Delineation of the European Urban Areas as used in ESPON 2013

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TABLE OF CONTENTS

1 Introduction

1.1 Preamble

The *European Observation Network for Territorial Development and Cohesion* (ESPON) is a program part-financed at the level of 75 % by the European Regional Development Fund under Objective 3 for European Territorial Cooperation. The rest is financed by 31 countries participating, 27 EU Member States and Iceland, Lichtenstein, Norway and Switzerland.

The mission of the ESPON 2013 Program is to:

"Support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory by (1) providing comparable information, evidence, analyses and scenarios on territorial dynamics and (2) revealing territorial capital and potentials for development of regions and larger territories contributing to European competitiveness, territorial cooperation and a sustainable and balanced development".

ESPON uses an open competitive process for the selection of projects.
More information is available at http://www.espon.eu/ .

Before the current program a first ESPON program was run from 2001 to 2006.

1.2 A brief context description

While interest in cities is growing again in Europe (project FOCI), ESPON projects had to face a lack of reference, definition and delimitation of the urban areas. Many of them had to base their work on previous list of cities themselves generally coming from heterogeneous national or local sources. Yet one of the most important elements of a serious study work is to settle the reflexions on solid statistics, which usually implies comparable and homogeneous data. What is the definition of a city by the way ? Is their a single agreed definition throughout the 27 European countries ? Certainly not, the delimitations and the definitions of the cities where usually based on local administrative delimitations, themselves depending on local or national policies. A city can be a single municipality while others are made of the aggregation of many small municipalities, it can even be smaller than the territory of its own municipality.

A first attempt was made to characterize the European cities by the project ESPON 1.1.1 from the 2006 program which established a list of about 2000 functional urban areas (FUA) still based on heterogeneous local delimitations but with a definition based on the concept of FUA which substitutes for the hazy concept of city and which merges the core cities and their hinterland. This list was then improved by ESPON 1.4.3. which provided a steadier methodology and definitions, which were further developed in the framework of the project ESPON Database 2013 and which will be presented below.

This paper shows what has been done to improve the above described situation.

2 Definitions

As mentioned above the concept of city is not satisfying for scientific works and we are therefore using two complementary concepts to define the urban areas, the Functional Urban Area (FUA) and the Morphological Urban Area (MUA).

The FUAs are defined as the labour basins of the MUAs which are defined as densely populated areas. The FUAs are based on commuting data and the MUAs are based on population densities, all at the level of the LAU2s.

The LAU2 is the smallest statistical and territorial unit defined at the European scale and it usually refers to the municipalities, or to the wards in the UK and Ireland. There are about 120 000 LAU2s in the 31 European countries covered by ESPON.

A FUA is a set of LAU2s, where at least 10 % of the active resident population commute and work in the neighboring MUA.

A MUA is a set of LAU2s with a population density higher than 650 inhabitants/km2, and this regardless the existing administrative delimitations. They were identified by ESPON 1.4.3. which put a minimum size of 20 000 inhabitants.

Further details and methodology follow below.

3 General Methodology

After having identified the MUAs (see definition above) we use the 2001 commuters data (from LAU2 to LAU2) from the Eurostat SIRE database, based on the census data. We totalize the commuters from any LAU2 to any set of LAU2s constituting a MUA, select all the LAU2-MUA combination with a commuting rate equal or higher than 10 %, and finally keep those with the highest rate. We then have a first draft of the FUAs (see figure 1), which is then finalized by incorporating the 'FUA' of the MUAs which are themselves into other's FUA with these, and by filling the holes and removing the LAU2s that are separated from the main part of its FUA (see figure 2).

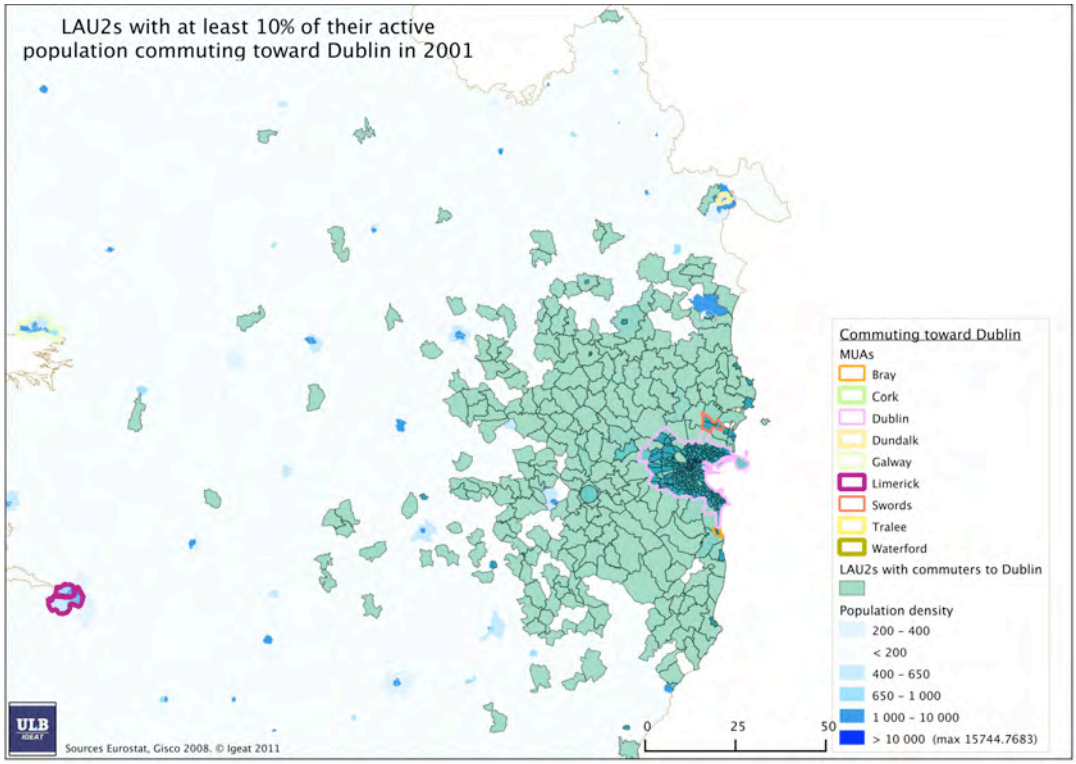

Figure 1 : Selection of the LAU2s with a commuting rate toward Dublin, Bray and Swords >= 10% of the active population.

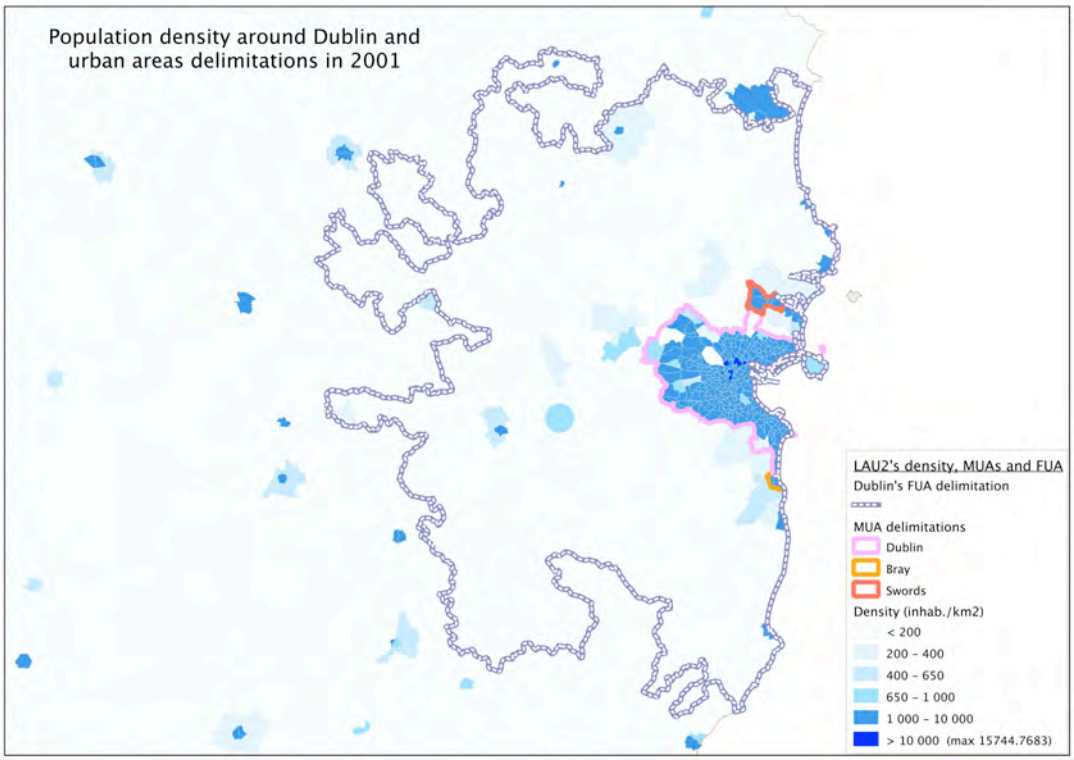

Figure 2 : Delimitation of Dublin's FUA after the cleaning and consolidation process

Theoretically each MUA has a FUA, each FUA has a MUA near its center. But reality can be less straightforward and we find a good number of slightly more or much more complex cases.

First a MUA can be a secondary MUA in another's FUA, like Bray and Swords near Dublin. This happens when the extent of a FUA takes in a small MUA or when the population of the MUA has a commuting rate higher than the chosen threshold to another MUA. Most cases

are obvious but a few are not, since the commuting flows are measured at the level of the LAU2 and a MUA can have several of these: one can therefore see that one part of a MUA is commuting toward another one while the rest of it is not. Those cases were solved by first checking if the secondary MUA was landlocked into the rest of the «main» FUA which would lead to consider the secondary MUA as actually part of the main FUA, second considering the literature and the commonly accepted facts. We don't see any major rule that could lead us to elaborate a methodology to classify these rare cases.
Second a FUA can have two «twin» MUAs (or even more) when the commuting flows from one to another are crossing each other (they are usually touching each other) and the LAU2s around them send commuters on a relatively high and equivalent level to the both of them. An example of this is Douai and Lens, or Béthune and Bruay-la-Buissière near Lille in France, or Locarno-Bellinzona in Switzerland.

We must here mention an unfortunate limitation of the database: except for the French residents there are no transnational commuters data provided, which is a non-sense for a European perspective. We have trans-border FUAs (see project ESPON Metroborder) around the French frontier but only for the French residents working in another country, not for the opposite although we know that there are commuters from Germany, Belgium or Italy working in French FUAs (Strasbourg, Nice, ...). In the ESPON Metroborder project this weakness was bypassed by assuming that the FUAs on both sides of the border are forming one entity, considering the results of ESPON 1.4.3 themselves based on the literature.
Besides all the data limitations mentioned above we have encountered here and there difficulties in some areas like Scotland or former East-Germany, due to too big incoherencies between the different database, and this because of radical reshaping of the LAU2s during the last ten years.

The poly-FUAs : ESPON 1.4.3 provided also a higher urbanization level called the "Poly-centric Metropolitan areas" (poly-FUAs), which where made of groups of FUAs of the same neighborhood. These were based on a distance criteria :

" In some cases, we have to consider the situation where different metropolises, with the centre of their cores distant from less than 60 km, are contiguous, or are only separated one from the other by other cities, with their own labour pool, or yet are bordered by other large, medium or small cities, distant from less than 30 km, also with their own individualized manpower basin. In these cases, we have identified conurbations of POLY-CENTRIC METROPOLITAN AREAS (poly-FUAs). We have also considered as forming a POLY-CENTRIC METROPOLITAN AREA two large cities distant one from the other less than 30 km and reaching together the level of 500,000 inhabitants. For the rest, we don't have considered as being a polycentric metropolitan area two or more large, medium or small cities with contiguous manpower basins, even if they reach together the threshold of 500,000 inhabitants.
So to form a poly-FUA structure we must have either :

- metropolises (> 500 000 inh.) with their centres less than 60 km apart, and labour basins touching each other
- 2 large cities (> 250 000 inh.) with their centers less than 30 km apart, and labour basins touching each other
- 1 metropolis and 1 large or medium city (> 100 000 inh.) with their centers less than 30 km apart, and labour basins touching each other

metropolises with their centers less than 60 km apart, labour basins separated only by the labour basin of a smaller FUA touching the both of them »

These poly-FUAs give in many situations a better depicting of the urban situation and can be used instead of the FUAs.

4 General structure of the FUAs

The FUAs may be elements of the higher structures named poly-FUA (see above General Methodology) but this "super-structure" is also related to their internal structure which reflects their functional nature.
The following diagrams summarize for instance four different situations in a high-density area, implying quite different realities as regards functions, economy, management of mobility and territorial planning, but which could be confused if the analysis did not sufficiently explicit the definitions used. Even if these four patterns are purely theoretical, they are respectively globally based on the situation of an old coal basin for the first one (type1), the Ile-de-France Region for the second (type 2, with new cities functionally not much independent from Paris), the Belgian central metropolitan area (type 3) and the big London metropolitan area (type 4), where secondary centers of the external fringe of the FUA have more decisional autonomy and are moreover doubled by a belt of important or specialized cities (cf. Cambridge, Oxford) inside the FUA.

These should be understood as milestones of possible urbanization situations or evolution paths, rather than an exhaustive typology. There can be numerous intermediary states between any of these types and it would be vain to classify all the FUAs.

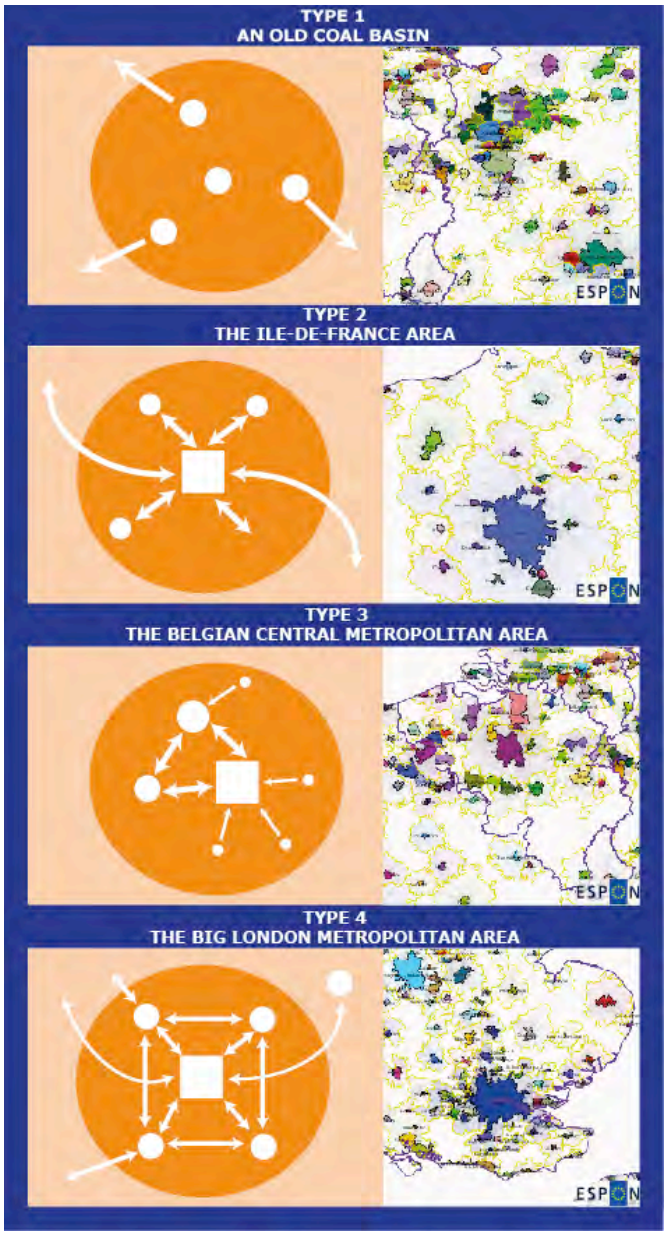

Figure 3 - Four different FUA types illustrated by the Ostrava region (1), the Ile-de-France Region (2), the Belgian central metropolitan region (3) and the London region (4).

5 Known issues

Besides the unavoidable incoherencies between the different databases that had to be joined together to create this database, there are specific problems we could not bypass :

The active population in Germany is wrong in at least half of the municipalities! This problem is somehow minimized because, first, when a LAU2 has a commuting flow toward more than one MUA (for example in Rhein-Ruhr region) what matters is the highest number of commuters whatever the active population is, considering that this happens in areas with a strong peri-urbanization and without free space between the FUAs. Second, the process of building the FUAs eliminates the LAU2s that are not among the others for a same FUA and homogenizes the area by making a ring around the LAU2s of the FUA. Third, the LAU2s where the commuters' number is higher than the active population are ignored. Fourth, the overestimation of the FUAs (there can't be underestimation) happens by including probably small municipalities at the fringes of the areas. But still, errors remain.
Same remark for Slovakia, but apparently with a smaller proportion of erroneous data.

In former East-Germany, especially in the Sachsen-Anhalt, there were many municipalities merging after the reunification. This leads to many incoherencies between SIRE and EUROGEOGRAPHICS, i.e. we have commuting numbers for LAU2s that don't exist anymore and we didn't spend time on trying to redistribute the commuters in the new LAU2s. This might perhaps be done but not in this project.

In the area between Glasgow and Edinburg we have the same problem than in Sachsen-Anhalt (see above).

In Portugal the commuting numbers in the core city areas are provided at the LAU1 level but this is not a problem because in every case we have a ring of municipalities (LAU2s) around this LAU1 that are included in the FUA. So any central municipality that would be out of the MUA but into that LAU1 area would be included in the FUA anyway.
Technically speaking, instead of making a ring surrounding the FUAs with the Postgis ST_ExteriorRing function we could explore the possibility to use the ST_convexHull function that minimizes the quirks in the shape of some FUAs, but it could lead also to exaggerate their size.

The original definition of the FUA is based on a proportion of the 'occupied' active population but all we have is the 'economically' active population, which includes the unemployed population. So this distorts the commuting rate by overestimating it by a maximum factor of 1.1, considering a 10 % unemployment. Besides the 10% value is not mandatory, it can be replaced by values between 10 and 15%.

6 Producing indicators

In collaboration with the project ESPON METROBORDER we have produced a list of indicators for all the FUAs. Since the FUAs are defined at the LAU2 level any information available at that same level can be used to characterize the FUAs, otherwise it is sometimes possible to downscale the NUTS3 values, as explained below.

Indicator	*Year**	*Source*	*Unit*
Population	2001	LAU2, EUROSTAT	inhab.
	2006	LAU2, EUROSTAT	inhab.
Population variation	2001 - 2006	LAU2, EUROSTAT	%
FUAs Areas	2008	EUROGEOGRAPHICS	km^2
MUAs Areas	2008	EUROGEOGRAPHICS	km^2
Compactness	synthetic indicator		%
GDP	2006	NUTS-3, EUROSTAT	Euro
GDP/inhab.***	synthetic indicator		Euro/ inhab.
Economical structure	2006	NUTS-3, EUROSTAT (6 big NACE sectors)	%
Unemployment**	2006	NUTS-3, EUROSTAT	%

Table 1 - list of the indicators available in the ESPON database

For some indicators some data are coming from different years. See Final ESPON Database 2013 report for the missing data issues.

** : Unemployment values should be used «with caution» !

6.1 The downscaling methodology

For the population and area indicators we have simply computed the FUA values from the LAU2 values. The compactness is the % of the population of the FUA actually living in the main MUA.

The economical indicators are computed by using the NUTS-3 values on which we apply a population ratio between the NUTS-3 and the intersection of the FUA and the NUTS-3. This is possible because we now have the LAU2 composition of the FUAs which make the link between those and the FUAs possible. The methodology is therefore useful to assess the urban areas throughout Europe (except in the countries where no commuting data are available – see above).

By way of illustration let's look at the Basel case. Basel is a complex case, it is a transborder metropolitan urban region with 5 MUAs and involving 7 NUTS-3.

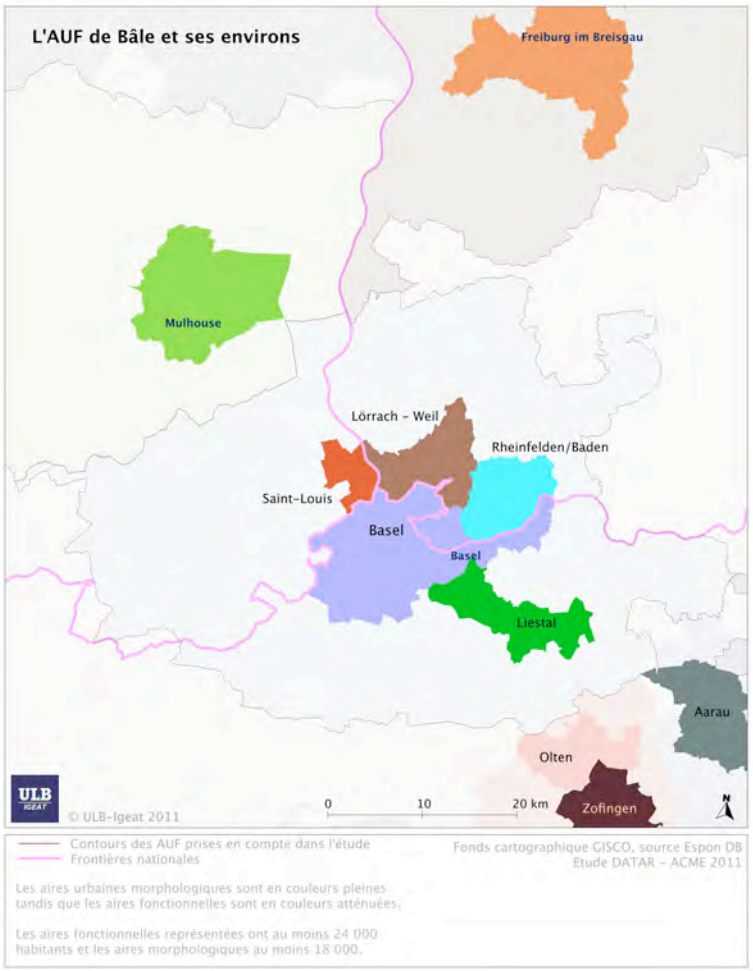

Figure 4 - The FUA of Basel in its region
The MUAs are shown in plain colors, the FUAs are in light colors delimited by a yellow line, the NUTS-3 are represented by the pink lines, and finally the gray shade shows the intensity of the commuting (the more grayish the higher the number of commuters is). The national borders are violet.

nuts3_06	pop_nuts3	pop_fua	FUA pop in nuts3	coef
CH023	248	827,3	31,7	13
CH025	69	827,3	0,1	0
CH031	185	827,3	188,1	100
CH032	266	827,3	258,7	100
CH033	572	827,3	52,6	10
DE139	221	827,3	215,6	100
FR422	738	827,3	91,4	13

Table 2 - correspondence between the nuts-3 and the FUA of Basel.

We see here (table 3) that the FUA of Basel extends over 7 nuts-3 in 3 countries, and we see in the table that this corresponds to different population values according to the nuts-3. We have computed for each of them a coefficient ('coef') in % giving what part of the nuts-3 indicator (for instance the GDP) we take from every nuts-3, the total giving the indicator value (for instance the GDP) of the FUA. In the particular case of the GDP or added values we assume that the productivity is equal everywhere inside each NUTS-3, which is not a bold assumption. For every other indicator we use the same methodology as long as we can make the same kind of uniformity hypothesis.

6.2 Displaying FUAs database on maps, one example

The FUAs database allows displaying innovative results for the all ESPON Area. For instance, the map of GDP per capita in 2006 (figure 5) show strong contrasts between FUAs, and give an additional picture of the situation as compared to classical maps produced at NUTS3 level. However, it is important to have a look to keep in mind that some of the values are estimated and such results must be interpreted carefully.

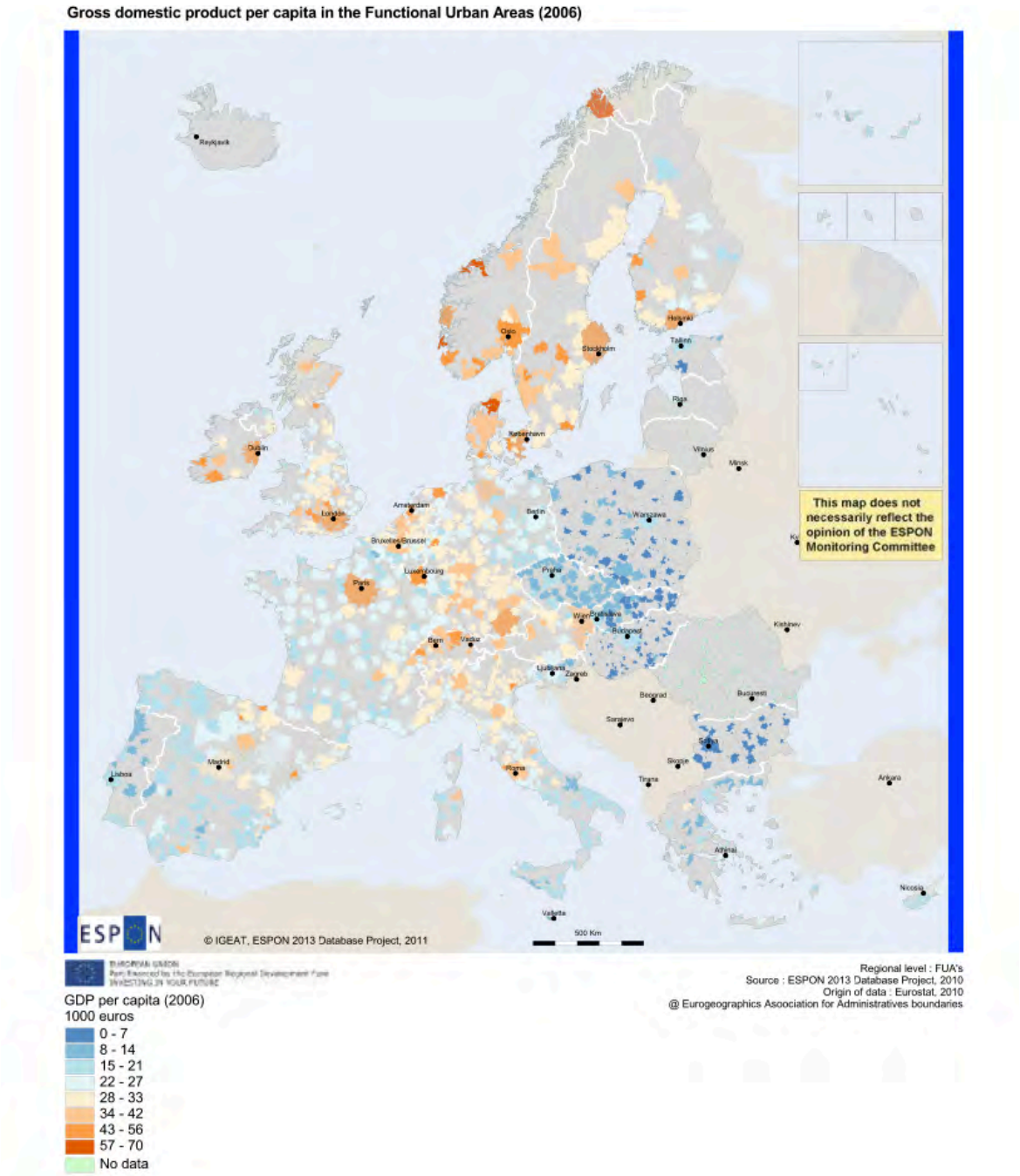

Figure 5 – Gross Domestic Product per capita 2006 in the FUA delineation

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