METHODOLOGY FOR MEASURING THE URBAN STRUCTURE OF TODAY'S CITY, USING THE LAND REGISTRY DATABASE. APPLICATION TO THE SOUTH-WEST SECTOR OF THE AUTONOMOUS REGION OF MADRID[1]

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I. INTRODUCTION

Urban sprawl has seen the consolidation in southern Europe of a new city model with its own type of features that have deeply transformed the characteristics and traditional location of urban land uses. The most significant changes are as follows: change of residence, with a clear predominance of low densities and single-family type dwellings, to territories increasingly further away; the decentralisation of industry; the emergence of new locations for services, polarised on arterial infrastructure and, finally, some internal renovation operations (new central areas) in large and medium-sized cities, in which services and facilities in general play an important role.

This process of change has occurred in parallel to a profound transformation in the urban structure of large cities. The territorial organisation of the traditional city, characterised by morpho-typological complexity and land use mix, is giving rise to a new type of urban territory, where emerging spatial forms stand out for the specialised and frequently monofunctional nature of the fragments of the new mosaic of today's city.

The objective of this research has been to show, based on urban land registry data, in a GIS environment, a methodology for measuring urban structure with the geo-referenced information available, consisting of the coverage of different land use variables. We carried

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out this task in the south-western area of the Autonomous Region of Madrid in two stages. During the first stage, we tried to *define a typology of basic structural units*, based on the potential combination of existing land uses in each cadastral plot. The second stage focused on the *reconstruction of the model of resulting structural units*, based on the previous units, through the adjacent integration of territorial units of similar thematic content, according to the previously defined models.

II. LAND REGISTRY DATABASES AND THEIR APPLICATION TO THE STUDY OF MADRID'S URBAN STRUCTURE

A considerable volume of geo-referenced information of special interest for carrying out different tasks associated with applying Geographic Information Technologies (GIT) in the analysis and evaluation of different aspects related to the current territorial model was recently made available to the public. In this respect, the urban land registry, prepared by the General Directorate of Land Registry of the Ministry of Finance and Public Administration, has sufficiently detailed and qualified information to achieve a goal such as the one we propose here.

In our case, the cadastral plot has become an important factor for studying and interpreting the city, by being able to relate its growth to its inherent urban structure and morphology. The use of the cadastral plot in urban studies is justified by creating a homogenous geographical body, whose intrinsic nature comes from its special relationship with the property and its content, in terms of its morphological, temporal and functional characteristics. To achieve the proposed objective, we have used the urban cadastral cartography of the south-west sector of the Madrid region, comprising a total of 211.321 plots.

III. DEFINITION OF BASIC FUNCTIONAL UNITS IN THE MADRID URBAN AGGLOMERATION, BASED ON LAND REGISTRY DATABASES

Having (spatial and thematic) geographical data, stored structurally in a database, linked to a Geographic Information System (GIS), has given us great database flexibility, allowing us to extract information derived from re-preparing the already existing database. We have therefore been able to obtain the combination of existing land uses in each plot in order to define taxonomic models from the resulting dominant typologies.

As the most representative starting uses, we have considered residential, commercial, industrial and office land use, subdividing the first, due to its importance, into two categories: single-family residential housing and multi-family residential use. There were 24 possible groupings of these five categories, according to the combination theory and its existence in the reality of the case in question. A detailed analysis of those existing land use combinations in the constructed cadastral plots, comparatively between the southern and western sectors of the Madrid urban agglomeration, helped us draw an interesting set of conclusions:

1. The number of exclusive-use constructed cadastral plots, in relation to the five land use categories considered, comprised more than 90% of the existing total for the entire southern and western areas of Madrid.

2. The residential fabric designed for single-family housing was noteworthy for the exclusivity of its use, as it was hardly associated with any other type of use (99.6% of the plots were exclusively residential).

3. Multi-family residential land was combined easily though with other uses, mainly commercial (44.4% of the plots shared, in number, both land uses, while barely 11.5% did so with industrial and/or office use).

4. Commerce was the most random type of land use most readily associated with other uses, mainly the multi-family residential fabric.

5. The industrial function stood out for its exclusivity and poor mix with other uses (in 92.7% of all constructed plots for industrial purposes, this type of use predominated exclusively).

6. Finally, we can highlight the trend of mixing office land with other uses, mainly multi-family residential use, commercial use and, to a lesser extent, industrial use, with major sector contrasts, because land exclusively for offices was more predominant in west Madrid (37.4% of total plots) than the south (20%).

IV. DEFINITION OF THE MAIN LAND USE PATTERNS OF THE DISPERSED CITY MODEL IN THE SOUTH-WEST SECTOR OF THE AUTONOMOUS REGION OF MADRID

The proposed land uses, with a view to obtaining real territory use patterns, are based on the two elements used in the preceding section: territorial unit of analysis and land use category (mixed). The spatial unit was, as indicated, the cadastral plot, while for the land use categories we have selected exclusively the most representative uses. Therefore, by grouping the 24 possible combinations, we have defined eight basic categories: exclusive single-family residential; dominant single-family residential; exclusive multi-family residential; dominant multi-family residential; exclusive commercial; exclusive industrial; exclusive office use; and mixed use (commerce, industry and offices).

We have reconstructed the formal territorial units or pieces of the urban mosaic from the basic functional units or plots, based on knowledge of the processes occurring in the city, as these allow us to interpret the spaces formed as a consequence of urban development dynamics, according to the needs of the production system, consumer tastes and new technological progress. Here, in line with the work of Font (1997)[2], we have differentiated between each of the following basic units of the urban fabric to be recognised in the geographical space analysed: *agglomerated or* urban settlements, whose main characteristic is the continuity of their plots, with respect to the central city, characterised by mixed uses; *extensions of previous urban plots* due to extension of their road networks, generally more monofunctional in nature (residential, industry); *threads or filaments*: linear formations along historic road infrastructure; *disaggregated* or tree-shaped settlements or in more or less closed packages on diverse topographies, predominantly residential in nature; *scattered settlements*, the result of the individual occupancy of rural territory, according to a self-organising logic, although without the marginality of previous times; *arterial elements*:

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2   Font, A. (1997): «Anatomía de una metrópoli discontinua: la Barcelona metropolitana», in *Papers, Región Metropolitana de Barcelona*, no. 26, pp. 9-19, Barcelona.

channels of communication and mobility, and *enclaves or nodes*: grouping of buildings and facilities, consisting of service centres and commercial facilities, located at strategic points in the territory (motorway junctions, transport interchanges, etc.) of maximum accessibility and/or metropolitan significance.

Based on this theoretical reference, we have proposed combining, in the Madrid metropolitan south-west territory, the existence of one of these basic units which would offer, as a trial, the line to be followed in the attempt to rebuild the global network of the entire city structure. In this attempt to identify and delimit territory use patterns in the Madrid region, as homogenous open fabrics, we have selected three examples following the explicit terminology of the work highlighted above: the Zarzaquemada district, in Leganés, which was developed during the 1960s (agglomeration); the Európolis park, located in the municipality of Las Rozas (enclave or node) and the Cerro Alarcón housing estate, located in the municipalities of Valdemorillo and Navalagamella, one of the largest low-density residential developments in the whole of the Autonomous Region of Madrid (disaggregated).

With this intention, we selected the database for each of these three structural units from the general land registry database, exporting the GIS dBase thematic database to the Statgraphics Centurión statistical programs package, statistically processing the information. This operation consisted in regrouping the initial land use categories, measuring the number of plots, the built area on the space occupied by the new categories and the average number of dwellings and productive establishments per plot.

The study of the three specific urban structure cases in the Madrid metropolitan south-west sector, each of different origin, has enabled us to show the path for obtaining the urban structure of the Madrid region, at a more general level, as well as discover certain fundamental aspects related to the change in the city model. So, in contrast to the intermingling of residential and activity functions in the traditional city (whose archetypal representative would be the Zarzaquemada district), where the zoning of uses respected the continuity of the urban fabric, in the new suburbs of today's city, residential areas and other activities occupy segregated sectors, with a lot of discontinuity between different specialised fragments. In this framework of reference, mixed shopping areas, such as Európolis, feed the so-called urban sprawl, making it a key part of these suburban development complexes, contributing to the disappearance of differences between the traditional centre and periphery, by moving or dispersing and also concentrating consumption and leisure functions in increasingly peri-urban spaces. The other example, the Cerro de Alarcón housing estate, shows the isolation of low-density residential packages, true islands connected and anchored to infrastructure, but separated from each other physically and socially. In this respect, single-family housing tends to homogenise the landscape, reduce metropolitan densities and enhance increasingly greater spatial fragmentation, which in some areas even leads to privatisation of the space itself.

V. CONCLUSIONS

Use of the urban land registry in the territory study offers new and very interesting insights, for such diverse purposes as assessing its problems, cartography, representation

and, finally, territorial planning. Its significance as such comes from the ability of the urban plot to integrate, in a small physical space, a set of key elements to interpret the city, in terms of identifying the logic of urban growth phenomena. In our case, the methodology developed from urban land uses, including multifunctional uses, shows the possibility of quantitatively analysing the structure of our cities progressively over time, helping to enhance the major contrasts existing between the compact city of the past and the present urban sprawl, based on the urban mosaic and functional pieces associated with each of its activity, consumption and leisure spaces.