



Definition of Functional Urban Areas (FUA) for the OECD metropolitan database

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Background

The OECD Territorial Development Policy Committee and its Working Parties have been increasingly called to provide a common base to understand urban areas so to be able to assess national urban policies in OECD countries. A common definition of metropolitan areas increases international comparability of the economic, social and environmental performances of metropolitan areas, adding to what can be learned from the countries' definition already in use.

The issue of comparability of metropolitan areas is directly tied to the choice of the unit of analysis, that is to say whether these are defined on the basis of administrative boundaries, continuity of the built-up area or functional measures such as commuting rates or other parameters, and to the size of components to be aggregated. Moreover, the accurateness of the definition has to be pondered with a) the availability of socio-economic indicators in a certain metropolitan area and b) the degree of international comparability in the choice of the different parameters.

Against this background, the OECD in collaboration with the EU (Eurostat and EC-DG Regio) has developed a harmonised definition of urban areas as “functional economic units”, thus overcoming previous limitations linked to administrative.¹ This definition chooses as building blocks for the functional urban areas smallest administrative units for which national commuting data are available (LAU2 in Eurostat terminology² and the smallest administrative units for which national commuting data are available in non-European countries).

The methodology used to identify the functional urban areas was approved by the OECD Working Party on Territorial Indicators in 2011. It is applied to 29 OECD countries and 1 179 urban areas of different size are identified.

The OECD metropolitan database includes a set of annual variables related to 275 OECD functional urban areas with 500 000 population and more. It is publicly available at <http://measuringurban.oecd.org/>

Methodology to delimitate OECD Functional urban areas

The definition of urban areas in OECD countries uses population density to identify urban cores and travel-to-work flows to identify the hinterlands whose labour market is highly integrated with the cores. The methodology consists of three main steps:

STEP 1. Identification of core municipalities through gridded population data:

In the first step of the procedure, the gridded population data are used to define urbanised areas or ‘urban high-density clusters’ over the national territory, ignoring administrative borders since urban cores are defined through gridded population data. The population grid data (1 km²) for European countries comes from the Corine Land Cover dataset, produced by the Joint Research Centre for the European Environmental Agency (EEA). For all the non-European countries, gridded population data comes from the Landscan project developed by Oak Ridge National Laboratory.

1 . For details OECD (2012) Redefining “urban”: A new way to measure metropolitan areas, OECD, Paris

2 . The only exception is Portugal, for which commuting data are available only for LAU1 regions.

An urban core consists of a high-density cluster of contiguous grid cells of 1 km² with a density of at least 1,500 inhabitants per km² and the filled gaps³. A lower threshold of 1,000 people for km² is applied to Canada and the United States, where several metropolitan areas develop in a less compact manner. Small clusters (hosting less than 50,000 people in Europe, US, Chile and Canada, 100,000 people in Japan, Korea and in Mexico) are dropped.

A municipality is defined as being part of a urban core if at least 50% of the population of the municipality lives within the urban cluster.

STEP 2. Connecting non-contiguous cores belonging to the same functional urban area

The urban cores defined in STEP 1 are found to be good approximations of contiguous, highly built-up surfaces. However, not all the urban areas in the OECD are characterised by contiguity in built-up development. Many of them are developing in a polycentric way, hosting high densely inhabited cores that are physically separated, but economically integrated. An important innovation of this methodology identifies which urban areas have such a polycentric structure. This is done by simply looking at the relationships among the urban cores, using the information contained in the commuting data. Two urban cores are considered integrated, and thus part of the same polycentric metropolitan area, if more than 15% of the residence population of any of the cores commutes to work in the other core. This step allows a correction for possible discontinuities in population density within the same urban centre (e.g. natural surfaces larger than 1 km² splitting one city in two parts).

STEP 3. The identification of the urban hinterlands

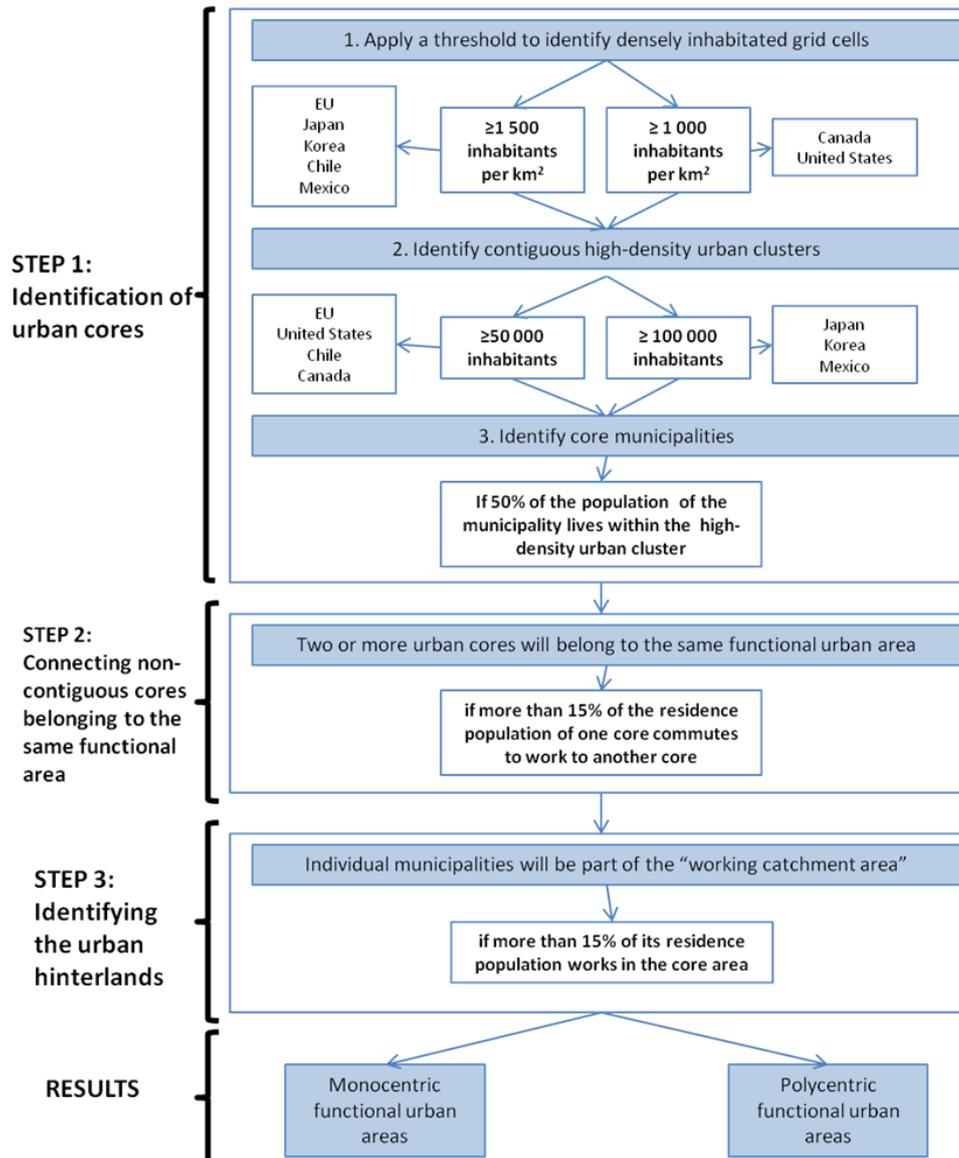
Once the densely inhabited municipalities are aggregated to form urban cores, and polycentric metro areas with tied cores are identified, the final step of the methodology consists in delineating the hinterland of the metro areas. The ‘hinterland’ can be defined as the “worker catchment area” of the urban labour market, outside the densely inhabited core. The size of the hinterland, relative to the size of the core, gives clear indications of the influence of cities over surrounding areas.

Urban hinterlands are defined as all municipalities with at least 15% of their employed residents working in a certain urban core. Municipalities surrounded by a single functional urban area are included and non-contiguous municipalities are dropped.

Data on commuting referred to circa 2000 year and are being updated on the base of the most recent data from 2011 Censuses.

3 . Gaps in the high-density cluster are filled using the majority rule iteratively. The majority rule means that if at least five out of the eight cells surrounding a cell belong to the same high-density cluster the cell will be added. This is repeated until no more cells are added.

Figure 1. Procedure to define Functional urban areas in OECD countries



This methodology makes possible to compare functional urban areas of similar size across countries. A classification of functional urban areas into four types according to population size is proposed:

- **Small urban areas**, with a population below 200 000 people;
- **Medium-sized urban areas**, with a population between 200 000 and 500 000;
- **Metropolitan areas**, with a population between 500 000 and 1.5 million;
- **Large metropolitan areas**, with a population of 1.5 million or more.

Methodological exceptions

The validation work carried out with national experts has brought some adjustments to specific functional urban areas. These adjustments are described in the Annex of the publication “Redefining urban: a new way to measure metropolitan areas” (OECD 2012), available online <http://www.oecd.org/gov/functionalurbanareasbycountry.htm>. In the case of United States, the US Census Bureau and the US Department of Commerce suggested adjusting the urban areas derived by the OECD methodology according to the boundaries of counties. Therefore the definition of urban areas in the US already takes into account the following modification:

- **STEP 1:** identify the counties that overlap with the OECD functional urban areas defined by Census tracts.
- **STEP 2:** compute the percentage of population in a functional urban area contained in a county.
- **STEP 3:** select all counties with a percentage above 50% in Step 2.
- **STEP 4:** drop non-contiguous counties.

OECD Metropolitan database

The OECD metropolitan database includes a set of economic, demographic and environmental variables on the 275 metro areas with a population of 500 000 or more over 29 OECD countries. The available variables in September 2013.

| Indicator | Description |
|------------------------------|---|
| <i>Population</i> | Total population within metropolitan areas |
| <i>Population density</i> | Ratio between total population and surface area within metropolitan areas |
| <i>Population growth</i> | Annual average population growth rate. |
| <i>GDP</i> | Gross domestic product measure the sum of the gross values added of all resident institutional units engaged in production. GDP are expressed in Millions of USD PPP's |
| <i>GDP per capita</i> | Ratio between GDP and total population |
| <i>GDP growth</i> | Annual average GDP growth rate. |
| <i>GDP per capita growth</i> | Annual average GDP per capita growth rate |
| <i>Total surface</i> | Total land area |
| <i>Urbanised area</i> | Urban land is defined as artificial land with built-up area cover or urban use. It includes, for example, residential and non-residential buildings, major roads and retail-ways and also open urban areas like parks and sport facilities |
| <i>Urbanised area growth</i> | Annual average Urbanised area growth rate |
| <i>Green area per capita</i> | Green areas are defined as the land in metropolitan areas covered by vegetation, croplands, forests, shrub lands and grasslands |
| <i>Sprawl index</i> | The urban sprawl index measures the growth in built-up area over time adjusted for the growth in population. When the population changes, the index measures the increase in the built-up area over time relative to a benchmark where the built-up area would have increased in line with population |

| | |
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| | growth. The index is equal to zero when both population and the built-up area are stable over time. It is larger (smaller) than zero when the growth of the built-up area is greater (smaller) than the growth of population, i.e. the density of the metropolitan area has decreased (increased) |
| <i>CO₂ emissions per capita</i> | Ratio between emissions and total population |
| <i>Air pollution</i> | Population exposure to air pollution (PM2.5) |
| <i>Employment</i> | Total employment within metropolitan areas |
| <i>Employment growth</i> | Annual average employment growth rate. |
| <i>Unemployment</i> | Total unemployment within metropolitan areas |
| <i>Unemployment growth</i> | Annual average unemployment growth rate. |
| <i>Labour force</i> | Total labour force within metropolitan areas |
| <i>Labour force growth</i> | Annual average labour force growth rate. |
| <i>Employment rate</i> | Percentage of metropolitan employment over total labour force |
| <i>Unemployment rate</i> | Percentage of metropolitan unemployment over total labour force |
| <i>Total patents</i> | PCT patent applications – count |
| <i>Patent intensity</i> | PCT patents applications per 10,000 inhabitants |
| <i>Administrative fragmentation</i> | Ratio between the number of local governments and the population in a metropolitan area |

The database is publicly available on the OECD Statistical Portal <http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES>. In addition it can be explored through interactive maps and histograms through the *Metropolitan eXplorer* <http://measuringurban.oecd.org/>. The Metropolitan eXplorer also offers a summary profile of each metropolitan area, including its **share over the national value**, as well as its **ranking** among the 275 metropolitan areas.

Data estimates and data sources

Socio-economic statistics at sub-national level comparable across countries are generally available for administrative regions (TL2 and TL3 regions of the OECD Regional database). While a set of indicators may in the future become available for the OECD functional urban areas, at present we suggest to derive estimates of the main economic indicators by adjusting existing regional data to the non-administrative boundaries.

Two broad typologies of methods have been used in the literature to adjust indicators at small-scale geography. The first one makes use of Geographic Information System (GIS) tools to disaggregate socio-economic data. GIS techniques are increasingly adopted in the literature, especially in the field of environmental indicators and other issues particularly attached to the geography of the territory, rather than to their functional or political organisation (Nordhaus et al., 2006; Milego and Ramos, 2006; Doll et al.,

2000)⁴. The second one, instead, scales down the values of interest by using correlated statistics available at different levels of geography from surveys or other statistical sources. Such a methodology, for example, is used by the UK Office for National Statistics to provide income estimates at ward level, downscaling the regional values through Census data such as household size, employment status, proportion of the ward population claiming social benefits, proportion of tax payers in each of the tax bands, etc. (Goldring et al., 2005).⁵ A similar method is used by the US Bureau of Economic Analysis to estimate the GDP for US Metropolitan Statistical Areas (Panek et al., 2007).⁶

The methodology applied uses a GIS-based methodology for the estimation of GDP, population, labour data at the functional urban level in OECD countries, since the amount of data required is relatively small and already available; in addition, this methodology is less dependent on the types of information available from surveys in different countries and therefore more easily applied consistently in different countries. The methodology is similar to that applied by Milego and Ramos (2006) to downscale socio-economic data from European administrative regions to a 1 km² regular grid level within the context of an Espon research (European Observation Network for Territorial Development).

The proposed methodology is composed by four main steps, each of which is to be carried out using GIS software.

- **STEP 1:** Taking the indicator at TL3 level and intersecting with the population grid (LandScan 2000).
- **STEP 2:** Attributing each 1 km² cell a value by weighing for population in each cell.
- **STEP 3:** Intersecting the layer of the indicator in each cell with the boundaries of metro areas. Cells that are not entirely included in one metropolitan area can be aggregated proportionally to the share of their area that falls within each metropolitan area (proportional calculation criteria) or, alternatively, by using a maximum area criterion.
- **STEP 4:** Sum of cells' indicator values belonging to each metro area.

The development of **environmental statistics** is a challenging task. While countries have started to invest more resources in monitoring of key environmental variables, data are rarely collected and analysed at the sub-national level. This is problematic given that national averages hide great geographical differences in contributions to national resource depletions and exposure to environmental risk.

The environmental indicators estimated at metropolitan level are based on two GIS-based methodologies⁷. The first set of indicators are based on remotely sensed source data at different levels of

4. Nordhaus, W., Q. Azam, D. Corderi, K. Hood, M.N. Victor, M. Mohammed, A. Milter, J. Weiss (2006), "The *G-Econ Database on Gridded Output*: methods and data", available online at geocon.yale.edu, Yale University, 75.

Milego, R. and M.J. Ramos (2006), *Espon 2013 Database*, Espon Publishing.

Doll, C.N.H., J.P. Muller and C.D. Elvidge (2000), "Night-time imagery as a tool for global mapping of socio-economic parameters and greenhouse gas emissions", *Ambio*, 29(3): 157-162

5. Goldring, S., J. Longhurst and M. Cruddas (2005), "Model-based estimates of income for wards in England and Wales, 2001/02", Technical Report, United Kingdom Office for National Statistics, London.

6. Panek, S.D., F.T. Baumgardner and M.J. McCormick (2007), "Introducing new measures of the metropolitan economy. Prototype GDP-by-metropolitan-area estimates for 2001-2005", *Survey of Current Business*, 87(11): 79-87

7. A thorough discussion of a larger set of environmental indicators produced with different methods from geographical sources can be found in Piacentini and Rosina (2012) *Measuring the Environmental Performance of Metropolitan Areas with Geographic Information Sources*, OECD Regional Development

resolution, and obtained through overlay analysis – e.g. the statistics for one region are obtained by superimposing the source data layer with the layer of metropolitan boundaries. In these cases, the metropolitan value is either the sum or a weighted average of the values observed in the source data within the (approximated) area delimited by the metropolitan boundaries. Examples of this first type of indicator are the measures of urban surfaces, obtained by moderate resolution satellite data at a global scale from the MODIS satellite sensor. The second set of indicators are obtained through data that are available at the national level and downscaled to the geographical level of interest using additional data inputs that capture how the phenomenon is distributed across space. Examples of this second type of statistics are the metropolitan estimates of CO2 emissions and air quality. The estimates of CO2 emissions are obtained by the *EDGAR Global Emission database* that provides country emissions levels, and have been downscaled to regular spaced “grids” (e.g. 1 km by 1 km squares) using additional data inputs that are correlated with the production of emissions, such as population density, roads and factories, energy and manufacturing facilities.

The construction of the previous socio-economic and environmental indicators at metropolitan level has been generated by using input data from a different set of data sources. The following table provides detailed information about the sources used in the metropolitan database. See Annex C in *Regions at a Glance 2013* for a detailed description of the method to adjust variables at metropolitan level.

| Indicator | Data sources |
|---------------------------------|---|
| Population | Estimated based on population data at TL2 or TL3 level from OECD Regional Database http://stats.oecd.org/Index.aspx?datasetcode=REG_DEMO_TL3 |
| GDP | Estimated based on GDP data at TL2 or TL3 level from OECD Regional Database http://stats.oecd.org/Index.aspx?datasetcode=REG_DEMO_TL3 |
| Labour | Estimated based on labour data at TL3 level from OECD Regional Database, except for Canada, the United States, Mexico and Chile where census data has been used; Canada: Statcan Census 2006 http://www5.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=94-579-XWE2006004&lang=eng The United States: Bureau of Labour Statistics – Local Area Unemployment Statistics http://www.bls.gov/lau/ Mexico: INEGI Censo de Población y Vivienda 2000 and 2010 http://www.inegi.org.mx/est/contenidos/proyectos/ccpv/default.aspx Chile: INE Chile. XVII Censo Nacional De Población y VI de Vivienda 2002 http://espino.ine.cl/CuadrosCensales/apli_excel.asp |
| Total and Urbanised area | US: NLCD 2001 (Version 2) and NLCD 2006 databases; Japan: Japan National Land Information 1997 and 2006; EU (except Northern Ireland): CORINE Land Cover 2000 and CORINE Land Cover |

Working Paper. http://www.oecd-ilibrary.org/urban-rural-and-regional-development/measuring-the-environmental-performance-of-metropolitan-areas-with-geographic-information-sources_5k9b9ltv87jf-en

| | |
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| | <p>Changes 2000-2006;</p> <p>Canada, Korea and Mexico: MODIS Land Cover data 2008, urban class refers circa to year 2001-2002. Data are derived from medium spatial resolution (500m) satellite imagery and should be taken as rough estimates.</p> |
| <i>CO₂ emissions</i> | <p>European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4.1. http://edgar.jrc.ec.europa.eu, 2010.</p> |
| <i>Air pollution</i> | <p>Van Donkelaar, A., R. V. Martin, M. Brauer, R. Kahn, R. Levy, C. Verduzco, and P. J. Villeneuve, Global Estimates of Exposure to Fine Particulate Matter Concentrations from Satellite-based Aerosol Optical Depth, Environ. Health Perspec., doi:10.1289/ehp.0901623, 118(6), 2010. http://fizz.phys.dal.ca/~atmos/datasets/World-PM25-20010101-20061231-RH50.TIF.zip</p> |
| <i>Patents</i> | <p>OECD Patent Database www.oecd-ilibrary.org/science-and-technology/data/oecd-patent-statistics_patent-data-en</p> |