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From Land-Use Planning to Mixed-Use Configuration. Similarities and Differences in two Urban Fragments of Barcelona Metropolis

Abstract The city of zoning, inspired by the principles of the Charter of Athens, soon generated some rejection in the urban debate of the second half of the twentieth century. Since then, it has been an increasing awareness of the need for the mixed-use urban composition to remediate the inherited monofunctional areas, looking for more sustainable and more efficient metropolises. Thus, contemporary urban planning and design must provide empirical and objective approaches to the different variables that characterize the city and its fragments. This paper presents a 3-year funded research project linking mixticity and proximity with the aim to understand some of the clues on the mixed-use configuration in compact urban areas. Taking Barcelona as case study, the complex relationship between density, topology and accessibility is explored through an analysis that mixes GIS mapping and morphological drawings of small fragments of the city and its metropolitan area. A series of graphics on selected samples (around 25 hectares extension) depict novel views of the districts and emphasizes differences and similarities among the urban fabrics of the compact city, evaluating the concentration and intensity of different services and programs, looking for new tools for the assessment and promotion of the mixticity in cities.

Keywords Barcelona, Activity, Mixed-use, Functional mix, Diversity

Introduction

This presentation focuses on the understanding of the mixed-use configuration of urban tissues by opposition to simplest image of the land-use planning, looking at the similarities and differences in some tissues in central Barcelona. It is well known how the city of zoning, inspired by the principles of the Charter of Athens, soon generated some rejection in the urban debate of the second half of the twentieth century. Since then, it has been an increasing awareness of the need for the mixed-use urban composition to remediate the inherited monofunctional areas, looking for more sustainable and more efficient metropolises. Thus, contemporary urban planning and design must provide empirical and objective approaches to the different variables that characterize the city and its fragments.

Two are the main goals of this paper: first, to develop a precise mapping process capable of measuring mixticity in non-specialized fabrics in order to offer some clues about the internal configuration of non-residential uses; and second, to understand street perception of proximity and the synergies, balances and scales of mixedness in relation with urban morphology. From a methodological perspective, the research tests new mapping tools to unveil which are the relations between concentration (number and distances) and intensity (area and variety) of different services and the territorial service that is provided to inhabitants (density and balance). Therefore, a series of x-ray analysis based on crossed databases of small fragments of the city and validated by fieldwork could depict the synergies between different compatible uses which may be used as a base on further developments of cities.

This is a piece of research of an on-going Competitive Project founded in the Spanish National Program for Research and Development 2020 entitled '[METRO·MIX] Proximity and Mixedness for Healthier Cities. Criteria and Tools for the Assessment and Promotion of Mixed-use Activities in Compact Metropolitan Areas'.

The first section of this article, Background, frames this investigation in related research on the mix of uses in Barcelona and presents the two cases of study. The second section, Methodology, details the databases tools used for the construction of the analysis plans that constitute the central body of this investigation. The third section, Results, analyzes and compares, map by map, the two urban fragments studied in relation to the activities on the ground floor, level on upper floors and in relation to the impact of said uses on the street. And finally, the fourth section, Final Considerations, points out future lines of this research.

Background

On Mixticity and Barcelona: Literature Review

Barcelona and its metropolitan area is presented as main case study, as a renowned example of a compact city that treasures a good tradition of urban design and urban planning practices. Several studies have evaluated models of mixticity in central Barcelona in relation to variables such as the diversification index, ecological matters and social exclusion (Garcia-Almirall, Roca-Cladera 2001; Romano, Beltran, Roca 2012; Marmolejo, Cerda 2016; Marmolejo et al. 2016) or vitality index (Delclòs-Alió, Miralles-Guasch 2018). The results and methodology are in these cases bound to statistics and geographical scales, because of the common use of aggregated data – districts, neighbourhoods and municipalities. Studies based on a functional analysis of the economic urban patterns (Font 2012) and an in-depth analysis of the residential urban fabrics (Corominas 2015) have characterized the nature of urban forms in the Barcelona metropolitan area. An analysis that includes the value of non-canon activities in the recent urban transformation of new tertiary neighbourhoods, claiming for the integration of the non-dominant, pre-existing activities has contributed to the ongoing discussion from a sociological perspective (Garcia et al. 2015).

The novelty of this research lies in the deliberately detailed scale of the work, which contributes with a new graphic interpretation of the data and results. In the last two years, previous approaches and results have been published by the same research group, among others: 1/ the research on the distribution of essential services in Barcelona, pointing out certain relations between proximity and the quality and quantity of premises and services at the city scale (Crosas, Gómez-Escoda 2020a, 2021) at the district scale, the urban mixticity has been analysed in the paradigmatic transformation area of the 22@-District Barcelona, were new scenarios for this area have been depicted taking into consideration the new demands for more affordable housing through a research by design experience (Crosas, Gómez-Escoda 2020b) and finally, exploring new methodologies of analysis at the block scale, looking at the forms of patterns of mixticitiy in Sagrada Familia neighbourhood (Gomez-Escoda et al. 2022).

On the Case Studies: Morphological Presentation

The research begins with a general perspective of the mixed-use throughout the Metropolitan Area of Barcelona, a political administration that encompasses more than 600 km^2 and 36 municipalities. The complex relationship between density, topology and accessibility is explored through an x-ray analysis which mixes GIS mapping and morphological drawings of small fragments of the metropolitan area. The research takes a series of samples of 500x500m (around 25 hectares extension) – represented in white (Figure 1) – aiming to depict novel views of the districts and emphasizing differences, and similarities among the urban fabrics of the compact city. In a second phase, the research moves to an in-depth analysis of the quantitative measurement and the qualitative spatial configuration of twelve fragments representing some diversity in terms of urban morphology and socioeconomic index. The selection of the case studies takes into consideration the morphological aspects but is focused on a functional metropolis-wide analysis. On the one hand, it is observed the intensity of residential floor area which points out the heterogeneity of the central city with some blank interior spaces and, paradoxically, relatively dense areas in the periphery can be also seen. On the other hand, the non-residential picture shows the tertiary attraction of the main arteries in the central city, but also scattered spots all around the metropolis. Mixing both layers (Figure 2), it results that the most residential and the most non-residential areas are combined in many areas of the whole Barcelona metropolis, breaking the prototypical scheme downtown-tertiary versus periphery-residential that characterizes certain metropolis worldwide.

On further development of these analyses, the research aims to point out with major precision those areas that are more intrinsically mixed, that means, those where the percentage of non-residential floor area is between 10% and 90%, avoiding the most monofunctional sectors. This condition is not only characteristic of the densest and most intense central areas, such as in the Barcelona's Eixample grid, where a remarkable mixedness is expected but also in other more peripheral selected areas. Therefore, the research has selected different frames with different mix configuration that can allow understanding a wide range of mixed-use interesting formulas in the current metropolis.

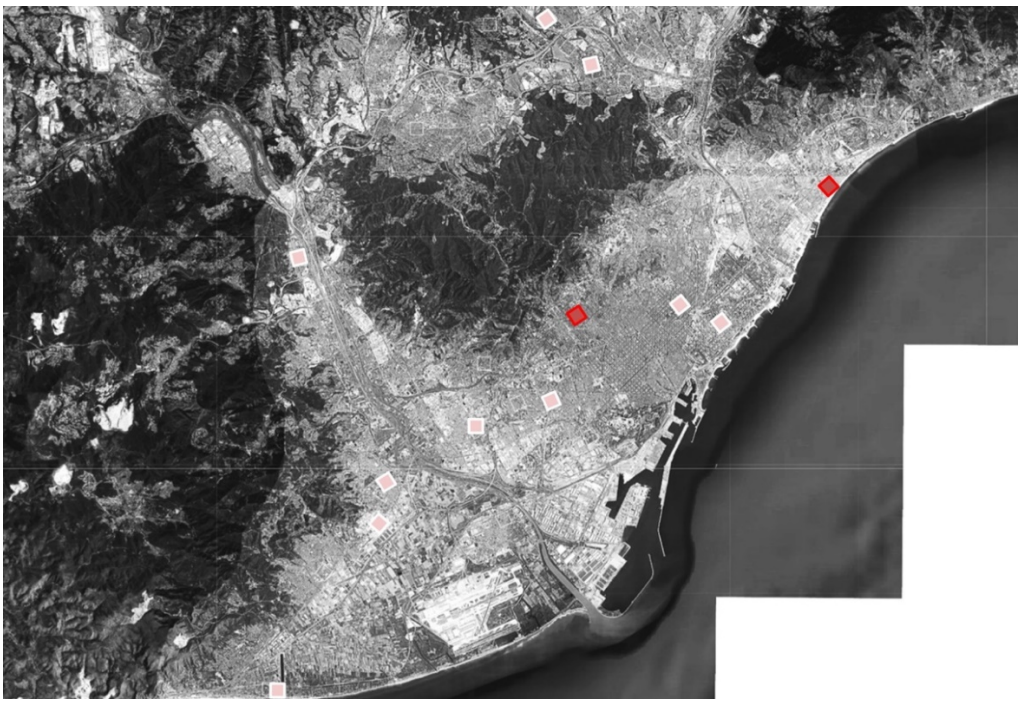

Figure 1. Metropolitan selected study cases. Tres Torres on the centre and Badalona on the right side
Source: authors' own work on the basis of Google Earth.

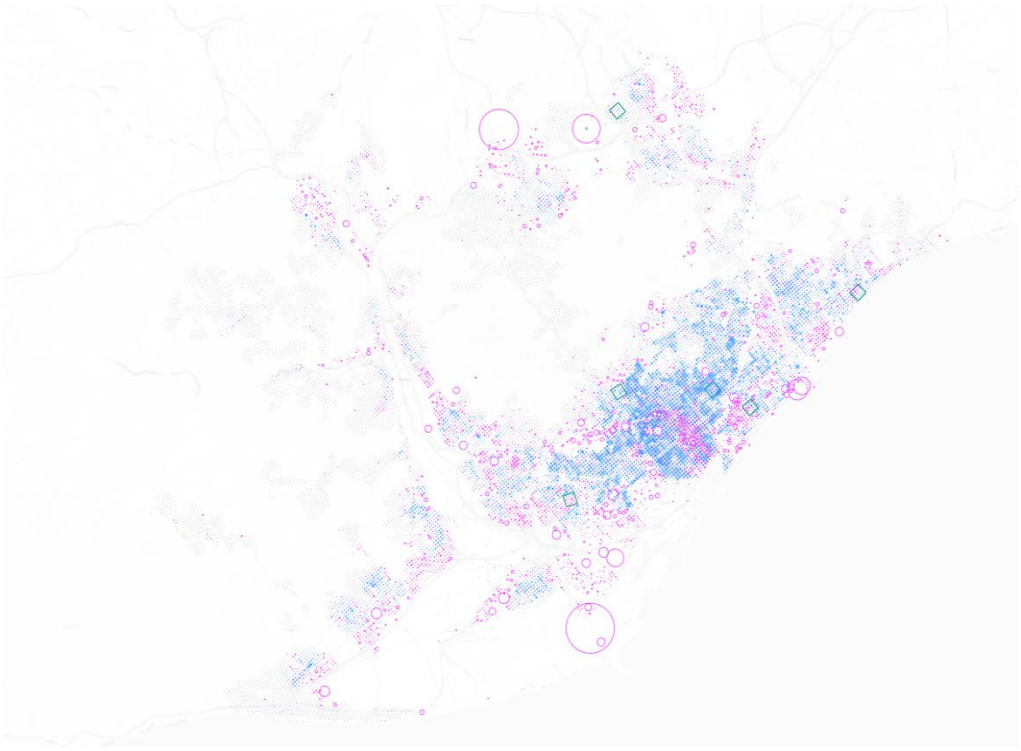

Figure 2. Metropolis-wide residential and non-residential floor areas
Source: authors' own work.

Among the 12 crops analysed, only two – represented in red – are described in this presentation, through quantitative measurement and qualitative spatial configuration representing some diversity in terms of urban morphology and socioeconomic index inside Barcelona and its metropolitan area. The two selected cases are (Figure 3): (1) Tres Torres, a mainly residential area on the upper side of Diagonal, that can be considered a wealthy district, with isolated tall buildings, hosting 5,300 inhabitants; and (2), the traditional centre of

Badalona, the third largest town in the Barcelona metropolitan area with low-height buildings and some commercial streets, hosting 3,980 inhabitants.

Figure 3. Aerial view of the two urban fragments selected. Tres Torres on the left, Badalona on the right (the order of presentation is maintained on the following images)
Source: Google Earth.

Methodology

Data and Sources

Two main public databases are key for the research, the accuracy of which has been reviewed through site visits. On the one hand, the research uses data from the Spanish Land Registry (2021) that allows the addition of information both on private activities on the ground floor (such as housing or private parking), as well as detecting uses at the upper floors.

On the other hand, the National Institute of Statistics (INE 2021) provides a wide range of demographic and socioeconomic dataset in a census section scale ranging from the age, gender, origin, income and studies of the inhabitants to the variation of people throughout the day on the area. This allowed the authors not only to depict socioeconomic graphics from the cases but also crossing it with the rest of the dataset.

In terms of the methodology, the research used the available data to analyse the cases as a primary method but detailed fieldwork was fundamental to update and revise the database through creating a basic mobile app linking geolocalisation and databases (Figure 4), always in line with the scope of the research resources and available human capacity and time. Through the fieldwork, the activities are located and categorized in seven groups and represented in different colours: food retail (orange), other retail (red), hospitality (yellow), services (maroon), industry and logistics (purple), public facilities (blue) and non-occupied premises (black). Apart from these activities, other complementary uses are taken into consideration and classified as follows: open spaces (white), common spaces (light grey), housing (turquoise) and private storage/parking (mint green).

Every dataset used is available for every Spanish city in the same format and, therefore, it allows the research to expand the scope to other cities without any methodological issue.

For the specific cases located inside the city of Barcelona, the research has used also the Inventory of Commercial Premises in the City (Ajuntament de Barcelona 2019) which offers a geolocated description of the ground floor activities, other than residential, classified in 86 activity categories. This dataset has been used as a reference for the fieldwork and the existing categories have been classified in the seven groups of the research.

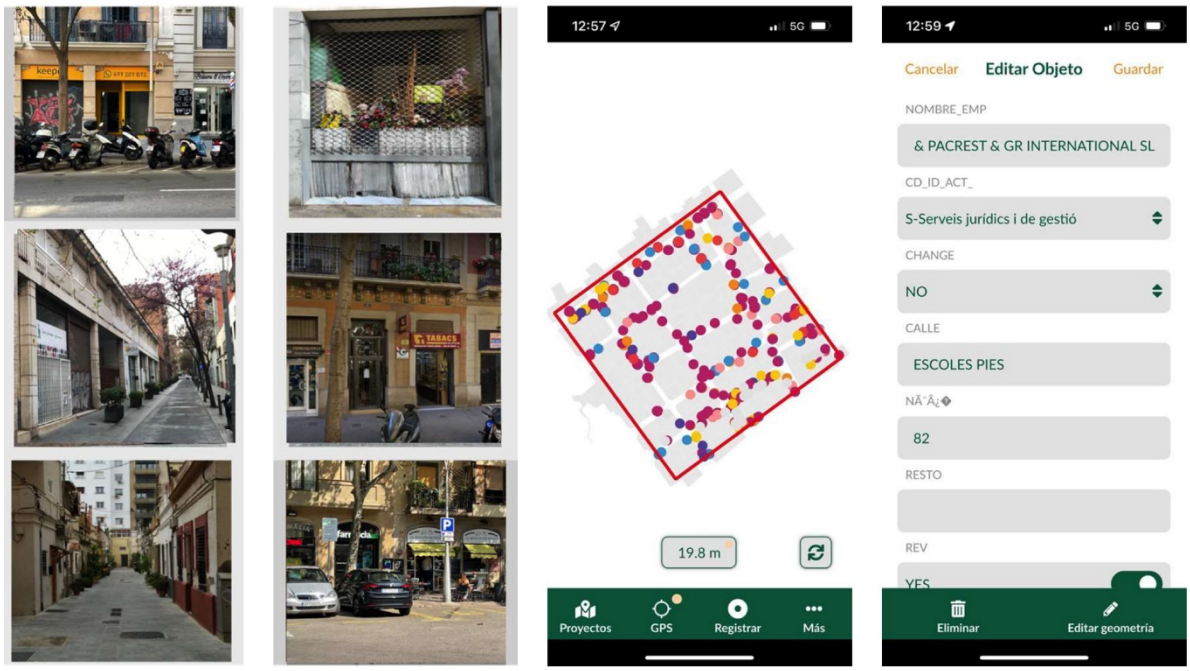

Figure 4. Detailed fieldwork analysis tools
Source: authors' own work.

Mapping and Indexes: four Complementary Approaches

The application of the methodological process developed by the research into the two aforementioned fragments led to a series of mappings and indexes that aim to depict the differences and similarities in the condition of mixticity and proximity. These mappings have been developed with GIS tools and are based on the datasets previously described.

Four different approaches offer a mix-use overview of the two selected samples, trying to illustrate through graphic images and index different kind of information, with a more generic or specific nature, with more complex or basic data elaboration. The four approaches look at: (1) urban planning standards; (2) mixed-use context; (3) ground floor activities; and (4) street perception of proximity.

Urban Planning Standards

The conventional comparison of the planning maps and regulatory standards (Figure 4) offers a first glimpse of the mixed-use condition, in the very basic differentiation of the public space that is defined by streets and parks, versus the blocks that allocate private activities. The planning information is taken from the Metropolitan Master Plan of Barcelona (AMB 2021).

The first comparison of the two districts shows the wide streets of Tres Torres in a quite regular structure that contrast with Badalona, with smaller blocks and streets, which configure a tighter tissue, with much more intersections. In morphological terms, this denser configuration is still stressed by a condition that can be identified in the aerial view of the two samples (Figure 2): the isolated buildings in Tres Torres have a front yard, whereas the traditional tissue of Badalona buildings are aligned with street façade.

The proportion of public facilities and green areas can be calculated with precision (square meters) resulting that they are relatively similar, even though their distribution responds to quite different logics, according to the chronology of their construction: Tres Torres is a modern tissue built in the second half of the 20th century and the case of Badalona was built in the 19th century, without any provision for public services. In regards to the private domain, there is a slightly higher percentage of private floor in Badalona to the detriment of public streets area.

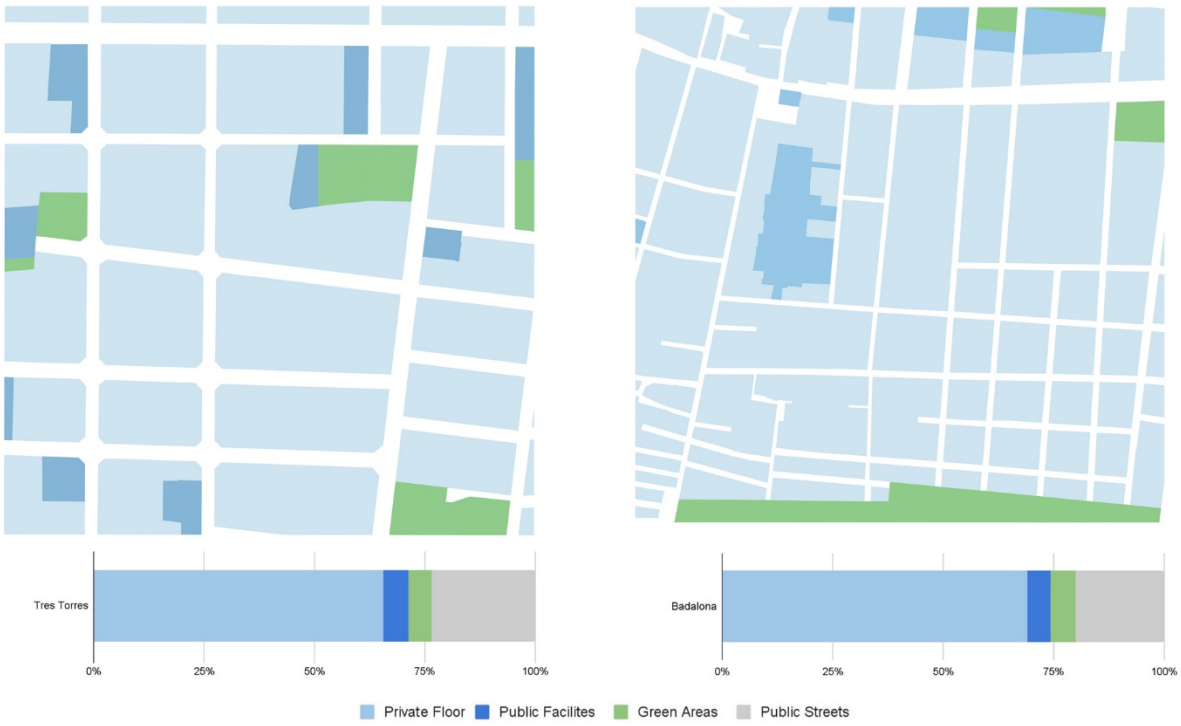

Figure 5. Urban planning standards
Source: authors' own work.

Mixed-use Context

In regards the balance between residential and non-residential uses, the research applies a plot-by-plot approach that illustrates the mixed-use context (Figure 5). First, the residential units linked to every plot by its land registry code are isolated from the rest of uses and depicted through GIS mapping tools in blue circles in the centre of the plot. Their diameter represents the total amount of dwellings within the plot. Second, a similar process is followed with the non-residential units that are represented in red (excluding parking and private storage). Finally, the number of ground floor activities identified in the fieldwork is represented in an inner coloured red circle which shows the proportion of non-residential units on the ground floor level with respect the total number of units (when the two circles match, it means there's only non-residential activities in the ground floor).

The same process has been followed in order to analyse the differences in terms of floor area and in this case, they are represented as an overall comparison in a bar graphic with the results of the whole fragment in square meters. Parking and private storage, previously excluded in the units analysis, have been added in grey.

This data has been used to classify the two cases by an index commonly used, the residential and non-residential balancing index (RNR Index), that measures the degree of mixture between the residential use and other uses. The formula is as follows, where 'Res' refers to residential uses and 'Nonres' to non-residential uses. In this research, this index has been applied from a plot point of view using the data from the Land Registry.

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

The results of the RNR Index for the two cases, always using the floor area (and not the number of units), are notably different: the RNR of Tres Torres is 0.23 and the one of Badalona is 0.69.

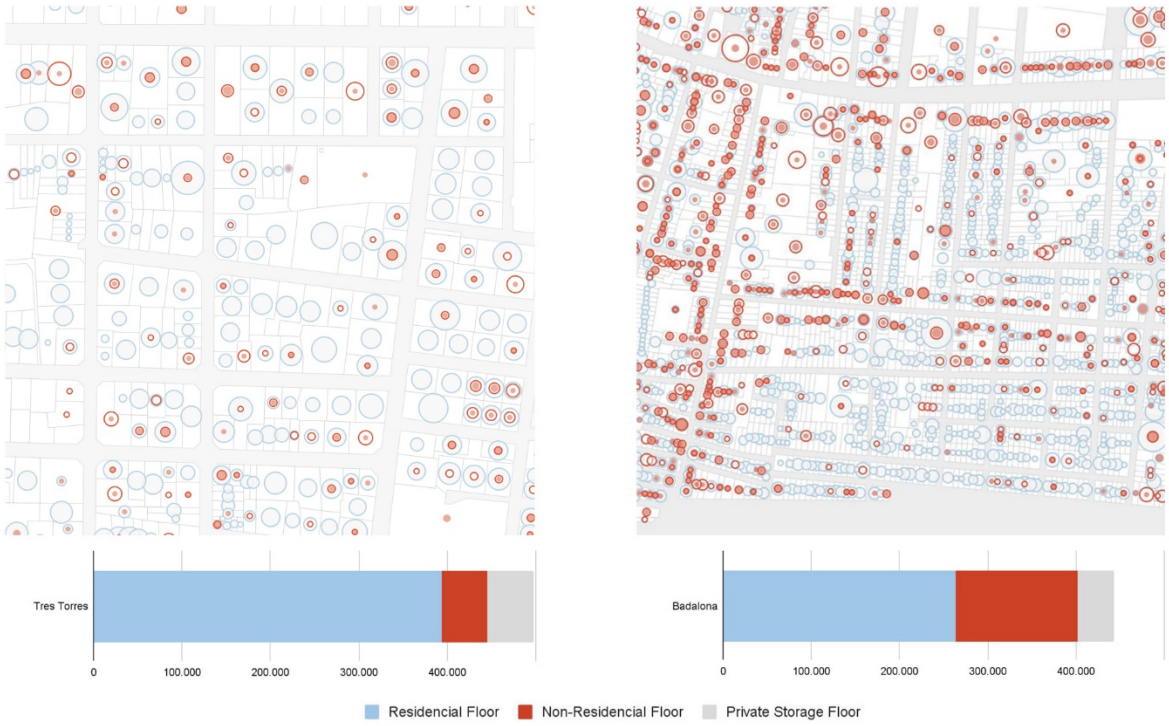

Figure 6. Mixed-use context
Source: authors' own work.

Ground Floor Activity

Focusing on the importance of ground floor activities, the research depicts a precise plot layout of the diversity of uses following the aforementioned methodology, consisting of the crossed analysis of datasets with detailed fieldwork (Figure 3). The process followed in the elaboration of these maps starts with the isolation of the built ground floor in the land registry dataset. The common spaces from the residential buildings such as the staircase and the collective hall are set aside from the rest of the ground floor uses, in order to get the real area of the premises and identify the morphology and dimension of the residential buildings' entrances. In addition to its shape, the land registry provides the number of units of non-residential activities of each plot which is used as a base for the fieldwork and to group each activity in its category.

Besides the seven categories related to economic activities (retail, hospitality, services, etc.) are also taken the housing units (individual dwellings or collective housing access and services), the private storage and the parking entrances. Once every entrance is identified and classified, the information is attached to the plot, splitting into two or three units when there is more than one activity. Each activity is represented by a colour-code that allows reading separately the size and the number of different programs within the area.

Finally, the two graphic bars summarize the amount, the size and the proportion of different groups of activities, in terms of floor area and units.

The mapping of the ground floor activities offers a clear comparison between the two areas in regards program dimension and distribution. Complementary from this reading, the research uses also a parametric resource for calculating the proportion among different categories. The LUM Index 'Land-Use Mix' based on the Entropy Index (Frank, Pivo 1994) states that, the more balanced the different categories are among them, the higher the index. The formula is as follows, where 'P_i' refers in each fragment to the percentage of floor area for each of the 6 categories (excluding non-occupied premises) on the ground floor level. The final result is the sum of each percentage multiplied by its own natural logarithm, converted to positive numbers.

$$\mathrm{LUM}_i = \left| \frac{\sum_{i=1}^{n} P_i \ln(P_i)}{\ln(n)} \right.$$

In this case, the parameter has been calculated taking the total area (square meters) occupied by each group of activities, but not the number of premises, as it seems to be much more representative. Six out of the seven categories have been considered (excluding the non-occupied premises), resulting a quite similar LUM index: Tres Torres 0.92 and Badalona 1.11.

Figure 7. Ground floor activities
Source: authors' own work.

Street Perception of Proximity

A more sophisticated approach aims to explain the street perception of proximity by depicting the interaction between the premises and the dwellings. The first map of this series depicts the residential units in the ground floor and the residential buildings' entrances. Crossing the information of the residential units in each plot and the buildings' entrances located in the fieldwork, the residential intensity and concentration are shown. Considering the associated daily flow of people, every node is represented with a diameter depending on the number of residential units it serves (Figure 7).

The circles located in each entrance cast a 'shadow' on the street, according to the daily movement of their inhabitants. They become a primary focus of flows in the sidewalk, complementary to the points of access to all the premises that are added in the second map of the series, showing in different colours the 'effects' of residential and non-residential activities (Figure 8).

Six of the seven categories of activities (excluding non-occupied premises) are grouped in two colours. On the one side, food retail, other retail, and hospitality premises are represented in a red 25 metres radius circle around the entrance. On the other side, purple colours are assigned to services, industry, logistics and public facilities whose entrances are normally less visually connected with the street and referred to non-daily services. The circles are all represented exclusively on the street.

As a result, the map shows not only the concentration of flows in the selected fragments, but also the blind façades and the lack of vivid commerce doors and dwelling entrances which generates spaces where the security feeling of the pedestrian might be critical.

Finally, the last map of the series aims to depict the proximity and mixticity of activities from a street point of view. In this case, the research has layered the drawing with a heatmap that counts the number of activities of each category at any given point within the 500x500 meters crop in a 20 metres radius (Figure 9). The result is a series of greyscale waves from GIS that are later on translated to a grid where each point represents the intensity of activities in circles with different diameters, varying from zero to five activities of that category found in a twenty meters radio.

Figure 8. Housing intensity on the ground floor
Source: authors' own work.

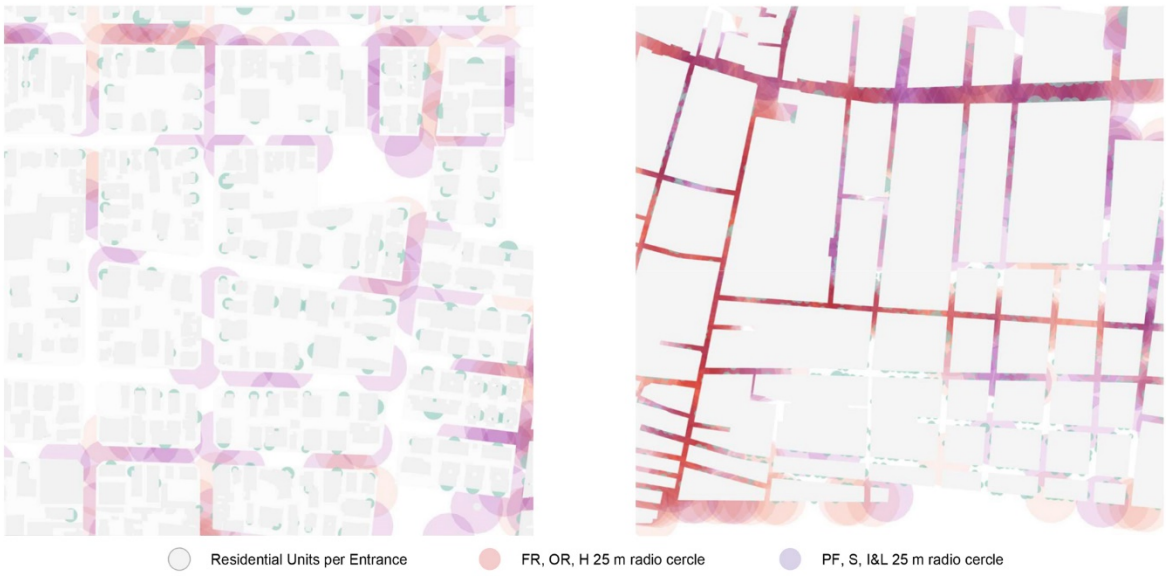

Figure 9. Street perception of intensity
Source: authors' own work.

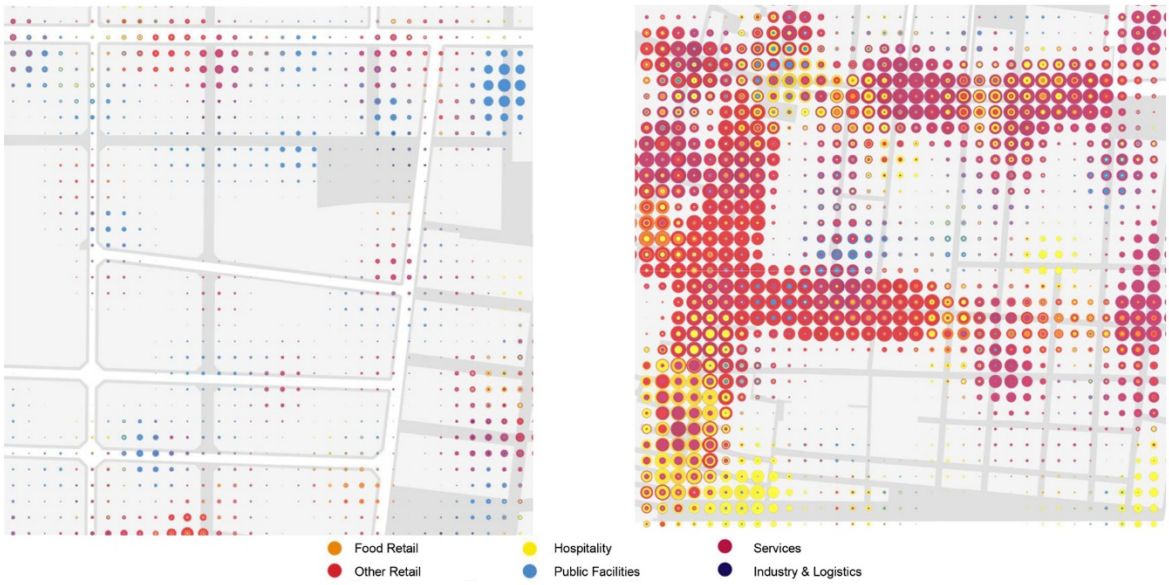

Figure 10. Street perception of proximity and mixticity
Source: authors' own work.

Results and Discussions

The mapping series combined with general and specific urban parameters provides new insights for the comparison of the two districts well characterised from the morphological point of view.

Table 1. Urban Parameters on Tres Torres and Badalona areas

Data	Tres Torres	Badalona
Population	5,300 inhabitants	3,980 inhabitants
Private Floor	164,261 m^2	172,783 m^2
Public Facilities	13,939 m^2	13,146 m^2
Green Areas	12,961 m^2	13,805 m^2
Public Streets	58,839 m^2	50,266 m^2
Built Floor	497,437 m^2	442,926 m^2
Residential Floor	393,648 m^2	263,678 m^2
Non-Residential Floor	51,202 m^2	134,264 m^2
RNR index	0.23	0.69
LUM index	0.92	1.11

Source: authors' own work.

In terms of land, it is of note the similarity in the proportion of green areas and facilities in both areas, with a slight difference in private land due to the geometry of blocks and the width of the streets. In terms of floor area, differences are much more substantial. The residential floor in Tres Torres is higher, with almost 400 thousand m2 (an average of 74 m^2 per person) while Badalona has around 260 thousand m^2 (an average of 66 m^2 per person). The proportion is just inverse in terms of non-residential floor: Tres Torres has around 50,000 m^2 which is less than 10 m^2 per person and Badalona has around 135,000 m^2 which gives more than 33 m^2 per person. (Figure 6). All these parameters depict the very first differences in terms of mixed-use.

The morphological grain in the two fragments is quite different, so it is the analysis of the mix-use at the plot scale. Despite the fact all encompass different streets, plots and buildings, a relatively more homogenous pattern can be seen in the mesh of streets of Badalona, whereas in Tres Torres it is not easy to set some logics of repetition (vertical or horizontal streets, corners, etc.) with a more random configuration (Figure 6).

Some important differences in ground floor activities distribution can be outlined (Figure 7): (1) The presence and absence of food retail (orange), other retail (red) and hospitality (yellow) give a first clue of the emptiness of the daily-need services in Tres Torres, besides the complex network around some streets in Badalona; (2) In terms of public facilities (blue), services (maroon) and industry and logistics (purple) the picture varies substantially with a more homogenous scheme in both cases, even though there is a higher concentration of bigger pieces along

the main streets on the upper part of both areas; 3/ Finally, the presence of non-occupied premises (black) and private storage and parking (mint green) points out some spots for new opportunities. In Tres Torres, due to the availability of underground parking, the ground floor is mainly residential. Badalona offers a completely different image due to lack of underground parking in the buildings, and most of the individual paired houses locate the parking space on the ground floor, which confers the empty feeling of life and activity in certain streets.
Looking at the global extension of the different uses on the ground floor (square meters), it can be stressed the very different proportion of retail activities (orange and red), and also how a very similar floor area destined to public facilities (blue) represents a very different proportion in both districts.
Regarding the street perception of proximity (Figure 8 and 9) the configuration of the two tissues is radically different. In Tres Torres the low density of premises configure in general non-vivid sidewalks in which only the residential buildings' access casts certain streets flow. However, within the 500 × 500 m crop, there is a higher presence of services and activities in the upper and right parts, showing certain clusters of activity in some corners. In Badalona, the narrow streets make more explicit the high flow of activities in the streets that are commercial axis, phenomena very explicit in the final heatmap. In the rest of the mesh, the perception of mixticity is much lower but still the impact of the existing activities and housing access distribution results in more vivid streets than the majority of the Tres Torres neighbourhood.

Final Considerations

Databases and GIS mapping have a high potential to unveil clues on the general relation between mixticitiy and morphology but are not normally consistent enough at the scale of city fragment analysis which still requires detailed fieldwork and a more 'artisan' approach.
In general terms, the research certifies the gap between the basic picture of the planning regulations versus the very complex image of the functional mixture in city fragments which makes explicit that more research is needed to build up more robust urban codes and more efficient cities.
The research testifies that there is only a relative match between the changing logics of the functional mix and the more permanent laws of the urban morphology, which means that an interesting field of research is identified in the understanding of programs distribution, not at a geographic scale, but at the scale of plots, corners and buildings.

Acknowledgements

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