

## Article

# The Cadastre as a Source for the Analysis of Urbanization Dynamics. Applications in Urban Areas of Medium-Sized Inland Spanish Cities

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**Abstract:** This article presents a methodological proposal using the cadastre as a tool to analyze urbanization dynamics. It is backed by an in-depth review of the related literature concerning Spain and Mediterranean Europe. The work uses the cadastre as a source of information, specifically leveraging the urban parcels and real estate obtained from the CAT files. After the data were collected, interpreted and organized, complementary statistical and cartographic methodologies and tools were used, together with the required database management. The goal of the study was to analyze the behavior of five intermediate cities and their urban areas, with the aim of comparing the construction dynamics between the cities and the municipalities located in their respective areas of influence in the period 2000–2016. The work is framed within the debate on urban sprawl, sustainability and the need for tools for town and regional planning. The main conclusion of the work reflects the necessity of a better understanding of the processes of transformation in cities, in which the use of cadastral data is key, given its reliability and updated information, despite the difficulty involved in accessing the data structure.

**Keywords:** cadastre; urban sprawl; urban areas; urbanization dynamics; medium-sized cities; urban sustainability



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## 1. Introduction

The cadastre is an indispensable tool for regulating objects. According to Henssen, it “is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Such properties are systematically identified by means of some separate designation. The outlines of the property and the parcel identifier normally are shown on large-scale maps which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel” [1,2]. This proposed definition is somewhat generic, given the notable diversity of conceptualizations and cadastral models across the EU. The primary characteristic is the heterogeneity in the processing of information, the historical and cultural constraints and the political and administrative organization of each Member State [3]. Comparetti and Raimondi proposed a classification of cadastres in the EU according to the administration and ministries responsible for the cadastre, the relationship between the cadastre and geodesy and general cartography, the identification of real estate (typically based on cadastral parcels), the type of cartography and the link between the cadastre and the land registry (if one exists) [4] (pp. 57–58). Nonetheless, the criteria used to classify them may be based on other factors, such as the use and purpose, the valuation system, the existence of different cadastres for rural and urban settings and even the peculiarities of each country [5].

Over time, socioeconomic and political changes in Europe have led to different ways of understanding cadastral models. Ting and Williamson (2013) suggest four key stages.

First, cadastres functioned as a record of ownership, with fiscal purposes being the main motivation. The concept then shifted, as land became a commodity, meaning the cadastre was obliged to broaden its functions, becoming a land market tool. In the third stage, at the end of the 1940s, in the post-WWII period, it emerged as a record of land parcels and registry of ownership, becoming especially useful for territorial planning. The last stage sees the cadastre functioning as a broader-based tool for territorial management, guided by principles of sustainable development, information and communication technology and economic reforms generated by globalization [6]. In the mid-1990s, the main debate centered on the process of automation, enhancing the importance of the cadastre as part of a wider land information system. According to Enemark and Williamson (2005), most cadastres around the world include aspects related to land value, tax systems and legal rights (albeit with minor differences in some cases), which allow for interaction between the identification of parcels, the registry of land rights and land value and taxation. This form of understanding the structure of cadastral data has given rise to the need to create more extensive definitions, able to reflect such interactions, advocating concepts such as cadastral systems and/or cadastral infrastructures [7] (p. 54).

With the intention of capturing these ideas, the idea of the multi-purpose cadastre (MPC) has gained prominence [8], and it has become a term now in use in the EU, due to the growing need for cadastral data structures. This concept is defined as tool that is “essential to consolidate the country as an articulated territory, integrated and cohesive in the physical, economic and social fields within its natural geographical environment” [9]. The structure of the MPC, which emerged as a development of the modern cadastre, has a much greater scope, as it no longer covers only matters related to the land market. According to Abdul (2000), the MPC generates a feedback system, in which all the users involved (different levels of public administration, public and/or private stakeholders, academic institutions, etc.) benefit from the model’s advantages, while also bolstering its development and improving the system [10]. The cadastre has become the center of any land administration system, as it exhibits information on the three Rs (rights, restrictions and responsibilities) [11]. The MPC supports land information systems, underpinned by data integration structures with information related to ownership, taxation, administrative questions, natural resources and other data on each individual parcel [12]. In this context, cadastral structures emerge as data sources for use in analyzing urban processes.

### *1.1. The Cadastre in Mediterranean Europe*

Despite their apparent similarity, most countries in Mediterranean Europe “have developed their own cadastral system because there are assumed to be huge differences between the systems” [13] (p. 33). The situations are varied and are the result of the different conditions of each Member State. Following Mirón Pérez (2000), France, Italy and Spain can be placed in the same category, in which the cadastre is a ministerial responsibility, given that its function is primarily for taxation purposes [14]. Comparetti and Salvatore (2019) also include Belgium and Luxembourg in this group [4], since the main use of the cadastre is related to the competent authority in cadastral matters. Thus, in these cases, cadastral responsibility resides in the Ministry of Finance or the Treasury.

In Italy, Francesco Rizzo underlined, among other things, the importance of unifying the rural and urban cadastres [15–17]. Currently, the Land Cadastre (Cadastrato Territoriale) and the Urban Building Cadastre (Cadastrato Edilizio Urbano) form the basis of the Italian Cadastre [18]. The former includes “the list of all rural properties and unbuilt land plots” [19] (p. 2), whereas the latter covers “buildings for civil, industrial and commercial use” [19], (p. 2). These are complemented by the Cadastre of Buildings (Cadastrato dei Fabbricati), which contains data on both urban and rural constructions [19]. Raimondi, Puccio and Egli (2020) advocate a unified, multi-purpose cadastre, holding a wealth of varied information, with functions that go beyond the traditional ones of identification and classification [20,21]. Among these is guaranteeing more sustainable soil use. To this end, the authors propose a cadastre constructed in three sections: “the urban soil cadastre, extra-urban soil cadastre

or land cadastre and the cadastre for the conservation of soil-biodiversity or natural to semi-natural pedodiversity” [22] (p. 2). From the urban perspective, this proposed reform of the cadastral system is justified by the presence of an inefficient model designed for tax purposes based on a valuation methodology that has become obsolete [23,24].

In France, the current system is based on the Cadastre Napoleonien from 1807, built upon a collection of exact maps of parcels and real estate [25,26]. The public administration is currently in the process of digitizing and creating alphanumeric and graphic databases in coordination with the IGN (National Geographical Institute) [27]. The French Cadastre “applies to all urban and rustic properties (built or not)”, and forms an “exhaustive, permanent, descriptive and evaluative inventory of landed property: the cadastre reflects the civil status of built and undeveloped property” [28] (p. 5). As in Italy and Spain, taxation is the main purpose of the French Cadastre, which gives meaning to the constant revisions and amendments to valuation implemented over the years [29,30]. Bearing in mind its role as a property register, it is worth highlighting its technical, fiscal and property functionality [31]. The official webpage of the French Government [32] provides access to information on parcel limits (the minimum unit of representation), topographic details, hydrographic matters, building details, etc. [33].

In Spain, France and Italy, the cadastre is the competent body for valuation, although only in the first country is there a massive system for the market-based valuation of real estate [3,34]. Thus, the authorities are currently dealing with the challenges of automating and creating cadastral databases, which since the end of the last century have been lent urgency by the emergence of the information society [35]. The disparities between the different EU Member States opened the debate on the need to develop a common framework for action. Since the beginning of the 21st century, the cadastre has been considered a key element of land information systems in Europe [5,36]. The revolution in technology has now paved the way for the geospatial revolution. Not only has the generation of cartographic products been changed by this technological revolution, but also the methods of generating data, the platforms to acquire and exchange geographic data, metadata services, etc. [37,38]. The 1st Congress on Cadastre in the European Union (2002) marked the start of a common cadastral policy in the EU, enabling Member States to exchange information, experiences and better practices [39].

### *1.2. The Structure of the Cadastre in Spain*

In Spain, Royal Legislative Decree 1/2004 establishes the Cadastre as an administrative registry for which the Ministry of Finance is responsible, in which the description of rural and urban real estate, as well as that with special characteristics, is managed [40]. The Spanish Cadastre is currently part of the Ministry of Finance, and, as provided for in Royal Legislative Decree 1/2004 of 5 March, approving the revised text of the law of the real estate Cadastre, “the multiple use of cadastral data does not detract from the fiscal nature of the institution, but upholds it, as such data serves as a reference for the management of different taxes at the three territorial levels of the tax authorities” [41]. The Cadastre includes complete and varied information with a great amount of detail. From the taxation and real estate perspective, it can be divided into the Rural Cadastre and the Urban Cadastre [42].

The foundations for the modern Spanish Cadastre were first laid in the 1980s. A milestone in this process was the creation of the Center for Cadastral Management and Tax Cooperation, an independent administrative organization with a legal character and equity capital [43]. Since then, advances have been made in the development of the data structure, bolstering the integration of new technologies. The Directorate General for the Cadastre has been recognized for its good practice in questions of public access and as an example of open public administration [44]. The result is a structured land information system with exhaustive data, in which the cadastral and alphanumeric databases are interrelated, providing a computerized system of territorial real estate [45]. At the beginning of the 21st century, the Cadastre covered 7575 municipalities, with data stored and updated on urban

and rural parcel subplots, constructions, urban units, etc. [46]. According to De Aragón (2018) “it can be stated that the Real Estate Cadastre currently boasts significantly updated data” [47].

The purposes of today’s Spanish Cadastre concern meeting strategic objectives related to maintaining real estate data, ensuring permanent knowledge of market values, promoting collaboration with public notaries, improving cadastral maps, enhancing digital transformation and the organizational model and deploying institutional outreach that helps strengthen the position of the cadastre within the public administration [48].

Cadastral data in Spain are available from two different sources. The first is the Directorate General for the Cadastre, which regularly publishes cadastral statistics on its online portal, providing highly detailed information on different areas (rural properties, special status properties and urban real estate, together with other economic and ownership aspects, new entries, property tax—IBI (real estate tax), in its Spanish acronym—tax ordinances, etc.) [49]. The Urban Cadastre section includes cadastral variables related to urban parcels (number, surface area in hectares, number of properties classified by main use and, in the case of dwelling, by type of construction, etc.). The second is the Cadastre website, where the so-called CAT files used in this research may be accessed.

In sum, despite the multiple definitions, particular nuances and cadastral systems across Member States, the element that links them all is the cadastral parcel: “physical area over which there is a concrete property right, different from those existing in adjacent plots” [50]. The cadastral parcel (the basis of this research) is considered the basic element of representation, with a unique identifier. As a result of its level of detail and possibilities for updating data, it has emerged as an outstanding source for research. It is a concept that has now been applied in both rural and urban contexts [6,37,51–57]. It can be used, therefore, to conduct a highly detailed study of transformations undertaken in cities, especially those that have occurred in recent years.

### *1.3. The Cadastre as a Source for Research on Cities. Application to the Study of Urbanization Dynamics*

The processes affecting the demographic, functional and morphological dynamics of cities have traditionally been associated with various stages: urbanization, suburbanization, deurbanization and reurbanization. The growth in the periphery of cities corresponds to suburbanization and deurbanization. The main territorial manifestation of these two stages is urban sprawl, understood as the dimensions of low density, continuity, concentration, clustering, centrality, multi-nuclearity, mixed uses and proximity [58].

This territorial reality has been given many names, such as anti-city [59], urbanized countryside [60], diffused city [61], metapolis [62], city-region [63], the spread-out city [64], postmetropolis [65], metacity [66] and inefficient city [67]. It has become a generalized reality in different sociocultural contexts, and Spain is no exception, having developed with special intensity during the “prodigious decade of Spanish urban growth” [68]. The causes have been analyzed by a number of authors [69–72]. A critical reading of these works suggests it is the consequence of the dynamic interaction of economic, sociological, cultural and demographic processes. Simply put, it refers to intense growth in housing and population over a short period of time, which in many cases is concentrated outside the existing city.

In the case of Spain, the essential reasons for the development of this city model are associated with the rise in people’s income in the first decade of the 21st century; policies favoring house buying; the arrival of labor immigrants (more than six million between the end of the 20th century and 2010); the increased demand for second homes in coastal areas revitalized by “sun and beach” tourism; the entrance of banks into the real estate sector (from the beginning of the 21st century); the emergence of private speculative investors, changes in the Building Code (1998); the shift from all land being protected to all land being developable, except for protected areas; the influence of development companies in public administrations; the adoption of the euro (2000); and money laundering in the construction industry [72]. In this setting, overaccumulation in the second circuit of capital [73] was

channeled into the construction sector, with urban areas being more dynamic, partly because the gains were greater [74]. Moreover, the competent administrations for territorial planning (the regional governments) have been permissive with, and in some cases, drivers of, such practices [71], leading to a situation of land mismanagement [70], which has been criticized in various areas of research.

The above is especially significant if we take into account the fact that cities are considered the center of economic development [75], as well as the scenario in which public policies for sustainable development are implemented, with the implicit idea of process, the systemic foundations of public policy and actions taken with a holistic approach [76]. The European Union has paid special attention to territorial management, with a focus on sustainable urban development, based on an “approach to complex reasoning about land” [77] (p. 155). Urban sustainability is grounded in a multidimensional approach, where various basic factors come into play, such as saving resources, reducing pollution and land use. Such aspects act in conjunction to enhance the population’s quality of life [78]. It cannot be overlooked that any “urbanization process should be oriented towards development of the human race and satisfying its needs” [79]. Urban agendas are drawn up in this line [80], for a city to be made for its inhabitants, and as such, to be at their service [81]. Under the concept of urban sustainability, changes in land cover can be viewed as key components of global change [82] and as direct indicators of human interaction with the landscape [83]. Similarly, changes in land use allow us to analyze sustainability processes as indicators of a country’s model of development [84,85].

The aim of the present work is to highlight the role of cadastral information in the analysis of a city’s morphological transformation, in the context of robust growth of urban sprawl and the increasing need for planning to safeguard urban sustainability. The cadastral parcel is the central variable in this research, and specifically the properties included in each one. A further aim is to use cadastral data to analyze certain aspects of urbanization dynamics, using the growth in numbers of dwellings to analyze the increase in urban sprawl. In particular, we focus on the effects on the medium-sized cities and their respective urban areas in the five provinces that make up the autonomous community of Castilla–La Mancha (Spain). The period covered by the study is 2000–2106. The study provides a novel methodological proposal that permits the analysis of how cities and urban areas grow. The analysis is conducted at the level of property, construction type and age in years.

Considering the methodological proposal developed, we propose the following hypotheses: recent processes of urban transformation can be analyzed by drawing on the evolution and distribution of the surface area, land parcels and real estate, depending on typology. Our initial hypothesis was that the urbanization dynamics in the period under study (2000–2016) were more intense in urban areas than their respective city centers. We also assumed that the changes had occurred under the dynamics of urban sprawl and the predominant construction type was single-family dwellings.

The work is divided into various parts. The introduction reviews the literature on the cadastre as a powerful tool and a source of information for research. The second section explains our methodology, which combines the use of the cadastre as a source of information and statistical and cartographic analysis as an instrument for the scale analysis of urban areas (using alphanumeric and cartographic information) The third section presents the results, whereas the fourth section is devoted to the discussion, intending to underline the role of research on urban areas in understanding cities and territorial planning and management. Finally, the fifth section presents our conclusions.

## 2. Materials and Methods

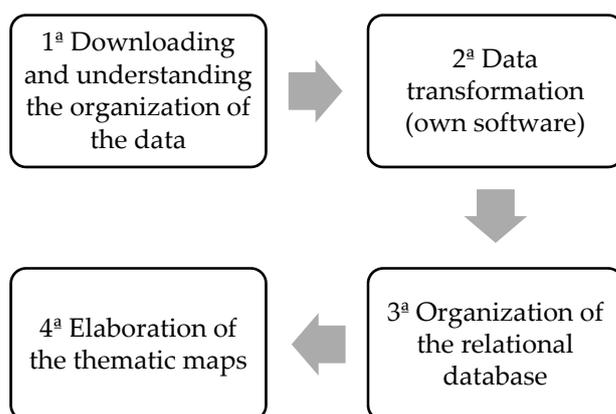
The main source used in this research is cadastral data, and more specifically, the CAT files, which contain highly useful geographic data [86]. Cadastral data contain detailed quantitative information on rustic and urban parcels and the property registered in each of these. Our analysis was focused on the evolution of a group of municipalities located in

urban areas around a number of cities, specifically, the capital cities of the five provinces of Castilla–La Mancha, an inland region of Spain. Based on demographic size in 2020, they could all be considered intermediate cities (between 50,000 and 250,000 inhabitants according to the classification of the Spanish Ministry of Development): Albacete: 174,336; Ciudad Real: 75,504; Cuenca: 54,621; Guadalajara: 87,484; and Toledo: 85,811 (National Statistics Institute (INE): 2021).

The criterion of urban area was defined using urbanization dynamics. First, we selected a 30-km radius around the provincial capitals, accounting for 202 municipalities (including the central cities). To form a proposal of each city’s urban area, we used the analytic hierarchy process (AHP), a multi-criteria analysis method, developed by Saaty in the 1960s [87]. It is defined as “a multi-objective and multi-criteria decision-making approach that uses pairwise comparison to arrive at a scale of preference among a set of alternatives” [88] (p. 286). The applications of this methodology have been very varied and belong to very diverse fields of study [89–94]. In the scope of geography, the most relevant studies are related fundamentally with territorial planning [95–97].

In this case, it was used to identify the dynamics of urbanization and demographics in the urban areas of the provincial capitals of Castilla–La Mancha. Applying this methodology allowed us to obtain the mean vector as a reference value to order the alternatives in the different rankings. The municipalities included in each of the urban areas are those that obtained a mean value equal to or greater than that of their central city, according to the criteria used, which were as follows: the population growth rates (based on data from INE), the number of urban parcels and their surface area in hectares (data extracted from cadastral statistics) and the number of real properties (taken from cadastral data, as described in the methodology section).

The reference period used in the AHP was 2000–2016. To compare and identify the different dynamics, we analyzed two subperiods: 2000–2008, characterized as one of the most dynamic in the recent history of Spain; and 2009–2016, which corresponds to the subsequent economic crisis. The unit of analysis was generated through exhaustive data cleaning, to obtain the real property (differentiated by period and type of construction) located in each parcel. This methodology comprised four stages (Figure 1).



**Figure 1.** Methodology for processing the CAT files.

### 2.1. CAT File Data Processing Methodology

As shown in Figure 1, the methodology used to process the cadastral data from the CAT files comprised four stages—the first three consisted of downloading, transforming and generating alphanumeric information, whereas the fourth entailed linking the data generated from the cadastral maps, also obtained from the cadastre website (Sections 2.1.1–2.1.4 respectively).

### 2.1.1. Downloading and Understanding the Organization of the Data

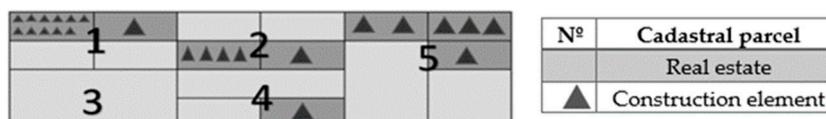
One of the main constraints in the process is the fact that the data available on the cadastral statistics portal [98] could not be used, as their structure does not permit their territorialization. To solve this problem, we mass-downloaded unprotected cadastral data for this study, including the vector maps and available alphanumeric data, with all the information on each parcel, except for the ownership and cadastral value of the properties [99]. The methodological process in this first stage included encoding the relational structure of the CAT files, which are flat text files without a line format. This means they must be converted into a database structure format. Each file had information from eight different records, each with its own data structure and different but complementary information. All the data were interrelated (Table 1).

**Table 1.** Structure of CAT files <sup>1</sup>.

Type of Record	Name of Record	Description
Type 01	Header record	One for the whole file, regardless of whether it includes information on only one municipality or various
Type 11	Land record	One for each cadastral parcel involved
Type 13	Record of constructed unit	One for each constructed unit in each cadastral parcel
Type 14	Record of construction	One for each construction of each constructed unit in each cadastral parcel
Type 15	Record of property	One for each property in each cadastral parcel
Type 16	Record of distribution of common elements	At least one for each common element that is shared, whenever it is necessary to specify special shared elements
Type 17	Record of agricultural parcels	One for each agricultural subparcel within each cadastral parcel
Type 90	Trailer record	One for the whole file

<sup>1</sup> Computerized cadastre remit file (urban, rural, and special status real estate) [100].

The structure of the cadastral information involves a scheme of interpretation whereby a parcel includes a number of properties and constructed elements. Figure 2 shows five parcels, composed of different real properties with which the constructed elements are associated—24 in this example—which is the same or more than the number of properties.



**Figure 2.** Example of organization of cadastral information. Own preparation.

One of the crucial issues with the source is the presence of occasional inaccuracies or mistakes in some fields, which may affect the final outcomes of the research. In the case of “Year of construction”, the oldest dwellings are typically referenced as 1900, which influences the quality of the information (in this case, only dwellings built after 2000 were used). The age of the property may sometimes vary depending on whether it is a reformed dwelling or not, which explains why, within one parcel, properties of the same type may appear encoded with different years. This question was interpreted as an error in the cadastre because, based on the Type 14 record, we can determine whether a property has been reformed, in the field “indicator of type of reform or renovation, in its event, for the purpose of calculating the age correction coefficient” (possible values—R/O/E/I or blank, where R: complete renovation, O: complete reform, E: intermediate reform, I: minimal reform).

Other errors were found related to construction type. To solve this problem, we established the following codes, after detecting and correcting each individual case:

- 0.0.0. for properties with no type or one type.
- 0.0.1. for properties with two types (1.1.1. and 1.1.2.) that correspond to urban multi-dwelling buildings, regardless of whether they are open or closed blocks.
- 0.0.2. for properties with two types (1.2.1 and 1.2.2.) that correspond to urban single-family dwellings, regardless of whether they are detached or semi-detached, terraced or closed blocks.
- 0.0.3. for properties with contradictory types (dwellings that, following the cadastral type, are both single-family and block dwellings).

2.1.2. Data Transformation

Once the relational model of the data had been determined (as exemplified in Figure 2), and to address the research aims, we designed and developed an analysis tool (software based on the structure of Access). The main aim of this tool was to convert and store the flat-text cadastral information (Figure 3) into a database organized into tables.

```

01G02      ALBACETE      20190719121504CCATDES
2900  7063402WJ9176S      02ALBACETE      900003A
 02ALBACETE      900003ALBACETE
00001992N0000588000000000000002117
CETE      900003ALBACETE
          00561VR      JAEN
          00561VR      JAEN      0076C0000 00000
561VR      JAEN      0076C0000 00000      T OD OS
          0076C0000 00000      T OD OS
          0000002718000027000002700000000000027
000E000027000000
    
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Figure 3. Flat-text formatless CAT file. Source: own preparation.

The outcome was a data management platform that permits CAT files to be processed (converting the alphanumeric data on the flat-text formatless files into an alphanumeric format fitted to the eight types of record shown in Table 1). The application was generated in the Visual Basic programming language (Figure 4).



Figure 4. Interface of the application generated to process the CAT files. Source: own preparation.

Broadly speaking, the tool comprises an import panel, a results panel and an information panel. Its function is to create a table for each of the record types. Despite being an essential stage, it is insufficient, since none of the eight types includes the number of properties at the cadastral parcel scale, its construction type or the geographic coordinates of where the parcel is located.

### 2.1.3. Organization of the Relational Database

Once the information was organized into tables, the developed structure determined the variables of analysis for the study. This stage was subdivided into two substages: the first was to filter and prepare the records used (Records 14 and 15 in Table 2); the second was to group this information into a single query. It is worth noting that the aim of the analysis was to identify where, when and how the urban growth occurred in the cities selected. To this end, we determined the number of properties in each of the cadastral parcels, the construction type and the age.

**Table 2.** Construction types selected <sup>1</sup>.

1.1 Urban multi-dwelling buildings	1.1.1. Open
	1.1.2. Closed block
1.2. Urban single-family dwellings	1.2.1. Detached semi-detached
	1.2.2. Terraced or closed block
1.3. Rural building	1.3.1. Exclusive use as dwelling

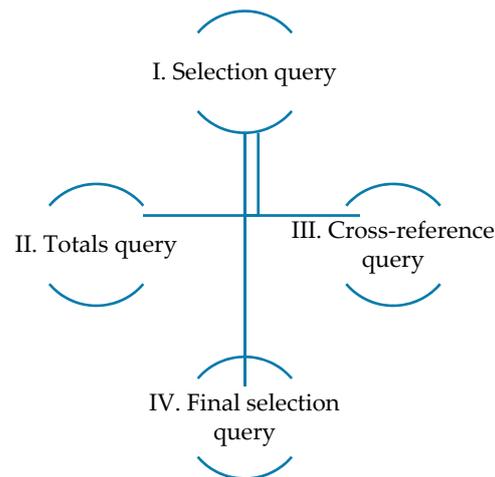
<sup>1</sup> Own preparation, using the document “Frequently asked questions on CAT format version 1.0”.

Nonetheless, and as mentioned, the difficulty lies in that this detailed information appears in none of the eight types of records. To find these final variables, we needed to cross-reference Records 14 and 15. To do this, from the original property table for Type 15, we selected the parcels with the field “Type of Property”, the UR (urban) (the possible codes are UR, RU or BI: urban, rural or special properties) and “Group key of properties with special characteristics, or of urban property use” coded as V (residential) (there are 16 possible codes: A, V, I, O, C, K, T, G, Y, E, R, M, P, B, J, Z, which correspond to the uses of storage-parking, residential, office, commercial, sport, shows, leisure and hospitality, culture, religion, urbanization and gardening—unbuilt land, unique building, agricultural storage, agricultural industry and agriculture). From this type of record, we also included the query for the fields of “Cadastral parcel”, “Sequential number of property (Loading number) within the cadastral parcel”, “First control character” and “Second control character”. The sum of the characters of the four fields (14 for the parcel, 4 for the loading number and 1 digit for each control character, with 2 in total) corresponds to the cadastral reference of the property in question (20 digits in total). Based on Record 15, we also included “Number of municipality” and “Year of construction”.

Once the data from Record 15 were processed, we associated the constructed elements with the properties to which they were related. This involved linking Type 14 and 15 records. When the properties and the constructed elements were linked, the records were significantly multiplied, which forced us to readjust the data so that each property corresponded to a construction type and a year of construction. This link was made using the fields of “Cadastral parcel” and “Serial number of fiscal property (loading number to which the value of the construction in the cadastral parcel is attributable)”. To obtain the construction type, the database was filtered again using the Type 14 record: the “Target code according to the code established by the Directorate General for the Cadastre” of construction elements designated as V (no detailed use) (a total of 172 possible codes and their respective descriptions can be consulted in Point 13 (Page 6) “Target code of construction. Description of codes” of the document “Frequently asked questions on CAT format version 1.0” available at: [http://www.catastro.minhap.gob.es/documentos/preguntas\\_frecuentes\\_formato\\_CAT.pdf](http://www.catastro.minhap.gob.es/documentos/preguntas_frecuentes_formato_CAT.pdf) (accessed on 12 March 2021). Although code V is described as no detailed use, it can be observed that these are dwellings, and as in the construction type fields, they are assigned values such as 1.1., 1.2. and/or 1.3., which correspond to records of dwellings of different types), as well as the field “Serial number of fiscal property” (loading number to which the value of the construction in the cadastral parcel is attributable) when it was not blank (if there is no value in this field, it is a common element and thus must be discarded to avoid posting errors). Furthermore, the construction type in “Construction type according to Technical Valuation Standards” had to coincide

with one of those in Table 2 (this can be consulted in Point 16 (Page 8) “Construction: Construction type” of the document “Frequently asked questions on CAT format version 1.0”, available at: [http://www.catastro.minhap.gob.es/documentos/preguntas\\_frecuentes\\_formato\\_CAT.pdf](http://www.catastro.minhap.gob.es/documentos/preguntas_frecuentes_formato_CAT.pdf), along with all the possible construction types associated with properties (accessed on 12 march 2021) (10 categories divided into 31 types, with 70 specifications).

Figure 5 summarizes the process of creating different queries. Once the relational structure between the tables was created, using the common field “cadastral parcel”, the process was as follows:



**Figure 5.** Procedure to create queries in the database. Source: Own preparation.

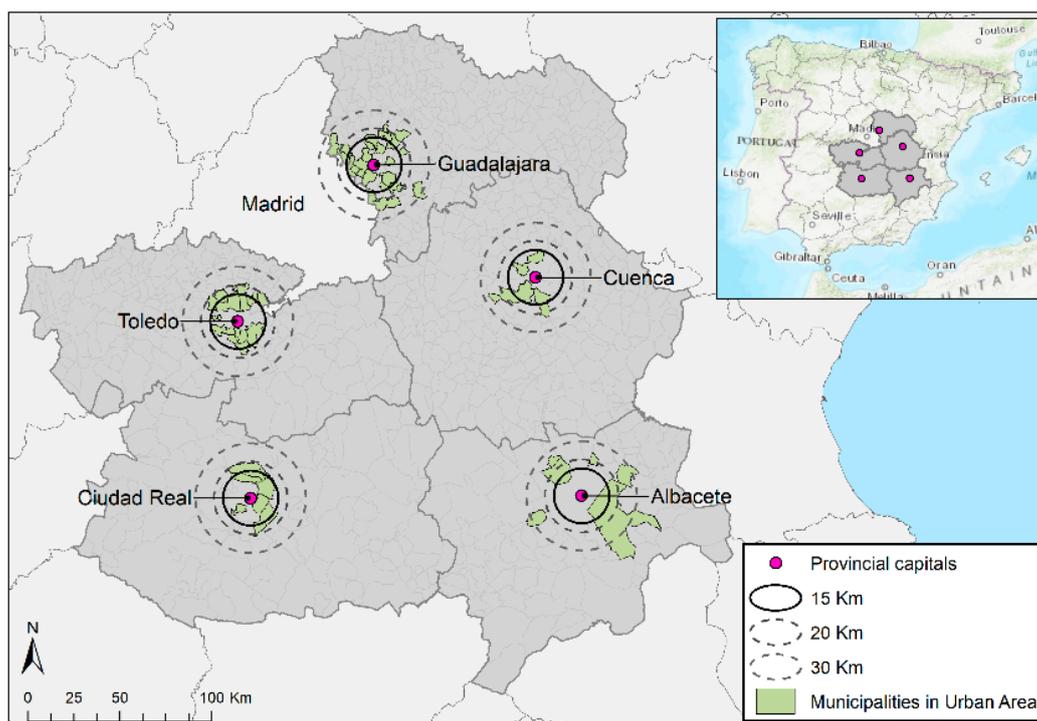
The selection query was consulted by (I) applying all the previously mentioned filters. This query yielded the totals query (II) to group the records together and count them. In parallel, and also as a result of query (I), a cross-reference query was generated (III), which served to count the properties by type. Finally, a selection query was created again (IV) to join the results of (I), (II) and (III).

#### 2.1.4. Elaboration of Thematic Maps

Creation of parcel-scale thematic maps, using the nucleus of population as the reference. The last stage of our proposed methodology allowed for integrated and comparative analyses, drawing on the selected cadastral records. The territorial reference used was the maps downloaded from the cadastre website, specifically the files labeled “urban without history”, available in shapefile format. Each municipality had different layers: “ALTIPUN”, “CARVÍA”, “CONSTRU”, “EJES”, “ELEMLIN”, “ELEMPUN”, “ELEMTEX”, “ERRLIN”, “HOJAS”, “LÍMITES”, “MAPA”, “MASA”, “PARCELA” and “SUBPARCELA”. In this case, we used the “PARCEL” shapefile. The thematic maps produced are the results of linking these files to the data generated from the CAT files.

### 3. Results

The results of the process allowed us to determine the urban area integrated in the five cities, with the municipalities included in each one (59 municipalities in the five urban areas at city scale, as follows: five municipalities in Albacete, five in Ciudad Real, four in Cuenca, 30 in Guadalajara and 15 in Toledo) (Figure 6). Within each of the areas, we analyzed the behavior of the construction of dwellings in absolute and relative values and by type (multi-dwelling and single-family dwellings). We analyzed two different periods (2000–2008 and 2009–2016). The results obtained were related to their respective central cities, conducting a comparative analysis of the dynamics of the cities and the peripheral municipalities, the latter being understood as manifestations of urban sprawl. The results of our study enabled us to generate an analysis at the parcel level, and, by aggregation, we obtained the information presented in this section for the different cities under study.



**Figure 6.** Urban areas of Castilla–La Mancha (Spain). Source: own preparation.

From a territorial perspective, these urban areas are characterized by proximity and continuity, as in most cases they include the first ring of municipalities (20 km), which border the area of each capital city. The aggregated data can be used to characterize the cities and their urban areas according to their dynamics and disparate behaviors. It is key to note that the situation of each of the capital cities is different.

Figure 6 and Table 3 show the outcome of this methodology, depicting the process of change over the period 2000–2016. It can be seen that in some urban areas the growth in real property was greater than in the cities to which they belong. This is the case for the city of Guadalajara. The growth dynamic in Toledo is also especially pronounced. The process was less intense in the other three cities, although their urban areas also grew proportionally more than the cities themselves.

The results show that the changes in the dynamics of housing were especially intense in urban areas. The single-family dwelling was clearly the dominant type of property in the period under study. It can also be noted that the increase in dwellings per inhabitant was higher in urban areas than in their respective cities. Finally, the sharpest growth was observed between 2000 and 2008.

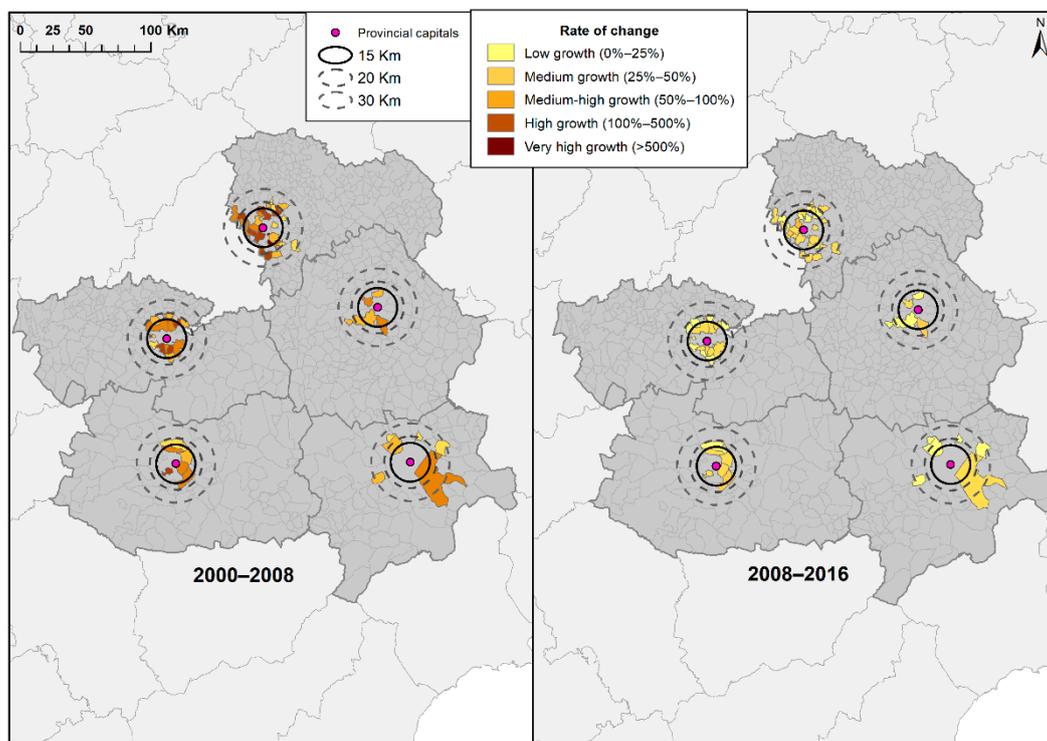
The appearance of sprawl-like development has been described as a type of “pollution threatening the quality of the natural environment” [101]. Compact cities consume less land, water and energy [102], and are thus associated with a more sustainable urban model. Nonetheless, there is some support for the model of a diffuse city, with a number of studies (albeit fewer) arguing against compact cities, or at least holding a more balanced position in the debate concerning compact cities vs. diffuse cities [103].

Comparing Figures 7 and 8 highlights two notions that coincide with the discussion in the above paragraphs. Firstly, it is shown that most of the municipalities in all the areas studied in Castilla–La Mancha present housing growth rates that are higher than those of the population. Secondly, across the years analyzed (2000–2016), in the first period (2000–2008) growth was more dynamic, whereas the second period (2008–2016) was characterized by a sharp fall in the growth trend (Figures 7 and 8).

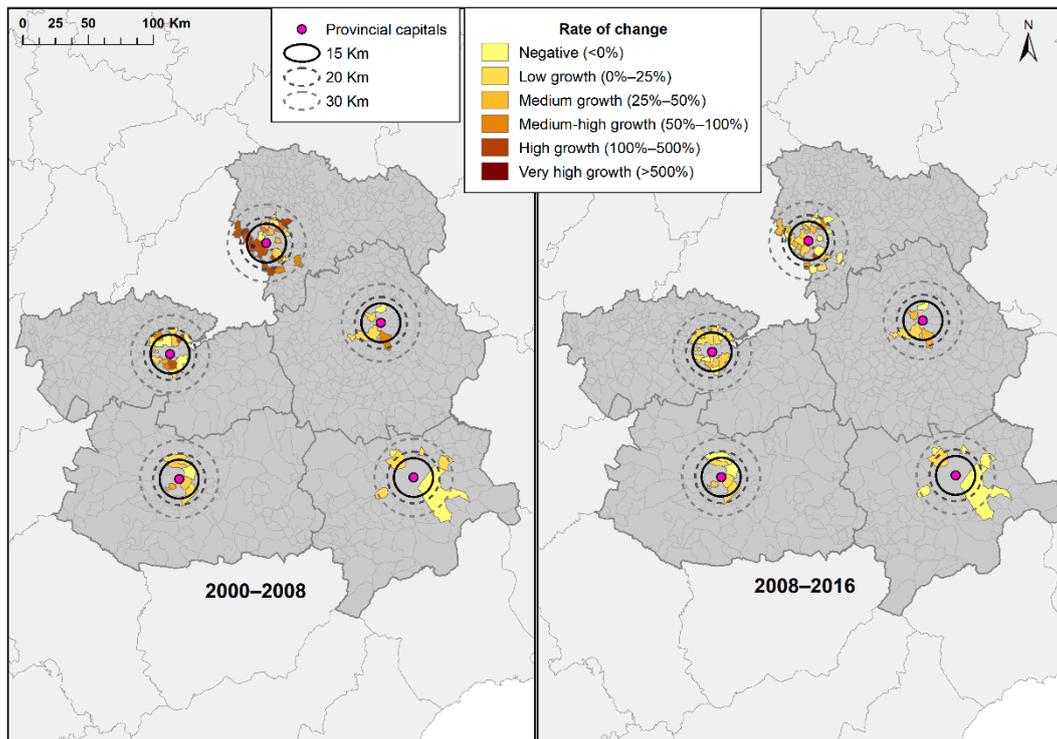
**Table 3.** Evolution of population and housing in the five provincial capitals of Castilla–La Mancha and their respective urban areas (2000–2016) <sup>1</sup>.

City and Urban Area (UA)	Total Multi-Dwelling Buildings		Total Single-Family Dwellings		Multi-Dwelling Buildings 2000–2016	Single-Family Dwellings 2000–2016	Total Dwellings 2000–2016	Population Increase 2000–2008	Population Increase 2008–2016	Total Population 2016	Ratio Inhab/dwg
	2000–2008	2009–2016	2000–2008	2009–2016							
Albacete	12.505	4.814	1.933	1.128	73.273	11.560	84.833	6.448	8.629	16.3972	1933
UA	960	259	766	483	1.859	4.986	6.845	516	529	8.195	1454
Ciudad Real	8.551	2.350	1.201	218	33.911	5.489	39.400	8.292	2.601	70.953	1801
UA	2.374	1.179	2.906	561	4.786	9.636	14.422	4.510	2.867	24.188	1677
Cuenca	6.012	1.330	877	173	26.125	4.303	30.428	4.025	972	50.373	1655
UA	301	405	613	225	831	2.536	3.367	564	684	3.510	1042
Guadalajara	7.404	2.332	2.025	271	34.357	5.813	40.170	4.434	4.395	73.809	1837
UA	5.755	1.850	16.087	2.792	9.342	37.654	46.996	34.998	15.532	74.715	1589
Toledo	5.082	3.113	3.053	349	30.447	7.800	38.247	6.235	3.373	77.185	2018
UA	4.451	1.114	8.028	1.680	9.051	23.131	32.182	11.529	7.730	53.506	1662

<sup>1</sup> Source: Cadastre for dwellings; National Statistics Institute (INE) for population. Own preparation.

**Figure 7.** Rate of change in real estate 2000–2008 and 2008–2016.

The processes in the first period, which clearly represent the “prodigious decade” of Spanish urban growth [68], helped consolidate the model of a sprawling, low-density city. They feature urban landscapes typified by developments of single-family dwellings. These new patterns of spatial organization generate an inefficient, segregated and unsustainable urban space [104].



**Figure 8.** Rate of change in population 2000–2008 and 2008–2016.

The combined analysis of the data provided by the cadastre (alphanumeric CAT files and vector maps) allows us to territorialize the housing behavior by type, according to centers of population over the period 2000–2016. Various examples will show the possibilities of using the cadastre to obtain detailed maps using the absolute data obtained.

The first example is Magán (Figure 9), situated in the urban area of Toledo. The growth in housing in the first study period (2000–2008) was 279%, but 12% in the second. Population growth also reached high levels, although they were lower than those of housing (141% between 2000 and 2008 and 18% between 2008 and 2016). What is striking in the case of this municipality is the expansion of its urban area, following the course of the CM-4058 road, in the form of single-family dwellings (detached, semi-detached, terraced and closed block). Meanwhile, the traditional urban core showed insignificant levels of growth.

The second municipality is Galápagos (in the urban area of Guadalajara) (Figure 10). In this case, population increased at a greater rate than housing across the two study periods. Between 2000 and 2008, demographic growth was 509%, whereas housing grew by 192%. These rates dropped notably over the period 2008–2016, with population increasing by 24% and housing by 3%. The results once more show that the first period (2000–2008) was more dynamic. The urban sprawl expanded from the traditional urban core towards the south. In Galápagos, urban growth was concentrated not only in the limits of the municipality, but also in other, smaller centers of population (such as Residencial Montelar, Figure 11) in the period 2000–2008, with the construction type typically being single-family dwellings (detached and semi-detached).

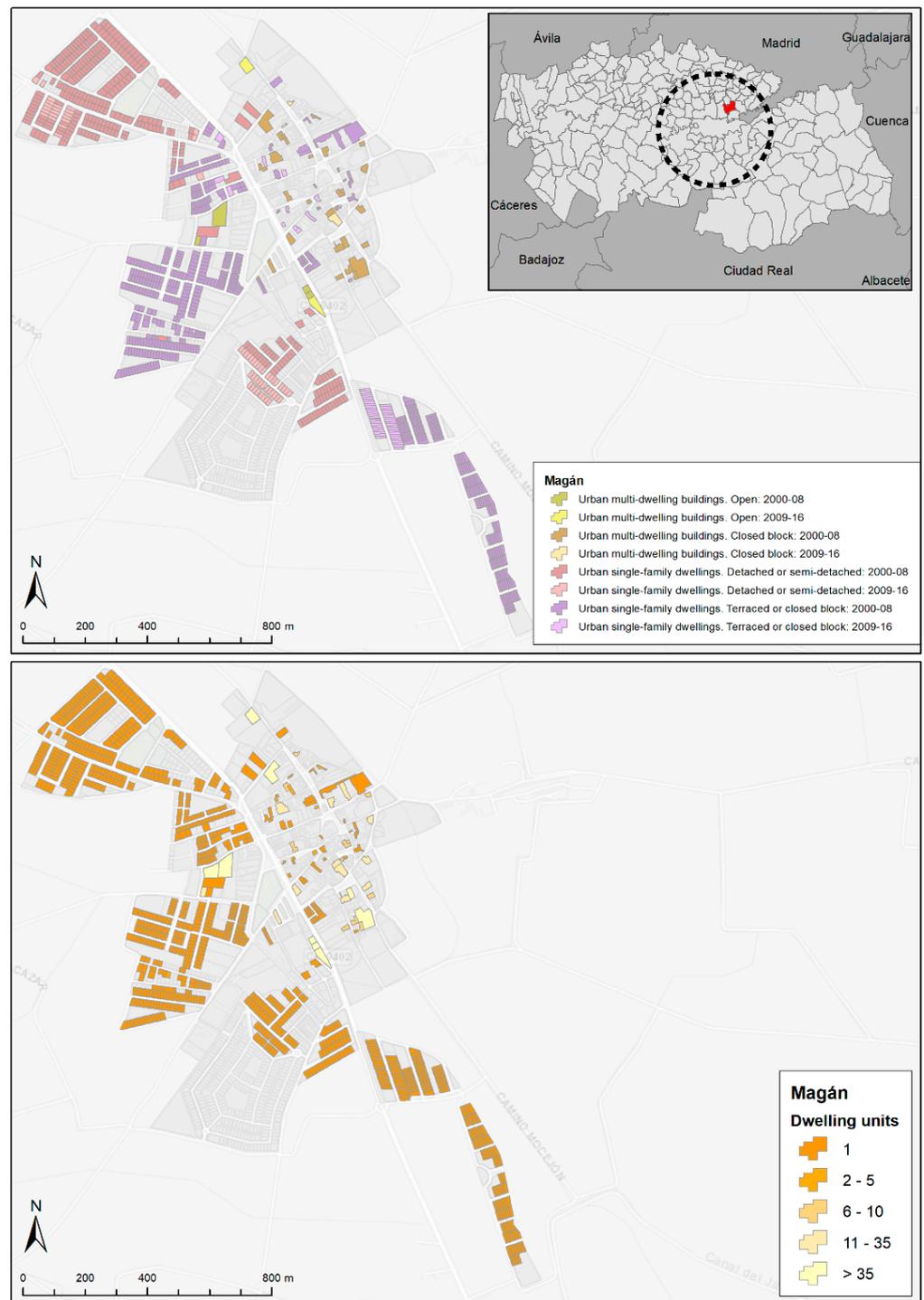


Figure 9. Number of dwellings and construction types (Magán). Own elaboration.

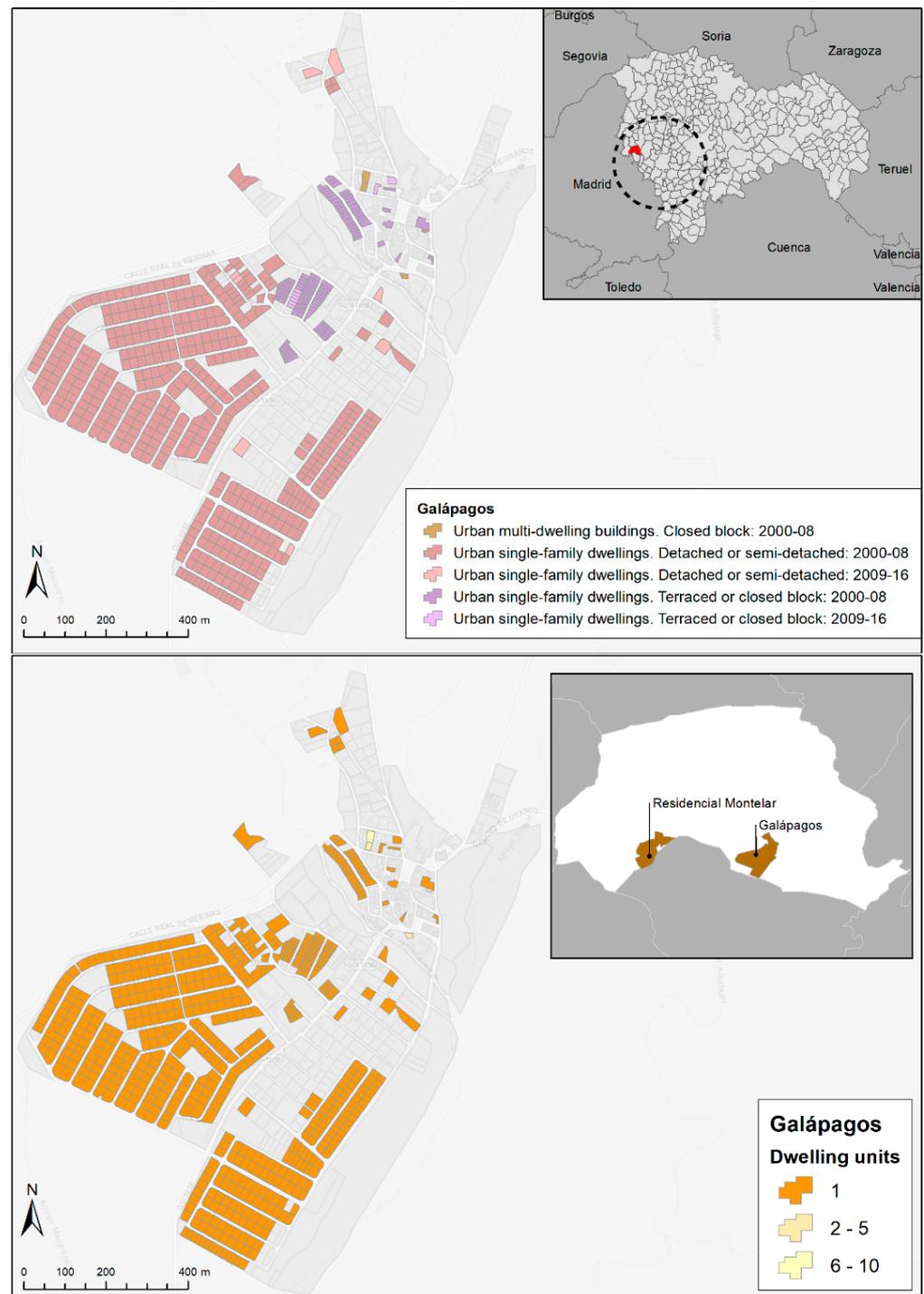


Figure 10. Number of dwellings and construction types (Galápagos). Own elaboration.



**Figure 11.** Number of dwellings and construction types. Own elaboration.

#### 4. Discussion

The approaches presented in the first two sections of this work deal with the conceptual framework of the city and the process of transformation towards the periphery. These aspects are directly related to the dynamics of the morphological change in urban spaces, to the debate on sustainability and the city model, to the shift in the public administration paradigm from government to governance, as well as to the need for detailed studies based on reliable, updated sources. The territorial delimitation and definition of a city is considered a complex task [105]. Since, 2011, the European Union has defined a city as a local administrative unit with at least 50,000 inhabitants, a population density of more than

1500 inhab/km<sup>2</sup> and at least 50% of the population living in one or more urban centers. It forms a functional urban area (FUA), in which more than 75% of the population live in the city center. It includes a commuting zone that includes adjacent administrative units (municipalities), where more than 15% of employed residents work in the city center. Overall, the functional area should comprise a population of over 100,000 [106]. This notion forms part of the complex conceptual debate on territorial reality related to polycentrism [107] (pp. 163–173). In this definition, there is an implicit concept of a city without exact limits, with urban sprawl as a generalized process, and this is one of the key problems to be addressed, namely, defining the territorial scope of a city and its changing dynamics. This requires precise knowledge, identifying the location of new dwellings, the trends over time and the construction types that are dominant in each period. However, while there is no consensus on the definition of city, neither is there one on the definition of the territorial scope of urban areas.

In Mediterranean Europe, cities have historically been characterized by a compact, intense and dense morphology. However, recent decades have witnessed processes of urban sprawl, which have been noticeable at different levels of the urban system, including intermediate cities. Such cities are now typified by the territorial fragmentation of their residential areas and the expansion of their urban sprawl, the formation of urban areas outside a radius of 15–20 km, and the proliferation of single-family dwellings. The urban area, as an actual dimension of a city and as a functional structure, has imprecise limits, which can be explained by the democratization of private vehicles and ICTs (Information and Communication Technologies) and the increasingly densified communication infrastructures [72]. As noted by Boix, “although a city may be similar to a municipal administrative unit, the scope of economic and social interaction tends to exceed the municipal dimensions, spreading to the nearest space” [108].

Urban sprawl processes are undeniably a tangible reality in intermediate Spanish cities [109–111]. This has been analyzed in a variety of fields of study and using different sources. A review of the literature reveals diverse findings depending on the scale of analysis, the geographic limits considered and the definition of urban sprawl used. In most cases, attention has focused on urban sprawl, using aerial photography or satellite images [112–114]. Consideration has also been given to demographic and construction dynamics, using aggregated data, supported by the opinions of municipal technicians [115,116]. Both approaches, however, are grounded in municipal-scale aggregated data accessed from different sources, with only the demographic information being disaggregated at a significant level.

In such studies, the cadastre has great potential as a source of analysis of urban dynamics and processes. The data it provides enable a high level of disaggregation. It can be applied for different uses: at the administrative level, to determine urban planning parameters; for research on growth and prospective studies on cities; geomarketing; urban indicators to characterize housing stock, etc. [52,111,117–119]. However, despite its potential, few applied studies have used data from this source, whereas even fewer have specifically used cadastral parcels as an element to analyze urban transformation processes. However, therein lies a significant part of its functionality, as it enables comprehensive knowledge of territory and boasts extremely valuable territorial information for use by both the public and private sector [120]. The cadastre is highly credible and thoroughly updated, guaranteeing effective management, and “has a significant impact on tax revenue and real estate values, supports urban planning, influences real estate values and effects the procedures of land management” [83] (p. 2). It has, in fact, the capacity to become a key tool for territorial analysis in processes where cadastral real estate is an indisputable reference.

The results of the case study underline the usefulness of the data and the methodology used helps to understand dynamics of urbanization. Nonetheless, there are certain limitations in the use of cadastral data, given that the structure of access complicates their use in research. It should be noted that although the information provided by cadastral statistics is varied and complete, this information cannot be territorialized. It is thus necessary to

resort to the CAT files, which contain the parcel identifiers and make it possible to link with the cartographic databases to generate thematic reference maps.

The main drawback is the level of complexity involved in interpreting and extracting the information. In fact, some authors have chosen to “forego the computerized and automated linkage of data from tables on cadastral parcels and data on real estate [ . . . ] mapping on GIS (Geographic Information System), by manually entering the year of construction, parcel by parcel” [121] (p. 522). Others have opted for a methodology similar to that used in the present study. Rello (2016) resorted to creating a relational database in PostgreSQL to obtain the information on the CAT files and, if necessary, work with variables related to the analysis of residential overcrowding [122]. In any event, even if this system is not available, with the cadastral maps and alphanumeric CAT files, it is possible to territorialize the results.

Nonetheless, despite the difficulties and problems related to the source, the CAT files provide extensive information and enable territorial analysis of cities, the conflicts resulting from their uncontrolled expansion and the sustainability of the urban model that has arisen in recent decades. The use of the land parcel and the number of properties inside them, the year of construction and the type of dwelling help to precisely define the dynamics of change in cities. This study validates its usefulness. In contrast to census information, which is clearly limited by issues of time (it is updated every ten years) and reliability (it is generated by sampling), the information from the cadastre has the advantage of being updated every six months, having extremely detailed information on the parcels and the elements associated with them, as well as having related maps. The multi-purpose cadastre is a highly valid tool in the field of territorial planning and the analysis of urbanization dynamics. Indeed, it is the key component of land administration systems, which, in turn, prioritize efficient and effective land markets [123] and sustainable development [124].

## 5. Conclusions

The debate on the concept of the city and its limits has numerous implications that affect its definition, but which also impact the growing importance of integrated urban areas in cities. This process has been ongoing since the end of the last century. The spatial, social, economic and environmental effects of urban sprawl have sparked a debate on the sustainability of this model. In fact, urban agendas, underpinned by international declarations, emphasize the need to return to the compact city. In this scenario, cadastral data should be at the heart of research and land-use management. It is necessary to generalize the use of the information available in cadastral databases because it is exact, reliable, updated and highly detailed, which makes it of great use to evaluate urbanization dynamics by analyzing the changes in the distribution of real estate and its age and construction types.

The case study proposed in this work underlines the suitability of cadastral data for the analysis of the different scale dynamics of urbanization, as regards both cities and their urban areas. To date, these analyses have been conducted using sources that allow for little disaggregation of data, thus limiting the validity of findings. The possibility of using urban parcels and real property underlines the need to advance the development of methodologies that permit greater use of the cadastre in urban studies in this research field. The advance in the methodology developed here facilitates the detailed analysis of the events of the period under study, as reflected in the case studies proposed in this work. These reflect the precision of the data generated in terms of the number of dwellings constructed, the types of construction, their location and the evolution over a time series of 16 years. The results show three dimensions of change—in the dynamics of construction, which are more intense in the peripheries than in the central cities, regardless of whether the context is one of economic expansion or recession; in the types of construction, as single-family dwellings have gained in prominence in urban areas, whereas the trend of block dwellings persists in the central cities; and in the lack of definition in the concept of the urban area as an element of analysis and a tool for planning, in a scenario in which

suburbanization processes continue to advance. This type of analysis is increasingly necessary and significant given the foreseeable dynamics of the effects of the COVID-19 pandemic in city peripheries.

Using this data should help administrators in the decision-making processes of government and governance of cities, which are of great significance to the much-repeated need for greater urban sustainability. The present work demonstrates the potential of the cadastre in quantifying and representing the processes, but also highlights the scant attention paid to the difficulty in utilizing the data. It is thus necessary to advance methodological proposals that help encourage their use.

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