 neighborhoods—27% of the total—without nearby healthcare access. Approximately 446,674 homes were within reach of neighborhood-level healthcare services, while 268,201 homes were not. Those with access could typically reach facilities within a 15-min walk, which met the standard 800-m service radius.

At the sector level, 548,154 homes were within a 1500-m radius of healthcare facilities, while 166,721 homes fell outside this range. This affects 279 neighborhoods, where residents rely on public or private transport to access services, leading to longer commutes and reduced quality of life.

At the zonal level, 624,821 homes across the DMQ had access to healthcare within a 2000-m radius, generally requiring motorized transport. Despite broad coverage, some rural areas remained underserved, with 235 neighborhoods lacking access to these services.

At the metropolitan level, of the 395 hospitals, only 22 were public, limiting options for residents unable to afford private services. The shortage of publicly accessible specialized hospitals highlights the need for policies that expand public healthcare and promote equitable access across the DMQ.

This analysis suggests that urban planning should prioritize the distribution of healthcare facilities to improve accessibility and reduce disparities between neighborhoods and city sectors.

4.5. Comprehensive Analysis Results

The comprehensive assessment of services across the DMQ's 1269 neighborhoods revealed that 381 neighborhoods, representing 30% of the total, offer a complete range of essential services. As illustrated in Figure 14, these neighborhoods were concentrated in urban areas including La Villaflora, the Historic Center, the hyper-center, Conocoto, Pomasqui, and the parish centers of Tumbaco, Guayllabamba, and Pifo. As part of the district's key centralities and parish centers, these neighborhoods are well-served. However, in underserved neighborhoods, residents must travel to other areas to meet basic needs, often relying on public or private transportation, which further exacerbates the city's longstanding mobility challenges.

Additionally, 236 neighborhoods lacked both banking and educational services, 29 lacked both schools and healthcare facilities, 154 were without banks or healthcare services, and 147 neighborhoods lacked educational, financial, and healthcare services.

These findings are cause for concern, indicating that a significant number of neighborhoods are lacking in essential services, forcing residents to undertake unnecessary commutes across the city. This study serves to show the urban gaps that exist, and to identify priority areas for the implementation of new services.

The results obtained in the research can be consulted and visualized at the link provided (https://geoquito.quito.gob.ec/portal/apps/webappviewer/index.html?id=4bb9efc653f64811b3f191bc545f31ec (accessed on 1 June 2024).

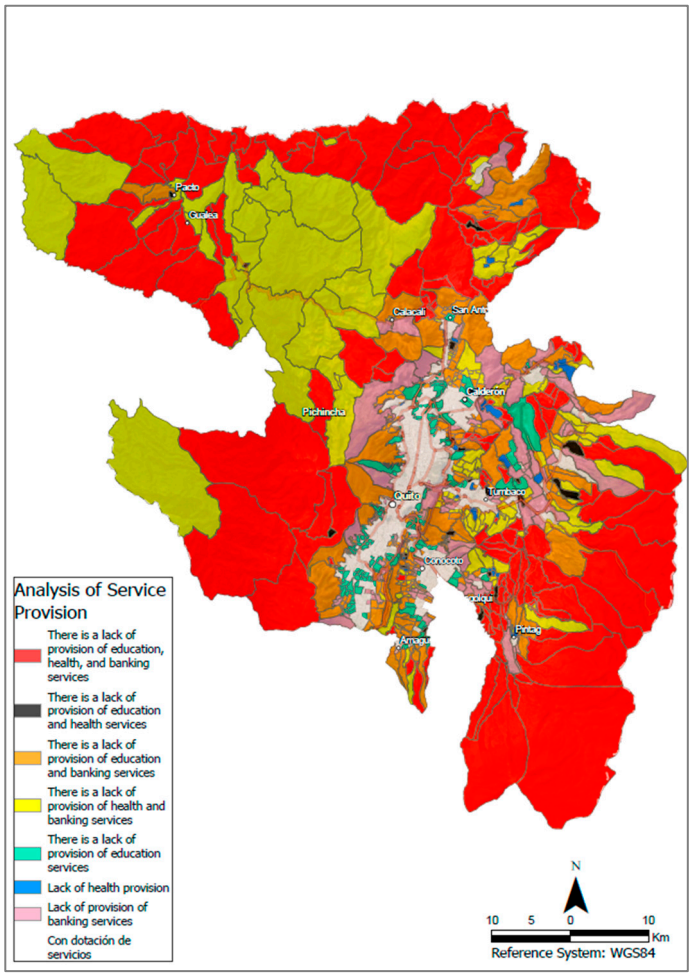


Figure 14. Comprehensive analysis of service provision within the DMQ.

5. Discussion

This section presents the findings on accessibility to educational, financial, employment, and healthcare services across the DMQ. It focuses on identifying key distribution patterns and proposing strategies to enhance accessibility, reduce unnecessary travel, and ensure a more equitable distribution of resources. Additionally, it presents an integrated approach, linking the various sectors evaluated.

5.1. Service Imbalance: Education

The analysis of educational coverage in the DMQ revealed significant disparities, particularly in rural and peri-urban neighborhoods. A total of 698 neighborhoods lacked access to educational facilities, creating a noticeable shortfall that has compelled many students to travel to nearby areas, increasing their dependence on both public and private transportation.

The application of the compensatory algorithm facilitated the redistribution of students to neighborhoods with available educational offerings. This resulted in a notable reduction in the number of underserved neighborhoods, with only 582 remaining. However, rural and peri-urban areas continue to be critical zones that require urgent intervention.

In urban areas, neighborhoods in southern Quito and on the periphery showed higher unmet demand, suggesting that educational planning has not adequately kept pace with population growth in these regions. Furthermore, the concentration of educational facilities in the city center may result in inefficiencies in the use of resources and an oversupply of facilities in these areas.

To address the deficit of educational units in certain areas of the DMQ, we propose the creation of a land bank that identifies suitable municipal, public, and private plots, considering criteria such as available area, land use, and the population to be served. This land bank would facilitate the strategic planning and location of new educational units. Additionally, we recommend establishing technical committees with the DMQ's Secretariat of Education, the Ministry of Education, and other relevant entities to manage the financing required for construction and the hiring of teaching staff.

As complementary measures, we suggest implementing double school shifts in existing units, expanding capacity without the immediate need for new infrastructure. It would also be useful to redistribute educational units from overserved areas to deficit zones using the identified land bank. These strategies would not only reduce the students' travel times, but also promote greater equity in access to education within the Metropolitan District of Quito.

5.2. Service Imbalance: Financial Services

The analysis of financial service accessibility in the DMQ revealed a notable degree of fragmentation in the distribution of banking institutions, ATMs, and cooperatives. Although 67% of neighborhoods had some form of financial service within a 10-min range, only 50.4% had effective access when walkability was considered. This imbalance particularly favors high- and upper-middle-income neighborhoods, while lower-income neighborhoods remain underserved.

The observed disparities in financial service coverage, especially in peripheral and rural areas, underscore the need for strategies to improve financial inclusion.

Currently, the Metropolitan District of Quito (DMQ) lacks a geographic database of ATMs, banks, and cooperatives, making it difficult to identify neighborhoods without access to financial services. This research and the generated tool enable the visualization and downloading of this information, benefiting entities such as the Superintendency of Banks, academic institutions, and local and government bodies by facilitating financial service planning for underserved areas.

To address these gaps, strategies should include improving safety in neighborhoods without financial coverage by enhancing street lighting, creating safe walkways, and installing surveillance cameras to attract financial institutions. Public–private partnerships could also finance financial infrastructure in vulnerable areas. Furthermore, promoting digital banking and mobile payments through educational campaigns and subsidies for devices and Internet access in low-income communities is essential. Additionally, financial entities should be incentivized to open branches or service points in the southern and northern DMQ through tax exemptions or subsidies. Finally, redistributing financial services via regulatory policies and agreements with banks and cooperatives can promote more equitable coverage.

5.3. Service Imbalance: Employment

The results of the survey on work-related commutes in the DMQ indicate that there are structural imbalances in the distribution of jobs and residences. The fact that 88% of respondents worked in parishes different from where they live reflects a fragmented urban development model that forces lengthy daily commutes and diminishes the residents' quality of life.

The prevalence of private vehicle usage (56%) underscores the challenges faced by the public transportation system in providing efficient and reliable connections between residential areas and job centers. While the Quito Metro has partially improved this situation, its reach remains limited.

To reduce work-related commuting and address employment distribution imbalances in the DMQ, strategies such as tax incentives and subsidies are proposed to decentralize businesses to neighborhoods with high residential density. These strategies also encourage the development of diversified economic zones in the north and south of the city, integrating

commercial, service, and residential activities. Additionally, remote work and coworking spaces should be promoted to minimize commuting in suitable areas.

Parallel to these efforts, improvements to the public transportation system are recommended including metro integration, adaptations for priority groups, and apps for schedule information. The construction of affordable perimeter parking, the implementation of bike lanes, and the promotion of electric bicycles are also proposed, considering the topography of Quito. These measures aim to balance employment distribution, improve urban mobility, and encourage sustainable alternatives.

5.4. Service Imbalance: Healthcare

The analysis of healthcare service provision in the DMQ revealed that while a considerable proportion of the urban area is served by sectoral and zonal healthcare facilities, rural and peri-urban areas continue to experience significant deficiencies in this regard. A total of 275 neighborhoods lacked access to local healthcare facilities, compelling residents to rely on transportation for medical care.

To address the imbalances in health service distribution in the Metropolitan District of Quito (DMQ), the following strategies are proposed:

First, we recommend building and improving the health infrastructure by establishing hospitals, clinics, and health centers in areas lacking these services, particularly in neighborhoods without access. Suitable land should be identified, possibly through a land bank, with financing support from the central government, municipalities, and international organizations. Additionally, expanding existing facilities with new specialized consultations and general care areas is essential.

Strengthening public transport routes to healthcare services, with direct routes to the main health centers in both urban and rural areas, is also necessary. To ensure that low-income communities have access, transport costs should be subsidized, removing economic barriers to healthcare.

5.5. Comprehensive Analysis

The findings indicate significant challenges in the distribution of essential services across the DMQ. Imbalances in the provision of services such as education, banking, healthcare, and employment services revealed that rural and peripheral areas are underserved, affecting the residents' quality of life and fostering a dependency on transportation.

To achieve comprehensive urban planning in the Metropolitan District of Quito (DMQ), a coordinated approach is necessary to optimize the existing infrastructure and redistribute essential services to areas with the greatest deficits such as peripheral and rural neighborhoods. This includes rehabilitating underutilized infrastructure, improving basic networks like water, electricity, and transportation, and establishing new service centers in partnership with the public and private sectors. Improving connectivity is key, requiring investments in efficient public transport, creating new routes, enhancing accessibility, and using geolocation technologies to identify vulnerable areas. Additionally, decentralizing services and creating development hubs in underserved areas will ensure a more equitable distribution of essential services.

Successful lessons from cities like Singapore [47], Copenhagen [48], New York [49], Barcelona [49,50], and Portland [51] can be applied to Quito. Singapore and Copenhagen have optimized mobility through intelligent transportation systems (ITS), which could improve connectivity in Quito. New York has implemented smart city technologies to redistribute services in underserved areas, a model that could be replicated in Quito's peripheral neighborhoods. Barcelona's creation of "superblocks" to decentralize services and Portland's zoning and public transport reforms for low-income communities offer further lessons. These cities' use of technology, public–private partnerships, and decentralization are key strategies for fostering more sustainable and equitable urban environments, which could enhance the quality of life in Quito.

6. Conclusions

The urban expansion in the DMQ has resulted in several issues including low population density and disorganized sprawl, leading to underutilized urban land and the conurbation of neighboring rural parishes. Furthermore, there is an oversaturation of services in the city center, a weak hierarchical structure in rural areas, and high vulnerability to natural risks.

In the education sector, the analysis revealed an imbalance in the distribution of educational services within the DMQ. Approximately 43% of neighborhoods demonstrated a balance between the supply and demand of educational services, while 46% faced unmet demand, particularly in the southern and peri-urban areas. An additional 11% exhibited an oversupply in the city center.

The analysis of the financial services in the DMQ revealed that while 50.4% of neighborhoods had some form of access, there was considerable variation in coverage based on urban areas and socioeconomic levels. Higher-income households had more extensive access to financial services, whereas lower-income neighborhoods remained largely underserved.

In terms of mobility, work commutes reflect the city's unbalanced urban development. Indeed, 88% of DMQ workers commuted between parishes, with 68% spending over 30 min on their journey. The prevalence of private car use (56%) and the low adoption of public transport and alternative modes, such as cycling and walking, underscore the need for efficient urban planning that promotes sustainable mobility and reduces congestion.

A significant proportion of neighborhoods in the healthcare sector lacked access to local facilities. Around 27% of neighborhoods did not have a nearby health center, posing a challenge to ensuring accessible medical care. The average walking time to healthcare centers was 15 min, underscoring the importance of improving service distribution in underserved areas.

Despite facing limitations such as outdated cartographic data, restricted access to official origin–destination surveys, and lack of funding, this study highlights significant imbalances in the provision of essential services in the Metropolitan District of Quito (DMQ). It underscores the need for improved data collection and spatial and mobility data updates to support future research. Additionally, it calls for territorial planning strategies aimed at addressing service deficits in education, healthcare, and financial access through initiatives like land banks, service decentralization, infrastructure strengthening, and public–private partnerships.

Moreover, analyzing mobility patterns and limited-service accessibility revealed a critical disconnect between residential areas and activity centers, stressing the need for an efficient public transport system and measures such as direct routes, subsidies for vulnerable groups, and diversified economic zones. Promoting remote work and adjusting school schedules can reduce transport dependence, improving productivity and quality of life.

Finally, analyzing imbalances in education, banking, employment, and health services requires specific methodologies tailored to each sector. Geospatial methods in education, walkability analysis in banking, and mobility studies in employment are crucial. In health, influence radii are used as per the current regulations. These approaches will help identify priority areas to improve access to these services.

Challenges in model validation arise due to the lack of reliable, spatialized data. Current datasets do not allow for the proper correlation of walkability patterns, making model accuracy verification difficult. The use of participatory GIS tools, like in the Ecosystem Services study in Loja, Ecuador, is recommended to involve communities in spatialized data collection, ensuring greater representativeness and reliability, thus providing a stronger foundation for evidence-based urban policies [52].

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