

Article

Territorial Impacts of the Ruta Viva Expressway in Peri-Urban Quito (2011–2024): A PCA-Based, Census-Tract Assessment

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Abstract

This study examines territorial transformations in five rural parishes of the Metropolitan District of Quito induced by the Ruta Viva expressway (inaugurated in 2013). Using census tracts for 2011, 2017, 2021, and 2024 and four variables—urban land use (COS/BCR), building permits (metropolitan licenses), land value, and population density—we construct a PCA-based territorial impact index and classify outcomes with Jenks natural breaks. Results show marked heterogeneity across parishes: Cumbayá–Tumbaco concentrates high-impact tracts and sustained consolidation, while Pifo–Tababela–Puembo exhibits selective or delayed changes. Over 2011–2024, land value more than tripled on average (with parish-level peaks > 200%), and the population grew 46%, reshaping density patterns. The findings highlight infrastructure-induced reconfiguration and underscore the need to align territorial planning instruments with value capture and inclusionary tools for more equitable and environmentally sustainable outcomes.

Keywords: peri-urban Quito; Ruta Viva; territorial impact index; Principal Component Analysis (PCA); land value appreciation; GIS-based analysis



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1. Introduction

In Latin America, large-scale road infrastructure projects have acquired a strategic role in shaping urban and metropolitan territories. Far from being merely technical solutions for mobility, these works profoundly reconfigure land-use patterns, stimulate real estate dynamics, and alter existing socio-spatial relationships. In particular, the expansion of road corridors in peri-urban areas has consolidated new functional centralities and fostered accelerated urbanization processes with far-reaching territorial implications.

In the case of the Metropolitan District of Quito (DMQ), the capital of Ecuador, the construction of Ruta Viva—a 12.52 km expressway connecting the city with the new Mariscal Sucre International Airport—constitutes a clear example of this phenomenon. This project represents a significant transformation of the metropolitan infrastructure of Quito. Its development emerged as a response to the growing need to improve transport connections and accompany urban expansion [1].

Ruta Viva, executed by the Metropolitan Public Company of Mobility and Public Works (EPMMP), was financed through municipal funds and multilateral loans. Its construction was structured in three phases: the rehabilitation of 12.8 km of existing road, the construction of complementary infrastructure such as ramps and bridges, and the extension of 4.3 km to connect with the E35 highway, totaling 17.1 km. Beyond consolidating airport access, the project reconfigured the territorial dynamics of the northeastern metropolitan area.

This infrastructure not only improved interurban connectivity but also induced socioeconomic and cultural transformations in the peri-urban areas of Quito's rural parishes [2].

The parishes of Cumbayá, Tumbaco, Puembo, Pifo, and Tababela, located in the direct area of influence of the project, experienced significant real estate dynamics and accelerated urbanization. This growth was accompanied by regulatory changes, variations in land values, increases in population density, and greater urban land use, revealing a multi-dimensional territorial transformation. Particularly, Cumbayá and Tumbaco concentrated strong real estate and commercial dynamics, consolidating themselves as new metropolitan centralities [3].

However, these changes also generated social imbalances and tensions between real estate capital and traditional rural land uses, raising questions about equity and sustainability in urban development driven by such interventions [4].

Ulloa-Espíndola et al. [5] emphasize the importance of adopting an integrated approach that brings together ecological, environmental, and social variables in territorial analysis. Such a perspective provides a more precise understanding of agricultural land transformations and the pressures associated with conserving protected areas in Quito's peri-urban fringe. In this regard, European experiences such as the MAES (Mapping and Assessment of Ecosystems and their Services) methodology applied in the Community of Madrid illustrate the relevance of incorporating environmental information into territorial planning at both regional and local scales, enhancing the identification of impacts and the protection of ecosystems [6]. Nevertheless, the scarcity of geoinformation in Ecuador remains a critical limitation, as it restricts the ability to assess in detail the effects of urban expansion on landscape morphology, local economic dynamics, ecological sustainability, and resilience to climate change and habitat fragmentation.

From a critical territorial standpoint, this article analyzes the impacts induced by Ruta Viva through a multivariable methodology, considering regulatory, urban, demographic, and economic parameters. Using Geographic Information System (GIS) and census tracts as the minimum unit of analysis, the effects of the road infrastructure were evaluated across different periods (2011, 2017, 2021, and 2024), integrating theoretical approaches on the right to the city, land value, and the social production of space [7,8]. See Section 2 for an extended review.

The study contributes to debates on the role of infrastructure in processes of uneven urbanization, providing empirical evidence for data-driven and equity-oriented territorial planning [9].

Research gap: Prior work typically examines these impacts in isolation (e.g., mobility performance, land market dynamics, or land-use change), whereas this study integrates building permits (metropolitan licenses), population density, land value, and urban land use within a single multivariable framework—a PCA-based impact index at the census tract scale.

From a regulatory standpoint, the PMDOT 2021–2033 and Ordinance PMDOT-PUGS No. 003-2024 (12 May 2024) define land classification and sub-classification, the urban–rural boundary, and instruments for land management in Quito. However, after Ruta Viva's initial implementation (2011–2013), these instruments are relevant for interpreting current

territorial outcomes along the corridor—particularly densification patterns, permissible uses, and the designation of logistical and industrial nodes in Tababela and Pifo [10,11].

In the context of contemporary urbanization, road infrastructure acts as a key agent in the reorganization of metropolitan territories. Lefebvre [12] emphasized that urban space is configured not only physically but also socially, under power dynamics that often privilege economic interests. Harvey [13] argued that projects such as Ruta Viva respond to dynamics of accumulation by dispossession, where land value becomes a strategic commodity. In Quito's northeastern corridor, these dynamics are expressed through accelerated land value appreciation, shifting centralities (e.g., Cumbayá–Tumbaco), and pressures on traditional rural land uses.

This phenomenon is intensified in contexts like Quito, where infrastructure functions as a vector connecting global capital (the airport) with the local territory, producing new forms of territorial inequality [14,15]. A fuller theoretical discussion is provided in Section 2.

Building on this conceptual framework, the objective of the present research is to determine the territorial impact induced by the implementation of the Ruta Viva, assessing its influence on densification dynamics, land valorization, regulatory land use, and urban expansion in the rural parishes of the northeastern area of the Metropolitan District of Quito.

2. Literature Review

The analysis of large urban infrastructure projects as agents of territorial transformation has been extensively addressed by various strands of urban geography, the sociology of space, and the political economy of development. In the Latin American context, these projects are typically embedded within processes of accelerated urbanization, where infrastructures act as vectors of spatial reconfiguration, articulating local scales with flows of capital and global connectivity [16].

Henri Lefebvre [12] introduces the concept of the social production of space, noting that urban transformations are not merely physical or functional, but reflect power relations, economic interests, and social dynamics. Within this logic, the city becomes a field of dispute, where political and economic conditions have access to land, housing, and services. David Harvey [13], for his part, takes up this line of thought to argue that large urban projects can constitute mechanisms of accumulation by dispossession by facilitating the appropriation of land value by real estate capital to the detriment of local communities.

From a critical perspective on urban development, Lungo [17] highlights the contradictions inherent to large urban projects—namely, the tension between project-based pragmatism and comprehensive planning, the private capture of land value increments, and weak citizen participation in territorial decision-making. Within this framework, road infrastructure not only responds to mobility needs but also acts as a territorial device capable of inducing valorization, densification, and displacement. In the same vein, Caldeira [18] argues that contemporary Latin American urbanization is marked by growing socio-spatial fragmentation, as infrastructure projects such as expressways or strategic corridors tend to reinforce inequalities by privileging specific urban enclaves. Her notion of urbanization by enclaves helps explain how infrastructure can operate as a mechanism of exclusion and territorial segmentation, generating benefits concentrated in areas with high capacity to attract real estate investment while leaving other areas marginalized.

The case of Ruta Viva in Quito falls within this type of intervention, as the roadway connects the consolidated urban center with the new international airport, generating a direct relationship between global capital and the local territory, with differentiated effects depending on parish type and relative location (urban, transitional, or rural).

Land value, understood as a social and economic construct, has been approached by multiple authors as an indicator of urban dynamics. Price variation in response to infras-

structure, regulation, and the real estate market is a well-documented phenomenon [19–21]. In the Ecuadorian case, the evolution of territorial planning instruments such as the Land Use and Management Plan (PUGS) and the Organic Law of Territorial Planning, Land Use and Management (LOOTUGS) has sought to regulate these dynamics, albeit with uneven results in terms of controlling urban expansion and territorial equity.

Recent empirical evidence (2015–2025) corroborates these mechanisms in comparable contexts. Using event study designs, highway expansions are associated with significant land-use conversion and reallocation of activities [22]. Airport-related externalities measurably shape housing markets and land values [23]. In Latin American metropolitan peripheries, unequal peri-urban mobility patterns reinforce dependence on urban cores and produce spatial inequities [24]. At the metropolitan scale, ring roads and peripheral corridors—conceptually akin to airport access expressways such as Ruta Viva—are linked to urban sprawl when economic–population–land–transport interactions are considered jointly [25]. In terms of instruments, the literature on land value capture connects policy design with land rent narratives, offering a conceptual basis to interpret value increments around infrastructure [26].

In this context, the use of GIS has become a fundamental tool for the multivariable spatial analysis of complex territorial processes. The ability to integrate regulatory, urban, and demographic variables has enabled the construction of indices of territorial transformation that facilitate the reading of spatial patterns, as demonstrated by recent studies on accessibility, urbanization, and the expansion of the urban frontier [27].

Additionally, Principal Component Analysis (PCA) has become an effective technique for identifying latent structures in the urban territory. In applied studies, it allows the reduction in sets of correlated variables into synthetic components that capture the underlying logic of urban growth. This technique is useful for assessing the territorial impact of large-scale infrastructures—such as airports, expressways, or shopping centers—and for generating integrated indicators that more clearly reflect the processes of transformation of urban space [28,29].

The application of PCA in longitudinal studies facilitates the detection of areas with significant structural changes over time, revealing zones that have experienced accelerated expansion or intensification of land use as a direct or indirect response to new infrastructures. In this sense, PCA not only allows the description of spatial trends but also the prioritization of critical areas for urban planning and sustainable territorial development [30].

In parallel, our PCA-based territorial measure is the paper’s main innovation. Instead of constructing a separate index, we applied a weighted composite of the first and second principal components (PC1 and PC2), which together explain more than 70% of the variance. This combined score served as the synthetic variable to classify outcomes using Jenks natural breaks into five categories: very high, high, medium, low, and very low impact. This approach provides a simplified yet robust way to capture the latent structures of territorial transformation.

3. Materials and Methods

3.1. Study Area

This research focuses on the rural parishes of Cumbayá, Tumbaco, Puembo, Pifo, and Tababela, located within the Metropolitan District of Quito (DMQ), Ecuador. The study area covers 397.94 km² and concentrates approximately 1.02% of the national population.

In general, the rural parishes of the DMQ have experienced accelerated territorial transformation in recent decades, particularly associated with extensive urbanization processes, fragmentation of the rural landscape, increases in land value, and pressure on local ecosystems [5,31,32].

The selection of the eastern axis of urban expansion responds to the need to analyze territories strategically affected by road projects with structural effects on territorial configuration. Although other infrastructures—such as the Oswaldo Guayasamín tunnel or Simón Bolívar Avenue—have also generated metropolitan impacts in Quito, Ruta Viva has played a leading role in transforming the northeastern rural parishes, turning them into key spaces for analyzing the relationships among infrastructure, population density, and territorial change. Figure 1 illustrates the location of the study area concerning the national and metropolitan context.

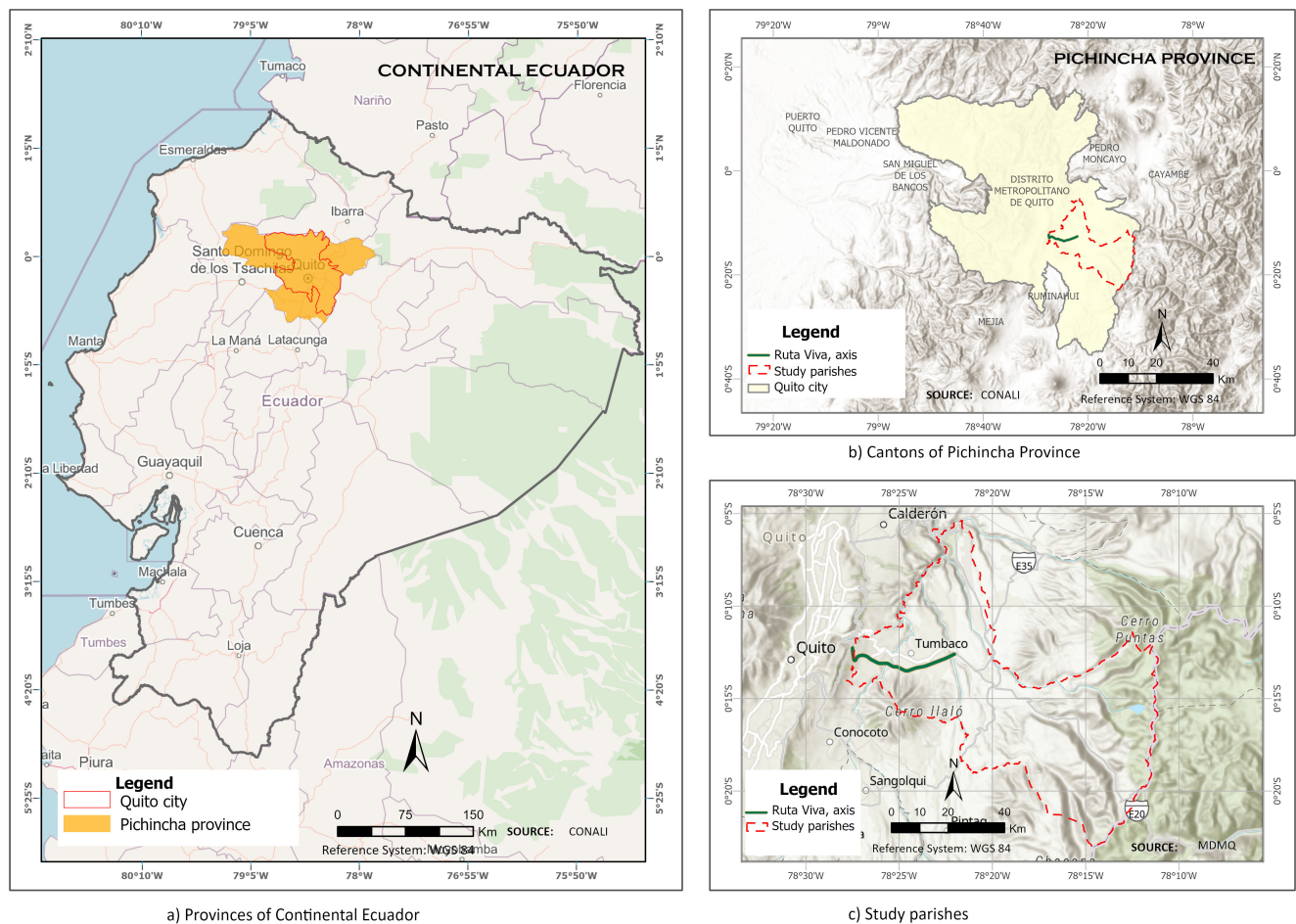


Figure 1. Study area location.

3.2. Data Compilation

To initiate this research, we compiled geographic data for the variables of population density, valuation intervention areas, metropolitan urbanistic licenses (building permits), and land-use regulation, as identified in Table 1.

Table 1. Inputs.

Input	Format	Date	Source	Scale/Resolution
Census tracts, housing units	hp	2010, 2022	INEC	1:5000
Orthophoto of the DMQ	tiff	2019	Military Geographic Institute (IGM)	1:5000
Land Valuation Intervention Areas (AIVA)	shp	2010–2011; 2016–2017; 2020–2021; 2024–2025	DMQ Open Government	1:5000

Table 1. *Cont.*

Input	Format	Date	Source	Scale/Resolution
Building permits (metropolitan licenses)	xls	2011, 2017, 2021, 2024	Metropolitan Directorate of Citizen ServiceF (DMQ)	Not applicable
DMQ road network	shp	2021	DMQ Open Government	1:5000
Land Use and Occupation Plan (PUOS)	shp	2011, 2017	Secretariat of Habitat and Territorial Planning (SHOT)	1:5000
PUGS	shp	2021, 2024	SHOT	1:5000
Urban and rural cadaster of the DMQ	shp	2011, 2017, 2021, 2024	SHOT	1:1000; 1:5000
Administrative boundaries of the DMQ (urban and rural parishes)	shp	2024	DMQ Open Government	1:5000

3.3. Methodology

This study develops a multivariable, multitemporal analytical methodology aimed at evaluating the territorial impacts induced by the implementation of the Ruta Viva road project in DMQ. The proposed analysis integrates regulatory, urban, demographic, and economic variables and allows the establishment of territorial correlations between road infrastructure and induced urbanization processes. The methodological strategy provides a robust technical framework for monitoring urban transformations associated with large connectivity projects, while supplying inputs to evaluate the effectiveness of planning, land management, and territorial ordering policies in contexts of accelerated metropolitan expansion.

As the minimum unit of analysis within the parishes under study, we consider the census tracts established in INEC's census cartography. Within the census grid, each tract has a unique identifier within its zone [33]. This distinction is essential to properly characterize land-occupation patterns and differentiate urban and rural dynamics within the study area.

The methodology integrates procedures of systematization, weighting, normalization, and factor analysis applied to four key variables: building coverage ratio (COS), building permits (metropolitan licenses), population density, and variation in land value. The analysis is conducted for the periods 2011 (before Ruta Viva's construction) and the years following its commissioning—2017, 2021, and 2024—concerning the applicable regulatory instruments.

Using GIS, the information was standardized, and scales were harmonized for variables that did not present data directly aggregated at the census tract level. Subsequently, a synthetic territorial impact index was constructed through the application of PCA, based on the variables developed for each study year. This method made it possible to identify census tracts with greater territorial transformation—based on the variance explained by the components—and to establish a year-by-year classification by impact levels (Very high, High, Medium, and Low) using the Jenks natural breaks algorithm.

Figure 2 presents the flowchart that illustrates the methodology used in the research.

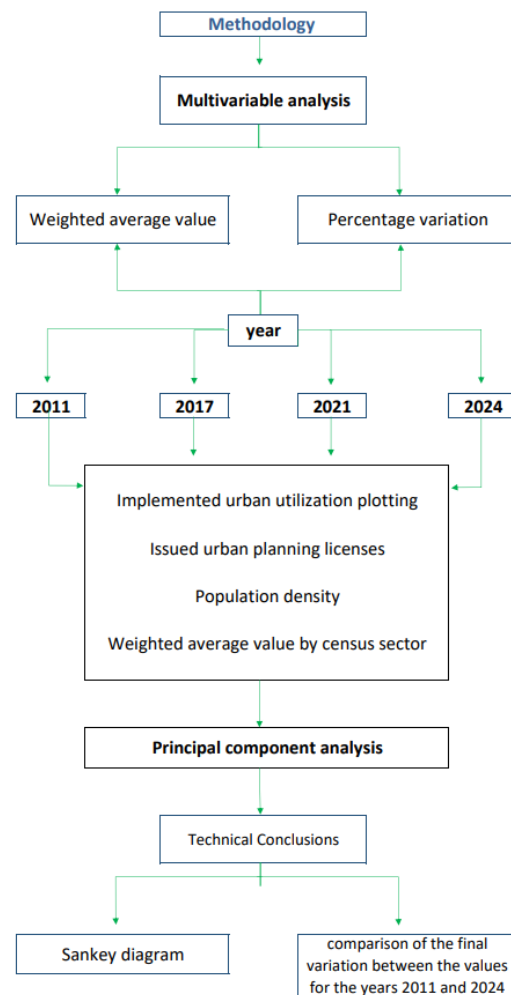


Figure 2. Flowchart of the methodology employed in the research.

3.4. Variable Analysis

This study applied a quantitative and spatial approach to analyze the evolution of key variables associated with territorial transformations in the rural parishes within Ruta Viva's area of influence.

For each variable, the methodological treatment is summarized as follows:

- COS. The regulatory instruments in force in each period were integrated with the census tract cartography.
- Building permits (metropolitan licenses). The license database for each year was integrated with the census tracts, and its spatial concentration was analyzed using the kernel density estimation (KDE) method.
- Population density. Gross density was calculated based on census data and projections, evaluating its evolution in the study territory (reported as inhabitants per square meter). For population density, we used official data from the Population and Housing Census (2010 and 2022) [34,35], complemented with projections for 2017 and 2024, calculating gross density as

$$D_p = N/St$$

where:

D_p : Population density;

N : Population of the census tract;

St : Area of the census tract (in hectare).

- Land value. The official cartography of AIVA was used. From this, the weighted average land value per census tract was estimated, and its percentage variation was analyzed across the four periods.

With the values of each variable, the PCA technique was applied to synthesize common factors of territorial transformation, identify dominant spatial patterns over time, and interpret the impacts induced by Ruta Viva on the land occupation model. In addition, the analysis of factor loadings associated with each component allows the interpretation of the evolution of urban structure, revealing which variables gain prominence at different moments of the urbanization process.

Before conducting the PCA, correlations among the indicators were analyzed for each year, yielding values greater than 0.15, which indicates that the correlation among variables is not very strong. Subsequently, Bartlett's test of sphericity (p -value = 0.000) and the KMO index (values above 0.65) were applied, confirming that the PCA algorithm has interpretive validity.

Subsequently, the following process flow was applied:

- Execution of the PCA by year on the standardized study variables.
- The first and second principal components (PC1 and PC2) synthesize more than 70% of the information contained in the variables; therefore, both components were used in each of the years analyzed [29].
- Derivation of a weighted principal component (PCm) obtained from PC1 and PC2 using their explained variances as weights, thereby generating a territorial impact index for each year.
 - $PCm = (PC1 \times Ev1) + (PC2 \times Ev2) / (Ev1 + Ev2)$.
 - Ev = Explained variance derived of PCA process.
- Spatialization of the results of the weighted component and year-by-year separation using Jenks natural breaks, which enabled categorization of the weighted component.
- The resulting groupings focus on urban growth and include the following categories: Very high, High, Medium, and Low.

PCAs and mapping were produced for all study years (2011, 2017, 2021, and 2024). For the transition analysis, this procedure was repeated independently for 2011 and 2024, generating two comparable endpoint classifications. Based on these two temporal dimensions, a transition matrix was constructed to calculate the final weight of territorial impact as a measure of the relative change in urban growth between both years.

The assignment of the final weight was based on an ordinal scale that quantifies the transition of each census tract according to its evolution in the urban growth classification. For example, a tract that moved from "Low" to "Very high" received a weight of +3; a tract that remained in the same category was weighted 0; and a tract that went from "Very high" to "Low" received a weight of −3.

This weighting makes it possible to synthesize, in a single variable, the direction and magnitude of urban change for each census unit. The result facilitates the identification of areas of accelerated expansion, consolidation, or urban contraction linked to the direct and induced effects of large infrastructures such as Ruta Viva, as illustrated in a comparative 2011–2024 map.

Finally, temporal evolution was represented employing a Sankey diagram in which, based on the weighted PCA values, proportional flows between nodes are displayed. Each horizontal line symbolizes a census tract flow, whose width is proportional to its magnitude. This diagram summarizes multiple variables into a weighted value representing the territorial contribution or relevance of each parish for each analysis period.

4. Results

The results reveal a heterogeneous evolution across the parishes studied, influenced by regulatory, economic, and demographic factors. The year 2017 stands out as a turning point, marked by the implementation of new urban planning regulations that modified the COS and the dynamics of licensing.

Likewise, an accelerated increase in land value is observed, with gains exceeding 238% over the period analyzed, as well as a significant rise in population density (46%), concentrated mainly in Cumbayá and Tumbaco.

Through PCA, spatial and temporal transformation patterns were identified, allowing the territory to be classified according to its degree of impact. The findings show that Cumbayá and Tumbaco present the highest weighted values within the territory, whereas Pifo and Puembo tend to increase their prominence, and Tababela has remained on a stable development path, reflecting disparities in development driven by Ruta Viva.

The results are detailed below and structured into five main axes: urban development (evolution of the COS and regulations), increase in building permits (trends in building authorizations), population density (demographic growth and spatial distribution), variation in land value (real estate dynamics and territorial valorization), and relationships among variables (via PCA).

4.1. Implemented Urban Development

The COS is a key indicator for analyzing urban expansion dynamics and the degree of land use in contexts of metropolitan transformation. In the rural parishes of Cumbayá, Tumbaco, Puembo, Pifo, and Tababela, 2017 marked a turning point in the evolution of the COS, with a significant decrease recorded in all cases. This pattern is directly associated with the implementation of new urban planning regulations—particularly the incorporation of Concertation Zones (ZC) within the PUOS—which, lacking specific zoning data and parameters of urban development potential, constrained the permitted intensity of land occupation during that period.

Figure 3 shows the distribution of total COS in the study area for the years 2011, 2017, 2021, and 2024.

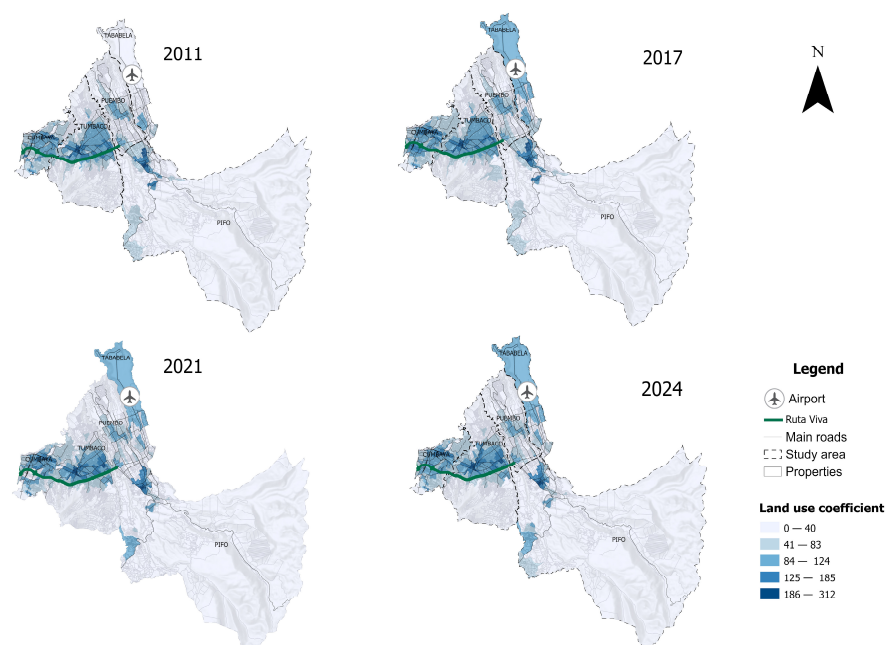


Figure 3. Total COS by year (2011, 2017, 2021, and 2024) in Cumbayá, Tumbaco, Puembo, Tababela, and Pifo.

At the parish level, the results show differentiated variations (Table 2). Pifo stands out as the parish with the highest cumulative growth in the COS during 2011–2024, reaching 5.16%, despite a sharp decline between 2017 and 2021 (−12.39%), which was reversed thanks to a significant recovery between 2021 and 2024.

Table 2. Percentage Variation in the Land Occupation Coefficient (2011, 2017, 2021, and 2024).

Administrative Parish	2011–2017	2017–2021	2021–2024	2011–2024
Cumbayá	2.86%	−3.94%	3.79%	2.56%
Pifo	17.89%	−12.39%	1.82%	5.16%
Puembo	5.04%	−6.95%	4.87%	2.50%
Tababela	26.75%	−35.90%	23.75%	0.55%
Tumbaco	1.93%	−7.64%	1.04%	−4.87%
Area-weighted mean	54.48%	−66.81%	35.27%	5.90%

This behavior suggests improved regulatory alignment and a progressive balance between planning and land occupation. Cumbayá and Puembo exhibit moderate positive growth in the COS, at 2.56% and 2.50%, respectively, reflecting stable and better-planned densification processes, characterized by intermediate declines that were subsequently offset by recoveries.

By contrast, Tababela shows the most unstable behavior, with an initial significant rise (+26.75%) followed by a sharp drop (−35.90%) and a subsequent partial recovery (+23.75%). The net variation over 2011–2024 is low (+0.55%), indicating that although there was a strong push for land occupation around the opening of Mariscal Sucre International Airport, subsequent regulatory parameters restricted its sustained consolidation. Finally, Tumbaco is the only parish that shows a net reduction in the COS (−4.87%), which could be interpreted as a loss of intensity in land occupation or as a displacement of urbanization pressure toward neighboring parishes with greater land availability and more favorable regulatory conditions.

4.2. Building Permits (Metropolitan Licenses)

The analysis of building permits (metropolitan licenses) is a fundamental tool for understanding land occupation patterns and urban transformation processes in the Metropolitan District of Quito.

These licenses, issued by the Municipality, authorize land use, development, or construction, and their spatial distribution makes it possible to identify development trends in the rural parishes under study—Cumbayá, Tumbaco, Puembo, Pifo, and Tababela.

When evaluating the concentration and variation in licenses in the study parishes concerning relevant urban events—such as the creation of Ruta Viva or the implementation of Mariscal Sucre Airport—Table 3 presents the number of licenses issued in the parishes studied in 2011, 2017, 2021, and 2024. It is evident that the parish of Tababela has fewer approved licenses both before and after the creation of Ruta Viva.

Table 3. Building permits (metropolitan licenses) granted in the study area.

Administrative Parish	2011	2017	2021	2024
Cumbayá	102	185	131	194
Tumbaco	76	454	167	285
Puembo	30	147	73	142
Pifo	5	89	33	49
Tababela	3	36	8	22
Total	216	911	412	692

The following map (Figure 4) shows the intensity of building permits (metropolitan licenses) at the census tract level, spatialized using kernel density estimation (KDE).

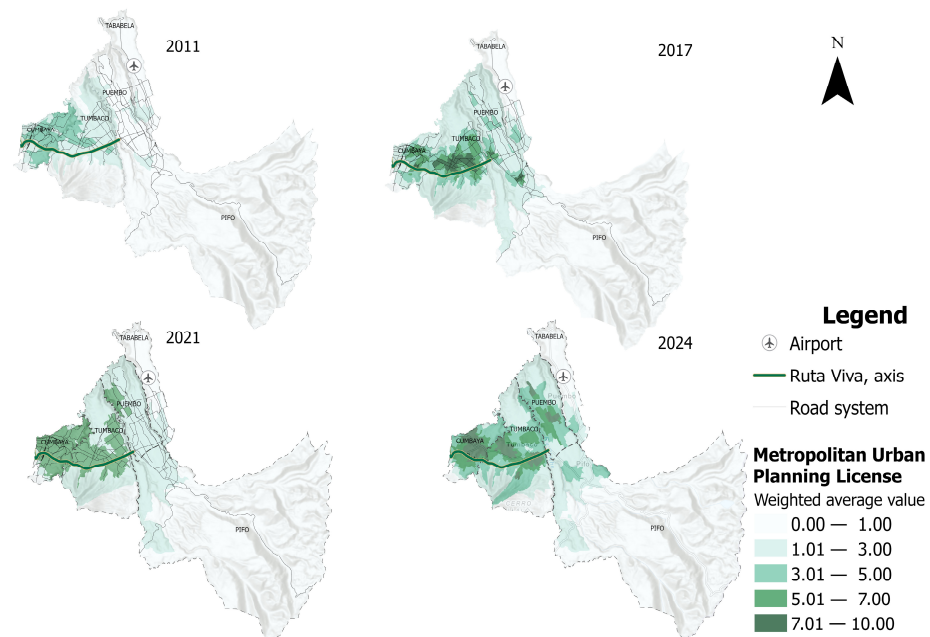


Figure 4. KDE intensity of building permits (metropolitan licenses).

4.3. Population Density

Population density—observed for 2011/2021 and estimated for 2017/2024 via $D_p = N/St$ with St in ha—is a key indicator for analyzing urbanization and territorial transformation processes, as it links demographic growth and land use. In this study, population trends in the rural parishes of the study area were analyzed for the period 2010–2024, revealing an overall increase of 46%, from 114,465 to 167,109 inhabitants.

This growth was particularly rapid between 2017 and 2024, a period in which a 26.6% increase was recorded, higher than the 15.3% increase observed between 2011 and 2017. This acceleration has directly affected population density levels, modifying the spatial distribution of inhabitants and accentuating concentration in certain areas of the territory.

Calculating population density per hectare makes it possible to identify significant disparities among parishes (Table 4). In 2024, the highest density corresponds to the parish of Cumbayá, with 20.1 inhabitants per hectare, representing 25.2% of the study area's total population. It is followed by Tumbaco, with a density of 12.2 inhabitants per hectare. In contrast, the parishes of Tababela and Pifo show the lowest densities, with 1.5 and 0.9 inhabitants per hectare, respectively. Moreover, these latter parishes have experienced little change over the last fourteen years; Pifo rose from 0.7 inhabitants per hectare in 2010 to 0.9 in 2024, reflecting a much more stable population dynamic. The evolution of population density by parish and by year is presented in Figure 5.

Table 4. Population density by parish and by year (inhabitants per hectare).

Administrative Parish	2011	2017	2021	2024
Cumbayá	15.00	17.30	19.94	20.11
Tumbaco	7.62	8.79	12.07	12.17
Puembo	4.28	4.94	5.60	5.64
Tababela	1.11	1.28	1.51	1.52
Pifo	0.65	0.75	0.91	0.92

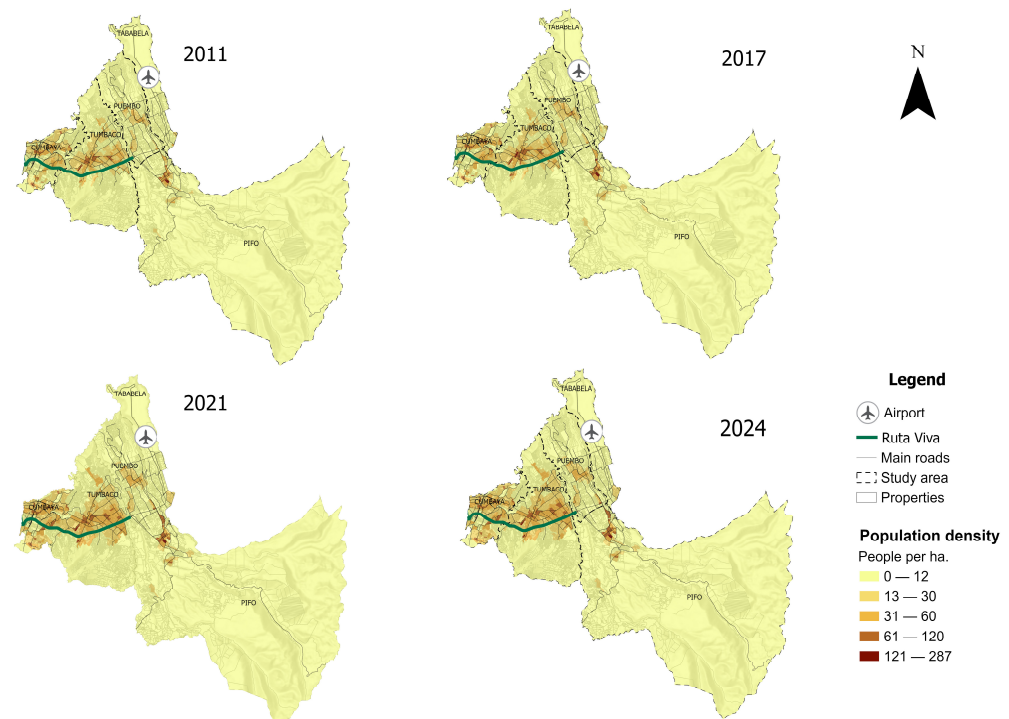


Figure 5. Population density by year (inhabitants per hectare).

4.4. Territorial Dynamics of Land Value

Urban land value—measured using the AIVA dataset—is a strategic indicator for understanding real estate dynamics and territorial transformation processes.

In the study area, there is a sustained upward trend in the price per square meter between 2011 and 2024, with an average increase exceeding 238%, rising from USD 38.01 in 2011 to USD 128.59 in 2024.

This growth shows significant variation among parishes, reflecting different rates and levels of urban consolidation. The parishes of Puembo, Tumbaco, and Cumbayá stand out for the highest percentage increases, followed by Pifo and Tababela.

This behavior allows us to infer the degree of land valorization and its implications for land occupation, investment, and territorial planning.

The evolution of land value shows a constant increase in each period analyzed. On average, the price per square meter across the entire study area has more than tripled, rising from USD 38.01 in 2011 to USD 128.59 in 2024. In general, the average values are: 2011: USD 38.01; 2017: USD 60.92 (60.02% relative to 2011); 2021: USD 114.18 (87.3% relative to 2017); and 2024: USD 128.59 (12.6% relative to 2021).

Growth is faster in the period between 2017 and 2021, while the slowest growth occurs between 2021 and 2024 (Figure 6). Although there is a general growth trend across all sectors analyzed, the percentage of variation in value increase differs, dividing the territory into three trends: the first and most significant is the increase in the parish of Puembo, which, over the entire analysis period, has increased in value by an average of 493%; the second includes the parishes of Tumbaco and Cumbayá, which have increased land value by an average of more than 200%; and finally, the parishes of Pifo and Tababela, whose average is greater than 100%. This is shown in the following Table 5.

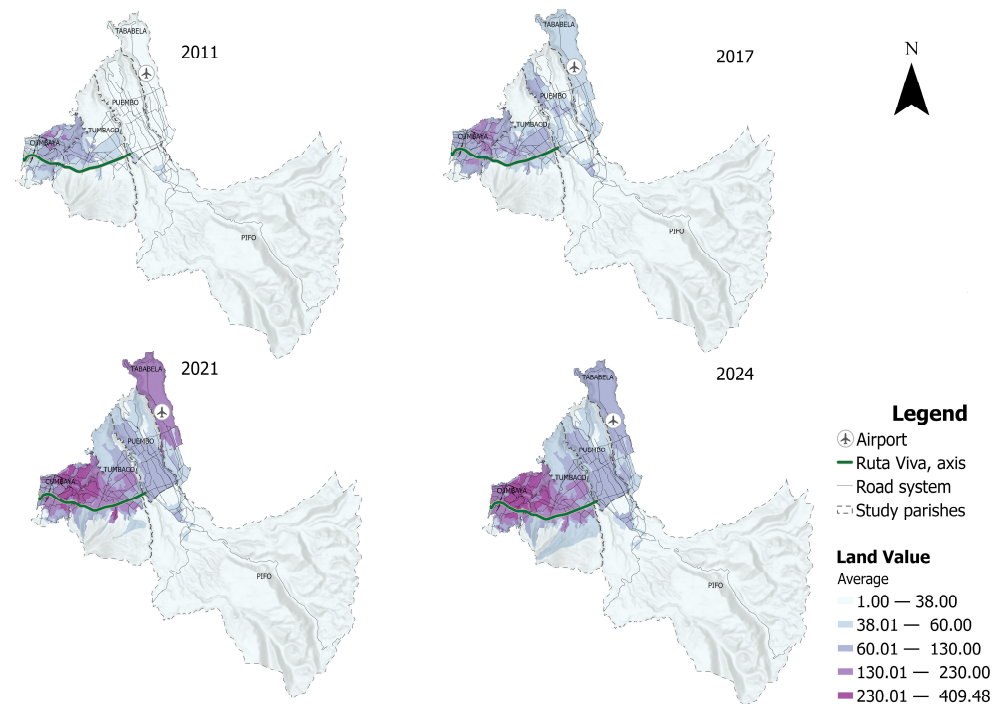


Figure 6. Land value in 2011, 2017, 2021, and 2024.

Table 5. Variation in Land Value in Cumbayá, Tumbaco, Puembo, Tababela, and Pifo.

Administrative Parish	2017–2011	2021–2017	2024–2021	2024–2011
Cumbayá	52.9	68.8	24.1	220.3
Pifo	46.4	31.7	11.5	115.1
Puembo	204.9	81.7	7	493.2
Tababela	87.5	40.7	−0.6	162.2
Tumbaco	49.6	121.2	5.5	249.2

4.5. Results of Variable Analysis by Year

For 2011, the exploratory analysis showed significant correlations between population density and the COS (65%) and between implemented urban development and building permits (73%). Two principal components were extracted, explaining 85% of the total variance. PC1, which explains 63.7% of the variance, grouped the COS, implemented urban development, and building permits, evidencing the formal consolidation of the urban fabric. By contrast, PC2, with 21.5% of the variance, shows population density with a high positive loading and high negative loadings for implemented urban development and building permits, associated with areas of unregulated population growth.

In 2017, similar correlations were observed: population density and the COS at 66% and implemented urban development and building permits at 52%. In this case, the two principal components explained 82% of the cumulative variance. PC1 (64.8%) represented institutionalized territorial management, integrating mainly building permits and the COS. PC2 (17.9%) reflected dynamics in which implemented urban development had a positive weight but population density had a negative loading, indicating areas with low regulation in the face of population growth.

For 2021, the correlations remained consistent: population density and the COS at 67% and implemented urban development and building permits at 75%. The two principal components explained 87% of the total variance. PC1 (62.8%) grouped building permits and the COS, representing formal structuring. PC2 (24.2%) showed the predominance

of population density with negative loadings for implemented urban development and building permits, indicating the persistence of spontaneous, unregulated growth.

In 2024, the correlations continued to be stable: population density and the COS at 67% and implemented urban development and building permits at 74%, with a determinant of 0.167. This value indicates acceptable multicollinearity and an invertible correlation matrix, consistent with suitable PCA conditions; while KMO/Bartlett statistics are not reported here, year-specific diagnostic checks were adequate. The two principal components explained 87% of the variance. PC1 (62.4%) reflected dynamics associated with regulation and territorial planning (implemented urban development, building permits, and the COS), while PC2 (24.5%) represented demographic pressure and spontaneous growth, with a primary loading on population density in contrast to the regulatory variables.

The following map presents the spatial distribution of the weighted values obtained through PCA for the years 2011, 2017, 2021, and 2024 (Figure 7). This representation identifies territorial changes in the rural parishes of the DMQ because of the implementation of the Ruta Viva road project. Darker shades indicate sectors with a higher concentration of variables associated with processes of urban consolidation, regulatory frameworks, and demographic pressure, while lighter areas reflect a lower intensity of these dynamics. This multitemporal visualization enables an integrated and synthetic comparison of the evolution of territorial impact.

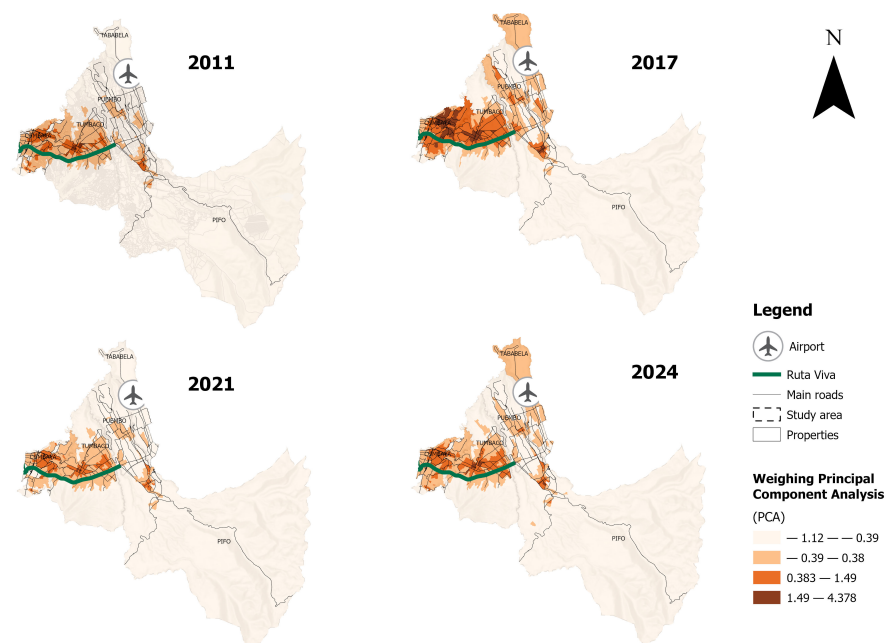


Figure 7. PCA Results, 2011–2024.

The temporal evolution of the weighted values derived from PCA, between 2011 and 2024, is presented in Figure 8. This graph illustrates the dynamics of territorial transformation for each parish under study, allowing the identification of trends and differences in impact levels resulting from the implementation of the Ruta Viva road project and the corresponding urban planning policies.

From this analysis, it is observed that the parish of Cumbayá consistently leads the weighted contribution, although it decreases over time, while Tumbaco and Pifo gain relative importance in the period analyzed. Additionally, a Sankey scheme was produced, presenting the weighted flows among the parishes of Tumbaco, Cumbayá, Puelo, Pifo, and Tababela from 2011 to 2024 (Figure 9). Each line represents a weighted flow obtained from the PCA, and the color of each line corresponds to the parish of origin.

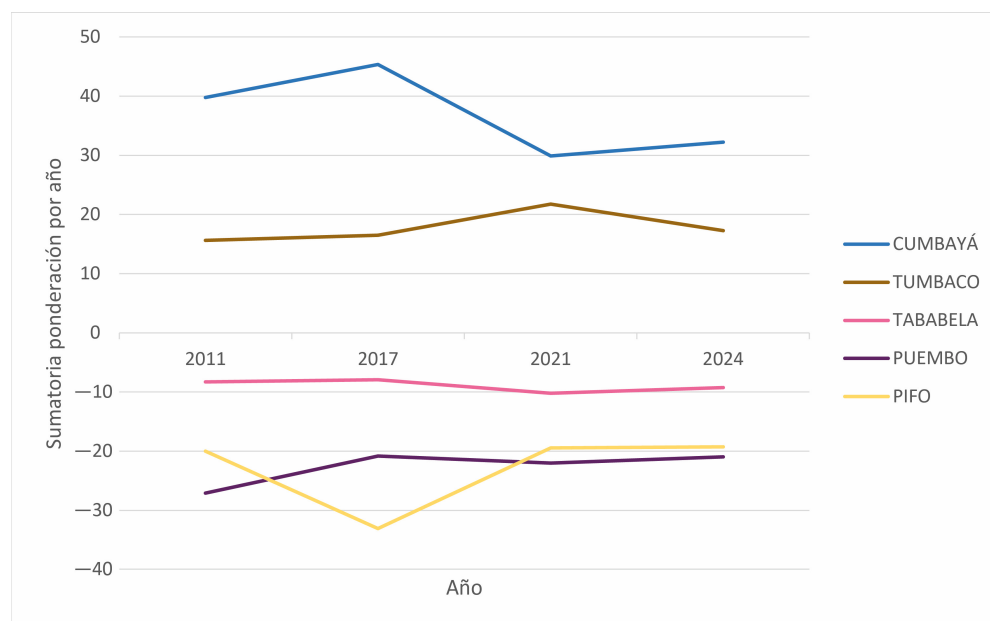


Figure 8. Evolution of the weighted value by parish.

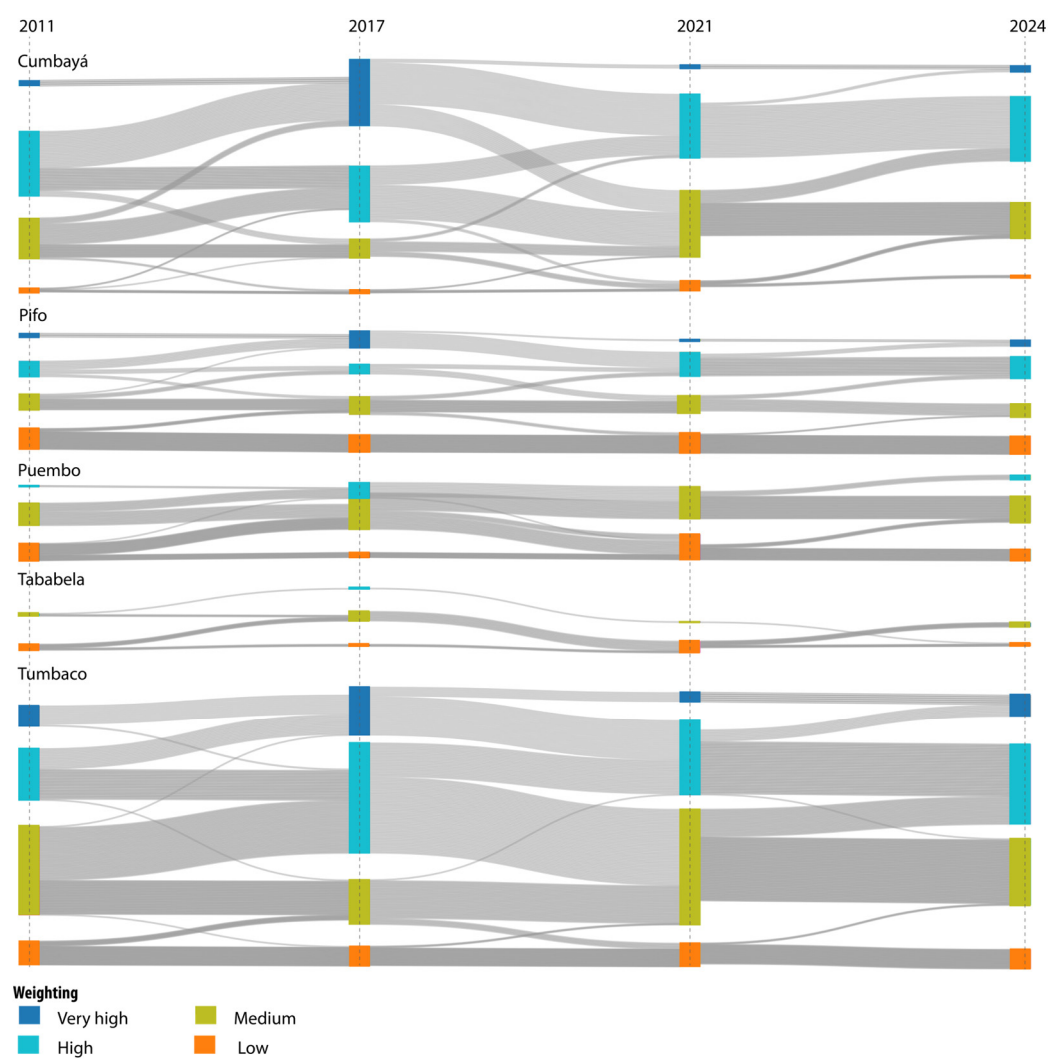


Figure 9. Sankey diagram of the evolution of weighted territorial impact levels by parish (2011–2024).

The graph illustrates the temporal dynamics of territorial impact categories (Very High, High, Medium, and Low) for the parishes of Pifo, Puembo, Cumbayá, Tababela, and Tumbaco between 2011 and 2024. Each flow represents the percentage transition of census tracts within each category between consecutive periods, highlighting stability or change in the intensity of territorial impact associated with the implementation of the Ruta Viva road project and related urban planning policies.

It is observed that certain parishes maintain relatively stable levels of impact, while others show significant transitions toward higher or lower categories, reflecting heterogeneity in territorial responses to dynamics of urbanization, regulation, and demographic pressure. This visualization makes it possible to identify spatial and temporal patterns relevant to territorial planning and management in contexts of accelerated metropolitan transformation.

4.6. Comparison of the Initial and Final Principal Components in Relation to Territorial Behavior According to the Territorial Impact Index

The application of the territorial impact ponderation, designed from the principal components method and categorized into values of decline (−1), stability (0), and increase (1 and 2), makes it possible to identify differentiated patterns of territorial transformation in the parishes analyzed (Figure 10). Here, categories 1 and 2 denote an increase of one or two-or-more classes, respectively, relative to the Jenks-based classification between 2011 and 2024. The analysis covers a total area of 39,794.47 hectares distributed among the parishes of Cumbayá, Tumbaco, Puembo, Pifo, and Tababela. The parish of Pifo, with 25,431.58 hectares, represents the largest territorial extension of the group. Nevertheless, 99.7% of its area (25,344.83 ha) remains under conditions of stability, while areas with increases (categories 1 and 2) barely reach 45.81 ha, indicating a localized and low-intensity impact. Decline, in turn, occurs in 40.93 ha, equivalent to 0.16% of the parish total.

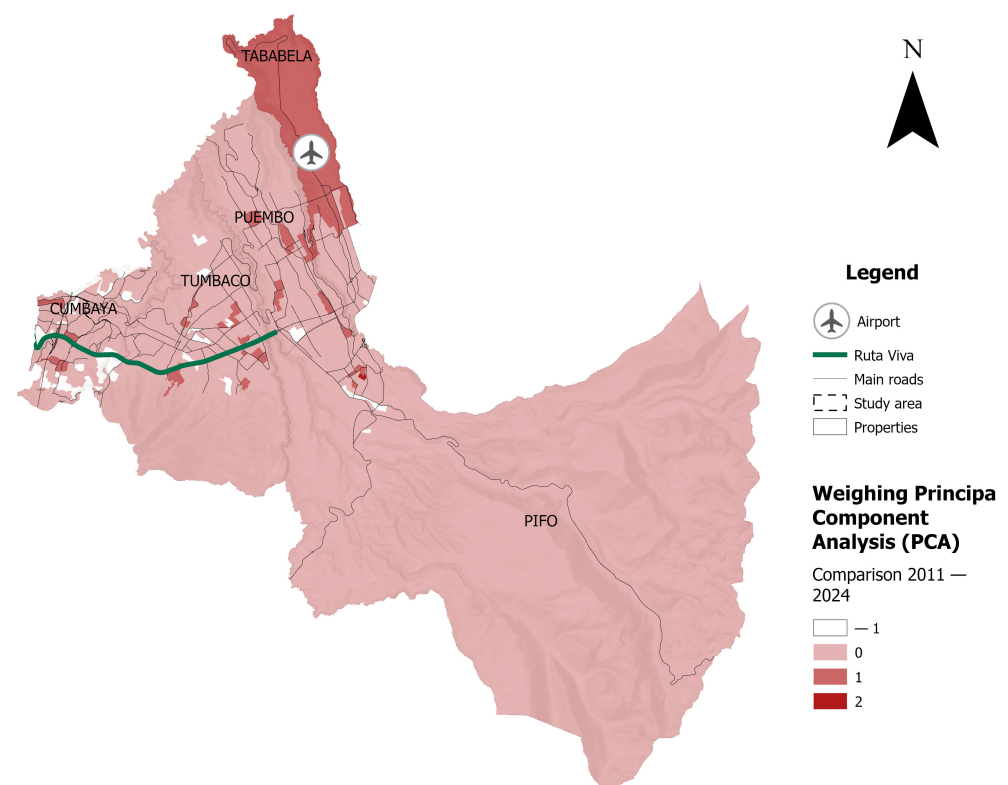


Figure 10. Comparative map of the initial and final principal components in relation to territorial behavior according to the territorial impact index.

In Tumbaco, which has a total area of 6553.63 ha, stability likewise predominates, with 6257.02 ha (95.5%). However, a moderate increase is observed in 158.76 ha (2.4%) and a territorial reduction in 137.85 ha (2.1%), suggesting mixed dynamics of expansion and contraction, possibly linked to the process of urban consolidation and real estate pressure in strategic sectors. Cumbayá, with 2097.26 ha, presents a more contrasting configuration. Although 80.6% of its area (1690.37 ha) remains stable, a significant percentage of decline is identified (327.78 ha, equivalent to 15.6%), and there is a moderate increase of 79.11 ha (3.77%). This behavior reflects a territory in transition, with areas of urban consolidation, regulatory constraints, or loss of previous uses in the face of new territorial dynamics.

In the case of Puembo, whose area amounts to 3174.38 ha, territorial stability predominates with 2958.98 ha (93.2%), although the increase is evident in 186.11 ha (5.9%), one of the highest proportions among the parishes studied. This suggests territorial expansion in specific areas, probably linked to new urban developments and changes in land value. Finally, the parish of Tababela constitutes the most representative case of positive transformation. Of its 2537.62 ha, a total of 1935.24 ha (76.2%) shows increases, evidencing a profound territorial change, probably associated with its role as an air and land connectivity node. Only 598.19 ha (23.6%) remain stable, while decline is marginal, with just 4.19 ha.

At an aggregate level, it is concluded that although most of the territory evaluated remains under conditions of stability (more than 95% of the total); the areas with increases concentrate the most relevant processes of territorial transformation linked to the commissioning of Ruta Viva. These processes appear heterogeneously among parishes, with Tababela and Puembo standing out as the most dynamic in terms of growth, while Cumbayá reflects sectors in functional contraction or with lower urban development potential.

5. Discussion

Overall, the results depict an uneven pattern of infrastructure-induced change across the northeastern parishes. COS trajectories (Table 2), permit dynamics (Table 3), density shifts (Table 4/Figure 5), and land value appreciation (Table 5/Figure 6) converge on a common gradient: stronger consolidation and market pressure in Cumbayá–Tumbaco versus more selective or delayed changes in Pifo–Tababela–Puembo.

We interpret these impacts as differentiated processes of urbanization, land value appreciation, and densification, with regulatory and land-management implications conditioned by parish type, preexisting conditions, and relative location.

5.1. Imbalance in Implemented Urban Development

Implemented urban development through regulatory instruments, measured by total COS, shows an uneven territorial pattern across the five parishes studied. As summarized in Table 2, Pifo shows the largest cumulative increase (2011–2024: +5.16%), Cumbayá and Puembo grow moderately (+2.56%, +2.50%), Tababela nets +0.55% after sharp swings, and Tumbaco declines (−4.87%). The 2017 drop aligns with the regulatory shift introduced by PUOS/ZC and is followed by a partial recovery. The commissioning of Ruta Viva generated a favorable environment for intensive urbanization in certain areas, particularly those with flexible regulations and high real estate pressure.

The data show that Cumbayá and Puembo maintained positive and sustained growth in their land occupation index, reflecting planned urban consolidation processes. By contrast, the parish of Tababela exhibits sharp swings in its indicators, alternating peaks of occupation with abrupt declines, possibly associated with planning conditioned by the presence of the airport and the intended logistics uses. Tumbaco, meanwhile, records a net reduction in the COS, which can be interpreted as the result of more restrictive regulation or a redistribution of urban pressure toward neighboring parishes.

These patterns can be understood as evidence of conflictive embeddedness, in which planning instruments interact contradictorily with speculative practices in the real estate market. Instead of controlling growth, regulation generates opportunities for uneven urbanization, deepening the tension between formal regulations and the dynamics of private land appropriation.

In studies conducted in the Buenos Aires Metropolitan Area, Hilda M. Herzer [36] warns that road infrastructure promotes fragmented urban expansion driven by real estate interests rather than comprehensive planning criteria, generating patterns of land use imbalance like those observed in Cumbayá and Tababela.

5.2. Uneven Increase in the Issuance of Building Permits (Metropolitan Licenses)

The number of building permits (metropolitan licenses) granted shows uneven growth across the parishes studied. While Cumbayá and Tumbaco concentrated most licenses in all the periods analyzed, parishes such as Pifo and Tababela maintained muted figures. Note that permit counts are not normalized by population, housing stock, or area; differences therefore combine regulatory, market, and scale effects. This pattern suggests territorial segmentation in construction activity, influenced by factors such as direct accessibility to Ruta Viva, the urban planning regulations in force, and real estate market demand.

In 2017, a significant peak in license issuance was observed, possibly associated with a period of regulatory transition and market expectations. However, this behavior stabilized in subsequent years, with a slight recovery in 2024. The analysis also shows that parishes with higher COS allocations do not necessarily concentrate on more licenses, indicating the need to review the relationships between regulation and territorial practice.

To address this concentration and promote more balanced development, parish-differentiated instruments are advisable—for example, streamlined approvals in low-dynamism tracts and inclusionary requirements or linkage fees in hot spots—while accounting for each parish's carrying capacity, land-use vocation, and service needs. In addition, a system of incentives and compensation should be established to encourage building in areas with lower dynamism, avoiding overload in the most consolidated areas.

Smolka [37] documents how public investments in infrastructure, without adequate redistribution mechanisms, generate disproportionate increases in land value, benefiting mainly areas with better connectivity, as occurred in Barra da Tijuca, Rio de Janeiro.

5.3. Population Density and New Centralities

Population density in the study area increased by 46% between 2010 and 2024, with Cumbayá concentrating most of this growth, at more than 20 inhabitants per hectare in 2024. Tumbaco also showed relevant densification, although of lesser magnitude. This growth is directly related to the improvement in accessibility generated by Ruta Viva and the progressive transformation of these parishes into new metropolitan centralities.

Likewise, the results show that accelerated demographic growth in parishes such as Cumbayá has generated increasing pressure on existing infrastructure, particularly on the local road system. With more than 42,000 inhabitants in 2024 and a density above 20 inhabitants per hectare, this parish is consolidating into an emerging centrality and accounts for 25.2% of the study area's population (Table 4), although without a proportional expansion of facilities, services, or urban carrying capacity.

This situation has led to incipient conditions of territorial saturation, where the concentration of intensive residential, commercial, and educational uses—without comprehensive spatial planning—reflects a model of occupation that tends toward functional fragmentation, automobile dependence, and overloading of road infrastructure. Incorporating river corridor social value mapping can help prioritize place-based mitigation in saturated

areas [38]. In this context, incorporating passive climatic strategies into public-realm design is pertinent for Ecuadorian cities [14].

This phenomenon falls within a pattern of unequal urbanization documented by Dureau et al. [39], who argue that metropolitanization processes driven by improvements in connectivity tend to generate new centralities without sufficient urban support, deepening gaps in access to services and facilities. In a similar vein, Monkkonen [40] warns that infrastructure and financing systems disconnected from territorial planning can induce discontinuous growth models, with densified areas lacking functional integration and other low-density zones remaining on the margins of the urbanization process.

By contrast, parishes such as Pifo and Tababela maintain very low densities—below 1.6 and 0.92 inhab/ha, respectively—evidencing an unequal effect of the road infrastructure and uneven territorial consolidation. These results reflect a pattern of selective urbanization, where certain territories become development poles while others lag in their integration into the metropolitan fabric.

Planning should address this asymmetry by integrating growth containment policies, adaptive zoning mechanisms, and the strategic provision of services in low-density areas, to avoid processes of dispersed, inefficient, and environmentally unsustainable urban expansion.

5.4. Variation in Land Value

The Ruta Viva has had a significant impact on land valorization. Between 2011 and 2024, the average value in the analyzed parishes tripled, with increases of 220.3% in Cum-bayá, 249.2% in Tumbaco, and up to 493.2% in Puembo. This phenomenon confirms that road infrastructure functions as a catalyst for processes of accumulation by dispossession, as proposed by Harvey [13], while simultaneously raising barriers to housing access and limiting the permanence of lower-income populations. If not managed through mechanisms of value capture and the equitable provision of public space, these effects tend to exacerbate territorial inequality and social segregation.

The analysis shows that the most rapid growth occurred between 2017 and 2021, coinciding with the boom in the construction of new urban developments and the strengthening of the real estate market. However, between 2021 and 2024, the rate of land value appreciation slowed, which could indicate a market maturation phase or a response to new urban planning regulations.

This dynamic aligns with Harvey's notion of accumulation by dispossession [13], insofar as public infrastructure facilitates the private appropriation of surplus value to the detriment of rural uses and local populations. However, it also opens the possibility for governance responses that mitigate these effects, such as land value capture mechanisms or redistributive instruments that redirect part of these gains toward public investment and equitable access to urban space.

The strong land value appreciation poses challenges for public territorial management, especially regarding equitable access to housing and the prevention of the displacement of rural populations. In this regard, it is recommended to implement land value capture instruments and land market regulation, aimed at ensuring that the benefits of road development can be redistributed more equitably across the territory.

Accelerated land valorization is a recurrent pattern in Latin America. In the case of São Paulo, Fix [41] analyzed how urban operations—conceived as public–private partnership instruments—have induced intensive processes of land valorization in strategic areas. Through strategic public investment in infrastructure, particularly the opening of new avenues and the installation of structuring facilities that act as attractors, accelerated land valorization processes have been fostered, encouraging real estate speculation, promoting

the displacement of lower-income populations, and concentrating capital in areas with high commercial value.

5.5. Integrated Analysis and Comparative Frameworks

The research reveals that DMQ faces significant challenges in the equitable distribution of territorial components. The territorial transformations induced by Ruta Viva show a strong asymmetry in the redistribution of urban development potential, access to building permits (metropolitan licenses), population densification, and land valorization. These imbalances affect rural and peripheral parishes more acutely, generating increasing long-distance commuting dependence to access basic services and employment opportunities, which directly affects the quality of life of their inhabitants [4].

These dynamics reflect the structural tensions described by Falú and Marengo [42], who warn that urban policies in Latin America often move among contradictory objectives, such as economic growth, urban competitiveness, and social equity. Without a coherent and articulated territorial vision, urban interventions tend to reinforce spatial and functional inequalities, producing fragmented and inequitable territories. Recent regional evidence using survey-based indicators also underscores the value of integrating sustainability perceptions into territorial policy design [9].

In this context, it is pertinent to draw on the literature on contested urban commons, which documents how local communities deploy civic practices of defense, negotiation, and reappropriation of space in the face of speculative urbanization. These responses, although heterogeneous, constitute a counterweight to accumulation logics and make visible alternative forms of territorial governance based on cooperation and the collective use of urban resources.

By contrast, international experiences have shown that it is possible to reverse these processes through integrated planning models. Complementary approaches to participatory river governance and citizen science can help align environmental management with community priorities in peri-urban corridors [10], see also the evaluation and mapping of social values in urban river ecosystems [38]. Rodríguez et al. [43] highlight the potential of transit-oriented development (TOD) as a strategy to promote more equitable, compact, and efficient cities. This approach links urban expansion with sustainable mobility systems and rational land management, strengthening peripheral centralities and reducing the need for long journeys.

Comparatively, international cities have implemented comprehensive strategies to manage the territorial effects derived from large infrastructures, offering lessons that can be adapted to the context of the Metropolitan District of Quito. The case of Curitiba (Brazil) is especially relevant, as it structured its urban growth along trunk road corridors, articulating public transport with planned land uses, which made it possible to contain dispersed expansion and promote well-equipped peripheral centralities. This model could be replicated in the northeastern DMQ by articulating Ruta Viva with strategies of regulated densification and provision of public services.

For its part, Medellín (Colombia) has demonstrated how the integration of transport infrastructure with land management instruments—such as partial plans and valorization—can transform historically marginalized areas, combining public investment with effective regulation. In Quito, this would be applicable through value capture mechanisms in parishes such as Puembo and Tababela, where the increase in land value has not been accompanied by equitable development.

In addition, cities such as Barcelona (Spain) have implemented strategies to decentralize services through “superblocks” and proximity zones, reducing the need for travel and balancing the distribution of urban facilities. This approach could be consid-

ered in the rural parishes of the DMQ to avoid the concentration of services in a few centralities and to strengthen local provision networks. Moreover, socio-cultural valuation of urbanized fluvial landscapes and their ecosystem services can inform resilient, place-based interventions [11,38,44].

On a broader scale, the European experience provides methodologies that can enrich territorial management in Quito. The European Union's Mapping and Assessment of Ecosystems and their Services (MAES) initiative has become a benchmark for integrating ecosystem assessments into land-use planning, enabling the mapping of environmental services at different scales and providing regulatory support for protecting strategic areas and managing territories under urban pressure [45]. Likewise, studies on green infrastructure in Madrid have shown how the planning of ecological corridors, urban green spaces, and buffer zones contributes to climate resilience and to a more equitable distribution of environmental benefits in metropolitan contexts [46]. In the case of Quito, where the Ruta Viva has been primarily associated with agricultural land transformation and real estate valorization, frameworks such as MAES could serve as a basis for justifying the protection of rural lands and conservation areas, complementing the urban-territorial approach with criteria of sustainability and socio-ecological resilience [47].

Finally, Vancouver (Canada) offers a successful example of land market regulation and coordinated metropolitan planning, which could be replicated in Quito through inter-institutional management that aligns land use, transport, and urban development financing policies.

The results show that the Ruta Viva has not generated a homogeneous pattern of transformation, but rather heterogeneous territorial dynamics: real estate consolidation in Cumbayá–Tumbaco, speculative processes in Puembo, relative stability in Pifo, and a logistical positioning in Tababela. These differences can be understood through the lens of critical geography. The accelerated land valorization and real estate pressure in Puembo reflect what Harvey [13] terms accumulation by dispossession, as infrastructure enables selective capture of urban rents. The coexistence of densified areas and territories that remain stable or marginalized, as in Pifo, aligns with Caldeira's notion of fragmented urbanization [18]. At the same time, the strengthening of Tababela as a logistics hub illustrates what Le Galès [48] describes as fragmented governance, characterized by discontinuous and reactive state interventions that consolidate strategic centralities without balanced planning. Taken together, these processes confirm Lefebvre's thesis [7] on the unequal production of space, in which road infrastructures operate as devices that reconfigure metropolitan hierarchies and deepen territorial inequalities.

These international experiences reinforce the need for Ruta Viva to be conceived not only as road infrastructure, but as the structuring axis of a comprehensive territorial strategy. This should articulate land-use planning instruments, mobility, housing, and services, with a focus on territorial equity. Operationally, aligning PMDOT 2021–2033, PUGS, and Ordinance PMDOT-PUGS No. 003-2024 with targeted value capture and inclusionary tools would help distribute benefits and mitigate displacement risks in high-pressure corridors. Only through coherent, cross-sectoral urban policies sensitive to local dynamics will it be possible to move toward a less fragmented, more cohesive, and resilient city.

In this context, it is pertinent to highlight that regulatory and market incentives—although not the specific focus of this research—constitute underlying factors in the differences observed among parishes. Their incorporation in future studies would allow for a deeper understanding of how these dynamics influence the unequal valorization of land and the distribution of urban benefits. Likewise, their analysis represents a necessary step toward linking the empirical findings with the design of territorial planning policies and with regulatory mechanisms for the real estate market.

6. Conclusions

The evidence indicates a shift from a context of regulatory vacuum and uncontrolled expansion (2011) toward a regulated and more structured urban consolidation model (2024). The formalization and subsequent elimination of ZC, together with the implementation of the Land Use and Management Plan (PUGS), were instrumental in establishing a more robust planning framework.

COS trajectories show a marked 2017 adjustment consistent with the regulatory shift, followed by recovery in 2021–2024. Permit dynamics—peaking in 2017, dipping in 2021, and recovering in 2024—suggest the direct influence of regulatory cycles on construction activity: Tumbaco concentrates the highest number of building permits (metropolitan licenses), Puembo rebounds after an interim decline, and Pifo/Tababela remain at lower levels under more restrictive regimes. Land value increased substantially between 2011 and 2024, with the strongest appreciation in Cumbayá and Puembo, reflecting heterogeneous market pressures across the corridor.

Spatial results based on the territorial impact index indicate that Cumbayá concentrates a large share of high and very-high impact tracts; Tumbaco shows a transitional pattern with active development; and Pifo, Puembo, and Tababela exhibit lower transformation under restrictive regulation and low density. Overall stabilization in permits and land value points to a market moving toward more efficient land use and stewardship.

These results suggest that clear, adaptive regulation helps realign legal frameworks, market dynamics, and existing infrastructure, guiding growth toward a more structured, sustainable, and efficient model that accounts for demographic pressure and institutional enforcement capacity. Policy-wise, consolidating alignment among PMDOT 2021–2033, PUGS, and Ordinance PMDOT-PUGS No. 003-2024, and complementing them with value capture and inclusionary instruments, would help distribute benefits and mitigate displacement risks in high-pressure areas.

Limitations and future work. First, permit counts are not normalized by population, housing stock, or tract area; future analyses should report rate-based indicators. Second, the temporal cadence of AIVA updates may smooth within-period price dynamics. Third, potential endogeneity between airport access and the Ruta Viva corridor warrants quasi-experimental designs building on our index (e.g., staggered DID and synthetic controls). These steps would sharpen attribution while preserving the census tract granularity that distinguishes this study.

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Abbreviations

PCA	Principal component analysis
COS	Coeficiente de Ocupación del Suelo; building coverage ratio (BCR)
PC1	Principal Component 1
PC2	Principal Component 2
DMQ	Distrito Metropolitano de Quito; Metropolitan District of Quito
IGM	Instituto Geográfico Militar; Military Geographic Institute
INEC	Instituto Nacional de Estadísticas y Censos; National Institute of Statistics and Censuses
PMDOT	Plan Metropolitano de Desarrollo y Ordenamiento Territorial; Metropolitan Development and Land-Use Plan
PUGS	Plan de Uso y Gestión del Suelo; Land Use and Management Plan
PUOS	Plan de Uso y Ocupación del Suelo; Land Use and Occupation Plan
AIVA	Área de Intervención Valorativa; Land Valuation Intervention Areas
GIS	Geographic Information Systems
KDE	Kernel density estimation
ZC	Concertation Zones
SHOT	Secretaría de Hábitat y Ordenamiento Territorial; Secretariat of Habitat and Territorial Planning
LOOTUGS	Ley Orgánica de Ordenamiento Territorial, Uso y Gestión de Suelo; Ley Organic Law of Territorial Planning, Land Use and Management

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