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Article

Jane Jacobs's Criteria for Urban Vitality: A Geospatial Analysis of Morphological Conditions in Quito, Ecuador

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Abstract. Urban vitality, understood as a key factor for the achievement of cities' sustainability, shows a strong relationship with urban morphology. The city theorist Jane Jacobs suggested morphological aspects to promote vital cities already in the 1960s, which remain valid in the present. However, few studies in the Andean region quantitatively exemplify this. This paper aims to test the measurement of urban vitality in a neighborhood of Quito, Ecuador, called La Mariscal, integrating Jacobs' approach. In particular, three urban vitality indexes are evaluated with the application of GIS software using cadastral data obtained from the municipality and field data collection. Results show that the context-based previous knowledge and the scale of analysis are essential factors in the configuration of dimensions, indicators, and spatial representation of any urban vitality index. In the study area land use mixture, contact opportunity, and accessibility dimensions are fundamental. Regarding indicators, the incorporation of the informal small-scale commerce, the quality of sidewalks, the street slope, and the good-conditioned street furniture is recommended. Finally, a hybrid representation (raster and vectorial) is suggested to precisely measure urban vitality at a block scale. Altogether, by providing a comparative approach, we intend to bring a useful framework for researchers and planners to study urban vitality in Andean cities.

Keywords: urban vitality index; urban morphology parameters; comparative approach; Andean region; GIS tools

1. Introduction

Urban vitality is a central topic in 21st-century urban agendas. According to the United Nations (UN), an estimated 60% of the world's population occupied urban areas by 2021, while South American numbers increased to 82% of the total [1]. This urban expansion presents considerable challenges regarding the sustainability of the planet. In this regard, the UN suggested in the year 2016 seventeen Sustainable Development Goals (SDG) to guarantee the human growth viability [2]. The eleventh goal, Sustainable Cities and Communities, highlights the significance of conceiving good places to live, which must include a transversal answer to environmental, economic, and social requirements. Descending this concept to a small urban scale, the perception of a successful neighborhood is related to the idea of self-sufficiency and proximity, having the possibility of close access to food supply (shops, supermarkets), health (hospitals, recreation areas), education (kindergartens, schools, universities), and housing, placing the commodity and quality of life of the inhabitants in the center of the urban discussion [3].

One of the pioneers in the study of urban vitality was the American Canadian city theorist Jane Jacobs (1916-2006). She wrote a highly controversial book in 1961, "The Death and Life of Great American Cities", which remains valid more than sixty years later. In the first chapter, Jacobs pointed out the importance of people's concentration in the achievement of urban vitality. According to this, she presented sidewalks as one of the main elements in the nature of cities. She coined the expression

“eyes on the street”, referring that having people walking around and looking through windows would guarantee street safety, among others [4]. In the second chapter, Jacobs analyzed diversity, relating it primarily to economic and morphologic factors, concluding that the need for primary mixed uses, the need for small blocks, the need for aged buildings, and the need for concentration of people were substantial dimensions to provide urban vitality. In the third and fourth chapters, she highlighted the importance of reducing border vacuums, referring to big urban areas with massive single uses, and having good accessibility as additional complements to motivate people to walk on the streets [4].

Since the 1970s, a significant number of authors have reviewed and interpreted Jacobs’s approach defining several indexes, composed of different dimensions and, at the same time, structured by a sum of indicators: the index of total diversity[5], the primary diversity index [6], the Jacobs’s diversity index [7], the compact city index [8], the Simpson diversity index [9], the Shannon’s index [10], the walkability index[11], the entropy index [12,13], the gravity index [14], the JANE index [15–18], the urban vibrancy index [19], the Morphoindex [20], the urban form index [21], the urban comprehensive vitality index [22], the urban vitality index [23], and Moran’s index of urban vibrancy [24]. Additionally, the total number of publications regarding urban vitality increased by 527% from 2008 to 2018 [25].

Most studies of urban vitality have been developed in Asia, more specifically in China, Shenzhen [26–28], Hong Kong [29], Shanghai [27,30,31], Tianjin [27,32], Chengdu [27,33,34], Wuhan [27] and Qingdao [18,27]; in South Korea, Seoul [7,35–37]; in Singapore, Singapore [20]; in Vietnam, Ho Chi Minh [38], and in Turkey, Kayseri [39]. To a lesser extent, similar investigations have been conducted in North America, more precisely in the United States, with special attention in Seattle and Washington [11], followed by Manhattan [14,40], Portland, Brisbane, Indianapolis, and Chicago [14]. In Australia, Melbourne, and Adelaide [14] have been studied. In Europe, research has taken principally place in England, London [41]; in the Netherlands [42,43]; in Italy, Bologna, Florence, Milan, Palermo, Rome, and Turin [44,45]; and in Spain, Barcelona [15,17]. Finally, in South America, only Santiago, in Chile, has been analyzed [16].

The definition of a clear geographic scale is essential to comprehend urban vitality [35,46]. Investigations have predominantly focus on the metropolitan scale [7,28,36,38,47]. However, some studies pay attention to the district and neighborhood scale. According to this, [17] compares the thirteen neighborhoods that conform the district of Nou Barris in Barcelona, but without descending to the block scale. [48,49] approach the block scale but only examine the accessibility dimension. [18] proposes a decrease in scale, but not exactly defining the conditions per block. The fact of not accentuating the importance of the block scale could lead to a misunderstanding of the closest environment, the belonging space, and the essence of urban vitality [50].

The scale of the study area is directly related to the representation system. Two main spatial representations are used to map urban vitality: the raster-based and the vectorial-based. In most cases, the first one uses a regular raster of squares, which adopts a quantitative gradient of pixel divisions, symbolizing the ponderation of the chosen categories. Moreover, the size of the study area usually determines the pixel area. The smallest ones, around 50x50m, include districts or neighborhoods of study [17,39], while the large ones, from 100x100m up to 250x250m, usually provide the analysis of the whole area of a city [15,16,51,52] or the comparison of various metropolis [20,27,53]. The second representation method uses the administrative boundary of districts or neighborhoods, which commonly coincides with the street layout [11,38,54–56]. Additionally, another interesting way of illustrating urban vitality is mapping continuous lines on the street layout with different gradient colors, leaving the blocks empty [34], using alternative diagrams with different sized and colored circles and linear diagrams based on x and y coordinates [31] and 3D space-time cubes [28].

The review of studies on urban vitality in the last ten years allows us to identify two major research gaps that structure the present research: i) there is a lack of studies on urban vitality at block scale in the Andean region, ii) there is no evidence of the application and comparison of different indexes in a single case study. Regarding the first gap, only one study uses GIS quantification to

measure urban vitality, more specifically in Santiago, Chile [16]. Nevertheless, there is potential practice-oriented research since several initiatives in Argentina and Ecuador examined urban morphology to inform sustainable principles at a neighborhood level, although not directly applying urban vitality indexes [49]. On this subject, it is worth mentioning Salvador Rueda, who carried out several projects in agreement with the Municipality of Quito, in which he developed the Superblocks Study at the Historic Center of the city between 2013 and 2015, promoting private traffic reduction and active mobility [57]. The Llactalab laboratory in Cuenca, Ecuador, developed a GIS tool on urban morphology and sustainability [58]. Additionally, studies do not usually illustrate urban vitality with a morphological characterization and representation of blocks. Nevertheless, this is probably the most appropriate scale of analysis considering the daily component of the movements of the inhabitants within the area. Concerning the second gap, there are no publications, which illustrate the application of more than one index of urban vitality in the same study area, avoiding the possibility of contrasting results.

According to these gaps, the present work aims to provide a comparative approach, by the application of different indexes at a block scale in the same study area, La Mariscal neighborhood, in Quito, Ecuador, replicable in other Andean cities. Objectives are aligned to contrast different dimensions, indicators, and representation proposals. Research questions are: Which criteria can orient the selection of dimensions and indicators for measuring urban vitality? Which representation system is more precise for measuring urban vitality at a block scale? In this sense, we focus on morphological features derived from Jane Jacobs's approach. The remainder of this paper is organized as follows: Section 2 describes Materials and Methods; Section 3 provides the Results, Section 4 discusses the paper's findings, and Section 5 states the conclusion.

2. Materials and Methods

2.1. Study area

La Mariscal neighborhood is located north of the Historic Center of Quito, Ecuador, and was planned in the 1920s and officially baptized in 1922 as "Ciudadela Mariscal Sucre" [59] as an extension to house some of the wealthy families of the capital living in the colonial center. It has a population of 7732 inhabitants [60] in an area of approximately 1.82km² [59] and was initially designed with the typical garden city principle: big villas surrounded by private green spaces. Furthermore, it included a reticular street layout created over 100 years [59], with 163 blocks, where around 50% shows square and rectangular shapes between 80m. and 120m. in length. In the 1940s, a new development of townhouses took place in the northern part of the area, and in the 1970s and 1980s, the construction of high buildings in the main avenues complemented its urban morphology [59]. In the last two decades, a significant number of multi-family housing have been added to the rich morphological panorama. This urban growth process has given rise to a fabric that combines residential uses with a rich variety of amenities within a walking distance. Despite presenting a low population density, the combination of different building typologies in a small-scaled street layout with abundant activities on the ground floor and well-provided of public facilities and services, positions this neighborhood as a good case study to map urban vitality at a block scale.

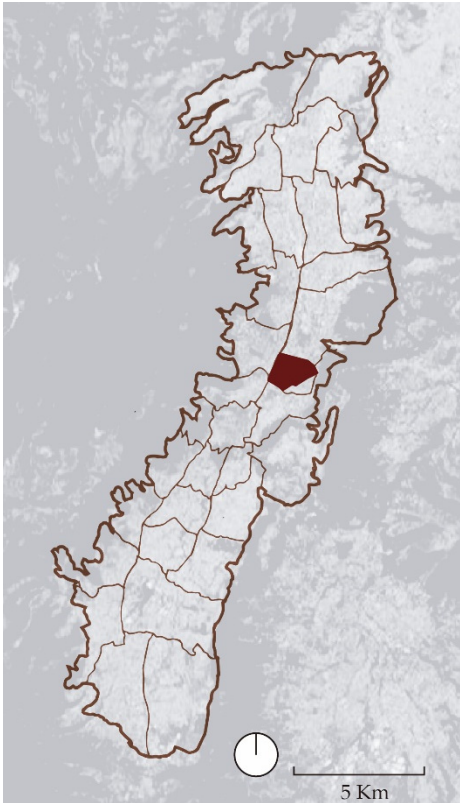


Figure 1. Metropolitan District Quito, la Mariscal neighborhood.

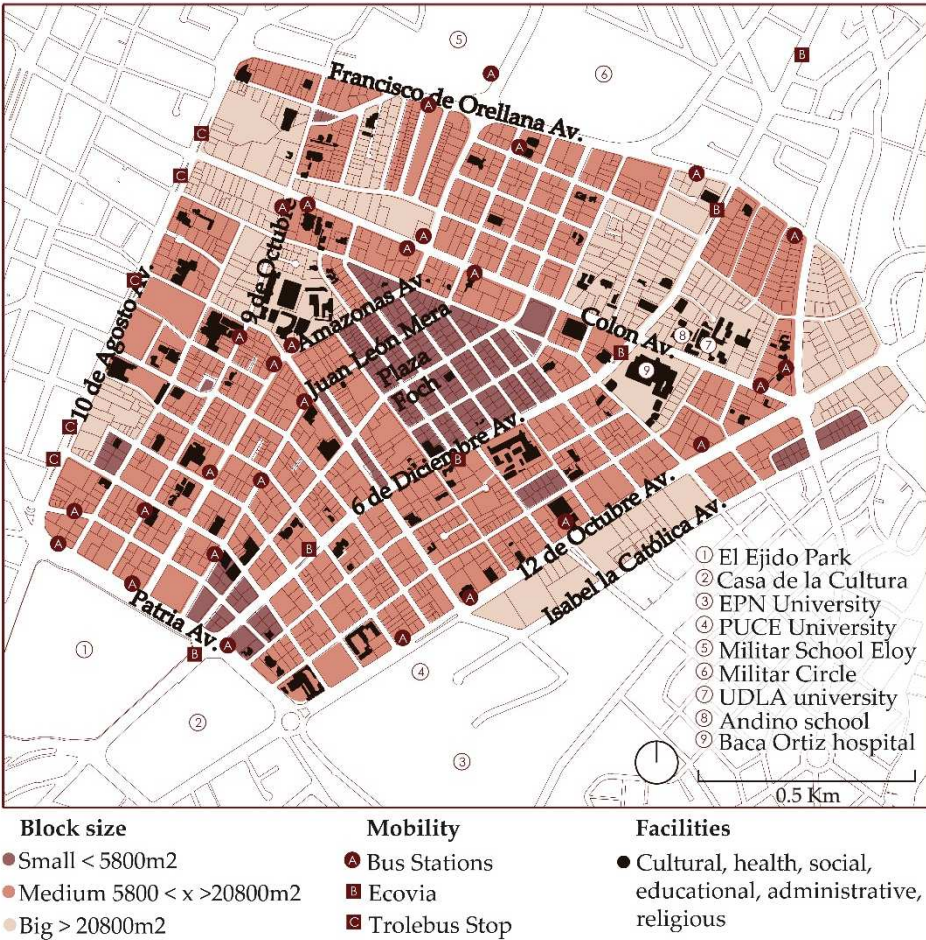


Figure 2. Study area morphological plan.



Figure 3. Dimensions derived from Jane Jacobs in the study area.

2.2. Dimensions derived from Jane Jacobs

In this article, we interpret and adapt six morphological dimensions derived from Jane Jacobs [4], to measure to what degree a contemporary urban area can be considered vital.

1. The **density** dimension derives from “the need for concentration” recommended by Jacobs. Currently, it highlights the relevance of population density combined with the understanding of the built environment shaped by factors such as the density of buildings, commercial activities, and public facilities. In the study area, there is a remarkable presence of housing and commercial density. Nevertheless, the Floor Area Ratio (FAR) could be considerably increased based on the regulations of the municipality.
2. The **land use mixture** dimension derives from “the need for primary mixed uses” recommended by Jacobs. Currently, it emphasizes the significance of land use diversity in attracting a significant number of people. For instance, the presence of kindergartens, schools, restaurants, bars, discotheques, hospitals, and daycare centers, would promote more presence of children, teenagers, youngsters, families, and elderly people, respectively. In the study area, it is ensured as a result of the significant number of schools, universities, health centers, housing, offices, administrative buildings, churches, and commerce present.
3. The **contact opportunity** dimension derives from “the need for small blocks” recommended by Jacobs. She posited that small blocks promote more interaction in the streets than large blocks [4]. Currently, it associates the urban layout and elements such as distance to pocket parks and Wi-Fi spots with the possibility of interaction for walkers. In the study area, it is represented by a heterogeneous reticular urban layout conformed by morphologically different grideal-patterned subsectors, and the presence of pocket parks and Wi-Fi spots.
4. The **aged buildings** dimension derives from the “need for aged buildings” recommended by Jacobs. It underlined the idea that older constructions would be more receptive to locating people with fewer economic resources promoting social diversity. For this paper, since we have only considered morphological parameters, we have associated aged buildings with the original big villas surrounded by generous private green gardens and interpreted them as urban vitality propellers due to their current public use after rehabilitation as heritage buildings.
5. The **accessibility** dimension derives from the “need for accessibility” recommended by Jacobs. Currently, it is related to the importance of having close access to public transport stops, facilitating a good connection with the rest of the city, as well as promoting universal

accessibility. For example, it should facilitate that people in wheelchairs do not present problems if they have to climb a curve, or parents who push a baby cart may not struggle with rough sidewalks. In the study area, it is covered by different public transport stations. Nevertheless, the neighborhood presents limitations regarding universal accessibility because of the inappropriate quality of sidewalks and high street slopes.

6. The **border vacuums** dimension derives from the “absence of border vacuums” recommended by Jacobs. It correlates the idea that massive, gated areas inside the city, usually with one single use, such as railways, highways, or gated residential communities, make continuous walking more complicated, and, therefore, urban vitality decreases. There is a presence of external border vacuums in the external perimeter of the study area.

2.2. Methods

2.2.1. Indexes, calculations, and data sources

This section examines the applied indexes, their dimensions, indicators, formulas, weighting, and data sources (Table 1). In this sense, three indexes have been selected from an exhaustive literature review.

Index 1

Index 1 contains nine indicators to measure the six morphological dimensions derived from Jane Jacobs: density, land use mixture, contact opportunity, aged buildings, accessibility, and border vacuums. Dimensions are weighted with 20% of the total each, except the last two dimensions, weighted with 10% of the total each, following Jacob's theories that the four first dimensions were the most meaningful. The representation is generated by a raster of 50x50m in order to get more detailed information at a block scale. The original index was applied in Barcelona, Spain [15], and in Santiago, Chile [16]. It has been selected because it is the only index of urban vitality tested in the Andean region.

Index 2

Index 2 contains six indicators to measure four dimensions derived from Jane Jacobs: density, land use mixture, contact opportunity, and accessibility. Dimensions are weighted equally, with 25% of the total each, considering the relevance of accessibility in the contemporary reality of cities. The representation is generated by a vectorial block system, which oscillates between 750m² and 45.500m² per block. The original index was applied in Chengdu, China [33]. It has been selected because of the optimization of dimensions and indicators, and the incorporation of a morphological indicator that correlates the regularity and size of blocks (Richardson Compactness Index - RCI).

Index 3

Index 3 contains eighteen indicators to measure the six morphological dimensions derived from Jane Jacobs: density, land use mixture, contact opportunity, aged buildings, accessibility, and border vacuums. Dimensions are weighted with 20% of the total each, except the last two dimensions, weighted with 10% of the total each, like in Index 1. The representation is generated by a raster of 50x50m in order to get more detailed information at a block scale, like in Index 1. The original index was applied in Barcelona, Spain [17]. It has been selected because of the reduction in the scale of application, from the city to the district, and the addition of indicators related to land use mixture, contact opportunity, and accessibility dimensions.

A WGS84 referential system and a universal transversal coordinating system Mercator (UTM) for zone 17S are established [61,62]. Additionally, the study area is masked and indicators are normalized as follows:

$$Z \text{ scores} = (\text{number-average})/\text{standard deviation} [63]$$

Once indicators are normalized, they are processed in the GIS 10.5 software to obtain the results of urban vitality for each index.

Table 1. Dimensions, indicators, formulas, weighting, and data sources of the three applied indexes.

	Index 1			Index 2			Index 3		
Dimensions	Indicators	Ind. score	Dim. score	Indicators	Ind. score	Dim. score	Indicators	Ind. score	Dim. score
Density	Population Density ^a Number of permanent residents / cell area	33%	20%	Floor Area Ratio (FAR) ^b Total built-up area / block area	33%	25%	Population Density ^a Number of permanent residents / cell area	33%	20%
	Housing Density ^a Number of dwellings / cell area	33%		Building Density Index ^b Total floor area in a block / block area	33%		Commercial Density ^c Number of retailers / cell area	33%	
	Building Density ^a Number of buildings / cell area	33%		POI Density Index ^{c, d, e} Number of POIs / block area	33%		Public Facilities Density ^d Number of facilities / cell area	33%	
Land use mixture	Building Use Mix (BUM) Index ^a $-\sum (Pi * \ln (Pi)) / \ln(m)^{-1}$	50%	20%	Entropy ^{c, d, e} $-\sum (Pi * \ln (Pi))^{-1}$	100%	25%	Building Use Mix Indicator ^c $-\sum (Pi * \ln (Pi)) / \ln(m)^{-1}$	25%	20%
	Residential/Non-Residential (RNR) Index ^a $RNR = 1 - (Res-NonRes) / (Res+NonRes) ^{-2}$	50%					Residential/Non-Residential Balance ^a $1 - (Res-NonRes) / (Res+NonRes) ^{-1}$	25%	
							Commercial and Facility Mix ^c $-\sum (Pi * \ln (Pi)) / \ln(m)^{-1}$	25%	
Contact opportunity	Block Size ^a Area of the polygon in ArcMap = Calculate Geometry (Area in Hectares)	50%	20%	Richardson Compactness Index (RCI) ^a $RCI_i = \frac{\sqrt{4\pi A_i}}{C_i}$ (Where Si is the area, Ci is the perimeter of the block)	100%	25%	Distance to intersections ^a Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	30%	20%
							Distance to squares & pocket parks ^a Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	20%	
	Street Width ^a Street area expressed in percentage in 1 cell of 50m x 50m	50%					Distance to public Wi-Fi spots ⁱ Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	5%	
							Benches ^a (1 = presence of Benches, 0 = Absence of Benches)	15%	
							Betweenness ^{b, h} $Betweenness = \frac{RTW^*(i)}{n_{ij}(i) \cdot W(i)}$ $\sum_{j,k \in -i(i)} a(i,j) \cdot a(i,k) \cdot W(j)$ ⁶	30%	
Aged Buildings	Presence of Aged Buildings ^f (1 = presence of Aged Buildings, 0 = Absence of Aged Buildings)	100%	20%	—	—	—	Presence of Aged Buildings ^f (1 = presence of Aged Buildings, 0 = Absence of Aged Buildings)	100%	20%
Accessibility			100%	Rail-transit convenience index (RTI) ⁱ Euclidean Distance (vector) $= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$	100%	10%	Distance (meters) to public transportation ⁱ Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	40%	10%
	Distance (meters) to public transportation ⁱ Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	100%					Street slope ^a (%) $= \frac{\Delta Y}{\Delta X} \cdot 100 = \frac{y_2 - y_1}{x_2 - x_1} \cdot 100$	20%	
							Street lighting ⁱ Number of streetlights / Cell	20%	
							Presence of 30 km/h areas ^c (Maximum vehicular speed) (1 = presence of 30A, 0 = Absence of 30A)	10%	
							Distance to pedestrian crossings ⁱ Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	10%	
Border vacuums	Distance (meters) from BV (exclude large parks) ^{a, s} Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	100%	10%	—	—	—	Distance (meters) from BV (exclude large parks) ^{a, s} Euclidean distance (raster) $= \text{Max}(x_2 - x_1 , y_2 - y_1)$	100%	10%

Data Sources:

a. Data and cartography of the VII Population and VI Housing Census 2010 at the census block level. Source: Instituto Nacional de Estadística y Censos (INEC).

b. Cartography of Buildings, 2019. Source: Municipio del Distrito Metropolitano de Quito.

c. Cartography of the Metropolitan Licenses for the Economic Activities Exercise – LUAEs, 2019. Source: Municipality of the Metropolitan District of Quito.

d. Cartography on centers for senior citizens, daycare centers, schools, colleges, etc, 2019. Source: Municipio del Distrito Metropolitano de Quito.

e. Field data collection: on-site direct observation, 2022. Source: Authors’ elaboration.

f. List of heritage buildings, 2017. Source: Secretaría de Territorio Hábitat y Vivienda, Municipio del Distrito Metropolitano de Quito.

g. Cartography of Parks, 2019. Source: Municipio del Distrito Metropolitano de Quito.

h. Road map, 2019. Source: Municipio del Distrito Metropolitano de Quito.

i. Cartography of access to public Wi-Fi stations, 2019. Source: Municipio del Distrito Metropolitano de Quito.

j. Cartography of Bus Stops, Ecovía, and Trolleybus Stations, 2019. Source: Municipio del Distrito Metropolitano de Quito.

k. Terrain elevation model, 2019. Source: Municipio del Distrito Metropolitano de Quito.

l. Open Street Maps cartography of street lighting and crosswalks, 2022.

Additional information:

1. Pi is the proportion of land use I in a 50x50m cell and where m is the number of existing land uses in the study area. When calculating this index, it must be considered that the mathematical indeterminacies derived from the calculation were replaced by values of zero. The categories for this indicator are: 1) parking lot, 2) commercial, 3) office, 4) residential, 5) abandoned lot, 6) restaurant, 7) hotel, 8) empty lot, 9) educational facility, 10) administrative facility, 11) religious facility, 12) under construction, 13) security facility, 14) bar/discotheque, 15) health facility, 16) plaza, 17) gas station, 18) garage, 19) cultural facility and 21) park.

2. The indicator evaluates the coexistence of residential and non-residential land uses in a 50 m x 50 m cell. The indicator takes values between 0 and 1. Res_i is the proportion of exclusively residential uses and $NonRes_i$ is the proportion of non-residential uses. The indicator uses the categories of the previous item.
3. Where P_i is the proportion of category i of POIs in a block: The categories are: 1) Retail and wholesale, 2) Scenic sites, 3) Government and organization, 4) Sports and cultural, 5) Financial and insurance, 6) Textile and food, 7) Restaurants, 8) Companies and enterprises, 9) Residential, 10) Transportation, 11) Public Facilities, 12) Hotel and recreation, 13) Medical and healthcare, 14) Research and education.
4. Where P_i is the proportion of a business category i in a 50 m x 50 m cell and where m is the total number of business categories existing in the study area.
5. The indicator evaluates the coexistence of pixels with basic (supermarkets, bakeries, etc.) and non-basic (cultural centers, museums, etc.) urban elements in a 50 m x 50 m cell. The indicator takes values between 0 and 1.
6. The betweenness centrality of a building i is defined as the number of times that building i is located along the shortest path between all pairs of other buildings within a specified radius r . Thus, n_{jk} refers to the number of shortest routes from a building j to a building k within a radius r . On the other hand, $n_{jk} [i]$, describes a subselection of routes passing close to building i . $W [j]$, refers to the weight of each building and its relation to the population.

3. Results

The three existing indexes have been tested in the study area. Results on the applied dimensions and indicators are described, and a comparison between the three final maps of urban vitality is provided. The red color shows a more positive connection between urban morphology and urban vitality regarding Jane Jacobs' approach, while the navy-blue color represents the opposite (Figure 4).

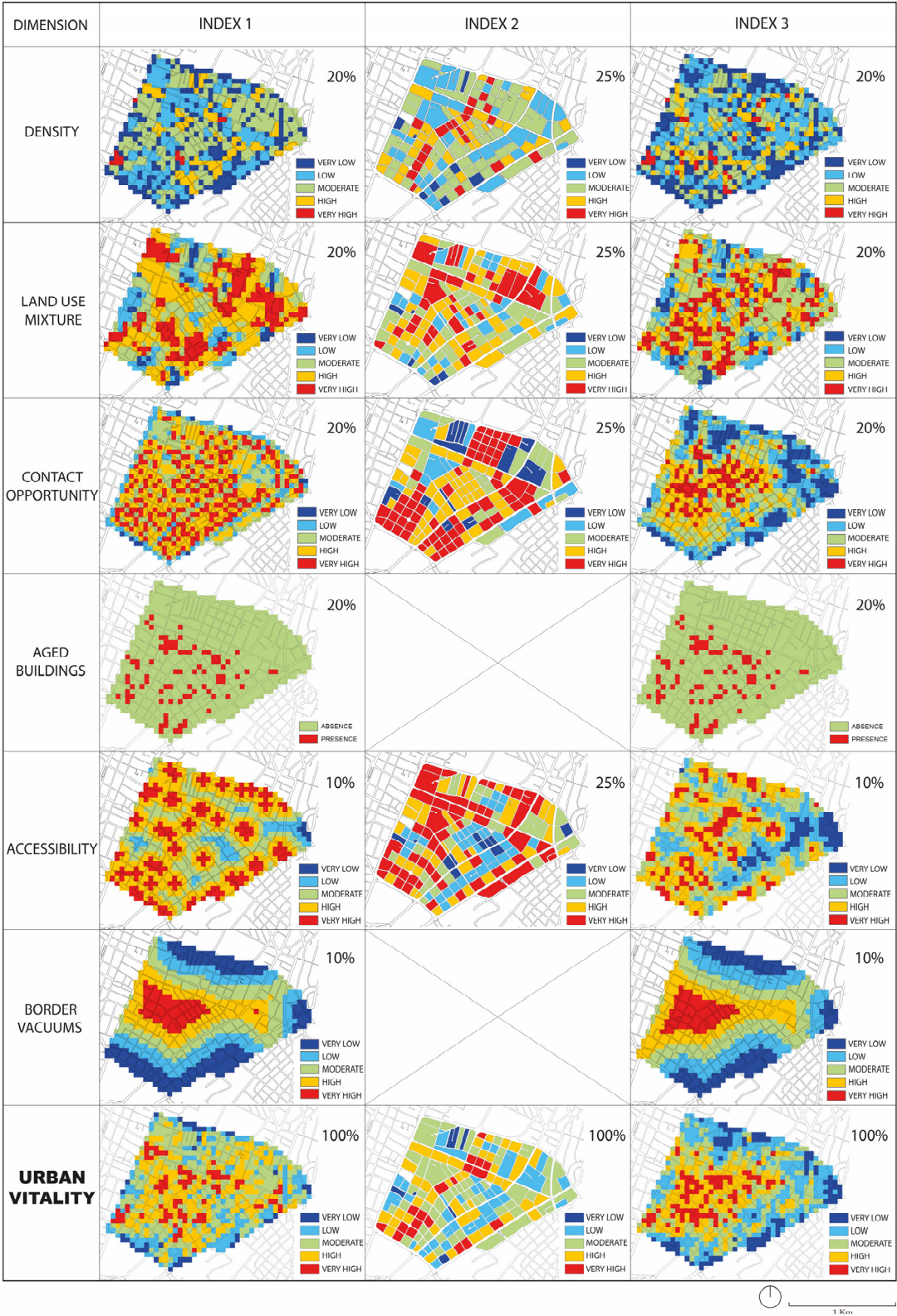


Figure 4. Maps per dimension and final maps of urban vitality of the three indexes applied in La Mariscal.

3.1. Density

The density dimension aims to illustrate the potential concentration of people in the neighborhood. It emphasizes a uniform distribution of three indicators for the three indexes. Index 1 and Index 3 use the population density indicator and combine it with the housing density indicator and the building density indicator in Index 1, and the commercial density indicator and the public

facilities density indicator in Index 3. According to this, in the specific case of La Mariscal, the commercial density indicator and the building density indicator play a very important role. This area concentrates both, the most popular places to go out in the city, and the smaller plots of the area with townhouses. Moreover, the public facilities density indicator shows evidence of having multiple services within the area. Index 2 relies on the POI density index indicator, the floor area ratio indicator, and the building density indicator, which may be interpreted as a balanced combination of the other two indexes. The POI density index indicator, presents a correspondence between the block area and the number of POI within it, meaning that if there is only one POI occupying the whole block, such as the case of hospitals and schools, the POI density index indicator will be very low. Final density dimension maps show slight differences between the three indexes. Index 1 and Index 3 have middle-low density values homogeneously distributed across the neighborhood. In contrast, in Index 2, the density is concentrated in the areas close to the neighborhood's core, the Plaza Foch, and in the Colon and Amazonas Avenues, where many high-rise buildings with offices are located (Figure 4).

3.2. Land use mixture

The land use mixture dimension measures area's the diversity of activities. In Index 1 and Index 3, indicators are the building use mix and the residential-nonresidential balance. Both approaches connect the proportion of uses and the residential use. Moreover, in Index 3, there is an addition of two indicators, the commercial and facility mix, and the basic non-basic commercial and facility balance. In Index 2, the entropy indicator is equivalent to the building use mix indicator. On this subject, differences between the two maps are explained because of the integration of additional categories more connected to the specific vitality of La Mariscal neighborhood in the entropy calculation, such as restaurants and bars/discotheques. Final land use dimension maps illustrate that the areas with the highest level of land use mixture, common in Index 1 and Index 2, are close to the intersection of the 6 de Diciembre and Colón Avenues, where different residences, offices, the pediatric hospital Baca Ortiz, the UDLA university and the San Francisco de Sales and Andino schools are located, and close to the intersection of the Tamayo and Vintimilla streets, where a remarkable number of restaurants close to the Pontificia Universidad Católica del Ecuador are placed. Additionally, Index 2 also shows a higher proportion of land use mixture close to the intersection of the Amazonas and Colón Avenues (Figure 4).

3.3. Contact opportunity

In accordance with Jane Jacobs postulate that smaller blocks provide a higher possibility of interaction, the block size indicator in Index 1, the Richardson Compactness Index (RCI) indicator in Index 2, and the distance to intersections and the betweenness indicators in Index 3 are the ones that better relate these two crucial factors. In Index 3, the street width indicator illustrates the benefit of having narrower streets to get more interaction. The distance to squares and pocket parks and the presence of benches, indicators of Index 3, help to understand where people could be sitting and, consequently, how this may impact the number of people congregated. In la Mariscal, there is a low presence of pocket parks and benches. Additionally, it is essential to emphasize the importance of the inversely proportional relationship of some indicators of this dimension. In Index 1, the bigger the blocks, the stronger the confrontation with contact opportunity, whereas, in Index 3, this is represented by the distance to intersections, distance to squares and pocket parks, and distance to public Wi-Fi spots. The longer the distance, the smaller the possibility of contact opportunity. Unlike what happens in the other five dimensions, final maps present evidence of different results. In Index 1, there is a homogeneous distribution of contact opportunity. In Index 2, the higher levels are located in most of the regular and grideal areas of the neighborhood, and in Index 3 contact opportunity is placed in the central areas, where, the distance to intersections is smaller and the highest levels of betweenness are mainly concentrated (Figure 4).

3.4. Aged buildings

The aged buildings dimension relates to the idea that old constructions connected to the original city garden villas of the neighborhood present bigger areas than the contemporary buildings and, therefore, can be easily adapted to public facilities or amenities, increasing urban vitality. For instance, the Benjamín Carrión cultural center, the Manuela Cañizares school, the French embassy, the Symphonic National Orchestra of Ecuador, and several hotel boutiques occupy heritage buildings. The aged buildings indicator has been alike applied in Index 1 and Index 3. It illustrates the presence of patrimonial buildings more than approximately 60 years old. These constructions are practically homogeneously distributed across the area delimited by the Patria, 12 de Octubre, Colón, and 10 de Agosto Avenues, contributing to the expansion of different land uses (Figure 4).

3.5. Accessibility

The accessibility dimension aims to represent the quantity and location of public transport present in the area, as well as particular accessibility parameters. In Index 1 and Index 2, only one indicator absorbs the whole dimension weight, distance to public transportation, and rail transit convenience index (RTI), respectively. In both scenarios, the distance to the nearest Metrovía or Ecovía stops, a kind of tram, which possesses its own lane, and traditional bus stops are considered the main factor. In Index 3, four more indicators were added: street slope, street lighting, presence of maximum vehicular speed areas of 30 km/h, and the distance to pedestrian crossings. The street slope reduces the accessibility and coincides with some areas where public transport stops are completely absent. The presence of 30km/h areas is very limited in the study area and the distance to pedestrian crossings is comparable with the distance to intersections indicator of the contact opportunity dimension. The street lighting indicator shows that there is a presence of lighting but it is non-homogeneous distributed across the area. Even though the first impression by observing the final maps of the three indexes is that there are numerous differences, a closer interpretation reveals a critical number of similarities. The highest value of accessibility is mainly located in the broader streets of the neighborhood, where public transport stops are concentrated: the four perimetral avenues, Patria, 12 de Octubre, Francisco de Orellana, and 10 de Agosto, and three internal avenues, 6 de Diciembre, Colón and Amazonas. Additionally, two internal streets, Juan León Mera and 9 de Octubre, also concentrate a significant number of bus stops in the south-north direction. It is also important to emphasize that the northeast corner, the central zone, and the Tamayo and Leonidas Plaza streets, mostly in navy- and sky-blue tones, are the ones without any direct connection to public transport (Figure 4).

3.6. Border vacuums

The border vacuums dimension aims to illustrate the presence and position of these big areas characterized by massive single uses. It only concerns one indicator from Index 1 and Index 3. In this case, it is worth mentioning that there is no border vacuum inside the study area, but in its perimeter. The Militar School Eloy Alfaro on the north side; the US ambassador's residence and the Pontificia Universidad Católica del Ecuador on the east side; and the Casa de la Cultura on the south side are considered border vacuums because of their gated reality. The el Ejido park, a green public space of 14,21 ha., is situated in the south part of the neighborhood and concentrates multiple activities such as outdoor dancing, biking, picnicking, and games for children and can be crossed without problem by pedestrians. This possibility of walking through the park and connecting different surrounding areas is the reason why it was not been included as a border vacuum in calculating the dimension of Index 3. Final border vacuums maps concentrate the higher levels in areas close to the north, east, and south perimeter (Figure 4).

3.7. Final maps of urban vitality

The areas with very high intensity of urban vitality are mainly located in the neighborhood core, and two of the main internal streets, the Colón and Amazonas Avenues, (Figure 4). On one hand, the

concentration of the highest values in the central neighborhood core in Index 1 and Index 3 may respond to the presence of aged buildings in this area, as well as the building density indicator and commercial density indicator in Index 3. Additionally, the presence of the smallest blocks, represented by the block size indicator of Index 1, the Richardson Compactness Index (RCI) of Index 2, and the distance to intersections of Index 3, also contribute to promoting contact opportunity in this area. On the other hand, the lowest score on the upper right corner in Index 3, may respond to the influence of four indicators: distance to squares and pocket parks (no parks in this area), the street lighting (insufficient), the street slope (step slop in this area) and the block size (biggest blocks in this area).

As a final step of the analysis, the final map of each index is synthesized for comparison using the five different ranges of urban vitality: very high, high, moderate, low, and very low (Table 2). Index 1 presents 39% of the area of study with ranges between very high and high, whereas Index 2 increases this area to 68%, and Index 3 reduces the area to 32%. Regarding ranges of urban vitality between very low and low, Index 1 shows 23% of the area of study, while Index 2 decreases to 4% of the area, and Index 3 increases to 41% of the area. In this sense, it is essential to highlight the possible influence of having the border vacuums dimension in the two indexes where the low and very low levels are more evident. Regarding the moderate range, the fluctuations are not as representative as mentioned before: Index 1 presents this score by 36% of the area, whereas Index 2 decreases to almost 27% of the area and Index 3 illustrates 26% of the area. Finally, the sum of the first three ranges, very high, high, and moderate generate a remarkable score of urban vitality within 76% of the area of study in Index 1, 95% of the area in Index 2, and 58% of the area in Index 3.

Table 2. Level of urban vitality for the three final maps.

URBAN VITALITY LEVEL	P1	P2	P3
	%	%	%
VERY LOW	4,82	0,70	11,99
LOW	18,80	3,74	29,49
MODERATE	36,66	26,94	26,32
HIGH	29,73	54,25	22,21
VERY HIGH	9,99	14,37	9,99

4. Discussion

The present study's results contribute to discussing the two research questions: Which criteria can orient the selection of dimensions and indicators for measuring urban vitality? Which representation system is more precise for measuring urban vitality at a block scale? Moreover, future lines of research are suggested.

Regarding morphological dimensions, it is essential to define which are the most relevant in each particular study area in order to reshape Jacobs’s approach. To this extent, the density dimension highlights notable differences depending on the context. In several contemporary Chinese neighborhoods, it is associated with high-rise buildings [28,29,64], while in European areas conceived as city extensions in the second half of the 19th century, like the Eixample of Barcelona, it refers to urban compactness, represented by approximately eight-story buildings inserted into compact blocks [15]. Furthermore, Chinese cities such as Shenzhen, Nanjing, and Chengdu present an indissoluble connection with the land use mixture dimension [26,34,65]. Moreover, in Turkey, more particularly in Kayseri, special attention is put on the creation of a need for small buildings' dimension [39]. In addition, the contact opportunity and aged buildings dimensions are notably remarkable in cities where historical layouts are predominant [15,17]. Likewise, even though the accessibility dimension was secondary for Jane Jacobs’s approach in the 1960s [4], it is crucial for urban vitality calculations in the present, not only because of the importance of public transport stations, but also for the relevance of integrating vulnerable collectives such as children, the elderly, or people with disabilities in the composition of urban areas [66–68]. Besides, the border vacuums dimension needs to be extremely precisely defined, for instance, the inclusion or exclusion of big parks, depending on their

role in the study area. This difficulty in defining the specific characteristics of border vacuums is probably the reason why it is not included in several indexes of urban vitality [1–3]. In the specific case of La Mariscal, the land use mixture, contact opportunity, and accessibility dimensions play a very significant role. The first one as a consequence of the remarkable number of restaurants, bars, discotheques, political institutions such as international embassies and consulates, and public and private schools and universities located in the area. The second one due to the historical layout heterogeneity of the neighborhood. The third one because of the significant number of residents, who use public transport to move inside Quito, more than 70% of the total [69,70].

Regarding the indicators' selection for each dimension, two main criteria are recommended: context and scale. It is essential to add context-related indicators to reinforce the connection to the study area and to incorporate more building-scale morphological indicators to gain accuracy. Regarding the first, the inclusion of four new context-related indicators in the case of the Andean region would substantially improve the urban vitality measurement. First, an informal small-scale commerce indicator, very common and a determinant of urban vitality. Second, a quality of sidewalks indicator, meaning having no barriers to generate continuous walking with a wheelchair or similar, as a result of the insufficient level of quality of a significant part of the streets in the region [48,71]. Third, a slope indicator due to the complex orography in most of the cities of the region. And finally, a good-conditioned street furniture indicator, including banks and big trees to protect from the high UV factor in the countries close to the Ecuadorean line, either in parks or streets. Besides adding new indicators, a deep understanding of the context would facilitate reconsidering the street width indicator, which illustrates a controversial topic connected to the culture of the place. For instance, in Mediterranean cities, there is a context-based concern that relates pedestrian streets (usually narrow) with walkability and, consequently, urban vitality [3,48]. On the contrary, in the Andean context, people tend to concentrate more on wide streets where public transport stations are located, due to the unusual presence of pedestrian streets [72]. According to building scale new morphological indicators, façade length and door encounter rate [40], and building entrance density [35], would reinforce the block characterization's relevance in relation to what happens on the ground floor, which highly determines urban vitality worldwide, including the Andean context. Besides context and scale criteria, it becomes also fundamental to evaluate on how to calculate the indicators. For instance, in several studies, the distance from border vacuums indicator measures the distance to these areas using the proportional color gradient representation [15–17]. However, we think that it should be reinterpreted, simplifying its calculation to presence or absence, assuming that its influence will be no longer than a maximum of three blocks. Moreover, the POI designation, which concerns the calculation of several indicators, should be weighted according to the specific role of each building in the study area [26], usually related to the use and size. For example, in the case of the La Mariscal, restaurants, bars, and discotheques are part of the area's main attractions, as well as political institutions, such as international embassies and consulates. Likewise, there is a metropolitan pediatric hospital, called Baca Ortiz, occupying the whole block, which promotes more urban vitality than a small restaurant, due to its size and 24/7 schedule.

Ultimately, the question of the most precise representation system for measuring urban vitality has been a subject of great interest among urban researchers. On one hand, the use of raster calculations in this context has revealed a lack of correlation with urban morphology, particularly at the street layout level [20,53,73–76]. However, the use of a small-scale unit of measurement, such as a 50 x 50-meter raster cell, has shown promise in identifying hot and cold spots. On the other hand, the use of a block (polygon) representation as a unit for calculation has been shown to clearly connect the specific urban layout to urban vitality, albeit at the expense of excluding some street and plot characterization [18,19,33,45,65,77]. In light of these findings, it is noteworthy to consider a combined approach that leverages both rastering and polygonal results, for instance by descending to the plot analysis, to comprehensively understand urban dynamics at a block scale. Such criteria would allow for a more nuanced understanding of the relationship between urban morphology and vitality, and enable the identification of specific urban features and patterns that drive urban vitality at the block scale.

Limitations of the present article and future lines of research

Two types of limitations are worth mentioning for this study: methodological and conceptual. Regarding the first one, official open data sources are almost inexistent in Ecuador. In the specific case of Quito, official data present access problems and certain incoherence, due to the update limitation by the local government agencies. On this subject, there is no official data regarding de Building Use Mix Indicator (BUMI) and the Residential Non-Residential Balance indicator (RNR). The data used to calculate these indicators was manually raised in 2022. Furthermore, the last national census was developed in 2010, generating some possible inconsistencies concerning the permanent population of the study area.

Regarding conceptual limitations, although the application of the three selected indexes has offered a rich array of dimensions and corresponding indicators, in representative current studies on urban vitality focused on morphological parameters a lack of inclusion of the time dimension has been identified. In this regard, future approaches should include time-sensitive indicators. For instance, land use influence on urban vitality changes during day or night hours (f.i. discotheques at night), and on week or weekend days (f.i. schools). Time-based indexes of urban vitality would contribute to a more detailed understanding of morphological parameters that determine people's activities [19,52,75]. This could also promote the assimilation of the variability concept, which refers to a dynamic attribute regarding the flexible quantity of people present in the same area at different times of the day [41,78]. Moreover, the inclusion of time in measuring urban vitality may also lead to a significant relationship between people's concentration and street security [29,79].

Finally, the morphological approach used for this study could be enriched with complementary data on people's activities (f.i. mobile phone big data on people's daily mobility) and sociodemographic data [76,80,81].

5. Conclusions

This paper aimed to analyze Jane Jacobs' morphological conditions for urban vitality at a block scale in a neighborhood of Quito, Ecuador, as a representative case study in the Andean region. Learnings show the importance of considering context-based previous knowledge and scale of analysis for selecting and modifying any urban vitality index. According to this, dimensions such as land use mixture, contact opportunity, and accessibility, and indicators such as informal small-scale commerce, quality of sidewalks, street slope, and good-conditioned street furniture are highly encouraged to be incorporated. Additionally, the use of a hybrid representation system approach, which combines the raster and the polygon, would greatly improve our ability to analyze and measure urban vitality and support evidence-based decision-making in urban planning and design. The correct interpretation of these findings would help to better understand Andean cities, being able to promote more vital and sustainable places to live.

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