

Methodology to Identify Dispersed Occupation on a Local Scale¹

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The study of urban dispersion on a local scale requires the adoption of operational concepts. This research uses the notion of "Base Land Unit" (BLU), which represents a functional and experiential reality.

The current paper presents an explanation of this concept and a methodology to distinguish BLU of dispersed occupation from other types of Units (concentrated, unbuilt...).

The developed methodology comprises three different methods:

- Identification of Building Ensembles by Digital Method;
- Calculation of the Disaggregation Index of Continuous Building Ensembles;
- Criterion for Identifying BLU of Dispersed Occupation.

A detailed description of each phase is presented, as well as the results of its application in the case studies of the Research Project (Évora and Aveiro-Ílhavo).

Keywords: Dispersed occupation, local scale, methodology.

1. Urban Dispersion on Several Scales

The shape of urbanization in the past few decades is quite different from the traditional one, its traits are:

- global webs of economic relations;
- urban man's great mobility in everyday displacements;
- spread of buildings and new developments throughout the territory.

As a result, emerging urban territories have been classified as *generic, extensive, dispersed, diffuse, discontinuous, fragmented...* This limitless city is conceptualized by several authors, as the *Global City*, the *Metàpole*, the *Edge City* or the *Città Diffusa*" (Font, 2004:12).

The vast majority of analyses focusing these new urban territories use large concentrations, large cities as their referents. However, some of the phenomena identified – namely constructive and functional dispersion and fragmentation – are common to most growing cities, including small and mid-sized ones and even to some cities facing economic and demographic decline.

It is, after all, a widespread phenomenon resulting from financial, economic and cultural globalization, as well as the growth in mobility allowed by the private car (Carvalho and Pais, 2009).

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Although dispersed occupation occurs on several scales, this Research Project intends to study the phenomenon only on a local scale.

2. Base Land Units

To define conceptually "Local Scale", the starting point is the broader concept of "Land Unit" (LU), defined as a portion of land that reveals itself as a unit, from a geographical, historical, functional and/or administrative perspective.

The concept relies on perception/recognition and can be considered at different scales (e.g. World, Europe, the Iberian Peninsula or Portugal). A Land Unit can also be assumed in a voluntaristic way, as for example, in a hypothetical creation of Administrative Regions in Portugal (Carvalho, Pais *et al.*, 2008; Carvalho, 2009; Carvalho e Marinho, 2010).

The recognition of Land Units is more difficult in urban territories that, because of its fragmentary and dispersive expansion dynamics, are not consistent with the administrative limits.

The complexity associated with the delimitation of urban Land Units is not only applied to the city scale, it can be also found in the "wider ensemble in which the city is integrated"; and also in each one of the "city parts". The terms "city", "wider ensemble in which the city is integrated" and "city parts" result from the adoption of a hierarchical territorial scale that can be useful to understand and also manage urban territories.

Despite the mentioned difficulty, and taking into consideration the need of an adaptation to each particular reality, the three terms can be related to well known Land Units: Metropolitan Area or Urban Conurbation, Extended City, City Part and Base Land Unit (BLU).

In this Project, "Local Scale" corresponds to the Base Land Unit scale. BLU is a concept that integrates and almost coincides with other well known ones, namely that of the neighbourhood, in its everyday meaning, and that of the neighbourhood unit.

The latter stems from American sociological studies concerned with weakening social rapports among neighbours. Clarence Perry formulated it in the 1920's and the majority of modernist planners, those of the Garden City and those of the Athens Charter (Mumford, 1982:541-542) adopted it. It aims at strengthening neighbourly relations, along with effective and rational public (or collective) service, namely in what concerns facilities.

BLU scale/territorial scope is thus conceptually linked to a demographic dimension suitable for good basic facilities service, often named local facilities. Adopting conclusions drawn by a recent study on the matter (Carvalho and Marinho, 2009), the reference, preferable population may be that of 3.000 users (residents or employed in the area), admitting an interval between 1.000 and 5.000 with natural consequences on the facilities to consider.

The BLU concept differs from the neighbourhood unit for introducing non-segregationist cautions (Carvalho, 2003:191) and taking on a broader meaning, as it does not necessarily refer to an exclusively residential area – it may also encompass central or industrial ones, techno-centres, a dispersed settlement area, or even an agricultural and/or forested area within the Extended City.

The concept is mostly based on functional and experiential characteristics and, consequently, a single BLU may encompass very distinct morpho-typological patterns.

Considering that dispersed occupation expresses itself not only through the existence of isolated buildings, but also through small fragments of concentrated buildings which are only recognized as urban dispersion when looked at on a broader scale, the possibility of using a unit more detailed than BLU was refused, because it wouldn't allow the recognition of this reality.

Thus, the analyses carried out so far highlight BLUs as the most suitable unit to identify dispersed occupation on a local scale.

The adoption of BLUs as the study unit also has the advantage of enabling the recognition of multiple morpho-typologies of urban dispersion, taking into account their agro-forestry uses and their collective practices.

3. Base Land Units Delimitation

To delimit BLUs, with operative and/or analytical purposes, it is necessary to adopt differentiating attributes. A detailed description of these attributes, as well as of the best methods for their identification, is presented in Carvalho, Pais and Gomes (2010).

BLUs, as experiential units, are mainly delimited through their uses, their functional/structural organization and, consequently, the presence of barriers and boundaries. The legacy of the "neighbourhood unit" concept, and the idea that BLUs' area is defined according to a minimum public service/ number of residents, makes "dimension" other essential attribute to its delimitation (especially in the analysis of residential units).

The methodological sequence adopted to delimit BLUs starts with a preliminary identification of the Extended City, an area that integrates the city centre and its nearest surroundings, including agro-forestry interstitial spaces.

To do so, one uses a method called "Empirical Knowledge on Cartography and/or Aerial Photography", which consists in gathering a set of privileged territory experts that, knowing the research conceptual framework, delimit territorial units on cartography.

Through this method it is possible to sketch a first delimitation of the Extended City, based on the recognition of key barriers/boundaries and dominant land uses, with particular attention to the presence, or absence, of buildings. Additionally, physical networks that structure the territory are also considered in this preliminary delimitation, as well as the existence of infrastructure and services that, by their characteristics, should be integrated in the Extended City area.

After this first approach, one should delimit and define building ensembles within the Extended City. To perform this task a method called "Identification of Building Ensembles by Digital Method" was created; its explanation will be further presented in the current paper.

The application of the "Digital Method" results in three types of building ensembles: "continuous", "dispersed" and "rarefied". Their spatial definition and typification is a very precise reference to the following steps of the methodological sequence.

Next, the final delimitation of the "Extended City", "City Parts" and "BLUs" is held through "Empirical Knowledge on Cartography", complemented by statistical data and taking into account the results of the "Identification of Building Ensembles by Digital Method" previously performed.

The "Empirical Knowledge on Cartography" is very helpful at this stage, allowing the identification of two essential attributes: existing barriers/boundaries and land uses, facilitating also the recognition of networks that internally structure the Territorial Units, which is crucial to BLU.

The use of statistical data supports the empirical method, providing precise information about the social characteristics of the residents and about the size of the population and number of buildings in each Unit. It also provides information on services and infrastructure provision.

After the delimitation of BLUs in an Extended City, one intends to characterize its occupation, which, considering the objectives of this Research, means distinguishing BLUs of dispersed occupation from other types of units (unbuilt, concentrated...).

To accomplish this task a methodology that comprises three different methods was developed:

- Identification of Building Ensembles by Digital Method;
- Calculation of the Disaggregation Index of Continuous Building Ensembles;
- Criterion for Identifying BLUs of Dispersed Occupation.

A detailed description of each phase is presented next, as well as the results of its application to the Research Project's case studies (Évora and Aveiro-Ílhavo).

4. Methodology for Identify Base Land Units of Dispersed Occupation

4.1 Identification of Building Ensembles by Digital Method

This method resorts to Geographic Information Technologies (ArcGIS) and consists of an aggregation of buildings, based on maximum distances between them, to which marginal strips of road sections directly serving them were added.

This aggregation allows the identification of continuous, dispersed and rarefied ensembles, each reporting to a successively larger distance between buildings.

The distances considered in the abovementioned exercise (which will be explained further on) are presented in the Table 1.

Table 1 – Distances and Areas Considered in the Method

	Continuous Ensembles	Dispersed Ensembles	Rarefeid Ensembles
Buffer radius of each building	10m	45m	80m
Buffer radius of road sections that marginate buildings	40m	80m	120m
“Islands” and “Peninsulas” Size	≤ 5.000 m ²	≤ 10.000m ²	≤ 20.000m ²

It should also be mentioned that:

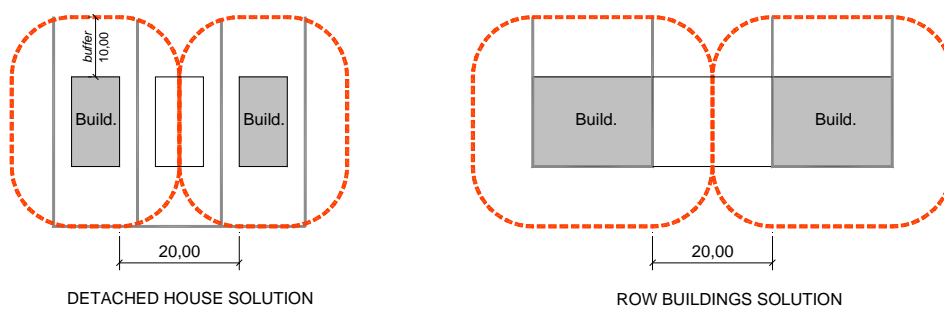
- Only buildings with covered areas of at least 30m².
- Ensembles of less than five buildings are disregarded.
- Areas corresponding to “islands” and “peninsulas” are added (small spaces inside each ensemble).

The method is essentially digital. However, it demands some manual checks and additions, namely regarding the inclusion of road sections that are part of the ensembles’ internal structure and of “peninsulas” (areas partially interiorized in the ensembles).

One should bear in mind that each building’s buffer, multiplied by two, equates the maximum distance between two buildings to include them in the same ensemble.

The criterion behind the distances defined was that of two buildings belonging to the same ensemble whenever the distance between them allows enough space for one lot and the construction of one building (and no more), characteristic of the urban fabric in question.

Specifically, to generate Continuous Ensembles, is applied a buffer radius of 10m (distance between buildings = 20m), translating the following situation:

**Figure 1** – Buffer radius in Continuous Ensembles

To generate Dispersed Ensembles is applied a buffer radius of 45m (90m distance between buildings), based on parcels of 50m x 100m = 5.000m² (minimum area for horticulture use)², as presented in the next Figure.

² Decree n.º202/70, of 21 de April

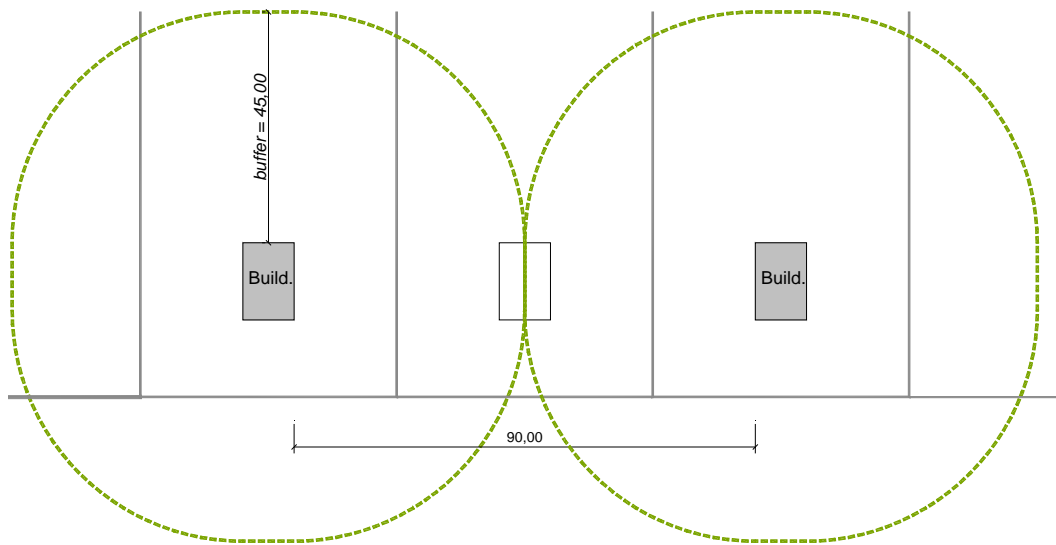


Figure 2 – Buffer radius in Dispersed Ensembles

To generate Rarefied Ensembles is applied a buffer radius of 80m (distance between buildings = 160m), based on parcels of 15.000 m² (85m x 170m), dimension between the minimum area for horticulture use (0,5ha) and the one for tillable land (2,5ha)³, which can be translated in the following scheme:

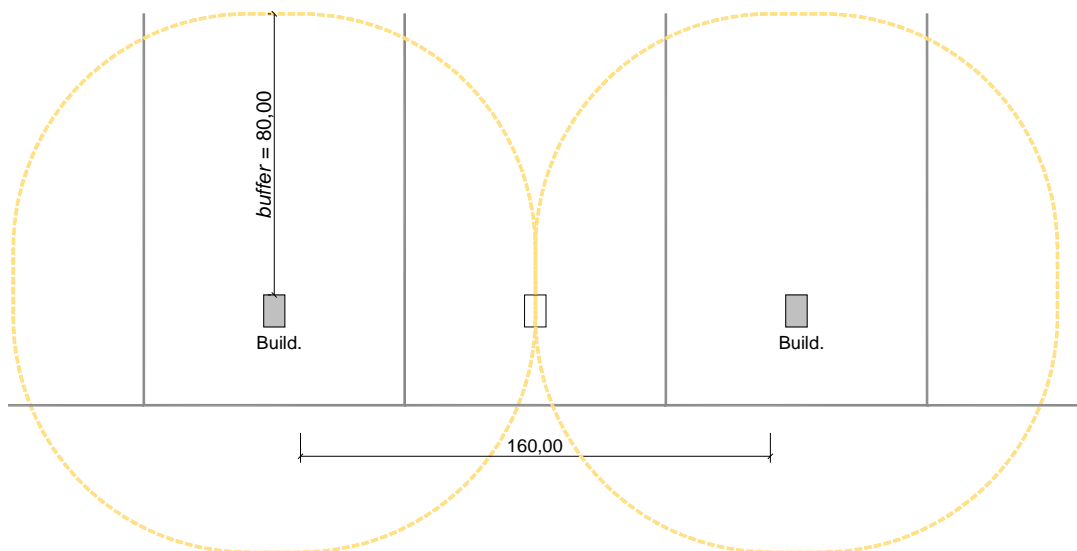


Figure 3 – Buffer radius in Rarefied Ensembles

³ Idem

The road sections that surround buildings belonging to the ensemble or those essential to its internal connectivity are included in the initial ensemble area.

The road buffer consists of two strips, one on each side of the way's axis; its respective depths coincide with those of the buildings' buffers, in standard situations for each ensemble typology, as shown in Figure 4.

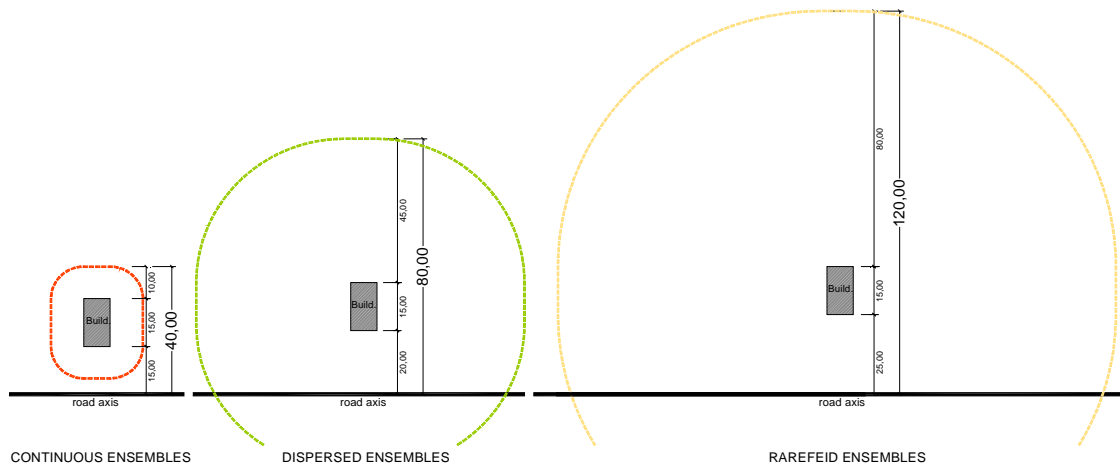


Figure 4 – Road buffers in Continuous, Dispersed and Rarefied Ensembles

In relation to the majority of digital methods of building aggregation developed by others, this one is different in the following aspects:

- It considers three different types of buffers, allowing the identification of three distinct types of building ensembles; while other methods consider a single aggregation buffer.
- It considers a 10 meter buffer to identify Continuous Building Ensembles, which is a very small radius when compared with other methods (that usually use buffers of 50 meters).
- It includes the roads' influence area around buildings, considering that these sections correspond to an existing building capacity.
- It disregards the small unbuilt areas located inside the ensembles, assuming them as public spaces supplementary to built occupation.

The building ensembles that result from the application of this method can be studied in-depth, calculating parameters such as area, perimeter, quantity of building area, implantation area, among others, for each one of the ensembles.

With the aim of studying dispersed occupation, the results of applying the method to the case studies (Évora and Aveiro-Ílhavo) enabled, in the case of this research, to conclude that the presence of Continuous Ensembles is not always synonymous of concentrated occupation. For example, in Aveiro-Ílhavo most of the Continuous Ensembles located outside the city centre are linearly extended and occupy agro-forestry areas, corresponding to a specific type of dispersed occupation. At the same time, one can note the existence, in both cities, of very small Continuous

Ensembles, isolated or surrounded by Dispersed and Rarefied Ensembles that also contributes to urban dispersion.

4.2 Calculation of the Disaggregation Index of Continuous Building Ensembles

Having recognized the existence of Continuous Ensembles that, on the scale of the Extended City, correspond to a dispersed occupation, it became necessary to find ways to distinguish them. To do so, an indicator called Disaggregation Index of Continuous Building Ensembles (DI) was created; the index takes into consideration:

- The Ensemble's Area, assuming that the shorter an ensemble is, the bigger its disaggregation within the Extended City is.
- The Building Occupation (implantation or construction index of the buildings incorporated into an ensemble), assuming that the shorter the building occupation index is, the bigger the disaggregation of an ensemble is.
- The Ensemble's Shape, assuming that the bigger the relationship between perimeter and area (P/\sqrt{A}), the bigger the disaggregation of an ensemble is.

DI's mathematical formula is based on the articulation of three indicators related to each of the aforementioned aspects. The construction of these indicators assumes minimum and maximum benchmarks, namely:

- Area Indicator (AI) – an aggregate ensemble has an area of 100ha or more; and an ensemble with maximum disaggregation is the one that has an area of 1ha or less.
- Building Occupation Indicator (BI) – an aggregate ensemble has an implantation index of 0.5 or over; and an ensemble with maximum disaggregation is the one that has an implantation index of zero (abstract value).
- Shape Indicator (SI) – an ensemble reaches the minimum disaggregation when the relation P/\sqrt{A} is equal to 3.6 (figure corresponding to the shape of a circle); and an ensemble reaches the maximum disaggregation when P/\sqrt{A} is equal to 13.6 (given the difficulty of setting a referential, this value resulted from practical experiences).

The DI is the result of a long experimental work that included the construction of each indicator and their pondered sum.

The adopted Disaggregation Index of Continuous Building Ensembles is presented in Figure 5 and consists in an indicator sum (area + building occupation + shape), assuming, however, that the area (AI) is the most import characteristic of a disaggregate ensemble.

The division of the sum by three (and not by four) corresponds to the ambition, faced with practical cases, to set the DI value between zero and one (since the indicators never reach their maximum values at the same time).

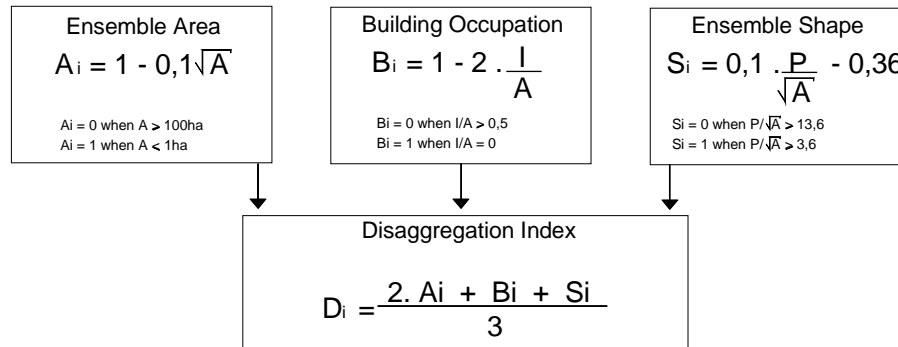


Figure 5 – Disaggregation Index of Continuous Building Ensembles

Two observations are worth making:

- The indicators that compose the DI, individually considered, can also provide important information about an ensemble.
- Theoretically, these indicators may be applied to Dispersed and Rarefied Ensembles; but to do so, they would have to be tested and adapted, probably assuming different mathematical expression.

4.3 Criterion for Identifying BLU of Dispersed Occupation.

Through the methods presented so far in this paper, one can identify within a BLU:

- Continuous Building Ensembles more or less aggregated;
- Dispersed Building Ensembles;
- Rarefied Building Ensembles;
- Unbuilt Areas.

Considering the area of each ensemble in a BLU it is possible to create an indicator (called "Degree of Urbanisation") in which the area of Continuous Ensembles with a high aggregation index gives a maximum contribution to the degree of urbanization; and Unbuilt Areas are considered null.

However, alone, this indicator can interpret distinct situations as being similar; for example, a BLU composed by Continuous Ensembles surrounded by Unbuilt Areas can obtain the same Urbanization Degree than a BLU where Dispersed Ensembles are predominant.

Knowing that this indicator is not sufficient to identify BLUs of dispersed occupation, one considers that this type of BLU should ensure, in addition to a medium/low Urbanization Degree, a significant presence of Dispersed Ensembles and/or Continuous Ensembles with high Disaggregation Index as well, to prevent confusion with situations mostly concentrated, rarefied or unbuilt.

After conducting several experiments applied to the case studies, the adopted criteria are:

- A BLU of dispersed occupation is the one that has an Urbanization Degree of 0,07 or more and equal or inferior to 0,35, according to the mathematical formula presented in Figure 6.
- Concomitantly, a BLU of dispersed occupation must have, at least, one of these conditions:
 - a) The Dispersed Ensemble's area within the BLU should be superior to the Continuous Ensembles area.
 - b) The Average of the Disaggregation Index of Continuous Ensembles integrated in a BLU should be higher than 0,7.

$$UD = \frac{[Cx(1-di/2)] + (Dx0,4) + (Rx0,2)}{LBU \text{ Area}}$$

C - Continuous Building Ensembles
 di - Continuous Building Ensembles Disaggregation Index
 D - Dispersed Building Ensembles
 R - Rarefied Building Ensembles

Figure 6 – “Urbanization Degree” - Mathematical Formula

The "Urbanization Degree" of a BLU, presented in Figure 6, considers the three types of building ensembles which may exist within a BLU in the following way:

- The Continuous Ensembles' area contributes totally to the Urbanization Degree when their Disaggregation Index is zero. When this Index approximates the value 1, the Continuous Ensembles area contributes only with 50%. Thus, it is assumed that the lower the Disaggregation Index of Continuous Ensembles, the greater the Urbanization Degree is.
- The Dispersed Ensembles' area contributes with 40% to the Urbanization Degree of a BLU (therefore, less than the area of the more disaggregated Continuous Ensembles).
- The Rarefied Ensembles don't characterize an urbanised BLU, so they are the ones who influence this indicator less. Specifically, the Rarefied Ensembles' area should contribute only 20% to the Urbanization Degree, which implies, for example, that a BLU occupied by Rarefied Ensembles and Unbuilt Areas will obtain a UD close to the minimum values.

5. Application of the Methodology to the Case Studies

5.1 - The Research Project's case studies are two quite distinct cities. Évora is generally regarded as a concentrated city; while Aveiro-Ílhavo is usually associated to a more dispersed or diffused territory.

The “Identification of Building Ensembles by Digital Method” in this two Extended Cities confirmed the enormous difference between both; however, it highlighted a reality that doesn't exactly match this dichotomy, in fact the Dispersed and Rarefied Ensembles occur mainly in the surroundings of Évora.

The results of the method's application, presented in Figure 7, show, as one would expect, that Évora is characterised by the presence of a large Continuous Ensemble that aggregates all the central urban area (historic centre and closest neighbourhoods).

Surrounding this central area, there are many small and isolated Continuous Ensembles, together with large Dispersed and Rarefied ones.

In Aveiro-Ílhavo the situation is rather different. There is a concentrated and Compact Continuous Ensemble (Aveiro city center, in the strict sense) and another ensemble, concentrated but not compact (which corresponds to Gafanha da Nazaré). In the north (Cacia area) the predominance of Dispersed Ensembles is evident. The rest of the Extended City is dominated by the presence of Continuous Ensembles organized linearly, that in distant areas from the Centre are surrounded by Dispersed Ensembles and by Unbuilt Areas.

In Aveiro-Ílhavo one should also note the nonexistence of Rarefied Ensembles, even in the most remote areas of the Extended City.

5.2 – Facing the need to differentiate types of occupation, namely through the analysis of their Continuous Ensembles, the already described Disaggregation Index (DI) was applied. In this particular research, the Continuous Ensembles were clipped according to the existence of strong physical barriers (water lines, highways...). This prior task was done before the DI application and through "Empirical Knowledge on Cartography".

Results obtained, presented in Figure 8, demonstrate the effectiveness of the Disaggregation Index to differentiate Continuous Ensembles. Particularly, the results show:

- A single maximum aggregation situation (near zero value) that corresponds to Évora's historical centre. In Aveiro-Ílhavo no ensemble has a disaggregation index similar to this.
- At the next level (disaggregation between 0.2 and 0.5, are the ensembles bigger than 40ha, that can be associated to a traditional concentrated occupation; in particular neighbourhoods surrounding Évora's City Walls (Horta das Figueiras, Malagueira, Vista Alegre and Sra. da Saúde) and, in Aveiro-Ílhavo, the central nucleations of the two municipalities included in the Extended City, in addition to other areas (Barra, Costa Nova, Esgueira and Gafanha da Nazaré).
- Ensembles with a Disaggregation Index between 0.5 and 0.7 that (by their characteristics and their surroundings) seem to integrate a transition between concentrated and dispersed areas.
- Ensembles with high disaggregation (above 0.7) that correspond generally to small building ensembles, in some cases with irregular shapes and extended perimeters, surrounded by Dispersed or Rarefied Ensembles, or even Unbuilt Areas; not fortuitously located in the most remote and isolated areas of the Extended City.

5.3 – The identification of BLUs of dispersed occupation in Évora and Aveiro-Ílhavo, presented in Figure 9, proves the effectiveness of this methodology. Some cases, which in an empirical analysis were seen as dubious, are also positioned near the established mathematical limits. Therefore, the "Urbanization Degree" application should be tested in these "border cases" to verify the established

limits, defining, if necessary, intermediate classes between dispersed, concentrated and unbuilt BLUs.

In particular, the application of the "Urbanization Degree" revealed, in the Évora case, that the BLUs of dispersed occupation are located, as one would expect, throughout the surroundings of the city center, confirming the administratively established urban perimeter. Mostly, these units integrate Dispersed Ensembles, sometimes combined with small and disaggregated Continuous Ensembles.

One should also note the existence of two BLUs of dispersed occupation (Estrada de Lisboa/Sto. Antonico and Boa Morte/Garraia) with a very low Urbanization Degree (near 0.07). Therefore, these two cases must be analysed in a more precise and rigorous way.

The three BLUs that constitute the historical centre (Sto. Antão, S. Mamede and Sé e S. Pedro) achieve the highest degree of urbanisation, between 0.85 and 0.9. In fact, these BLUs do not get the maximum Urbanization Degree only because they integrate unbuilt areas along the City Wall.

In Évora there is an unbuilt BLU (with a degree of urbanisation under 0.07), which corresponds to the "Verde Monumental", a heritage area that integrates some convents and ensures ecological connections with the city surroundings.

In Aveiro-Ílhavo, the Urbanization Degree does not vary as widely as in Évora.

Specifically, the BLUs with an UD over 0.5 correspond to Aveiro center, Gafanha da Nazaré and Barra. In the next level one can find the BLUs that compose the centre of Ílhavo, Aradas and the expansions of Aveiro's central area to the south, crossing the National Road (EN109).

BLUs of dispersed occupation are mainly located in distant surroundings of Aveiro and Ílhavo centres and in the north part of the Extended City.

There were several situations very close to the established limits to distinguish the dispersed occupation (Cacia, S. Bernardo or Gafanha do Carmo are some of the BLUs whose Urbanisation Degree is near the mathematical limit between the concentrated and dispersed occupation). However, in general, the results of the application of this indicator, assessed from an empirical point of view, seem very reasonable.

Identifying BLUs of dispersed occupation through the presented methodology is therefore a starting point for more detailed analysis to verify the results obtained. The following Figures show the outputs of the three aforementioned phases.

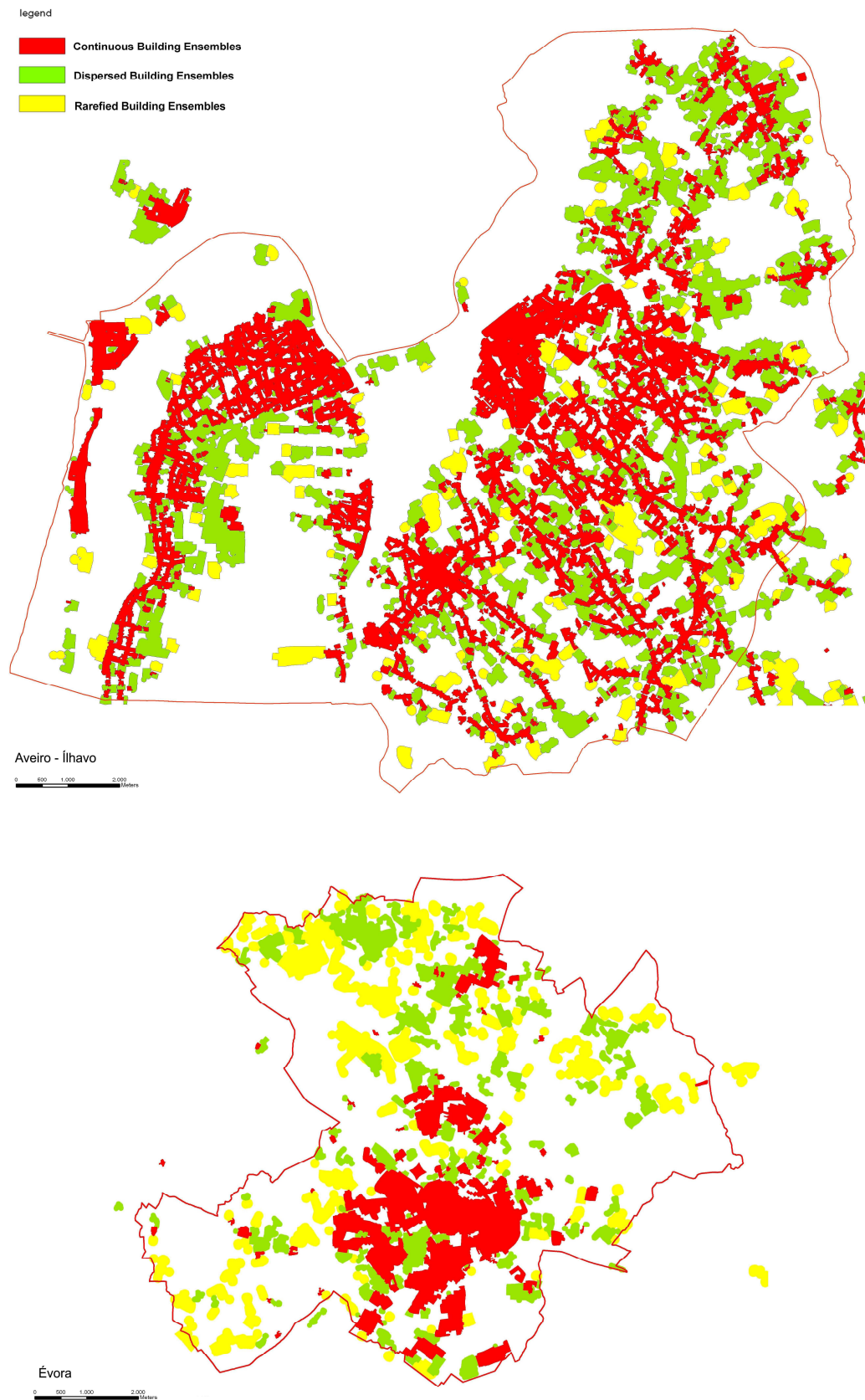


Figure 7 – “Identification of Building Ensembles by Digital Method” - Overview of the application results to Aveiro-Ílhavo and Évora

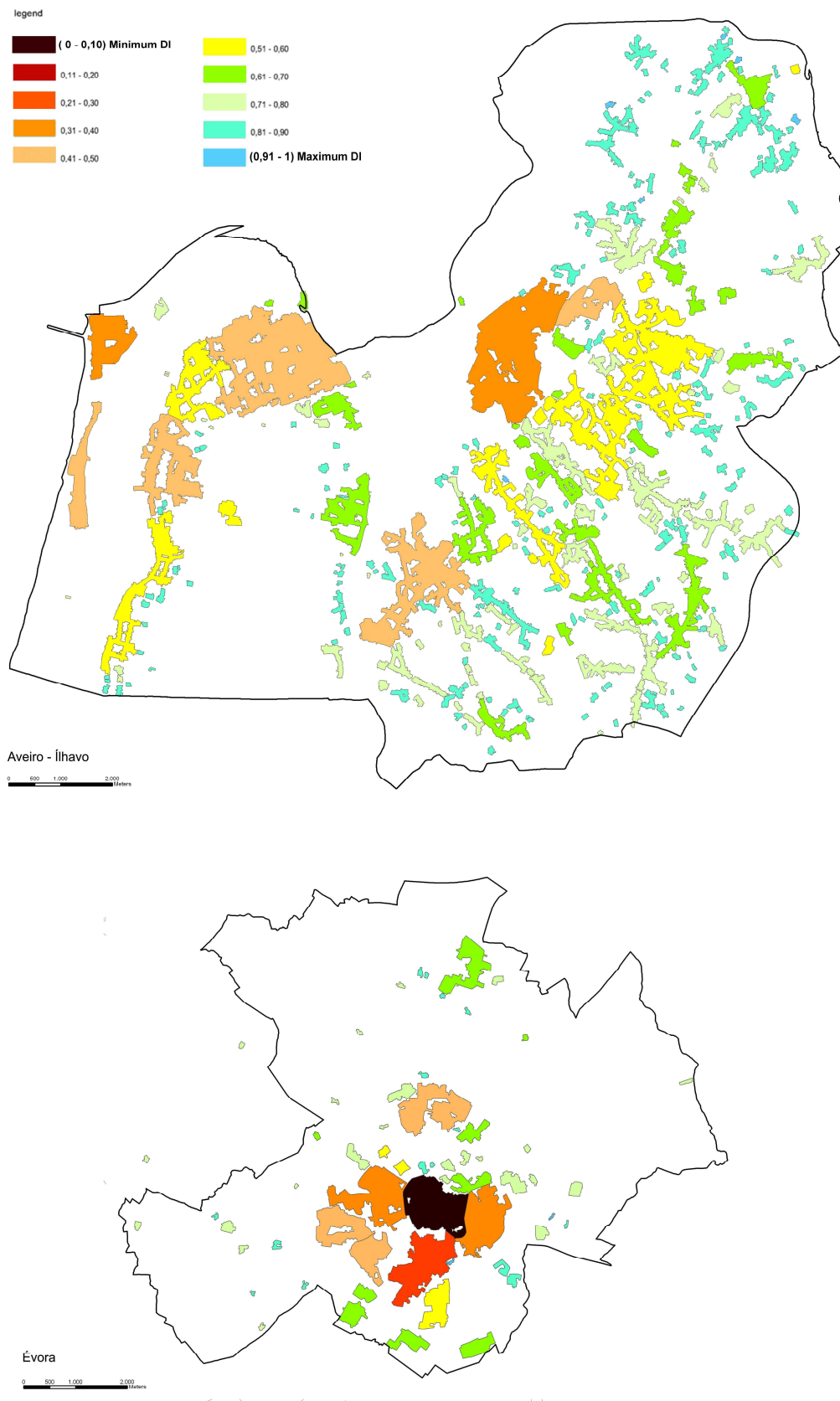


Figure 8 – “Disaggregation Index of Continuous Building Ensembles” - Overview of the application results to Aveiro-Ílhavo and Évora

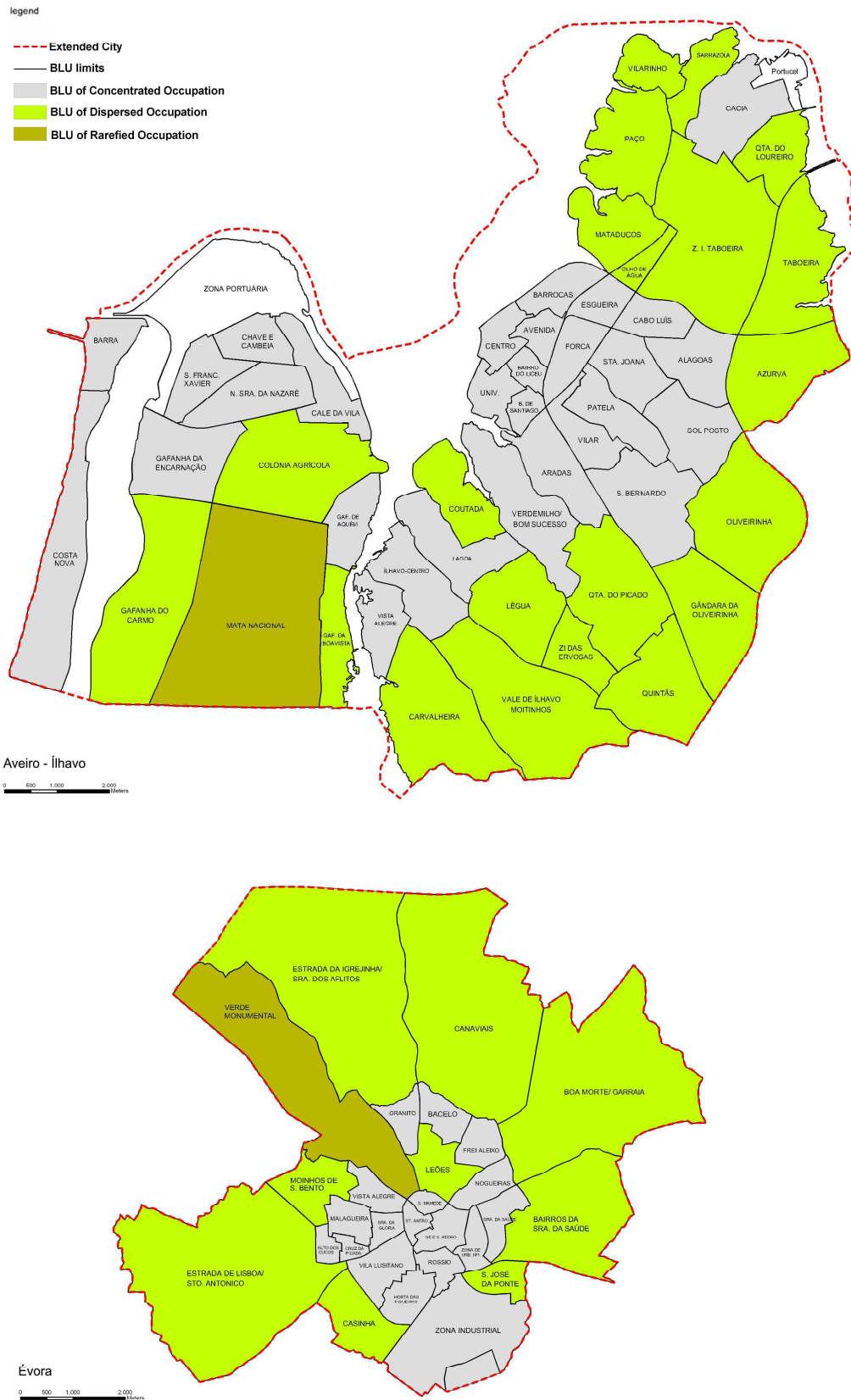


Figure 9 – “Urbanization Degree” - Overview of the application results to Aveiro-Ílhavo and Évora

6. Concluding remarks

The presented methodology is effective for identifying BLUs of dispersed occupation and, consequently, BLUs of concentrated occupation and unbuilt BLUs.

This methodology can be used on a national scale, assuming, however, the need of a prior identification/delimitation of BLUs (as described in this paper).

One should note that the delimitation of a BLU of dispersed occupation gives way to a new challenge, to characterise and typify it, finding specific dispersion morpho-typologies.

This will be, therefore, the next step of the current Research Project.

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