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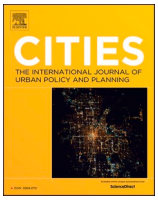

Jane Jacobs reloaded: A contemporary operationalization of urban vitality in a district in Barcelona

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ABSTRACT

The theories of Jane Jacobs have gained momentum as a framework to address the challenges faced by present-day cities. Of special relevance is the concept of urban vitality as an indicator of street vibrancy and quality of life among city residents. This study aims to revisit her principles from an applied perspective by developing an updated index that measures the conditions for urban vitality as described in her most celebrated book, *The Death and Life of Great American Cities* (1961), and by also incorporating contemporary contributions made by recent literature on the topic. We develop a composite measure of 22 variables of the built and social environment, and we test it in the urban context of a peripherical and low-income district in Barcelona (Spain). Results show that urban vitality can be found in a wide variety of urban spaces such as compact fabrics and even housing projects, only when population density is combined with physical features that promote intense and diverse human activity. The methodological tool developed in this paper is intended to serve as a basis for future research as well as to guide public policies that aim to address some of the key challenges of contemporary urban agenda.

1. Introduction

Cities can be regarded as successful when they are capable of hosting vibrant street activity, whereby people with different characteristics can safely come together in the public space, at different times, and for different purposes. Vitality is, ultimately, an indicator of *good* urbanism (Lynch, 1984), as vital environments offer everything that citizens need, not only to transit public spaces, but to *stay* and *use* them. One of the first voices advocating such ideas of diversity, vitality, and street buoyancy was the American-Canadian theorist Jane Jacobs (1916–2006). By opposing most of the principles and logics accepted as common-practice during her life, Jacobs provided a new approach to understanding how cities work, which she accomplished by shifting the focus from what was built (or to be built) to human beings (Sassen, 2016; White, 2014).

Her principles have been recurrently rediscovered and revisited to respond to different needs and from different contexts, and are still relevant in the present day (Hirt & Zahm, 2012). Many citizen organizations have incorporated her arguments to evaluate the neighborhood built environment using community-based approaches, for example, through different city walks inspired by Jane Jacobs (Jane's walk, 2020). Cities and other public institutions worldwide are also including her principles, either explicitly or implicitly, as part of their local planning strategies (Klemek, 2007; Schubert, 2014). Recent initiatives such as the "15-minute city" are a clear example of urban interventions that rely on the ideas about compact, diverse, and accessible cities (an ideology once coined by Jane Jacobs), some of which are likely to prevail in the post-COVID-19 era (Moreno, Allam, Chabaud, Gall, & Pratlong, 2021). Accordingly, her theories have also received increasing attention from urban researchers around the world, who have used her principles as a framework, and her general view on urban vitality as a lens through which we can reflect on how cities succeed or fail in guaranteeing quality of life for people (Lopes & Camanho, 2013).

More specifically, there is a growing line of research that aims to quantify the Jacobs postulates by using objective measures of the built and social environment (Braun & Malizia, 2015; De Nadai et al., 2016; Delclòs-Alió & Miralles-Guasch, 2018; He et al., 2018; Jin et al., 2017; Lu, Huang, Shi, & Yang, 2019; Sung, Lee, & Cheon, 2015; Wu, Ta, Song, Lin, & Chai, 2018; Zeng, Song, He, & Shen, 2018). Most of these efforts

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rely on high-resolution techniques to apply the ideas that Jacobs developed in New York in the 1960s to present-day cities. However, to properly analyze the potential vitality of today's cities, the Jacobs principles need to be updated by considering new insights and indicators of what can constitute vibrant city life. Furthermore, most of these analyses explore the ideas of Jacobs in large urban areas or in central and well-off neighborhoods, while there is less evidence of how the conditions of vitality play out in peripheral and more vulnerable areas. With this in mind, and based on related literature and previous work, the aim of this paper is to present a methodological tool that captures the potential of urban spaces to be vital environments. We provide an updated and extended version of the JANE Index of urban vitality (Delclòs-Alió & Miralles-Guasch, 2018), now composed of 22 variables of the built and social environment, which we then use to characterize the potential of urban vitality of Nou Barris, a peripheral low-income district in Barcelona (Spain).

2. Background

2.1. The conditions for urban vitality according to Jane Jacobs

In her definitive statement on American cities, *The Death and life of Great American Cities (1961)*, Jacobs described four generators of urban vitality: the need for primary mixed uses, the need for small blocks, the need for aged buildings and the need for concentration. First, Jacobs considered urban spaces that gathered multiple uses would be capable of hosting different activities throughout the day, which in turn would attract people with different needs and with different purposes. Second, Jacobs considered that cities should be designed at the human scale in order to provide opportunities for human contact, and thus they would be more conducive for social interaction. Third, Jacobs suggested that diverse and vibrant neighborhoods would require a certain degree of social mixture. In order to welcome different types of population, she considered it essential for cities to preserve a certain balance between new and old buildings, which from her perspective and in her time was an indicator of housing affordability. Fourth, Jacobs defended that concentration (of activities and people) could be regarded as the key requirement for urban vitality. She specifically referred to density of buildings, residences and population. Throughout her book Jacobs also mentioned two additional elements that are related to urban vitality (Sung et al., 2015): people's ability to move without depending on a car and the need to be wary of elements and spaces that could be harmful for human activity, for which she coined the term ‘border vacuums’.

2.2. Revisiting urban vitality

Some authors have been critical of the fact that the Jacobs hypotheses of urban design have been widely accepted as good principles, although they have not been scientifically tested (Marshall, 2012). Moreover, in the past decade (approximately) we find an increasing number of studies, from different disciplines, geographical contexts, and also based on different methodologies, that use the principles of Jane Jacobs from an applied perspective to evaluate present-day cities. The majority of studies to date have used the principles of Jacobs as a framework to describe the built environment in order to explore its association with a specific outcome (e.g., mobility levels, safety, health outcomes), while others have aimed at evaluating the adequacy of her principles solely for characterizing present-day cities (Shi, Miao, & Si, 2019). Both types of studies have used a similar set of concepts in order to describe the built environment under the Jane Jacobs framework, either by directly transforming her ideas to specific variables or by partially including new interpretations of what the conditions for vitality may be in present-day cities. In the following paragraphs we provide some examples of how the Jacobs generators of vitality have either been operationalized, reinterpreted, or expanded in recent studies.

Most studies applying the Jacobs framework to the study of cities have used, to some extent, some measure of concentration. Following the Jacobs rationale, concentration has been generally operationalized as population density (De Nadai et al., 2016; Delclòs-Alió & Miralles-Guasch, 2018; He et al., 2018; Sung & Lee, 2015), residential density (Garcia, Vale, Garcia, & Vale, 2018; Yoon & Park, 2018) or housing density (Faria, Ogura, & Sachsida, 2013; Lu et al., 2019; Sung et al., 2015). However, there have been other interesting reinterpretations of concentration. For instance, some studies have included other measures such as the density of “points of interest” (Lu et al., 2019; Yue et al., 2017), public facilities (Long & Huang, 2019) and other studies have used stores, bars, or restaurants (March, Rijal, Wilkinson, & Firidin Özgür, 2012; Wu, Ta, et al., 2018). The presence of such elements in the urban space has been related to the Jacobs “eyes on the street” concept, meaning that a maintained presence of people creates a sort of “natural surveillance” system that also has been proved to increase safety (Anderson, Macdonald, Bluthenthal, & Ashwood, 2012; Faria et al., 2013).

When measuring the need for primary mixed uses, the most common approach in applied studies has been to use land-use mix indices (De Nadai et al., 2016; He et al., 2018; March et al., 2012; Zeng et al., 2018), and also complementary indicators of the balance between residential and non-residential uses (Sung, Go, & Choi, 2013). Similarly, other studies have gone one step farther and applied this same logic to retail diversity in particular by incorporating mix and balance of business types (Sung et al., 2015; Yoon & Park, 2018).

Regarding the need for old and new buildings, some studies have incorporated this variable without change (Delclòs-Alió & Miralles-Guasch, 2018; Sung & Lee, 2015). However, in present-day cities it seems unlikely that the building construction year would be an accurate indicator for housing affordability (King, 2013). In a context where access to affordable housing is becoming increasingly problematic, other studies have suggested using more direct indicators of housing affordability, such as average housing price (Long & Huang, 2019).

Contact opportunity has been generally measured by means of specific street network characteristics. One of the most commonly used variables has been intersection density, considering that a higher number of intersections translate to a larger number of possible itineraries and opportunities to encounter others (Wu, Ta, et al., 2018). Additionally, other studies have also incorporated other notions of what spaces could be attractive for human interaction. In this sense, the presence of street furniture, such as benches, has also been regarded to have an impact on urban vitality (Sung et al., 2013; Xu et al., 2018). This may be particularly relevant for specific population groups such as older adults, who require resting places along their walking itinerary (Borst, Miedema, de Vries, Graham, & van Dongen, 2008). Similarly, other authors have drilled deeper into the ideas of Jacobs and highlighted that the presence of small parks and squares may also be regarded as potential forums of social interaction, compared to large public spaces (De Nadai et al., 2016). Lastly, the present-day need for human interaction not only takes place in physical space, but also virtually, and therefore some studies have also considered public internet connectivity in the public space as, in turn, potentially conducive for human physical interaction, especially among young people (Kim, 2018).

In terms of accessibility as one of the two complementary conditions for urban vitality, studies have generally referred either to the supply of public transportation, on the one hand, or to walkability conditions, on the other. Related to the former, distance to rail and metro stations, bus stops, bicycle parking, and other transport facilities are often used as indicators of accessibility (Sung et al., 2015). In terms of walkability, it is common to find studies specifically using the existence of sidewalks and their pavement conditions (Faria et al., 2013), the presence of traffic-calming schemes (Lunecke & Mora, 2018), slopes (Sung et al., 2013) or even street lighting (Jin et al., 2017; Zarin, Niroomand, & Heidari, 2015).

Lastly, in terms of the so-called border vacuums, researchers

generally refer to monofunctional urban spaces (i.e., large parks), natural elements that could act as barriers (i.e., rivers), and ground-level heavy transportation infrastructures (i.e., railways, roads) (De Nadai et al., 2016; Sung & Lee, 2015).

In summary, research efforts applied to the study of urban vitality in today's cities has gained momentum by means of diverse conceptual and methodological approaches. However, we identified unexplored issues in the literature. First, we found that most contributions used the original theoretical frame of Jane Jacobs for a wide variety of purposes, usually translating it directly to specific variables (such as density of population, land use, or transport accessibility). However, to our knowledge, usually there are fewer studies that actually reinterpreted her ideas or interpreted them with a present-day lens. Moreover, such contributions have only partially revisited the principles of Jacobs by focusing on a particular research field where vitality is measured with specific outcomes, rather than studying urban design from a global perspective. Hence, it is our opinion that there is still a need to bring the principles together in a harmonized manner.

Furthermore, we also identified a gap regarding the geographies, primarily in Asian and North American countries, which previous studies have focused on. To date, little attention has been paid to the European context, and more specifically, to Mediterranean cities. In this line, there is also a matter of what type of urban contexts is analyzed. According to some critical authors, idea of dense according to Jacobs (i.e., lively and diverse neighborhoods) is privileging a "middle class way of life" (Connolly, 2018; Kirby, 2018; Shake, 2015; Steil & Delgado, 2018), forgetting about more disadvantaged socioeconomic realities. In addition, street vibrancy is often identified with compact urban forms corresponding to central cores, while there is less evidence from other urban fabrics, specially focused on peripherical locations. In this sense, there is a need to understand how urban vitality operates in enclaves that present disadvantaged and socioeconomic contrasts, in terms of income and vulnerability indicators, because to date no studies have been developed in these contexts.

In order to address these research gaps, this paper has two primary aims: 1) present a synthetic index to measure the potential of urban vitality, updating the version of the JANE Index developed by (Delclòs-Alió & Miralles-Guasch, 2018) and considering recent critical suggestions in the literature; 2) assess the potential of this updated index in a case study corresponding to a low-income peripheral district in a Mediterranean city, characterized by presenting diverse social and morphological characteristics.

3. Methods

3.1. Study area

This study focuses on the Nou Barris district in Barcelona (Spain) (Fig. 1). Nou Barris (which presents an area of 804 ha) is located on the northern side of the city, bordering with the *Collserola* mountain range (i.e., with an elevation of 512 m at Tibidabo, Barcelona) and it is divided into 13 neighborhoods, with an overall population of 167.868 inhabitants (10.4% of the total City of Barcelona population) (Ajuntament de Barcelona, 2018). The mean of the population density is 20,900 inhab./km^2, which is higher than the City of Barcelona average (15,900 hab./km^2). The population in Nou Barris is not evenly distributed across its neighborhoods, which can be explained by different historical development patterns.

Until the end of the 19th century, Nou Barris was mostly a rural area with a small town core, corresponding to the present-day neighborhood of *Vilapiscina i la Torre Llobeta*. With industrialization, the dominant rural landscape started to host small industries and large infrastructures that were relocated on the periphery of the city, where they still remain today. The progressive arrival of the working-class population at the start of the 20th century initially resulted in a scattered urbanization process that resulted in informal slums first, and in low-cost public housing promotions in low-rise dwellings later (popularly known as "cheap houses") (García Soler, 1998), located in *Can Peguera*. However,

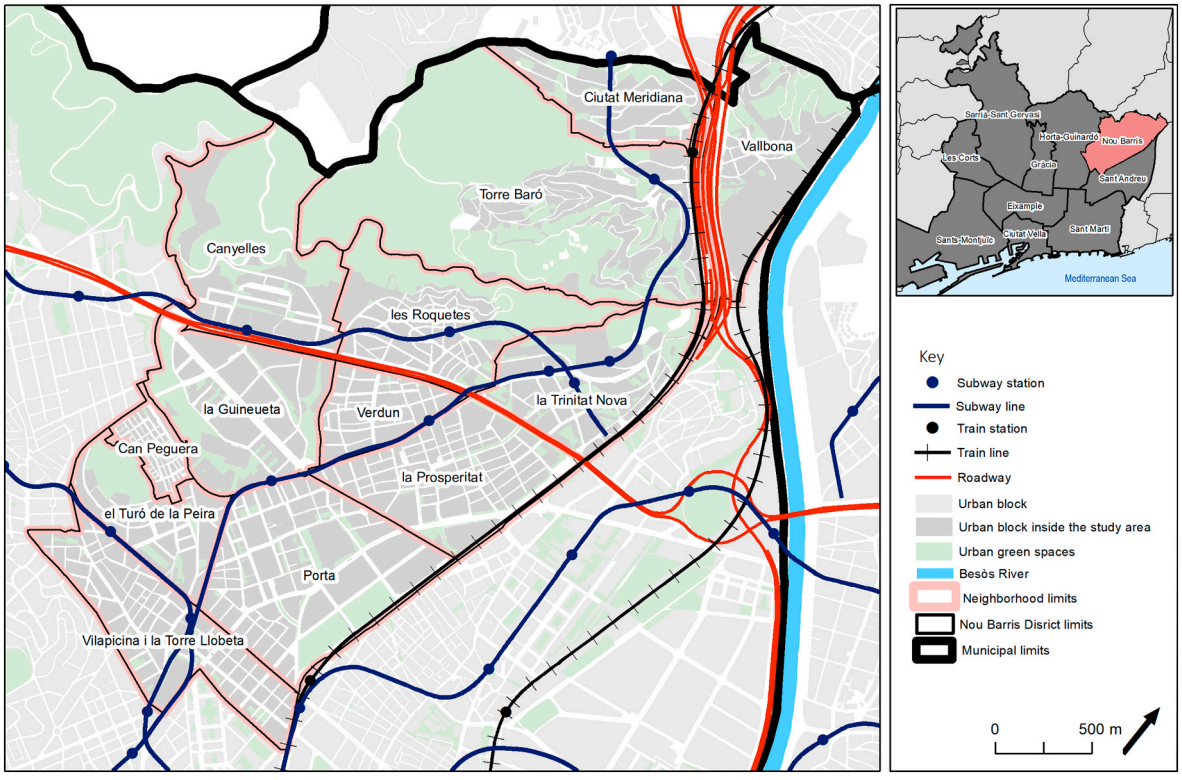

Fig. 1. Study area: Nou Barris district (Barcelona).
Source: own elaboration.

the largest transformations took place between the 1950s and 1970s. Nou Barris grew significantly due to the accommodation of the post-war migration workforce coming from rural areas of Spain. Newcomers established in both self-constructed shanty settlements and, later, in public high-rise housing projects in *Verdum*, *Roquetes*, *Ciutat Meridiana*, *la Guineueta*, *Porta, Turó de la Peira*, and *Canyelles*. These neighborhoods presented severe building inadequacies and almost no connection with the rest of the city (Domingo i Clota & Bonet i Casas, 1998). Improvements were accomplished in the 1980s and 1990s, mainly triggered by community-organized initiatives and demands that crystalized in urban policies such as interventions on housing, public spaces, and the provision of infrastructures that aimed to dignify this traditionally marginalized district (García Soler, 1998). The uneven development patterns of the district resulted in six main types of urban form (Fig. 2): a) historical centers; b) orthogonal urban expansions, c) high-rise housing projects, d) mid-rise developments, e) low-rise housing projects, and f) informal settlements of self-construction housing.

3.2. Variables and data sources

This study is based on the construction of an updated and extended version of the JANE Index, described in a previous work (Delclòs-Alió & Miralles-Guasch, 2018). We build on the four basic generators of vitality according to Jacobs (concentration, functional diversity, contact opportunity, and need for aged buildings) and two accessory principles (accessibility and distance to border vacuums). In addition, we incorporate other variables based on the recent literature exploring vitality and its drivers under the framework of Jacobs. The result is an updated JANE Index consisting of 22 variables compiled from diverse data sources, as summarized in Table 1.

Concentration is measured as the combination of three primary elements. *Population density* (pop./km^2) ("DENS") is the primary condition, as the presence of human life was considered by Jacobs as fundamental for vitality. However, in this new edition of the JANE Index we also include an indicator for *commercial density* (retail businesses/km^2) ("COM_DENS") and *density of public facilities* (public facilities/km^2) ("FACIL_DENS") as both attract the presence of people because they are considered to be points of interest (Wu, Ye, Ren, & Du, 2018; Yue et al., 2017).

Second, *Functional diversity* is defined as the presence of i) multiple urban functions and ii) a balance between residential and non-residential uses. First, two main indices were calculated: *Building-Use Mix Indicator* (BuMI) index and a *Residential-NonResidential* (RNR) balance index. BuMI is an adaptation of an entropy index calculated by the main six uses extracted from the municipal cadaster (residential, commercial, work-related, recreational, and others), which was calculated with the following expression:

$$BuMI = -1\left(\frac{\sum_{i=1}^{n} pi^{*}ln(pi)}{ln(n)}\right)$$

where p refers to the proportion of the use i in relation to the total possible uses n.

The RNR index was created with the following expression:

$$RNR = 1 - \left|\frac{\mathrm{Res}_i - \mathrm{NonRes}_i}{\mathrm{Res}_i + \mathrm{NonRes}_i}\right|$$

where Res_i refers to residential uses and $NonRes_i$ to non-residential uses. Both indices take values from 0 to 1.

Complementarily, in this updated JANE Index, we also considered the diversity of retail and other everyday facilities. Previous studies also pointed out that diversity per se does not necessarily guarantee the presence of everyday retail and other facilities (Yoon & Park, 2018), and therefore we also included an indicator of the balance between basic and non-basic facilities. These variables were included as two separate indices: *Commercial and Facility Mix* (CFMIX) and a *Basic-Non-Basic Facility* (BNB) balance indicator. The CFMIX index was calculated using the following expression:

$$CFMIX = -1\left(\frac{\sum_{i=1}^{n} pi^{*}ln(pi)}{ln(n)}\right)$$

where pi refers to the proportion of the activity type i in relation to all other possible categories, and n is the total number of categories.

The balance indicator between basic and non-basic facilities,[1] was calculated using the following expression:

$$BNB = 1 - \left|\frac{\mathrm{Bas}_i - \mathrm{NoBas}_i}{\mathrm{Bas}_i + \mathrm{NoBas}_i}\right|$$

For *Contact Opportunity*, the original index included the indicators of block size and street width. The updated index now considers five different indicators based on recent conceptualizations of what vibrant public spaces may require. First, we include the classical indicators of the built environment such as i) intersection density ("INTERSEC"), and ii) distance to specific meeting points, squares, and pocket parks (Peschardt, Stigsdotter, & Schipperijn, 2014) ("PPDIST"). We also consider microelements of the built infrastructure that encourage human relationships, such as iii) the presence of street benches ("BENCHES"), especially among seniors (Cao, Heng, & Fung, 2019). In order to include new perspectives that have also evidenced vitality occurring in a virtual dimension (Kim, 2018), we include an indicator that measures iv) distance to public Wi-Fi hotspots ("WFDIST"). Finally, we calculated v) an indicator of betweenness ("BTW") using urban network analysis tools (Sevtsuk & Mekonnen, 2012). The betweenness indicator measures the potential number of people that can go past a given building in a specific radius. In this case we used 600 m, which is approximately equivalent to 10 min of travel time on foot (Wei, Xiao, Wen, & Wei, 2016), and was calculated with the following expression:

$$BTW^{r}[i] = \sum_{j,k\in-\{i\};d[j,k]\le r} \frac{n_{jk}[i]}{n_{jk}} \cdot W[j]$$

where betweenness of a building i is defined as the number of times that the building i is situated along the shorter route between all pairs of other buildings in a specific radius r. Specifically, njk refers to the number of short routes from a building j to a building k in a radius r, and njk [i] is a sub-selection of these routes that pass close to i, and $W(f)$ refers to the weight of each building related to the population in the census.

Fourth, Jacobs highlighted that cities need to ensure buildings with different characteristics are present in order to guarantee a certain degree of socioeconomic diversity. With this intention, we first included the *building mean year of construction* ("YEARM") and the *standard deviation* ("YEARSD") to incorporate diversity of building construction years, which correspond to the original ideas of Jacobs. However, in cities such as Barcelona, housing affordability does not only depend on building age or type, as there are phenomena such as tourism and gentrification affecting housing accessibility (Cocola-Gant & Lopez-Gay, 2020; Gutiérrez & Domènech, 2020). For this reason, in this new index we also consider the average rent in the neighborhood in Euros ("RENT") as an updated indicator of housing affordability.

[1] Facilities considered as basic: everyday life retail (e.g., grocery stores, supermarkets, bakeries, pharmacies), educational and health facilities.Considered as non-basic or secondary facilities: property business, automotive commerce, personal equipment, cultural, leisure and recreational facilities, household furnishing, reparation (household appliances and automobiles), bars and restaurants, others.

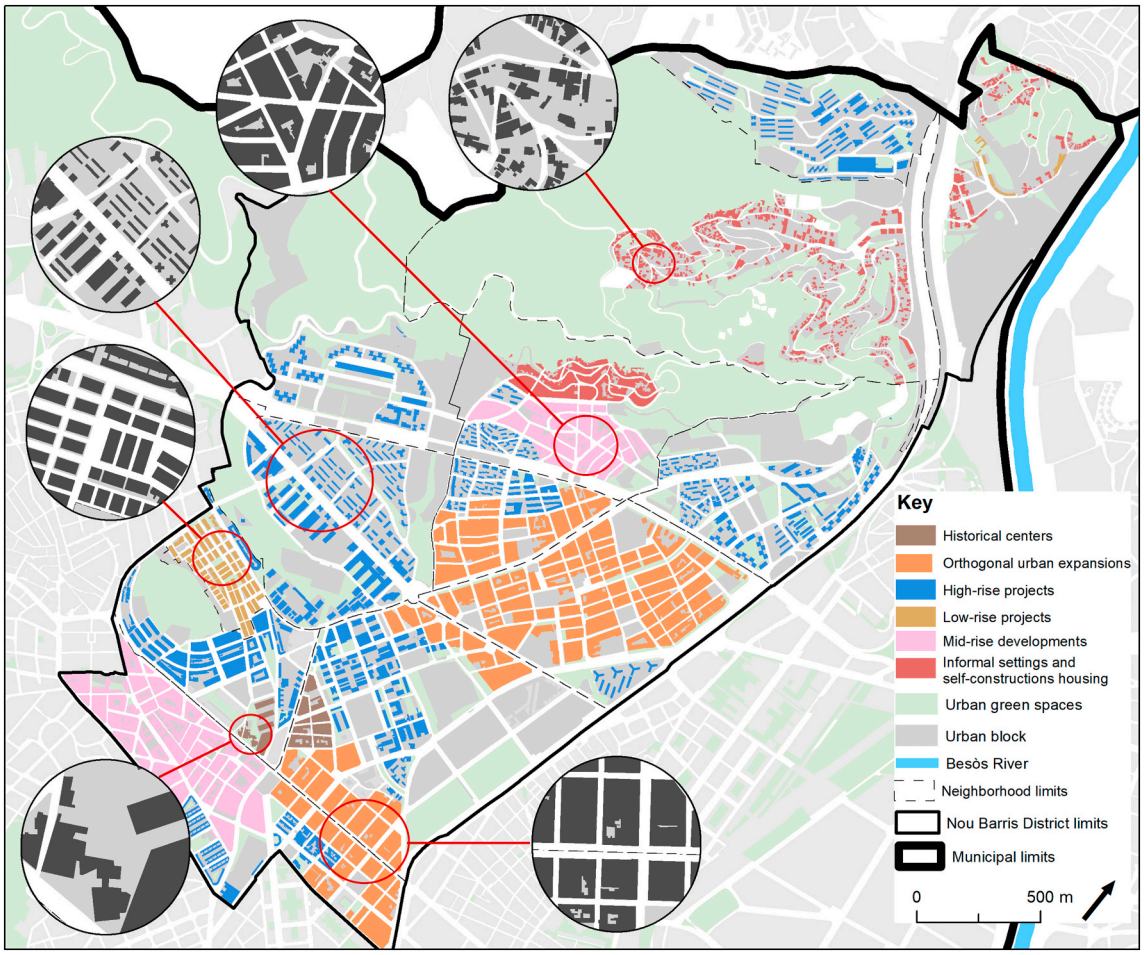

Fig. 2. Urban morphology types in Nou Barris.
Source: own elaboration.

Accessibility is defined by six indicators. The first is measured as the weighted distance to public transport ("TPDIST"), applying a weight system based on the transportation network hierarchy: interurban railway transport (40%), metro and tramway (30%), local bus lines (20%), and bicycle stations (10%). As a novelty, we include a set of five indicators related to pedestrian accessibility (authors): street inclination or slope ("INCLIN"), presence of street lighting ("LIGHT"), distance to the nearest pedestrian crossing ("PVDIST"), the presence of sidewalks ("SWALKS"), and finally, the presence of 30 km/h areas[2] ("30A"), as traffic calming interventions are evidenced to promote pedestrian activity (Barbosa & Baptista Neto, 2015).

Lastly, Jacobs defined the existence of certain uses and elements in the city that she considered detrimental to urban vitality, as they could act as "border vacuums" of human activity. In the present study, we use *distance from border vacuums* ("BVDIST"), considering large single-use buildings (5000 m^2 and above), large parks (5000 m^2 and above), large roads at the surface, and include dedicated parking areas and empty lots, regarded as barrier indicators for walking activity (Knapskog, Hagen, Tennøy, & Rynning, 2019).

3.3. Data processing and calculations

Jane Jacobs suggested that the appropriate scale for the detection and understanding of urban vitality was the street-level perspective. Following this reasoning, after data collection and pre-processing, we summarized the 22 variables in a 50 × 50 m cell grid (Fig. 3). This process was conducted to homogenize the spatial resolution of the original data at a scale considered proper for an in-depth analysis of street-level activity (Arranz-López, Soria-Lara, López-Escolano, & Pueyo Campos, 2017). This is also a novelty related to the previous JANE Index (Delclòs-Alió & Miralles-Guasch, 2018), whose grid was 100 × 100 m, in order to provide a higher resolution and come closer to what actually constitutes the street-level. Each cell is assigned a value for each of the 22 variables, following one of four calculation rules (Table 1): i) *Mean value* in a 100 m radius from the centroid of the cell, ii) *Presence* within the cell (yes or no), iii) *Count* within the cell, and iv) *Distance* from the centroid of the cell to the nearest element.

In order to have comparable indicators for each of the conditions, we standardized the 22 original variables to their corresponding z-scores. The sign of some variables was inverted since they were expected to have an inverse association with vitality. To calculate scores for each of the six conditions, we created a weighted sum according to the expected relevance of each of the variables for each specific condition.

In terms of *concentration*, starting with an 'equal-weights' logic, we granted a slightly larger weight to population density (4/10), as it is the basic condition for vitality according to Jacobs, compared to commercial and facility density (3/10 each), as described by the following expression:

$$\textbf{Concentration}\ (C) = zDENS\ \frac{4}{10} + zCOM\_DENS\frac{3}{10} + zFACIL\_DENS\frac{3}{10}$$

For *functional diversity* the main weight is granted to the building-use mix indicator (3/10) and to its complementary variable that captures

[2] Areas with maximum circulation speed of 30 km/h.

Table 1
Conditions and indicators used in the analysis.

Conditions	Indicators	Description	Original resolution	Calculation rule
Concentration (C)	DENS	(1) Population density (hab./km^2)[a]	Block	Mean (100 m radius)
	COM_DENS	(2) Commercial density (retail businesses/km^2)[b]	Points	Mean (100 m radius)
	FACIL_DENS	(3) Public facilities density (public facilities/km^2)[b]	Points	Mean (100 m radius)
Functional diversity (FD)	BuMI	(4) Building-Use Mix Indicator (0–1)[c]	Cadastral plot	Mean (100 m radius)
	RNR	(5) Residential-NonResidential balance (0–1)[c]	Cadastral plot	Mean (100 m radius)
	CFMIX	(6) Commercial and Facility Mix (0–1)[b]	Points	Mean (100 m radius)
	BNB	(7) Basic-NonBasic commercial and facility balance (0–1)[b]	Points	Mean (100 m radius)
Contact Opportunity (CO)	INTERSEC	(8) Intersection density[d]	Points	Count
	PPDIST	(9) Distance to squares and pocket parks (m)[e]	Polygons	Distance
	WFDIST	(10) Distance to public Wi-Fi hotspots (m)[f]	Points	Distance
	BENCHES	(11) Benches[g]	Points	Count
	BTW	(12) Betweenness[a]	Block	Mean (100 m radius)
Building diversity (BD)	YEARM	(13) Building average year of construction[c]	Cadastral plot	Mean (100 m radius)
	YEARSD	(14) Diversity of building year of construction[c]	Cadastral plot	Mean (100 m radius)
	RENT	(15) Average neighborhood rent (€)[h]	Neighborhood	Mean (100 m radius)
Accessibility (A)	TPDIST	(16) Weighted distance to public transport stations/stops (m)[i]	Points (stops and bicycle stations)	Distance (weighted)
	INCLIN	(17) Street slope (°)[j]	Street-level	Mean (100 m radius)
	LIGHT	(18) Street lighting[g]	Points	Count
	30A	(19) Presence of 30 km/h areas[k]	Polygons	Presence
	PVDIST	(20) Distance to pedestrian crossings (m)[g]	Polygons	Distance to nearest
	SWALKS	(21) Presence of sidewalks[g]	Lines	Presence
Border vacuums (BV)	BVDIST	(22) Distance to large single-use buildings, large parks, surface large roadways, parking areas, and empty lots (m)[e]	Polygons	Distance to nearest

Data sources:
[a] City blocks urban data 2016, Barcelona City Council.
[b] Retail inventory of the City of Barcelona 2016, Barcelona City Council.
[c] Municipal cadaster 2017, Ministry of Treasury.
[d] Road Graph by street section 2019, Barcelona City Council.
[e] Land use cartography 2016, Barcelona City Council.
[f] Wi-Fi public spots 2019, Barcelona City Council.
[g] Topographic municipal map at 1:1000 scale 2018, Barcelona City Council.
[h] Rental Market in Barcelona neighborhoods 2018, Barcelona City Council.
[i] Public transport stops and bike-sharing stations (Bicing) in Barcelona 2019, Barcelona City Council.
[j] Terrain elevations model 15 × 15 m 2019, Cartographic and Geological Institute of Catalonia.
[k] 30 areas in the City of Barcelona, Barcelona City Council.

the balance between residential and non-residential uses (3/10), since these two indicators represent the backbone of what constitutes a balanced land-use mix in a certain urban area, and are the two most common indicators used in similar studies (De Nadai et al., 2016; Sung et al., 2015). On a second level, commercial and facility mix and the indicator for balance between basic and non-basic retail and facilities are given a weight of 2/10. The expression is as follows:

$$\textbf{Functional } \textit{diversity}\ (\mathrm{FD}) = zBuMI\ \frac{3}{10} + zRNR\frac{3}{10} + zCFMIX\frac{2}{10} + zBNB\frac{2}{10}$$

For *contact opportunity*, the largest weight is attributed to the structural elements of built environment, that is, to the presence of intersections (3/10) and betweenness (3/10), followed by the presence of pocket parks (2/10), and lastly micro elements of urban space, such as benches (1,5/10) and presence of Wi-Fi hotspot (0,5/10), since these are especially attractive to specific population groups. The resulting expression is:

$$\textbf{Contact } \textit{opportunity}\ (\mathrm{CO}) = zINTERSEC\ \frac{3}{10} + (-1)zPPDIST\frac{2}{10} + zWFDIST\frac{0,5}{10} + zBENCHES\frac{1,5}{10} + zBTW\frac{3}{10}$$

For *building* diversity, the main weight (6/10) is given to the original ideas of Jacobs, regarding both the age of buildings (3/10) and its diversity (standard deviation) (3/10). Secondly, in order to nuance the effect of the previous two indicators, we included a rental price mean indicator with a weight of 4/10. It is described by the following expression:

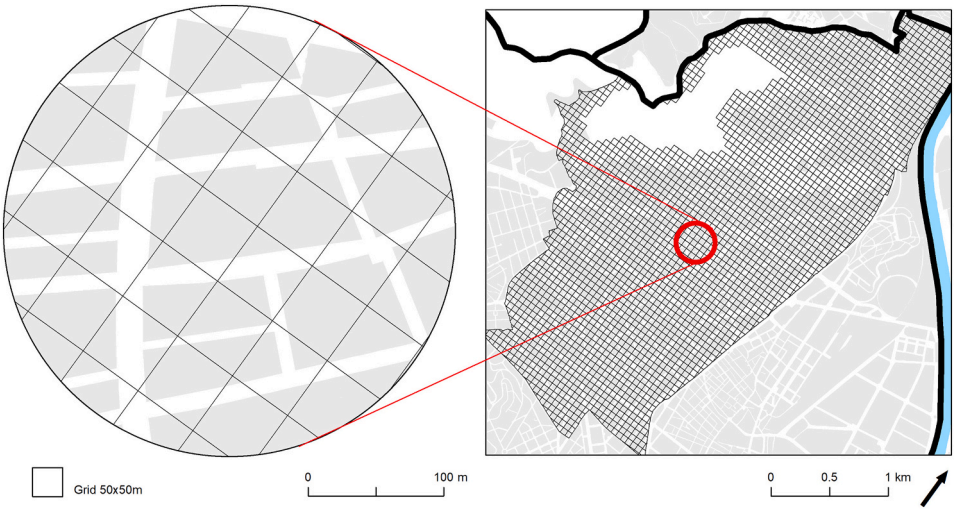

Fig. 3. Grid of 50 × 50 m cells used in the analysis.
Source: own elaboration.

$$\textbf{Building } \textit{diversity}\ (\mathrm{BD}) = (-1)zYEARM\ \frac{3}{10} + zYEARSD\frac{3}{10} + (-1)zRENT18\frac{4}{10}$$

For *accessibility*, the weighting scheme is based on spatial access related to each transportation mode (i.e., transportation modes that allow for greater spatial accessibility levels are granted larger weights), organized as follows: train, subway, bus, and shared-bicycle system. For the *pedestrian accessibility*, the largest weight is given to street slope (2/10), followed by the remaining street design elements such as street lighting (1/10), the presence of sidewalks (1/10), and pedestrian crossings (1/10), and lastly to the presence of 30 km/h areas (1/10). The expression is as follows:

$$\textbf{Accessibility}\ (\mathrm{A}) = (-1)zTPDIST\ \frac{4}{10} + zINCLIN\frac{2}{10} + zLIGHT\frac{1}{10} + z30A\frac{1}{10} + (-1)zPVDIST\frac{1}{10} + zSWALKS\frac{1}{10}$$

Finally, for *border vacuums* the same weight was granted to all

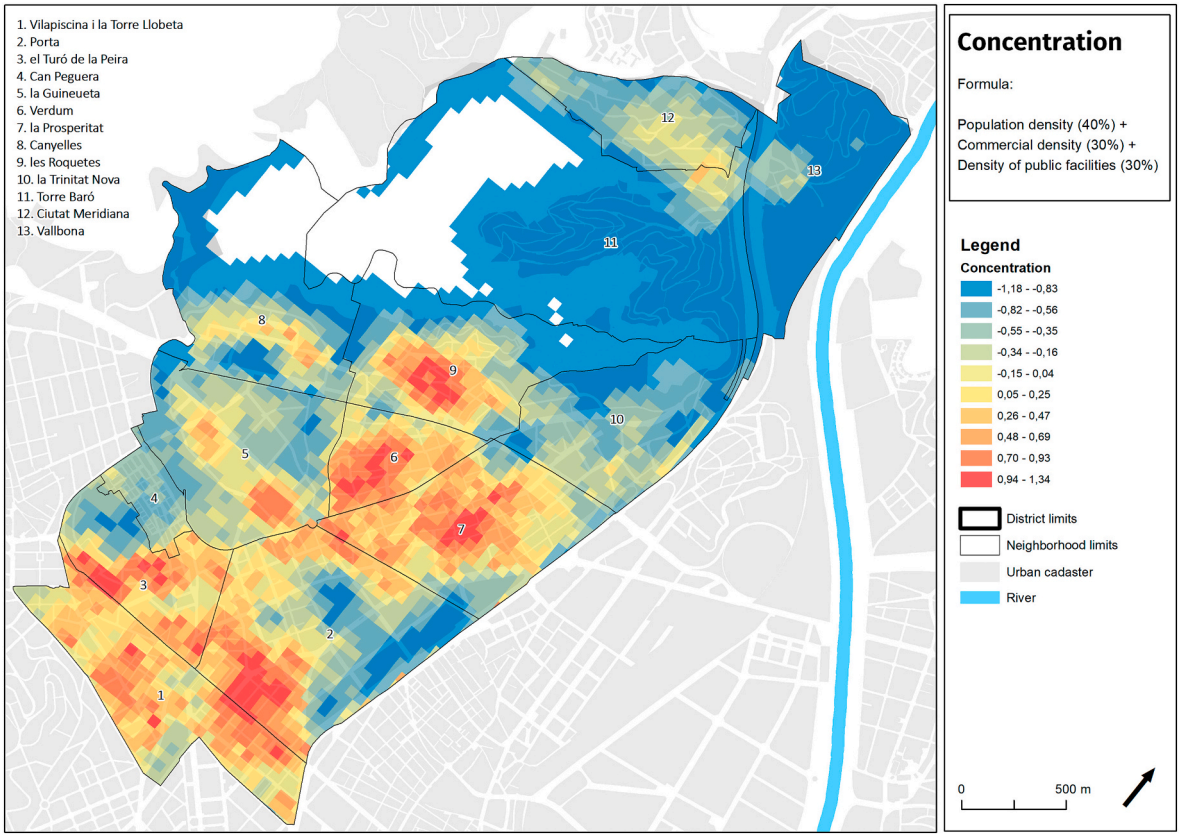

Fig. 4. Concentration values in Nou Barris.
Source: own elaboration.

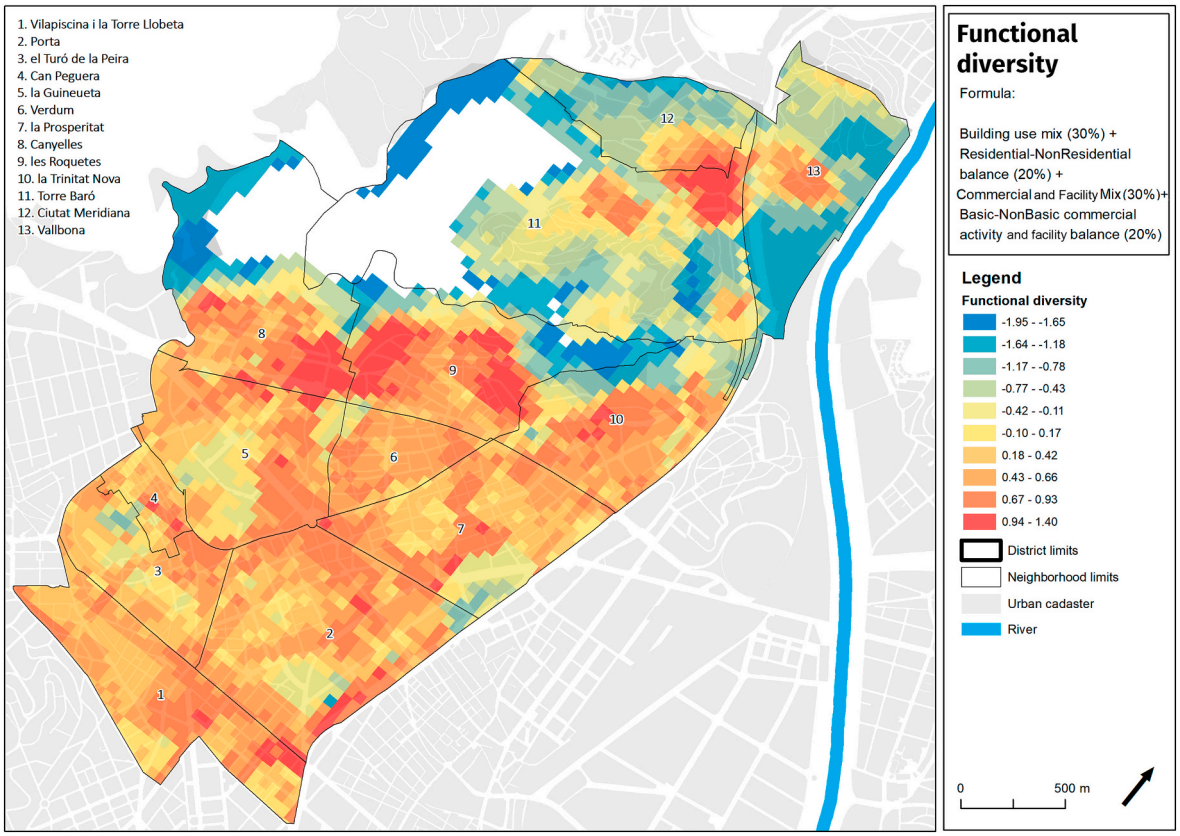

Fig. 5. Functional diversity in Nou Barris.
Source: own elaboration.

elements that could be considered to discourage urban vitality (large single-use buildings of 5000 m^2 and above, large parks of 5000 m^2 and above, large roads at ground level, dedicated parking areas and empty lots):

Border *vacuums* (**BV**) = zBV

Lastly, we calculated an updated JANE Index by creating a weighted sum of the conditions, while making a distinction between the basic and complementary conditions for vitality by assigning different weights (Sung et al., 2015):

$$\textbf{JANE} = C\frac{1}{5} + FD\frac{1}{5} + CO\frac{1}{5} + BD\frac{1}{5} + A\frac{1}{10} + BV\frac{1}{10}$$

4. Results

The results of measuring the conditions for urban vitality in the study area are shown in Figs. 4–8. We first present each of the conditions separately and then describe the final result synthesized by means of the updated JANE Index.

4.1. Concentration

High concentration values were found where high values of population, commercial and facility density overlap (Fig. 4). This is mainly the case for old historical cores (such as in *Vilapiscina i la Torre Llobeta* neigborhood), areas of orthogonal expansion (i.e., *La Prosperitat*, or *Verdum* neighborhoods) and areas dominated by high-rise housing projects (i.e., *Canyelles*, *Ciutat Meridiana*, *la Guineueta*). Low concentration values were mainly identified in areas located along the mountainous area in the north of the district. These correspond to neighborhoods with a high presence of self-construction housing, especially in *Torre Baró*. However, we also observed low concentration spots within the main urban footprint. These mainly correspond to large parks and to *Can Peguera*, a very singular neighborhood consisting in a low-rise housing project.

4.2. Functional diversity

The spatial distribution of functional diversity in Nou Barris is shown in Fig. 5. In an approximate estimation, high values of functional diversity were found throughout the district. Specific very high-value poles were mainly identified in neighborhoods forming a parallel line to the ring road (in *Canyelles* and *Roquetes*), in the north, around the train station of *Torre Baró*, and in the south east, close to a shopping center (in *Porta*). High values were also found in the central neighborhoods, following the patterns formed by the main promenades of the district (*Vía Júlia, Passeig de Fabra i Puig* or *Passeig de la Valldaura*), which gather around a variety of local shops, bars, civic facilities, and other services.

Low values of functional diversity were primarily found in spaces characterized by single-use developments and mountainous areas. Regarding the former, it is specifically the case of an agricultural land situated on the eastern side of *Vallbona*, close to the *Besòs* river, and an open-air parking area and energy infrastructure facilities in the north of *Trinitat Nova*. Proximity to mountainous territories also discourages the locations of residences and therefore of mixed services, which occurs in the northern neighborhood borders of *Torre Baró*, *Roquetes*, and *Canyelles*.

4.3. Contact opportunity

The distributions of places that provide opportunities for contact in Nou Barris are shown in Fig. 6. In general, we observed that areas with a

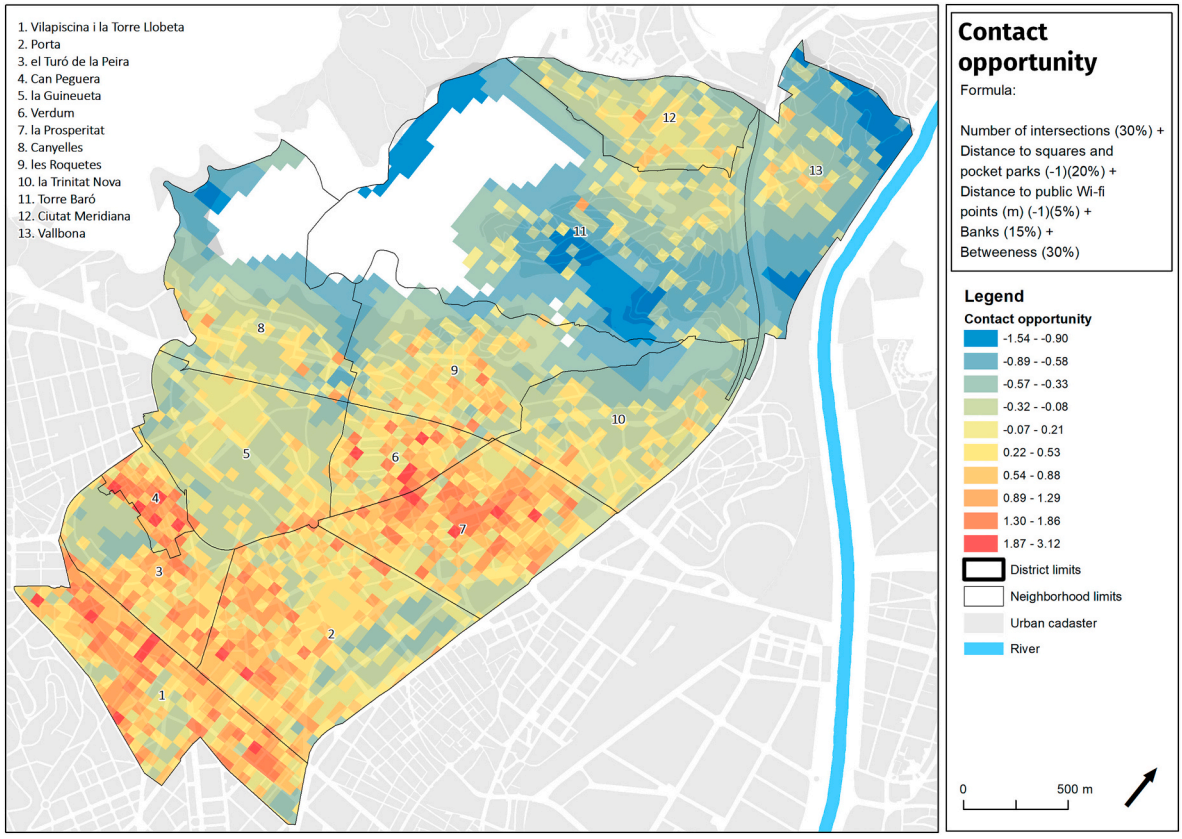

Fig. 6. Contact opportunity in Nou Barris.
Source: own elaboration.

higher degree of compacity generally provide more contact opportunities. This is mainly the case with historical cores (*Vilapiscina i la Torre Llobeta*), the orthogonal street pattern areas (i.e., *La Prosperitat* and *Verdum*), and the singular case of *Can Peguera*, which is characterized by a high intersection density in combination with a significant presence of meeting points such as squares or pocket parks. Conversely, the dominance of winding streets and the lack of walking infrastructure in large parts of the hilly neighborhoods of *Torré Baró* and *Vallbona* explain the low contact opportunity values in these areas.

4.4. Building diversity

Regarding *Building diversity* (Fig. 7), most of Nou Barris generally showed medium values. However, we observed that the diversity of edifications was higher in specific areas. This was the case of the central historical cores (*Vilapiscina i La Torre Llobeta, el Turó de la Peira*, and *Porta* neighborhoods), where many of the oldest buildings in the district are present. We also found a singular spot in the north-west part of *Canyelles*, where an ancient ensemble of old constructions is located which were originally part of a hospital and are currently preserved by a community-based project. The case of *Can Peguera* is remarkable too, as the neighborhood, originated by the construction of a public housing project, still remains in a public tenancy regime, having the most affordable housing prices of the district. Lastly, it is also noteworthy that lower rent prices explain how, in general, northern neighborhoods such as *Torre Baró*, *Trinitat Nova* and *Vallbona* presented values above the average for this indicator.

4.5. Accessibility and distance from border vacuums

The two accessory conditions to the Jacobs theory, *accessibility* and *distance from border vacuums*, are presented in Fig. 8. In broad terms, the central area of the district presents higher accessibility values. These results were mainly driven by higher degrees of public transport access, due to the closer distance to one of the main train stations in Barcelona, *Sant Andreu Arenal*. In addition, central neighborhoods are also characterized by lower slopes, the presence of traffic-calming areas, and a higher density of pedestrian crossings. The second pole of accessibility is identified in the northern side of the district. Despite a challenging terrain, with sinuous and sloping streets, there is a high degree of accessibility explained mainly by the location of another major train station that connects the three northern neighborhoods (*Vallbona*, *Torre Baró*, and *Ciutat Meridiana*) with other parts of the city and also to other municipalities in the Barcelona Metropolitan Area.

In terms of *border vacuums*, we mostly found them in the peripheral areas of the district. First, along the mountainous area of *Collserola*. Second, along major roads such as the *Ronda de Dalt*, which crosses through the neighborhoods of *Canyelles*, *Roquetes*, and *Trinitat Nova*, and also the *Avinguda Meridiana*, which borders the eastern side of the district from North to South. We also found border vacuums within the urban fabric: a cemetery and a shopping centre in *Porta*, an empty lot used for parking and energy and water supply infrastructures located in *Trinitat Nova*. Conversely, the spots farther away from border vacuums are mainly located in the old town cores (in *Vilapiscina i Llobeta*) or inside high-rise housing projects (in *La Guineuta*).

4.6. The JANE Index in Nou Barris

As the final step in the analysis, we synthesized the six conditions of urban vitality in an updated JANE Index. Higher values of the JANE Index correspond to areas with a higher potential for urban vitality, while lower values indicate the lack of such conditions. The spatial distribution of the index results in Nou Barris is presented in Fig. 9, first showing the crude results (Fig. 9, top), and then the categorized version

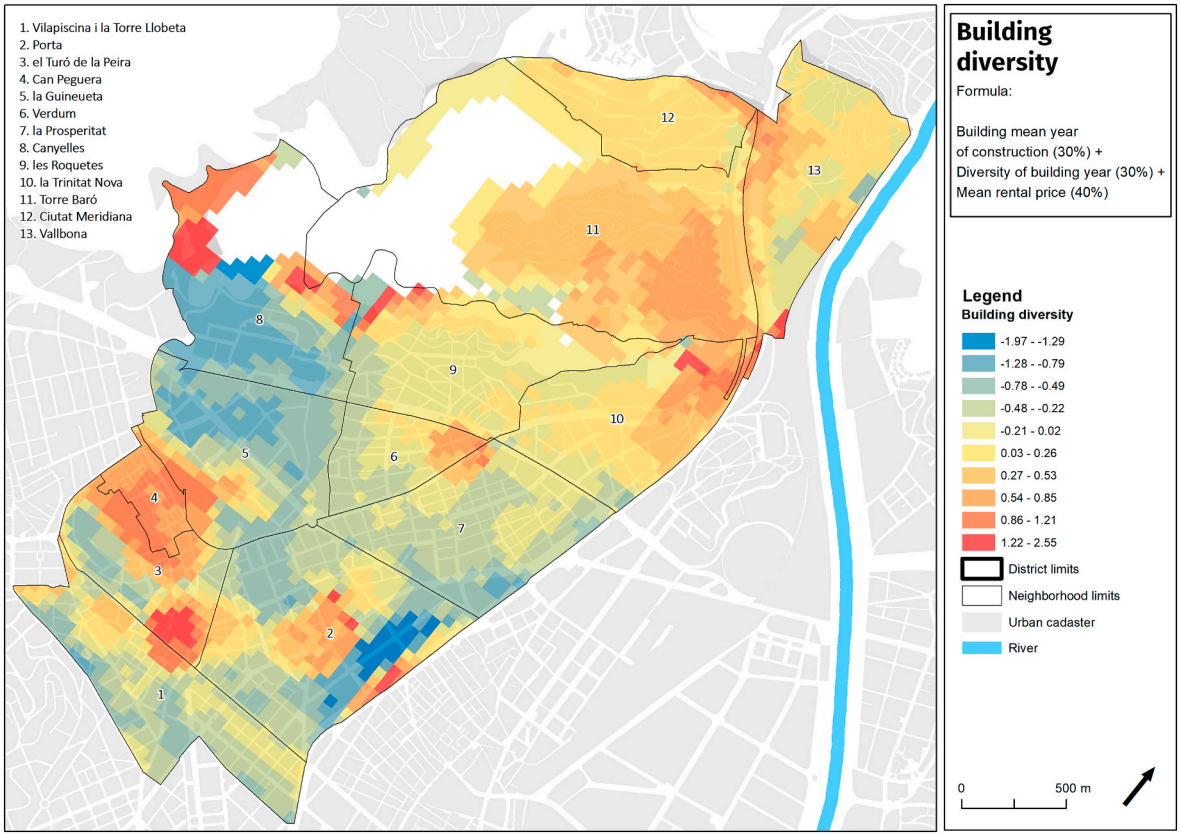

Fig. 7. Building diversity in Nou Barris.
Source: own elaboration.

of the index (Fig. 9, bottom), on which we will base our description.

The potential of urban vitality in Nou Barris presents a polycentric pattern, as we find high values of the JANE Index distributed in different sub-centers of potential vitality. In turn, different intensities of urban vitality potential are identified.

Areas with a *very high vitality* level cover 13% of the study area and are surrounded by *high vitality* rings, with this second category corresponding to 22% of the analyzed territory. We find these spots in diverse urban environments, which share high scores of most of the vitality dimensions. The largest being in the south of the district, around the historical fabric of *Vilapiscina i la Torre LLobeta* and following the main promenades of *Passeig de Fabra i Puig* and *Passeig de la Peira*. This area is characterized by the presence of older buildings and a mix of commercial and public facilities, resulting in high *diversity* and *accessibility* values, which are further enhanced by larger distances to *border vacuums*. In the center of the District we find a considerable extent of high vitality values structured around the avenue of Via *Júlia*, a civic axe where the *Verdum* and *La Prosperitat* neighborhoods converge. This sector scores high due to a high *concentration* and a higher relevance of pedestrian-oriented streets and meeting places, such as pocket parks and squares, which manifest in higher levels of *contact opportunity*. Additionally, in the unique urban context of the *Can Peguera* neighborhood, an old and affordable public low-rise housing project laid out in compact and orthogonal street distribution, we observed higher values of *contact opportunity* and *building diversity*. We also identified high-vitality spots in peripheral and sloping areas of the district, such as in the center of *Roquetes*, where *functional diversity* stands out, as a wide diversity of public facilities come together. Lastly, in the northern neighborhoods of *Torre Baró* and *Ciutat Meridiana*, high vitality is also to be found around the train station and the civic square, scoring highly mainly in terms of *accessibility*.

The *moderate vitality* category takes up approximately 25% of the analyzed territory, and it was primarily found in two specific urban contexts. On the one hand, in high-rise housing projects in *La Guineueta*, *Canyelles*, and *Trinitat Nova*, whose areas between blocks are equipped with pocket parks, benches, and green spaces, becoming conducive scenarios of social interaction. We also found considerable values of *functional diversity* explained mainly by the combination of residential, retail, and recreational uses. On the other hand, we identified moderately vital spaces in hilly and sinuous streets, mainly in the *Torre Baró* neighborhood. Despite the obstacles of the territory, the presence of urban elements such as public transport facilities and basic services (and hence *accessibility* and *functional diversity*) makes them urban spaces with an intermediate potential of urban vitality.

Lastly, *low* and *null* vitality environments represent 27% and 13% of the studied area, respectively. Both categories are present mainly near administrative district limits, but also, and interestingly, embedded within the urban fabric. The first situation corresponds to areas situated in the north, presenting very low values of *accessibility*, as they are close to the mountainous areas with pronounced slopes. Regarding the low and non-vital spots in central areas, they correspond mainly to monofunctional uses, tightly related to elements identified as *border vacuums*. This is the case with the great parks of the district and heavy ground-level infrastructures (such as the cemetery, sport facilities, and parking plot).

5. Discussion

This paper aimed to propose a recontextualization of the Jane Jacobs principles of urban vitality by means of an applied study. As vitality is considered a key indicator of wellbeing and quality of life among urban residents (Lopes & Camanho, 2013), this study contributes to the discussion about the nature of the drivers of urban vitality and how they are distributed in space. To do so, the study creates a synthetized index that

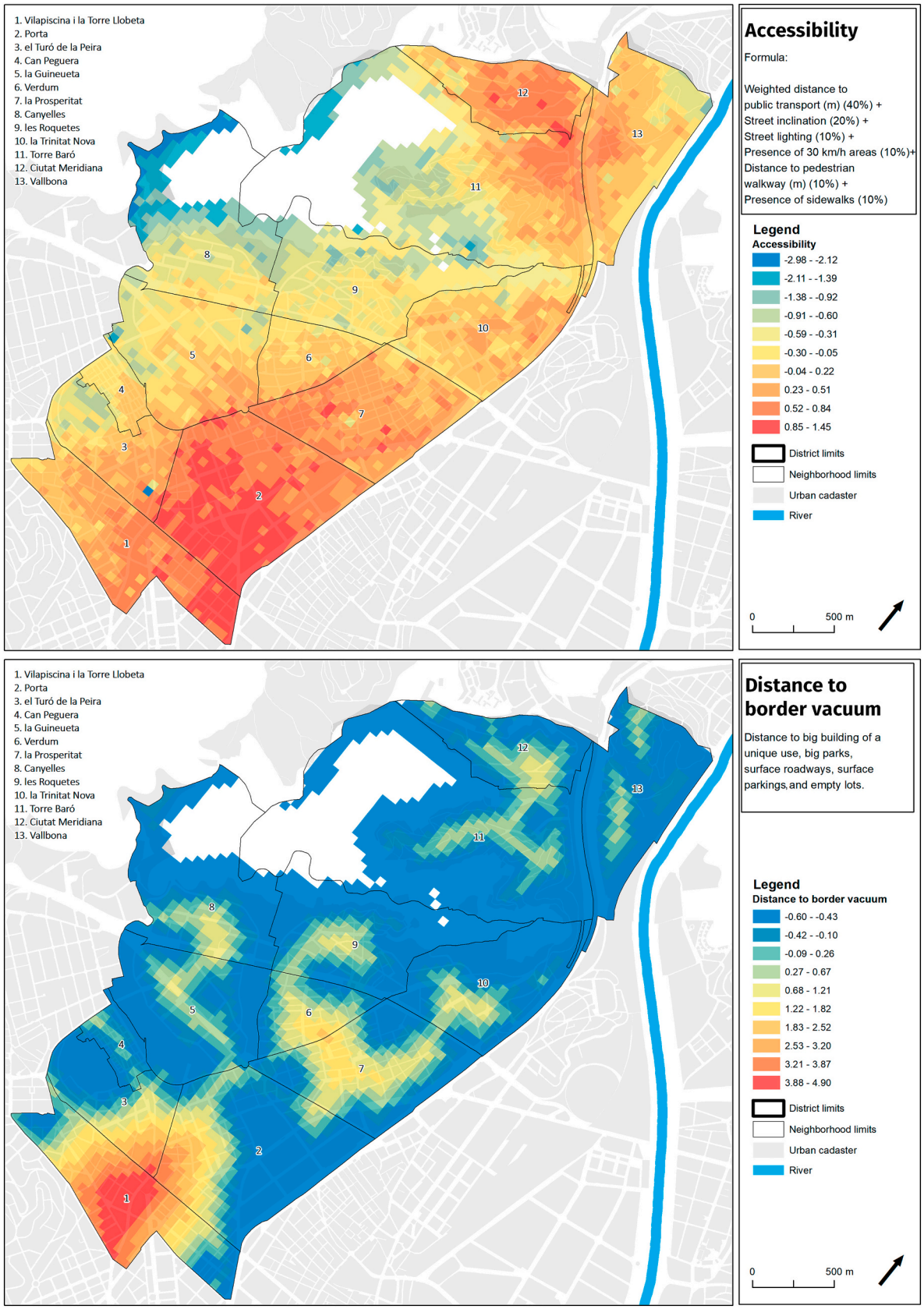

Fig. 8. Accessibility (top) and distance to border vacuums (bottom) in Nou Barris.
Source: own elaboration.

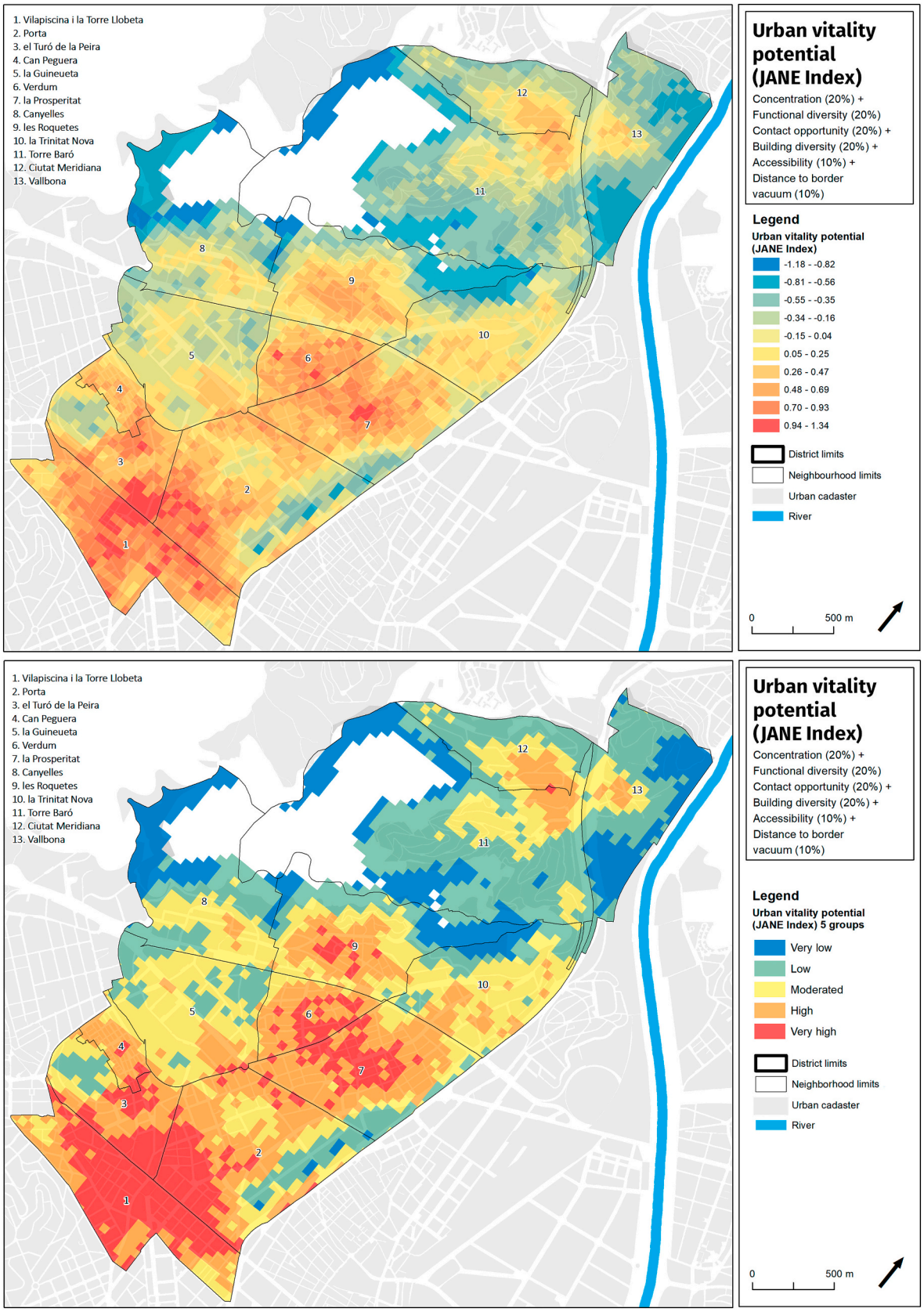

Fig. 9. JANE Index: crude (top) and categorized results (bottom).
Source: own elaboration.

builds on what was developed previously (Delclòs-Alió & Miralles-Guasch, 2018) and integrates theoretical and methodological suggestions made by the recent literature on the topic. The new updated JANE Index, composed of 22 variables and operationalized using a GIS-based process, is then applied to Nou Barris, a low-income peripheral district of Barcelona (Spain) with diverse morphological characteristics.

The results have evidenced that the conditions for urban vitality in a present-day city are not necessarily related to centrality, specific urban fabrics, or certain level of income, but instead, they can be the result of different combinations of certain urban features. In this sense, this study challenges the widely-held assumption that the highest levels of street activity and vitality are mostly found in inner-city districts, which are normally characterized by higher population densities and mixed uses (Garcia et al., 2018). Contrary to what occurs in other contexts where outer-city sectors are almost exclusively residential in terms of land use (De Nadai et al., 2016; Fuentes et al., 2020; Jin et al., 2017), the City of Barcelona presents a homogenous high level of density of population associated with a high provision of services and retail shops that are also in peripheral and low-income neighborhoods. Hence, urban vitality here follows a polycentric pattern. The city's decentralized provision of everyday facilities such as public markets, which in this district are evenly distributed across the outskirt neighborhoods and their coexistence with a dense network of local businesses (Fava, Guardia, & Oyón, 2016), activate proximity and vital dynamics (Marquet & Miralles-Guasch, 2015).

Different intensities of vitality potential are distributed throughout the district, displaying a polycentric pattern and covering a range of diverse urban fabrics. As expected, one of the main areas with high values of urban vitality potential corresponds to the historical core of Nou Barris, which fosters all the basic drivers for vitality. Neighborhoods with orthogonal street patterns also seem to foster the conditions for urban vitality. As is maintained by Jacobs (1961), high population densities combined with a mixture of land uses and meeting points (pocket parks, squares) and intersections, result in such a compact and intricate morphology that provides citizens with a constant opportunity for contact, as well as a diverse provision of facilities and businesses (Banai, 1998; Long & Huang, 2019).

However, in the case of Nou Barris it is especially noteworthy to observe how both moderate and high values of potential vitality were also found in unexpected and remote urban sectors, such as housing projects and areas within challenging slopes. This is the case of some of the northern neighborhoods, which for many years remained isolated due to their hilly nature and the barrier effect of heavy transport infrastructures. Strong neighborhood community mobilizations, together with the application of urban local policies during the recovery of democracy after 36 years of dictatorship, 1939–1975, under the Franco regime (and especially during the 1980s in preparation for the 1992 Barcelona Olympics), were crucial to equip these original-thinking residential neighborhoods with basic urban facilities (e.g., markets, schools, civic centers, public transportation), achieving considerable levels of diversity and accessibility (Blanco, 2009; Domingo i Clota & Bonet i Casas, 1998). In addition, housing affordability still plays a special part in the interpretation of certain values of vitality in the district. Despite the rental price bubble that Barcelona is currently experiencing (Blanco-Romero, Blázquez-Salom, & Cànoves, 2018), certain neighborhoods in the area correspond to the most affordable rental prices of the City of Barcelona (Observatori Metropolità de l'Habitatge a Barcelona, 2019). Furthermore, high values of urban vitality were found even in high-rise housing projects, one of the development models that Jacobs opposed the most in her time. In the case of such projects in Nou Barris we found that high potential for vitality could be explained by the combination of the intrinsic high residential density of such projects, the particular provision of inner pocket parks, compact pedestrian-oriented environments (intra-block spaces with a minimal presence of motorized transport, and a high potential for social interaction) and especially their combination with a significant level of accessibility that avoids the isolation effect which many other projects suffered from in the 20th century (Baldwin, Tammaru, & van Ham, 2018).

The rationale of Jacobs enables us to acknowledge that certain urban features may be regarded as promoters of vibrancy in neighborhoods that have been generally regarded as vulnerable (Cornado, Garcia-Almirall, Vima, Busqued, & Uzqueda, 2017). Specifically, following the inclusion of complementary indicators in the updated version of the JANE Index, such as the provision of facilities, basic services, housing affordability, and pedestrian accessibility, it is now possible to recognize nuances in relation to the potential of urban vitality. For example, this is the case of high- and low-rise housing projects, which presented lower scores of urban vitality potential if the abovementioned factors were not considered. Although it is true that these urban areas deal with socio-economic challenges (Antón-Alonso & Porcel, 2018), we may appreciate some of the strengths the built environment offers when designing policies that aim to ameliorate life conditions of residents. As suggested by recent studies, these housing projects offer an urban form with open spaces that could potentially meet present-day car-free urban interventions reclaiming space for people and active sustainable lifestyles (García-Pérez, Oliveira, Monclús, & Díez Medina, 2020).

In this sense, the ideas of Jacobs offer an interesting framework to address some of the challenges faced by cities in the 21st century in terms of health, sustainability, and equity. Proximity and pedestrian-oriented environments as found in Nou Barris may contribute to better health and safety outcomes (Giles-Corti et al., 2016; Nieuwenhuijsen, 2018). Urban vitality through the lens of Jane Jacobs may also be relevant in order to re-think cities from a gender perspective, since the idea of "*eyes on the street*" (which mainly translates to higher levels of safety resulting from the presence of people and strong social networks) (Humphrey, Shane, Small, & Thurston, 2017), combined with access to care facilities encourage the use of public space by women (Khalili & Nayyeri Fallah, 2018; van den Berg, 2018). Finally, we may retake the concern of Jacobs on guaranteeing affordability in order to find different kind people living in neighborhoods. In this sense, a range of housing accessibility indicators should be considered when designing urban policies that are able to guarantee diversity. In this study we included an indicator for the average price of rent, which is not sufficient to guarantee housing access. Nou Barris, despite being one of the most low-priced districts of the City of Barcelona in terms of housing, does not ensure affordable housing, as it is also one the areas with major vulnerability related to housing exclusion (Toma, 2018), being affected by evictions (Gutiérrez & Domènech, 2018) and a precarious physical state of the buildings (Cornado et al., 2017).

The findings of this study may have relevant implications for future practice, as they can be used to develop targeted interventions in different urban contexts. We identify two main directions in which urban policies should move towards. First, in areas that do not seem to gather the theoretical conditions for vitality, policies should focus on improving the conditions that may be missing. In the specific case of Nou Barris, northern areas seem to require improvements in terms of pedestrian accessibility together with a considerable potential for increasing density. Second, in areas that already present a considerable potential for vitality, efforts should be aimed at preventing the unwanted collateral risks of vitality, and thus aim to avoid the deaths of these areas due to their own success (Romagnoli, 2020), that is, to guarantee that vital spaces are not triggering pernicious dynamics of social exclusion, as is already happening in certain parts of the City of Barcelona, outside of the district (Cocola-Gant & Lopez-Gay, 2020). In Nou Barris, this is especially the case with southern neighborhoods. One of the main vectors to correct or address such processes corresponds to efforts aimed at guaranteeing housing affordability; for instance, by deploying rent control or increasing the supply of public housing options (Observatori DESC, 2020).

This paper presents some limitations that could inform future studies. First, from a methodological perspective, our approach is limited by the inherent constraints of synthetic indices of this nature.

Our calculations were based on a selection of key variables that were integrated by means of a specific combination of weights which, despite being grounded in theory and the previous literature, could be modified depending on the territorial context. Second, our approach could also be limited conceptually. The index presented in this paper offers a static vision of the conditions of vitality, a screenshot of certain aspects of the built environment, while other authors have pointed to the need to adopt a more dynamic perspective (Kang, Fan, & Jiao, 2020). That is, to explore how urban spaces are occupied and used differently throughout the day and by different social groups. This would call for an exploration of how such conditions may vary over time and would be based on the characteristics of urban residents. Similarly, the so-called "relational wellbeing" approach (Pérez del Pulgar, Anguelovski, & Connolly, 2020), derived from the analysis of social relationships and connections that can take place in public space, could also be relevant when studying urban vitality. Lastly, in this line, our study has paid a limited attention to the interaction between vitality and socio-economic vulnerabilities. In this sense, future studies may explore the complex relationship among the physical environment and social aspects by using the proposed framework.

Despite these limitations, we believe this study can be regarded as a useful tool to re-think the characterization of the built environment using the rationale of Jane Jacobs in contemporary cities. Hence, we have established a framework that may allow fellow researchers and practitioners to determine the potential of urban spaces to be vital, contributing to a wider discussion about what constitutes a vital city, in this case specifically applied to the Mediterranean context. Results found here can be taken as a departure frame for future research to launch deeper analysis from specific approaches using data from other urban phenomena. Finally, the replicability of the JANE Index, as one of the main strengths, may allow calculating and quantifying the potential of vitality in other urban contexts.

CRediT authorship contribution statement

Irene Gómez-Varo: Conceptualization, Investigation, Methodology, Data Curation, Formal Analysis, Visualization, Writing – Original Draft.

Xavier Delclòs-Alió: Conceptualization, Methodology, Data curation, Formal Analysis, Writing- Reviewing and Editing.

Carme Miralles-Guasch: Conceptualization, Supervision, Writing-Reviewing and Editing.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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