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Making 'Retail Mobility Environments' visible for collaborative transport planning

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ABSTRACT
Under the context of collaborative transport planning paradigms, maps should be seen as learning instruments that create dialogue spaces between stakeholders involved in policy-making, rather than simply demonstration tools for transport planning diagnosis and outcomes. This paper explores the role of maps in collaborative transport planning through the elaboration process of the 'Retail Mobility Environments' map, a planning concept focused on how non-motorised modes and retail activity are interconnected. This map aims to provide a meaningful tool to assists stakeholders during policy-making, creating a common framework for discussion. The city of Zaragoza (Spain) is taken as case study. The map consists of two parts: (1) based on a mixed approach (both quantitative and qualitative), the spatial distribution of 'Retail Mobility Environments' is shown; (2) based on design approaches, specific characteristics of those 'Retail Mobility Environments' are detailed. The paper closes with some concluding remarks on the role of maps under collaborative planning schemes.

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1. Introduction

These are challenging times for Land Use and Transport (LUT) planning (Banister, 2005; Ewing, Hamidi, & Grace, 2016; Straatemeier & Bertolini, 2008). Instrumental rationality is under attack, resulting in new collaborative approaches (Bertolini, Clercq, & Straatemeier, 2008; Willson, Payne, & Smith, 2003). Today more actors are actively involved in the LUT planning process, triggering participation and learning processes between professional domains (Innes & Booher, 2010; Willson, 2001). The generic concept of 'Mobility Environments' (Bertolini & Dijst, 2003; Soria-Lara, Valenzuela-Montes, & Pinho, 2015) and more specifically the concept of 'Retail Mobility Environment' (RME), can be useful in providing solutions for both a more integrated LUT planning processes and the development of a discussion framework for the inclusion of a wider range of participants.

RMEs refer to the definition of city areas where retail activity and non-motorised accessibility are reciprocally interrelated in a specific way, providing additional insights for LUT policy-making. On the one hand, retail activity here refers to eight types of retail: food (e.g. supermarkets, groceries); fashion (e.g. clothes, accessories); household goods (e.g. furniture, DIY stores); leisure (e.g. cinema, bars), health and body care (e.g. gym, convenience store); technology stores (e.g. computer stores, mobile phone); stationary stores (e.g. office supplies, bookstore); and other retail (e.g. travel agency, car dealership). They have been clustered in daily, weekly and incidental retail. E-commerce, while interesting, is excluded, since only physical locations of retail activity generate passenger mobility, the focus of this study. On the other hand, non-motorised accessibility is here seen as the capacity to reach the mentioned retail categories by walking and cycling, specifically focused on the time-willingness of individuals to do that.

Four main types of RMEs are identified (Figure 1): (i) *Short-distance environments*, areas with high values for both non-motorised accessibility and retail activity, i.e. lively places with ample public spaces; (ii) *Non-motorised environments*, low values for retail activity and high values for non-motorised accessibility, i.e. places free of motorised vehicles, such as parks, boulevards, etc.; (iii) *Motorised environments*, high values for retail activities and low values for non-motorised accessibilities, i.e. highly dependent on motorised modes for shopping activities; (iv) *Long-distance environments*, low values for both retail activities and non-motorised accessibility, i.e. isolated retail stores and inoperative non-motorised transport. Despite the

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Figure 1. Types of RMEs. Picture sources: https://goo.gl/qYDO12; https://goo.gl/K76q0N; https://goo.gl/eM0q0D

growing progress regarding RMEs as transport planning concept at the city level (Arranz-López, Soria-Lara, López-Escolano, & Pueyo Campos, 2017), there is still lack of understanding how RMEs can be mapped to be useful in the context of collaborative LUT planning paradigms, which this paper seeks to address.

To enhance the visual language of LUT policy-making, maps should combine knowledge and expertise from different actors in an iterative fashion, as well as to unravel the complex and multi-dimensional relationships within LUT at the city level. First, maps should be seen as key instruments to trigger discussions and achieve agreements between transport planning actors, rather than exclusively represent specific LUT processes and/or LUT planning outcomes (Dühr, 2007; Soria-Lara, Zúñiga-Antón, & Pérez-Campaña, 2015). Accordingly, the maps' messages should be understandable and meaningful for a wide range of professional domains, combining both 'explicit' and 'tacit' knowledge (Soria-Lara, Aguilera-Benavente, & Arranz-López, 2016; te Brömmelstroet & Bertolini, 2008). Second, LUT integration requires maps to reveal the different dimensions of how land use relates to transport and vice versa. Limited attention has been traditionally paid to the combination between non-motorised accessibility and retail activity at the city level (Arranz-López et al., 2017; Krizek & Johnson, 2006). For these reasons, the process of mapping RMEs is seen as a crucial aspect for LUT policy-making under the context of more collaborative paradigms.

This paper addresses the issue *how to map RMEs so that they are meaningful and understandable for a wide range of professional domains*? The city of Zaragoza (Spain) was taken as a spatial laboratory for experimentation. In the remainder of the paper, Section 2 presents a literature review of how non-motorised accessibility and retail activity indicators have been traditionally mapped. Section 3 describes the case study, while Section 4 outlines the methodology used to map RMEs. Section 5 presents the obtained results, including the map of RMEs in Zaragoza (Spain). Finally, section 6 presents some concluding remarks.

2. Mapping non-motorised accessibility and retail activity

While RMEs actively integrate non-motorised accessibility and retail activity, traditionally these dimensions have been mapped in separately in LUT policy-making.

Looking at non-motorised accessibility, there are some interesting examples to be analysed. Iacono, Krizek, and El-Geneidy (2010) mapped both walking and bicycling accessibility to restaurants and shopping stores, showing new methods for estimating non-motorised accessibility through gravity-based models. Calculating accessibility indexes from a centrality-based perspective, Porta et al. (2009) and Wang, Chen, Xiu, and Zhang (2014) measured street centrality and its relationship with retail activity and other types of facilities. The authors used a kernel density from line features, obtaining a grid map. Another inspiring example is Jaskiewicz, Block, and Chavez (2016) in the context of health geography; they compared different accessibility methods (container, coverage, minimum distance, average distance, gravity kernel and two-step floating cachement area) using a mapping process to highlight differences and similarities. Along the same line, Eckert and Shetty (2011) mapped food access using the average distance to stores. Finally, it is needed to underline the study carried out by Song and Sohn (2007), which analysed accessibility of single-family houses to retail stores.

Looking at retail activity, Rotem-Mindali (2012) mapped retail fragmentation to assess urban liveability of neighbourhoods, using a least-cost modelling methodology. Aguilera Ontiveros and Bárcenas Castro (2014) mapped retail diversity through Shannon–Weaver and Ullman–Dacey indices to uncover the resilient capacity of several urban places. In the context of geomarketing, Roig-Tierno, Baviera-Puig, Buitrago-Vera, and Mas-Verdu (2013) mapped potential new retail sites using kernel density estimations.

As previously demonstrated, mapping approaches that integrate non-motorised accessibility and retail activity issues are sorely needed, especially to assist LUT policy-making processes under a collaborative framework. This paper takes a step towards providing such an approach, by showing a methodological process for mapping RMEs as geographical units, where non-motorised accessibility and retail activity are intrinsically interconnected, as well as by generating useful maps under the context of collaborative planning approaches.

3. Zaragoza: a Spanish compact city

The city of Zaragoza, located in the north-eastern of Spain (around 700,000 inhabitants) served as a case study (Figure 2). Zaragoza is facing substantial LUT challenges in the coming years. On the one hand, the local government is currently working on a new sustainable urban mobility plan. Actions in progress are: the extension of bicycle lanes network, the implementation of bike-sharing systems, the development of the second Light Rail Transit (LRT) line, as well as neighbourhoods' pedestrianisation across the city. On the other hand, local institutions are also promoting a revitalisation of traditional retail areas through big financial investments in traditional neighbourhoods.

Since a big transformation is carried out by local institutions on retails locations and non-motorised accessibility (Ayuntamiento de Zaragoza, 2006), the process of mapping how RMEs are located in the city can substantially contribute to make the policy-making process more efficient. In this context, a map design process that facilitate dialogue between actors involved in the transformation of Zaragoza can be crucial to achieve consensus. This is one of the main aims of this research.

4. The methodological process of mapping RMEs: data and methods

Mapping RMEs involved a sequential process that combined in an iterative framework data from institutions, and responses from individual citizen questionnaires. The methodological process involved four different phases (Figure 3): (i) Data gathering; (ii) Indicators for non-motorised accessibility and retail activity; (iii) Calculation of accessibility and retail

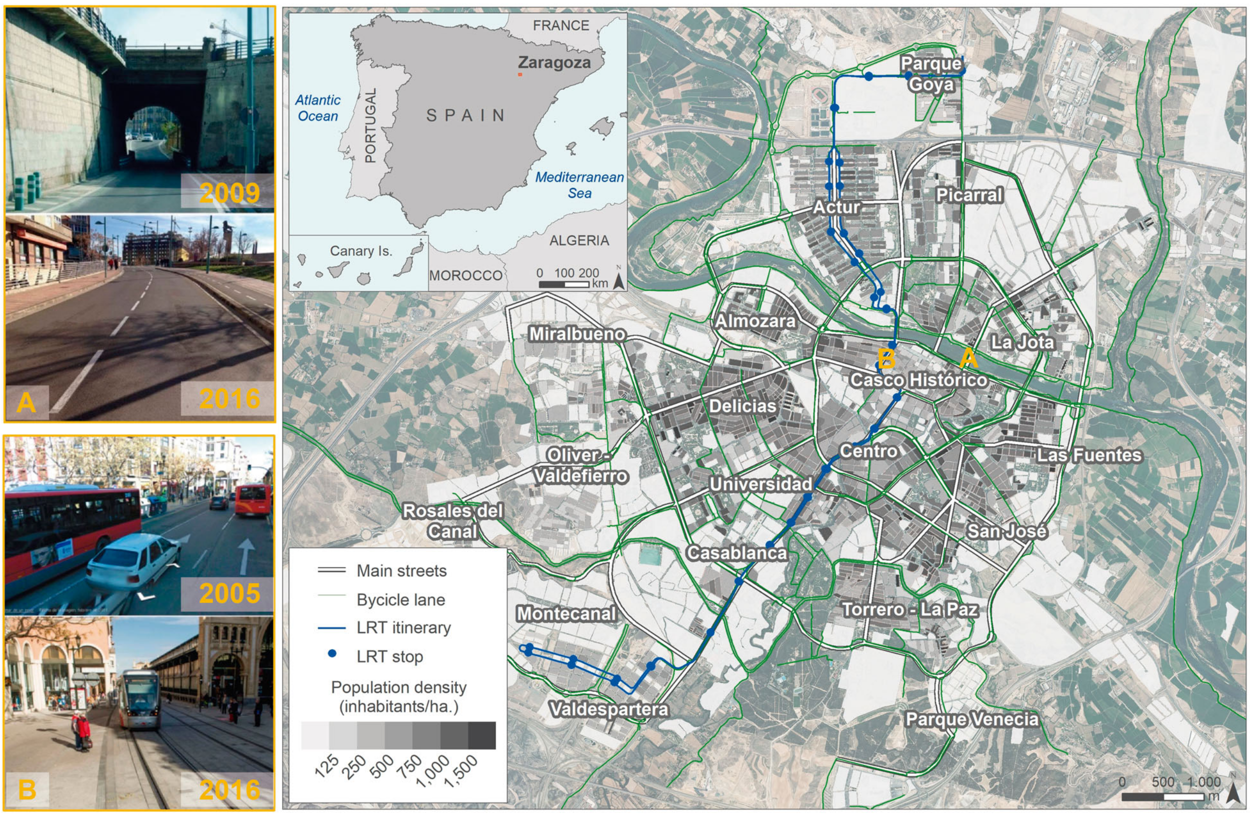

Figure 2. Zaragoza location map and transport infrastructures.

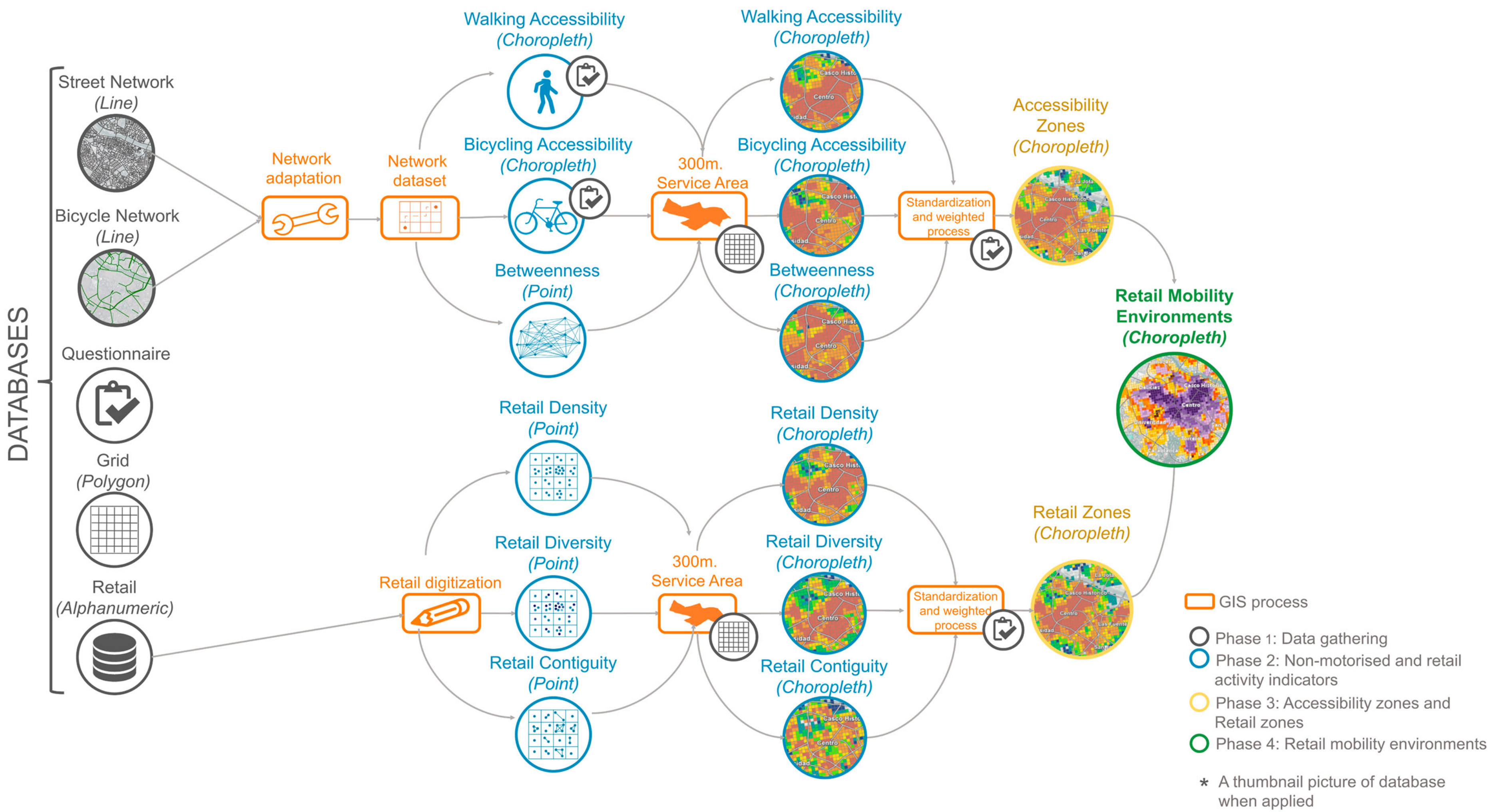

Figure 3. Methodological scheme.

activity zones; (iv) Identification of RMEs through the combination of non-motorised accessibility and retail activity values.

4.1. Methodological phase 1: data gathering

Four spatial datasets from several institutions and one ad hoc respondent questionnaire were initially used (Table 1).

The street network was adapted to be similar to the real street network, and topology rules were implemented to maintain spatial relationships between line features. Specifically, we analysed and cleaned the overlapping and the existence of dangles. A similar process was carried out for the bicycle lane dataset.

Retail locations were digitised in *My maps app* (powered by *Google*) from an original non-spatial database developed by the Spanish Ministry of Economy. Since this database only provided information about franchise companies and big distribution chains, it was cross-checked and completed with information from specialised websites, telephone directory listings and retail corporate websites in order to incorporate other the independent retails (e.g. groceries, bakeries, small clothes stores) yielding 3025 retail stores in total (around 60% of the total retail activity in the city of Zaragoza). Then, points with location of retail activities were converted into *ESRI* shapefile and classified into three categories: daily retail (e.g. supermarkets, groceries, tobacco shops), weekly retail (e.g. hairdresser, gym, pharmacy) and incidental retail (e.g. fashion and accessory, DIY stores, home products), in order to calculate accessibility.

The grid from the European Environment Agency was used to represent accessibility and retail activity indicators, for two main reasons: (i) it allows an easy adaptation to different spatial scales; and (ii) regular grids help overcome the minimum cartographic area problem. It was specifically customised from the original size (a 1 km long cell) to the optimal size for the study area (a 100 m long cell), for both the identification of the four RMEs in sufficient detail and the preservation of anonymity when other databases (e.g. population grids) are used.

Finally, an ad hoc questionnaire was disseminated via on-line (314 responses) and face-to-face (70 responses), from April to June 2016. Face-to-face interviews were relevant to obtain responses from the elderly population. The stratified sampling by age and gender supposed 384 responses with 95% confidence interval and a bias of 5%. Questions about the willingness to reach daily, weekly and incidental retail areas on foot or by bike, and user preferences about retail areas characteristics (density, diversity and contiguity), were asked.

Table 1. Databases.

No.	Dataset	Feature class	Source
1	Street network	Line	Spanish National Centre of Geographic Information
2	Bicycle network	Line	Zaragoza City Council open data website
3	Retail	Point	Spanish Ministry of Economy
4	Grid	Polygon	European Environment Agency
5	Questionnaire	None	Own elaboration and dissemination

4.2. Methodological phase 2: indicators for non-motorised accessibility and retail activity

Three non-motorised accessibility indicators were mapped: walking, bicycling and betweenness. The first two indicators estimated accessibility from households to retail stores by foot and by bike respectively. In a complementary way, the indicator 'betweenness' assessed the likelihood that people had to find retail stores once they are in their own shopping route. While a derived point feature class from the grid was used to compute walking and bicycling accessibility, betweenness used retail activity database.

In particular, a gravity-based model (Equation 1) was implemented for walking and bicycling accessibility. Gravity-based models consider the number and distribution of retail activity at destinations, and a distance-decay function (willingness to reach retail stores by non-motorised modes), empirically calculated from the questionnaire responses for both walking and bicycling accessibility and for each type of retail resulting in six distance-decay functions.

$$A_i = \sum_{dwi}\left(\sum_{j\neq i} E_j e^{-\beta X_{ij}}\right), \quad (1)$$

where: A_i is the accessibility for zone *i*; *dwi* are the three retail typologies; X_{ij} is the travel time between zones *i* (origin) and *j* (destination); E_j is the number of shops in destinations; and β is a parameter of the impedance function. This impedance function is different for walking and bicycling accessibility.

The entire process consisted of the following segments: (i) calculation of origin–destination cost matrix from every origin to all destinations; (ii) calculation of time cost along the networks, taking into account the length of the street, average walking speed (4 km/h according to literature; e.g. Marquet & Miralles-Guasch, 2014); and average cycling speed (12 km/h according to the bicycle's barometer for Spain); and (iii) calculation of accessibility for both walking and bicycling and for each type of retail in *RStudio*. Origin–destinations cost matrices were built from 4400 origins to 4400 destinations, producing in total 14,955,600 lines street network and almost 600,000 lines bicycle lanes. Once the origin–destination cost matrices were computed, the distance value of one cell was calculated as the sum of values from that cell to all destinations. Since walking and cycling

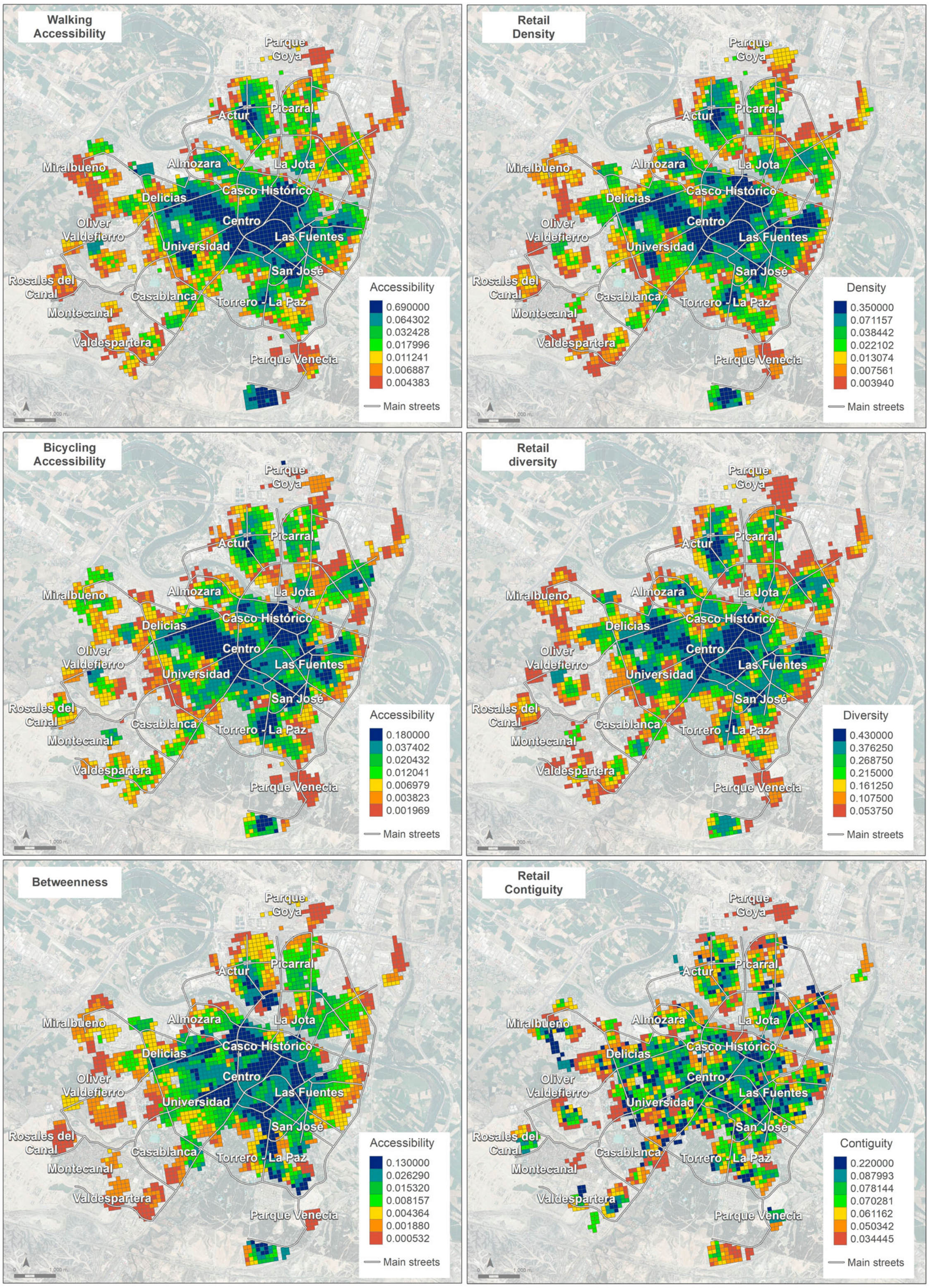

Figure 4. Accessibility indicators (left) and retail activity indicators (right).

accessibility were calculated for daily, weekly and incidental retail, the final maps for both walking accessibility and cycling accessibility were estimated by the sum of values for each type of retail. Cells with zero for both indicators were deleted to simplify the visualisation of the partial results.

Betweenness (Equation 2 and Figure 4) values were calculated with the Urban Network Analysis (UNA) Toolbox (Sevtsuk & Mekonnen, 2012). This refers to the likelihood to find retail stores on the usual citizens' route towards their shopping destinations. It is based on the location of retail stores (from each other) and their topological relationships with the network datasets (e.g. their location-side with respect to the network). The indicator has no units, and it is assumed that higher values represent a better location with compared to other stores.

$$B_i = \sum_{j,k \in G-\{i\}; d[j,k] \le r} \frac{n_{jk}[i]}{n_{jk}} \times W[j] \quad (2)$$

where B_i is the betweenness for each retail store $[i]$; n_{jk} is the number of shortest paths from retail j to retail k in the study area G; $n_{jk}[i]$ is the subset of these paths that passes through $[i]$, with j and k lying within the network radius r from i. To give a global view of how all retail stores interact between themselves without physical boundaries, a search radius was not considered here.

From the retail activity side, three retail activity indicators were also mapped. Retail density, retail diversity and retail contiguity (Figure 4). Retail density (Equation 3) indicated the intensity of retail activity in each cell; retail diversity (Equation 4) denoted the number of different types of retail in each cell; and retail contiguity (Equation 5) indicated the distance between retail stores in one cell.

$$D = \frac{n}{s} \quad (3)$$

where n is the number of stores in the cell; and s is the cell surface.

$$\text{Div} = \sum_{i=1}^{s} \frac{n_i}{N} \quad (4)$$

where s is the number of stores considered in the study; n_i is the number of retail stores of the type i; and N is the total number of retail activities.

$$C = D_{jk} \quad (5)$$

where D is the distance between stores j and k.

The six indicators presented in this section were computed as an average of the values in a 300 m service area from each centroid of the grid. The threshold distance was based on Agenda 21 recommendation as optimal distance for basic facilities accessibility.

4.3. Methodological phase 3. Accessibility zones and retail zones

Accessibility Zones (AZs) were calculated as the combination of walking accessibility, bicycling accessibility and betweenness. Retail Zones (RZs) were also calculated as the combination of retail density, retail diversity and retail contiguity indicators. Previously, a standardisation process of the values was considered, following a min-max normalisation method with final values set between 0 and 1. Once all indicators were standardised, AZs and RZs (Figure 5) were estimated using the sum of indicators. A multicriteria analysis was carried out by using an Analytic Hierarchy Process, weighting each indicator individually. The source for weighting indicators was the questionnaire mentioned in Section 4.1, which comprised peer preference of mode for reaching retail areas and preferences of retail areas. The following illustrates sample questions: *Do you prefer to go shopping on foot or by bicycle?* or *When you go shopping, do you prefer places where retail stores are close to each other or places where different type of retail stores are present?*

4.4. Identifying and mapping 'Retail Mobility Environments'

RMEs identification was made through AZs and RZs aggregation. The quantitative representation was calculated with a reclassification process of the values, according to the mean-value of AZs ($\bar{x} = 0.123$) and RZs ($\bar{x} = 0.356$).

A total of four 'Retail Mobility Environments' were identified in Zaragoza, with short-distance environments and long-distance environments as the most present. They are found in the consolidated city and the newest urban developments of the city, respectively. Motorised environments were identified in the intermediate edge of the city as the border area between short- and long-distance environments. Finally, non-motorised environments with a residual presence were identified with parks, pedestrian areas or the university campus. Unlike the other three, they did not follow an organised pattern.

5. A map to make 'Retail Mobility Environments' visible for collaborative planning approaches

The proposed map, under the context of collaborative LUT planning paradigms, has been designed as a single document under two key assumptions. First, the map shows how retail activity and non-motorised accessibility relate to each other across the city of Zaragoza. Second, the map must be understandable for different professional domains that usually take part in LUT planning process (e.g. architects, geographers, transport planners, environmental consultants, etc.). Designing a single map tries to address the challenge of processing all the information to facilitate the stakeholders understanding by a single look at the map. The rest of maps can be used for supporting this final map, adding more in-depth explanations and more details of the planning process.

The map is structured in two parts. The left side focuses on quantitative and qualitative approaches, which are closer to the geographer and urban planner's visions. The right side focuses more on design approach, orientated towards architects and civil engineers, among others. In this context, the map is depicted in a double A3 format (Figure 6) and should be read from left to right.

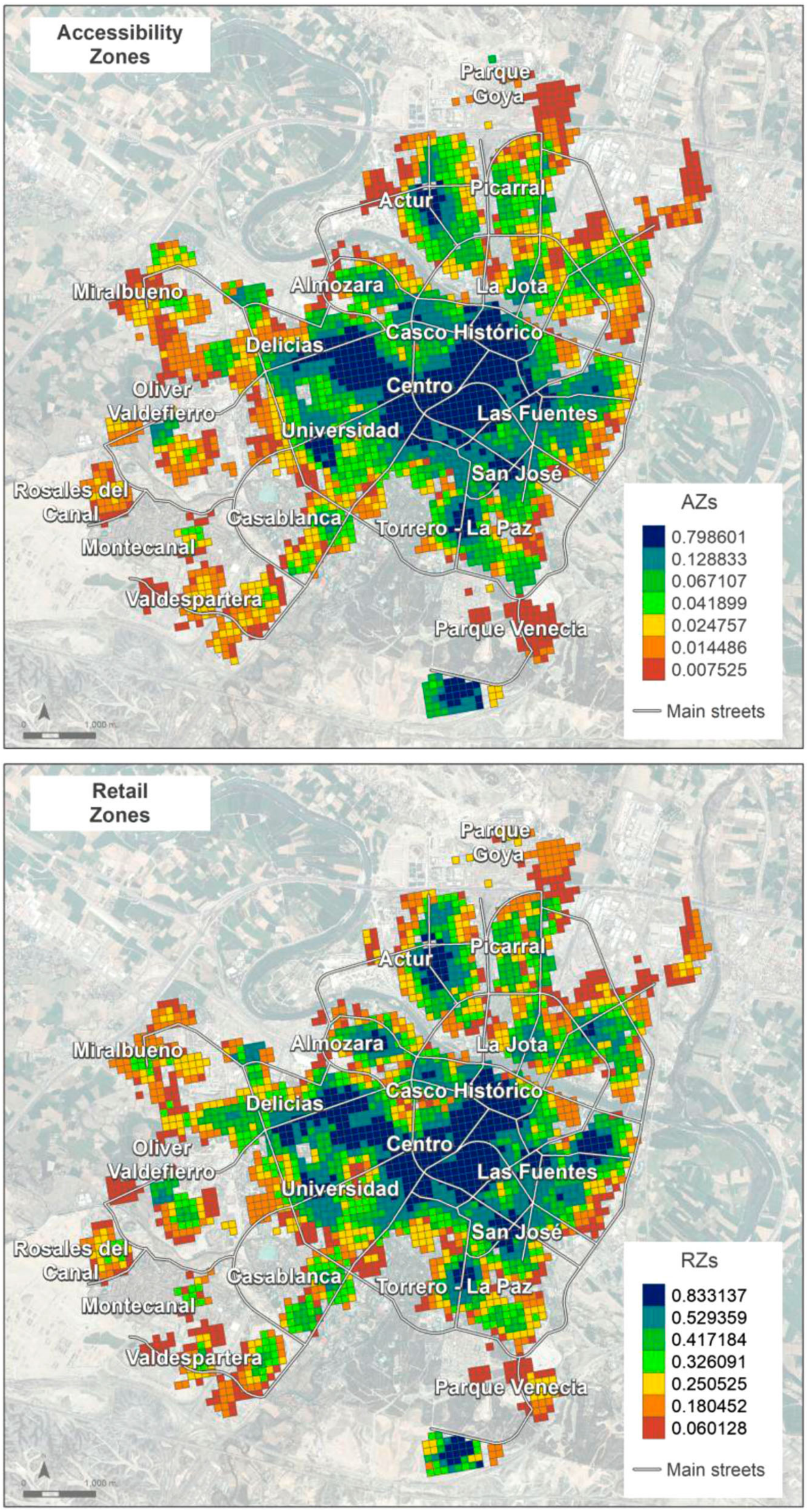

Figure 5. Accessibility zones (on the left), retail zones (on the right).

On the right side, the Main Map of RMEs and the supporting figures in the legend box are found. RMEs have been represented using a regular grid. Regular surfaces simplify the reading of the map and have favourable compatibility with other spatial datasets for policy-making (Dühr & Müller, 2012). In the legend, each RME has been divided into four subcategories. Threshold values correspond to quantile classification, since it represents more accurately accessibility and retail activity dynamics in the city. The graphic is showing RME distribution, with one point corresponding to one pixel in the map. Finally, a brief description of RMEs and author credits are included.

The right side is made up of a longitudinal profile and eight horizontal sections. The longitudinal profile

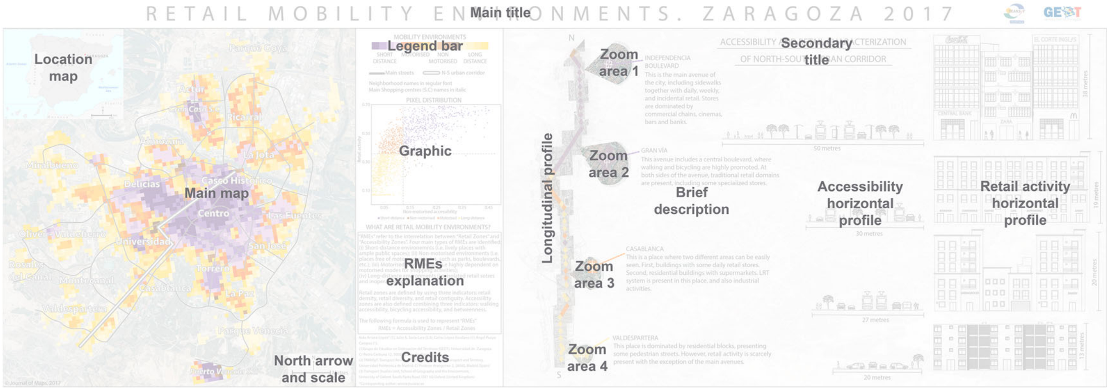

Figure 6. Final RMEs map scheme.

corresponds to a straight line from *Valdespartera* to *Casco Histórico* neighbourhoods. Four individual zoomed-in sections, at the most significant places for each RME in terms of retail activity and non-motorised accessibility, have been highlighted[1] and briefly described. Horizontal sections are showing the physical dimension of accessibility and retail activity in the zoomed-in areas. They explain some of the urban processes that take part in those places. The first column relates to accessibility characteristics, and presents different items such as LRT, sidewalks or bike lanes. The second column communicates the retail activity configuration as well as building and retail types. For example, in *Independencia Boulevard* well-known commercial brands have been included to highlight the presence of big companies. However, more traditional retail stores are found in *Gran Vía*. Both accessibility and retail activity horizontal profiles are drawn to scale and differences in length (accessibility) and height (retail) can be discerned between RMEs.

In sum, the combination of different 'languages' makes the map a useful tool for easily and clearly understanding the spatial concept of RMEs. Thus, the orderly sequence that RMEs follow in the map, from the city edges to the city centre, can be also seen in the horizontal sections. Urban form changes from more residential places (*Valdespartera* and *Rosales del Canal* neighbourhoods) to multifunctional areas (*Gran Vía* and *Independencia Boulevard*), where buildings integrate retail activity with other land uses, and non-motorised accessibility increases with transit areas for walking and bicycling.

6. Conclusions

While a growing number of studies and policy initiatives are utilising transport collaborative schemes, the dominant approach is still to use maps as the visual image of deliberative processes firmly rooted in instrumental rationality. However, in the view of this paper, maps – as the visual language of planning – should be used as learning instruments to actively involve stakeholders through the creation of dialogue spaces for discussion and debate. To address this particular point, here is elaborated a specific map that shows how RMEs are located in the city of Zaragoza (Spain) according to several viewpoints. The aim of the map is to allow a wide range of stakeholders from different professional domains to interact, finding familiar information, related to their respective 'explicit knowledge' (from more qualitative-oriented to more design-oriented), as well as a common framework to share views with each other.

Using maps as learning instruments means creating 'rooms for discussion', meeting-points where stakeholders can easily process the map's information in order to feel safe to participate and hear each other, as well as modulate their discourses when convenient to find win-win solutions. In the view of this research, maps can be an excellent instrument for gaining additional insights into the creation of a common language on how transport and land uses are reciprocally interconnected, facilitating the translation of scientific empiricism into real-life practice.

Further research should focus on testing the effectiveness of the elaborated map with stakeholders in real-life situations. Learning cycles based on experiential methodologies that involved different actors in situations close-to-real-life can be used to refine the present map, obtaining a distilled product ready for professionals in the field. In this context, the commitment of local institutions could facilitate these experiments, helping to bridge the existing gap between academic research and transport practice.

Software

The maps presented in the methodological section were drafted with *ArcMap 10.5*. The customised script in *RStudio* was also used for calculating walking and cycling accessibility indicators. The final map of RMEs (section 5) was created with *ArcMap 10.5* and *Adobe Illustrator CS6*. The longitudinal section was made in *Adobe Illustrator CS6* and the horizontal profiles of the city were built with *AutoCAD 2017*.

Disclosure statement

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Note

1. The non-motorised retail mobility environment was excluded as it had a residual presence.

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