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Demographic Factors of Change in Urbanisation Processes

Dynamics of national urban and rural population determining the Degree of Urbanisation

Melchiorri Michele, Schiavina Marcello, Florczyk J. Aneta, Freire Sergio, Kemper Thomas, and Pesaresi Martino

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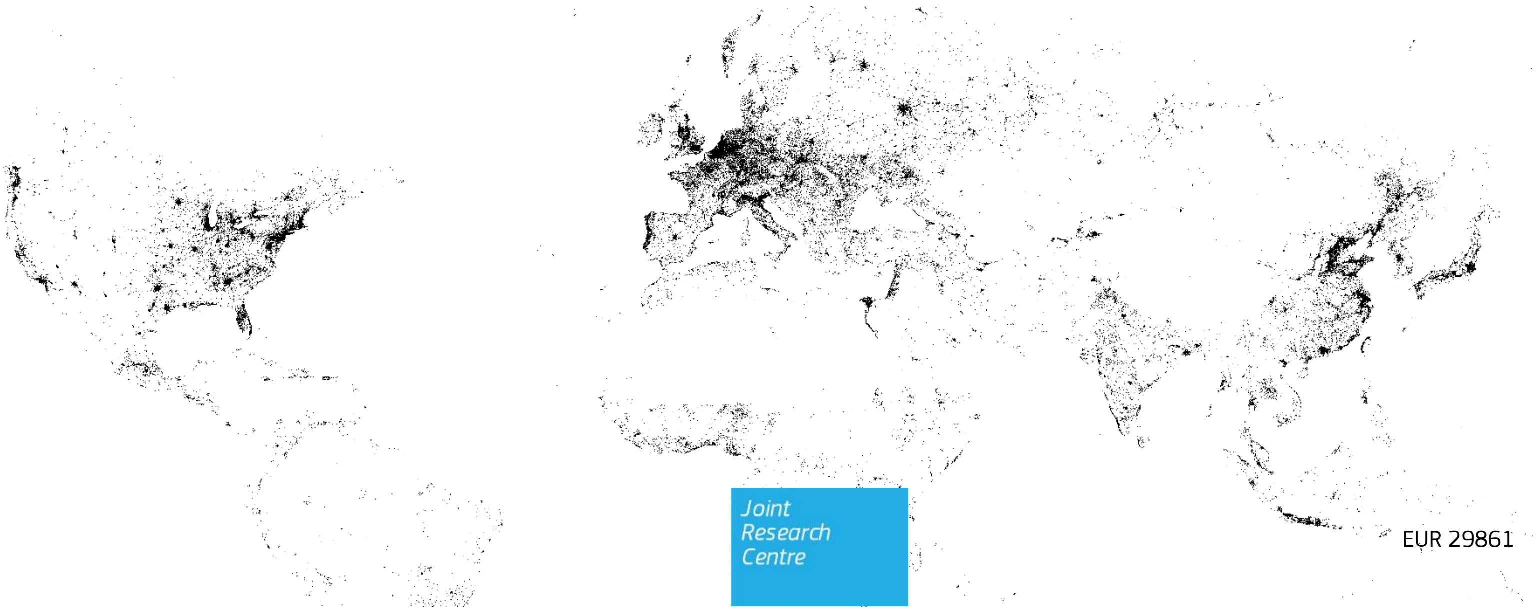

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Abstract

Information, theory and policy response to the process of urbanisation are growing as scientific evidences and global statistics on urban population refine. The Global Human Settlement Layer (GHSL) provides baseline data to determine the share of population living in urban areas using the GHSL Settlement Model Grid (GHS-SMOD). The SMOD ports the *Degree of Urbanisation* (Dijkstra and Poelman 2014) in the GHSL environment and applies it globally. The degree of urbanisation refers to the share of the total population living in urban areas.

The information on population distribution contained in the GHSL population layer (GHS-POP) and settlement typology from GHS-SMOD are available for four epochs: 1975-1990-2000-2015. GHS-POP and GHS-SMOD applied to urbanisation analysis are mainly used to estimate the shares of urban population per country in the different epochs, and to calculate the changes in the degree of urbanisation over time. This information is particularly relevant in support to policymaking as it quantifies the patterns of urbanisation, rural-urban transitions and population shifts. The sole relative change of the degree of urbanisation per spatial unit, is not a comprehensive indication of the demographic and spatial transformations taking place in that spatial unit (e.g. a country). The classification schema is also useful to develop and apply analytical methods and tools for better understanding of current and future urbanisation trends to inform development and cooperation actions.

In this technical report, we present a formalised application of the “Demographic Factors of Change in Urbanisation Processes” model to monitor variations in the degree of urbanisation at country level, analysing its demographic determinants (urban, rural and total population). The report proposes a formalised abstract classification of the cases of degree of urbanisation variations. The classification is then applied to the countries in the Region “Europe” as per the 2018 Revision of World Urbanization Prospects published by the United Nations Department for Economic and Social Affairs.

1 Introduction

1.1 Overview

The GHSL serves urbanisation analyses providing globally-consistent, multi-temporal, open and free data on the distribution of built-up areas (GHS-BUILT), population (GHS-POP) and human settlement typologies (GHS-SMOD) on Earth. The *Degree of Urbanisation* (Dijkstra and Poelman 2014) is an important and well-established measure/indicator adopted by Eurostat and used for producing statistics and indicators disaggregated by settlement typology but whose application outside Europe was until recently limited by data suitability and availability.

The GHSL geospatial data, due to its global coverage and characteristics, allows porting the *Degree of Urbanisation* to the global domain by enabling the worldwide classification of different settlement typologies (High Density Clusters (Urban Centres), Moderate Density Clusters (Urban Clusters), and Low Density Grid Cells (Rural Grid Cells)) and quantify for each type the amount of built-up areas, population and surface. The availability of this baseline information is used to support the European Commission-led voluntary commitment to develop a global, people-based definition of cities and settlements[1]. Additional applications include the testing of the *Degree of Urbanisation* at global level with the production of Country Summaries[2].The GHSL Data Package 2019 (Florczyk et al. 2019) contains improved GHS-BUILT, GHS-POP, and GHS-SMOD baseline data. Based on the 2019 GHSL release (GHS P2019), the overall *Degree of Urbanisation* for the world reaches 76.4% and has increased by 3% since 1975. This information could be supplemented by characterising the determinants of the degree of urbanisation change to characterise the urbanisation process in different areas of interest. This is carried out by analysing the urban and rural population dynamics.

This technical report presents different ways in which the net changes in total national population, total urban and rural population at national level determine the variation in the degree of urbanisation between two epochs. The method is particularly relevant to characterise cases where there is variation in the degree of urbanisation, to benchmark the net demographic performance of urban areas vis-á-vis the one in rural areas, and the overall change of the total national population. The ultimate goal is to define which demographic and territorial processes take place in territories that undergo similar changes in the degree of urbanisation, and so to help identifying policy response options with the production of baseline data underpinning a better understanding and documentation of conditions and development trends.

1.2 Rationale

The classical demographic definition of urbanisation is based on:

$$U_t = \frac{P_u}{P_T}$$

Where the share of urban population at a given time (U_t) is determined by the ratio between the population of a given spatial unit accounted in urban areas (P_u), over the total population of the spatial unit (P_T – that is composed by urban population P_u, and rural population P_r). This formalisation dates back to the traditional studies on urbanisation by Davis (Davis, 1955).The degree of urbanisation of the same spatial unit at a subsequent year (U_{t+1}) can be calculated with the same formula and the respective P_u and P_T obtained from the baseline population data at the corresponding *t+1* year. Having quantified U_t and U_{t+1} it is of interest to calculate the change of the degree of urbanisation of the spatial unit (e.g. a country) between the two epochs:

$$\Delta U = U_{t+1} - U_t$$

The change in the degree of urbanisation of the spatial unit can be positive or negative, depending on the net changes of the urban population (P_u) or the total one (P_T) whereas:

[1] https://ec.europa.eu/commission/commissioners/2014-2019/cretu/blog/presenting-voluntary-commitments-eu-meet-new-urban-agendas-objectives_en

[2] http://ghsl.jrc.ec.europa.eu/CFS.php

$$\Delta U > 0 \qquad\qquad \Delta U < 0$$

$$\Delta P_u > U_t \, \Delta P_T \qquad\qquad \Delta P_u < U_t \, \Delta P_T$$

From the above concepts, Table 1 simplifies the different conditions for degree of urbanisation changes. In principle, the degree of urbanisation grows in four circumstances, determined by the combination of total and urban population variations (growth and decline), and declines in other three circumstances. To characterise further the changes in the degree of urbanisation it is necessary to disaggregate P_T in its P_u, and P_r components. Table 1 demonstrates that change in the degree of urbanisation indicator alone is not capable to characterise the process of urbanisation taking place in a given area of interest. For example, the degree of urbanisation in a situation of positive change of P_T and P_u can increase or decline; similarly, it can increase even with a net loss of urban population.

Table 1. Synthetic table of combinations of national and urban population dynamics between two epochs in a positive or negative domain of degree of urbanisation change

Degree of urbanisation change	National population change between t_1 and t_{t+1}	Urban population change between t_1 and t_{t+1}	Discriminant
ΔU	ΔP_T	ΔP_u	
+	+	+	P_u and P_r disaggregation
+	+	+	P_u and P_r disaggregation
+	-	+	
+	-	-	
-	-	-	P_u and P_r disaggregation
-	-	-	P_u and P_r disaggregation
-	+	+	

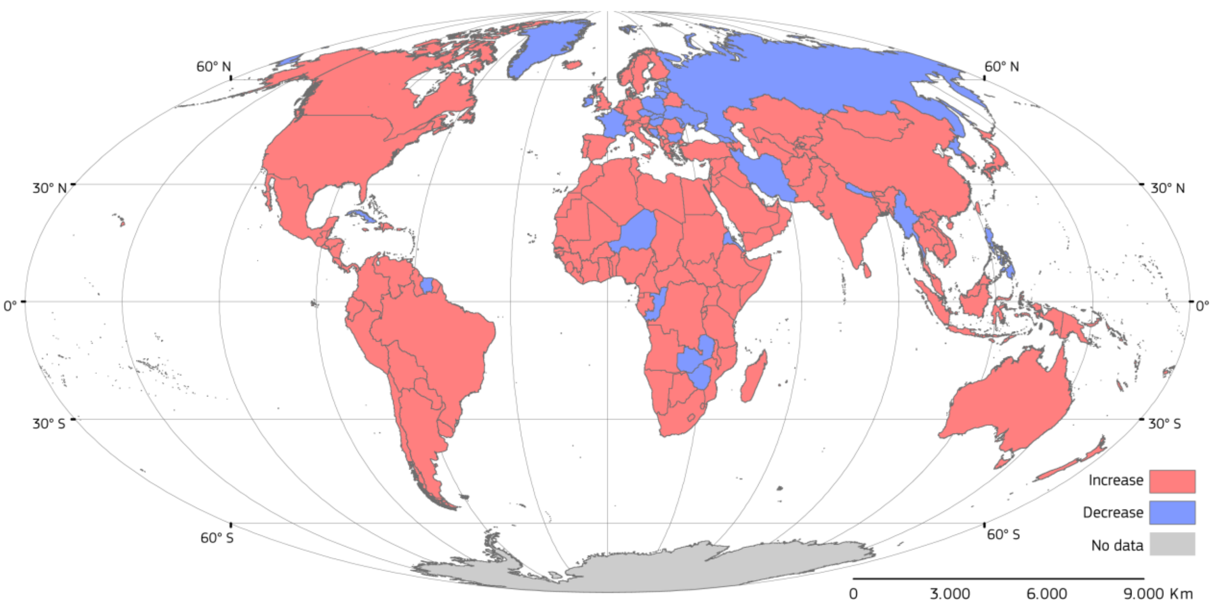


Figure 1. Change in the degree of urbanisation between 1975 and 2015 per country, binary

2 Data description

Demographic analyses on urbanisation require two main pieces of information, one to quantify population distribution, the other to classify settlements and respective population into urban versus rural classes.

The Global Human Settlement Layer (GHSL) is produced at the European Commission – Joint Research Centre and it is supported by the Directorate-General for Regional and Urban Policy. GHSL maps population density (GHS-POP) and settlement typologies (GHS-SMOD), for the epochs 1975-1990-2000-2015. An additional layer (GHS-BUILT) mapping presence and density of built-up areas for the corresponding years is available. All GHSL layers are consistently produced to grant comparisons across time and regions of the world.

In this technical report, data are sourced from the GHS-POP and GHS-SMOD contained in the GHSL Data Package 2019 (Florczyk et al. 2019), epoch layers 1975 and 2015. National population statistics for the test application of the methodology were extracted from GHSL in combination with the Database of Global Administrative Areas v2.8 (GADM[3]). Territories in the Region "Europe" were identified from the World Population Prospects: The 2018 Revision, Classification of Countries by Major Area and Region of the World (United Nations, Department of Economic and Social Affairs, Population Division 2018).

2.1 Population

GHS-POP (Schiavina, Freire, and McManus 2019) is a spatial raster dataset that depicts the distribution and density of population, expressed as the number of people per cell. Residential population estimates for target years 1975, 1990, 2000 and 2015 provided by CIESIN GPWv4.10 were disaggregated from census or administrative units to grid cells, informed by the distribution and density of built-up as mapped in the GHS-BUILT global layer per corresponding epoch (Freire et al. 2016, 2018).

2.2 Settlement Model

The GHS-SMOD raster dataset (Pesaresi et al. 2019) delineates and classifies human settlement typologies using a logic of population size, population and built-up area densities as a refinement of the 'degree of urbanisation' method as described by EUROSTAT[4] using the GHS-POP and GHS-BUILT as input.

The GHS-SMOD at level 2 classifies each 1 km grid cell into one of the classes with a two digit code (30 – 23 – 22 – 21 – 13 – 12 – 11 – 10). Classes 30 – 23 – 22 – 21 together form the "urban domain", while classes 13 – 12 – 11 – 10 form the "rural domain".

2.3 Spatial Units of Analysis

In this report the areas of interest are selected using country extents. To generate urban and rural population statistics per country we used a spatial layer to delineate territories, the Global Administrative Map layer (GADM), and a statistical dataset to name and assign countries to major regions of the world (with the country classification adopted by UNDESA for the 2018 Revision of the World Urbanization Prospects)[5]. Although for the purpose of this report the analysis is conducted at national level, this methodology could be applied to every user-defined extents (e.g. NUTS2 or 3 levels, UN Major Areas, custom areas, etc.).

[3] http://gadm.org/

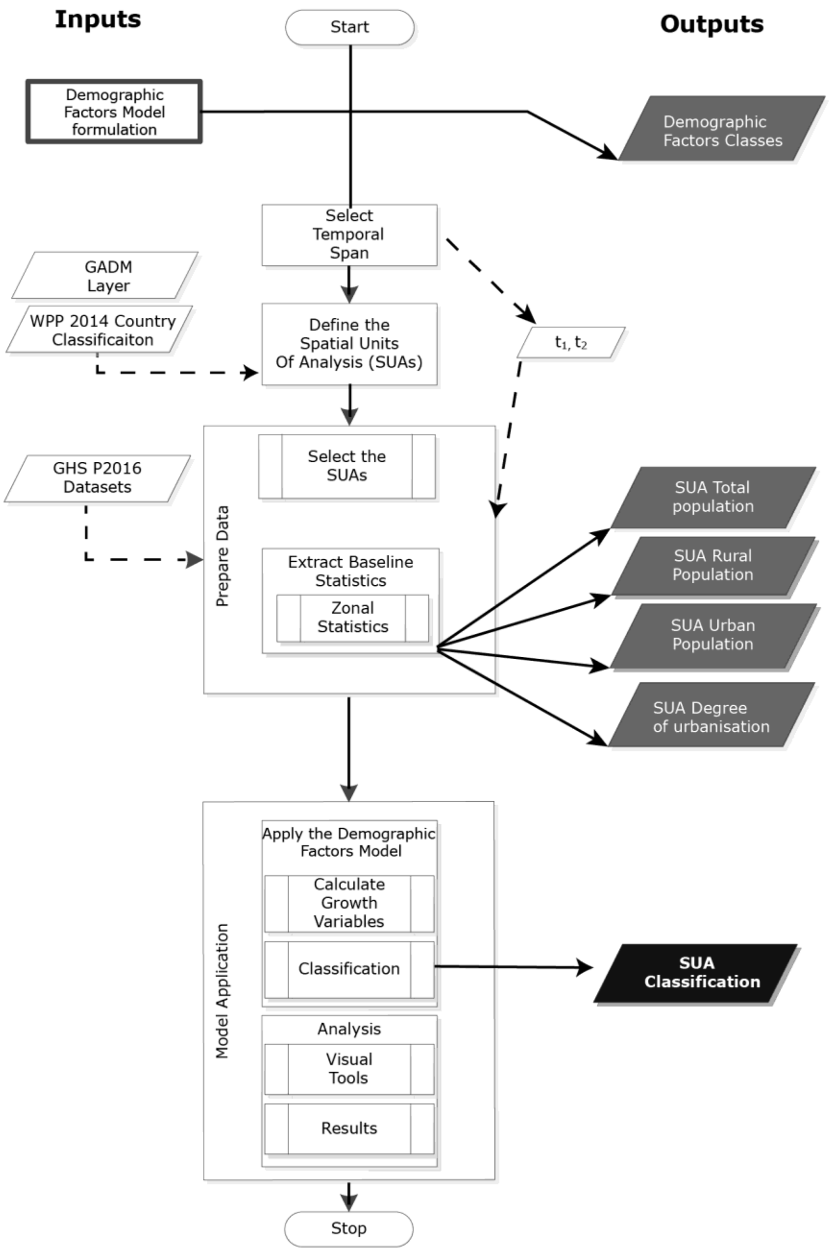
[4] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Degree_of_urbanisation

[5] VAT has been excluded from the analysis

3 Methodology and Implementation

The workflow was implemented in four main phases. The first one consisted in the selection of the temporal span of the analysis (1975 to 2015), and areas of interest to be analysed (spatial units of analysis -SUAs, here selected as country extents as delineated in the GADM layer and the WUP 2018 country classification). In the second step, the GHSL Data Package 2019 layers (GHS-SMOD and GHS-POP) were injected in the GIS environment to extract zonal statistics over the selected SUAs (Territories in the Major Region Europe). From these first two steps, it was possible to generate a geospatial layer and a multi-temporal statistical dataset containing for the year 1975 and 2015 the following information: total national population, urban and rural population per country, and the degree of urbanisation. In the third step, the *Demographic Factors of Change in Urbanisation Processes model* was applied and the different cases of degree of urbanisation variation codified and labelled. The fourth phase was implemented with statistical analytics to apply the model to the SUAs. The fourth phase delivered a comprehensive classification of countries, formalised in (Table 4 p.17).

Figure 2. Methodology workflow



3.1 Cases of national and urban population change

The degree of urbanisation of a country varies to the extent in which absolute changes in the urban and total national population manifest. In practice, to characterise a positive or negative change of the degree of urbanisation it is necessary to analyse the absolute changes in the components of the ratio, namely urban and national (urban and rural) population. This methodology is provided to make explicit the differences between the demographic patterns that determine variations in the degree of urbanisation. In fact, countries where the degree of urbanisation changes in the same way may undergo opposite demographic trajectories. Table 2 presents a classification of these patterns.

Table 2. Classification of positive and negative degree of urbanisation changes between epochs, national population and urban / rural population variables

Degree of urbanisation change	National population change between t_1 and t_{t+1}	Urban population change between t_1 and t_{t+1}	Rural population change between t_1 and t_{t+1}	Case		
ΔU	ΔP_T	ΔP_u	ΔP_r	Classification	Determinant	Name
-	**+**	**+**	**+**	**1a**	$\Delta P_u < \frac{U_t}{(1-U_t)} \Delta P_r$	Rural driven de-urbanisation and demographic growth
+	**+**	**+**	**+**	**1b**	$\Delta P_u > \frac{U_t}{(1-U_t)} \Delta P_r$	Urban driven urbanisation and demographic growth
+	**+**	**+**	**-**	**2**		Urban polarised urbanisation and growth
+	**-**	**+**	**-**	**3**		Urban resilient decline
-	**-**	**-**	**-**	**4a**	$\Delta P_u < \frac{U_t}{(1-U_t)} \Delta P_r$	Urban driven demographic decline
+	**-**	**-**	**-**	**4b**	$\Delta P_u > \frac{U_t}{(1-U_t)} \Delta P_r$	Rural driven urbanisation and demographic decline
-	**-**	**-**	**+**	**5**		Rural resilient de-urbanisation and demographic decline
-	**+**	**-**	**+**	**6**		Rural polarised de-urbanisation and demographic growth

The *demographic growth* or *decline* labels refer to changes of ΔP_T, *urbanisation* or *de-urbanisation* refer to the degree of urbanisation change, respectively positive and negative, whereas a settlement typology (*U* or *R*): (i) *drives* the change, if the ΔP (*U* or *R)*is greater than the other, in a national change like effect; (ii) *polarises* the change, if its dynamic is concurrent to the national one, in a mix like effect; (iii) is *resilient* to the change, if its dynamic is the opposite of the national one, in a competitive like effect.

3.1.1 Degree of urbanisation variations

Net national and urban population changes determine degree of urbanisation variations. Figure 3 displays the sectors of the ΔP_r versus ΔP_u scatter plot where countries with increasing and decreasing degree of urbanisation are plotted. The degree of urbanisation variations model includes eight possible combinations, four respectively for positive and negative change. Figure 3 also shows the ranges of slopes, as a function of U_t (between 0 and 1 that correspond to a completely rural or urban population respectively), splitting the sectors.

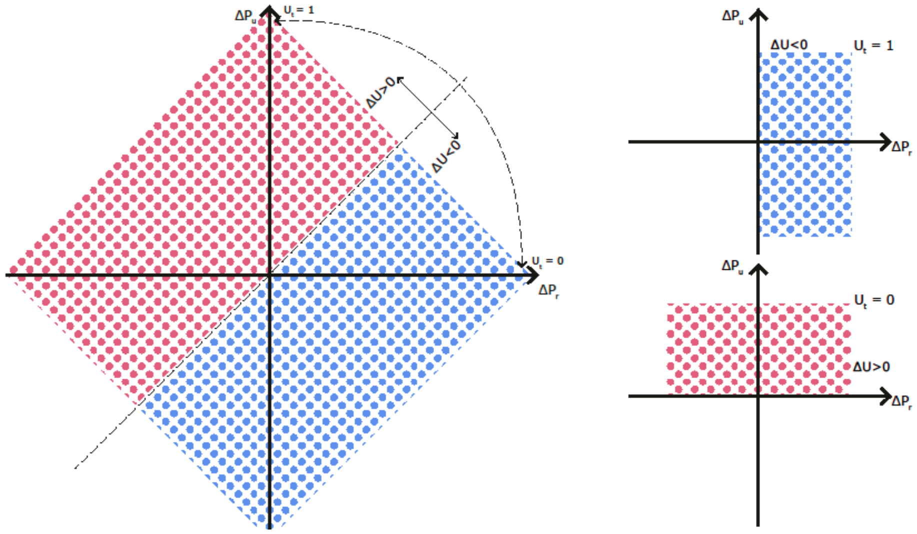


Figure 3. Sectors of positive and negative change of degree of urbanisation

3.1.2 Net national population changes

To analyse variations in the degree of urbanisation, the first differentiation concerns a positive or negative demographic balance at national level. In the domain of growing national population there are four cases, where two are related to growth of degree of urbanisation (1b and 2), and two to decline (1a and 6). In the instance of declining national population (four cases), two are related to positive variations of the degree of urbanisation (3 and 4b) and two to decline (4a and 5). Figure 4 shows the sectors of a ΔP_r ΔP_u chart of positive and negative change of national population.

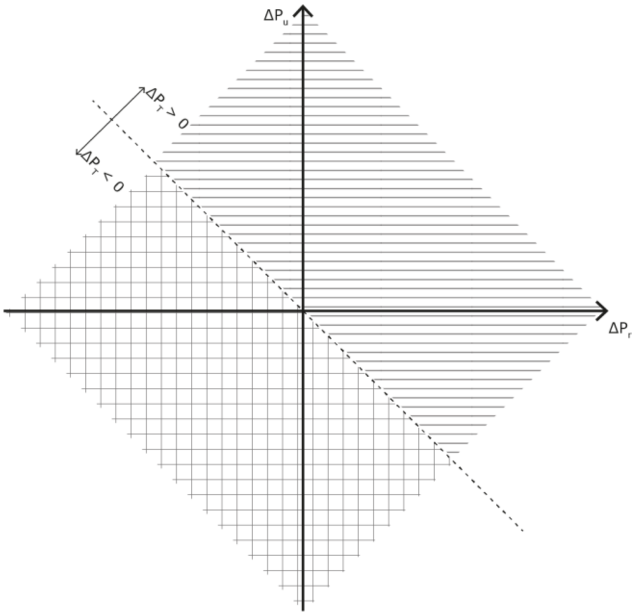


Figure 4. Sectors of positive and negative change of total population

3.1.3 Net urban population changes

The net growth of urban population is not the only determinant of growth in degree of urbanisation of a SUA. From Table 2 it emerges that the net growth of urban population is responsible for the positive change of the degree of urbanisation in three cases (1b, 2, 3), while in one (1a) net urban population growth does not result in positive degree of urbanisation change. Net decline of urban population is mostly associated with a negative variation of the degree of urbanisation (cases 4a, 5 and, 6), and only in case 4b net urban population decline results in a growth of the degree of urbanisation. In graphical terms, SUAs that account for a positive net change of urban population are plotted in quadrants I and II of the ΔP_r ΔP_u scatter plot (Figure 5).

3.2 Urban and rural population dynamics as proxies for degree of urbanisation variations

Table 2 makes explicit that the degree of urbanisation variation manifests as a combination of urban and rural population dynamics. These can take place in an instance of positive or negative national population balance. The set of degree of urbanisation variations can be fully explained only taking into consideration: a) the national demographic trend; b) the net change of urban population (P_u); c) the net change of rural population (P_r). The interplay between the urban and rural population variables and their aggregate (P_T) determine the result of the ΔU.

Figure 5 (a combination of Figure 4 and Figure 3) synthetizes the eight cases of degree of urbanisation change, disaggregating changes in rural and urban population. Areas plotted in shades of red correspond to an increase in the degree of urbanisation, the ones in blue to a decline. The sectors intertwine ΔU, ΔP_r and ΔP_u. The "urbanisation slope" *m* of the line defining the spaces with increasing and decreasing degree of urbanisation (i.e. $\Delta P_u = m\Delta P_r$, the "urbanisation line") plays a key role in determining the classification by splitting cases 1 and 4 in their "a" and "b" alternatives. Such urbanisation slope is determined by the ratio between the degree of urbanisation at time *t* and one minus the degree of urbanisation at time *t*:

$$m = U_t/(1 - U_t)$$

This section describes the factors determining variations in the degree of urbanisation.

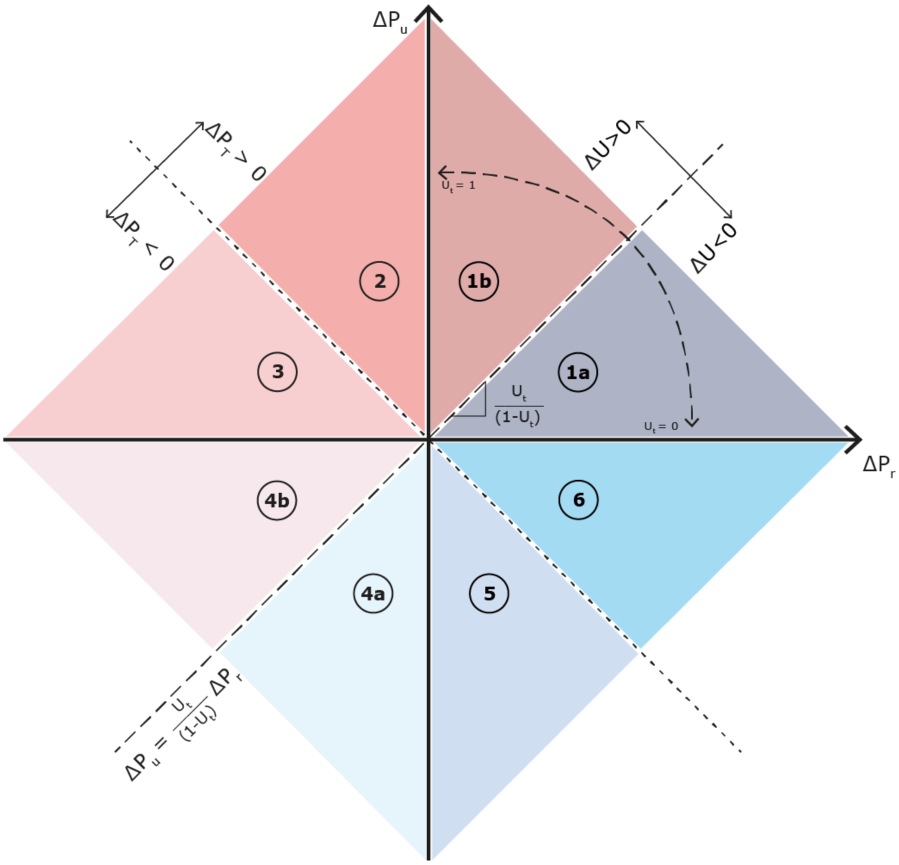


Figure 5. Plot sectors by degree of urbanisation change classification

3.2.1 Rural driven de-urbanisation and demographic growth

Case name 1a. The *rural driven de-urbanisation and demographic growth* areas are subject to an increase of total population, with both urban and rural population growth, but a decline of the degree of urbanisation. In such case the population growth is more substantial in rural areas with an absolute change in the urban population that is smaller than the rural one times the urbanisation slope (i.e. $\Delta P_u < m\Delta P_r$).

3.2.2 Urban driven urbanisation and demographic growth

Case name 1b. The *urban driven urbanisation and demographic growth* characterises areas with an increase of total population, with both urban and rural population growth, and a simultaneous growth of the degree of urbanisation. In contrast to the previous case, the net change of urban population is greater than the one in rural areas times the urbanisation slope (i.e. $\Delta P_u > m\Delta P_r$).

3.2.3 Urban polarised urbanisation and demographic growth

Case name 2. In the case of *urban polarised urbanisation and demographic growth*, both the total population and the degree of urbanisation grow. The growth of total population is determined by an increase in urban population that is greater than the loss of rural population. A specific case of case *urban polarised urbanisation and demographic growth* takes place when the loss of rural population is null (i.e. $\Delta P_r = 0$); this situation represents the *pure urban growth*.

3.2.4 Urban resilient urbanisation and demographic decline

Case name 3. A pattern of *urban resilient urbanisation and demographic decline* shows a loss of total population, with a growth of urban population and an increase of the degree of urbanisation. This pattern is a sign of the advantages of urban areas that are resilient to population decline and actually experience a trend opposite to the overall one. A specific case of *urban resilient urbanisation and demographic decline* takes place when the growth of urban population is null (i.e. $\Delta P_u = 0$), this situation represents the *pure rural decline.*

3.2.5 Urban driven de-urbanisation and demographic decline

Case name 4a. The u*rban driven de-urbanisation and demographic decline* areas are subject to a declining total population, with both urban and rural shrinking populations, and a decline of the degree of urbanisation. In such case the population decline is more substantial in urban areas with an absolute change in urban population smaller than the rural one times the urbanisation slope (i.e. $\Delta P_u < m\Delta P_r$).

3.2.6 Rural driven urbanisation and demographic decline

Case name 4b. The *rural driven urbanisation and demographic decline* is a condition of total population loss, with both urban and rural populations shrinking, but facing growth in the degree of urbanisation. In this case, the population decline is more sizable in rural areas with an absolute change in urban population greater than the rural one times the urbanisation slope (i.e. $\Delta P_u > m\Delta P_r$).

3.2.7 Rural resilient de-urbanisation and demographic decline

Case name 5. In the case of *rural resilient de-urbanisation and demographic decline*, both the total population and the degree of urbanisation decline. The decline in total population is determined by a rural population increase greater than the loss of urban population. In this case, rural areas play a competitive-like effect and manifest an opposite trend compared to the total one. A specific case of *rural resilient de-urbanisation and demographic decline* occurs when $\Delta P_r=0$, this case is of *pure urban decline.*

3.2.8 Rural polarised de-urbanisation and demographic growth

Case name 6. In this last case, classified as *rural polarised de-urbanisation and demographic growth*, the total population grows but the degree of urbanisation declines. However, an opposite dynamic takes place in rural and urban settlements, with population growing in the former and declining in the latter. A specific case of *rural polarised de-urbanisation and demographic growth* occurs when the loss of urban population is null ($\Delta P_u=0$), with this situation representing *pure rural growth*.

3.2.9 Stable or pure shift cases

In cases of ΔP_u and ΔP_r lying on the urbanisation line, there are situations of *stable urbanisation and demographic growth* (when both are positive) or *stable urbanisation and demographic decline* respectively (when both are negative).

When such cases happen in situations of U_t = 1, the *stable urbanisation and demographic growth* coincides with the *pure urban growth*, generating the *pure urban growth and stable urbanisation*; also the *stable urbanisation and demographic decline* coincides with the *pure urban decline*, generating the *pure urban decline with stable urbanisation*. In situations of U_t = 0, the *stable urbanisation and demographic growth* coincides with the *pure rural growth*, generating the *pure rural growth with stable urbanisation*; also the *stable urbanisation and decline* coincides with the *pure rural decline*, generating the *pure rural decline with stable urbanisation*.

The cases where ΔP_u and ΔP_r are equal in module but have opposite sign are of pure shift. *Rural to urban shift* occurs when $\Delta P_u<0$, and $\Delta P_r>0$; the *urban to rural shift* occurs when $\Delta P_u>0$, and $\Delta P_r<0$. Although the mathematical formulation requires a strict definition, pure shift cases could be estimated with a tolerance (i.e. as a percentage difference in module).

4 Application

The methodology described in the previous sections has been tested in the sample of 51 countries forming the Major Region Europe in the World Urbanization Prospect 2018. The interest is to apply the *Demographic Factors of Change in Urbanisation Processes model* to characterise the degree of urbanisation variations of countries in the European Region between 1975 and 2015. The test is made at national level using GHSL (GHS-POP and SMOD), to exploit the full set of countries in the Region, but the disaggregation can be repeated for other spatial units for which data is available (e.g. at NUTS2 and NUTS3 levels).

4.1 Occurrence and geographical distribution of degree of urbanisation change cases

Overall, urban and rural population in the selected sample of countries changes by about 45 million people in urban areas (ΔP_u), and about 16 in rural areas (ΔP_r). In 32 countries the degree of urbanisation increases between 1975 and 2015 (cases 1b, 2, and 4b), and in the other 19 it declines (1a, 4a, 5, and 6). The majority of territories (16 occurrences) where the degree of urbanisation increases suffer an *urban driven urbanisation and demographic growth* (1b) situation (examples include Belgium, Germany, Denmark, Spain, the Netherlands and the United Kingdom). Thirteen other countries account for *urban polarised urbanisation and demographic growth* (2) –including Austria, Italy and Portugal. Other 3 countries (Croatia, Romania and Serbia) develop with a *rural driven urbanisation and demographic decline* pattern (4b) (territories are listed in Table 3). Croatia, Romania and Serbia are the only countries analysed where the degree of urbanisation increases in conjunction with a net demographic loss ($\Delta P_t<0$). Such loss exceeds 250 thousand, 2 million and 720 thousand people respectively, and in Croatia and Serbia the majority of population is lost in rural areas while rural and urban population loss is almost equal in Romania. In the situations of declining degree of urbanisation, the majority (8 cases) follows the *rural driven de-urbanisation and demographic growth* process (1a) –including France, Poland and Russia. The other occurrences are evenly distributed across the remaining change cases (four occurrences in cases 5 and 6; three occurrences in case 4a).

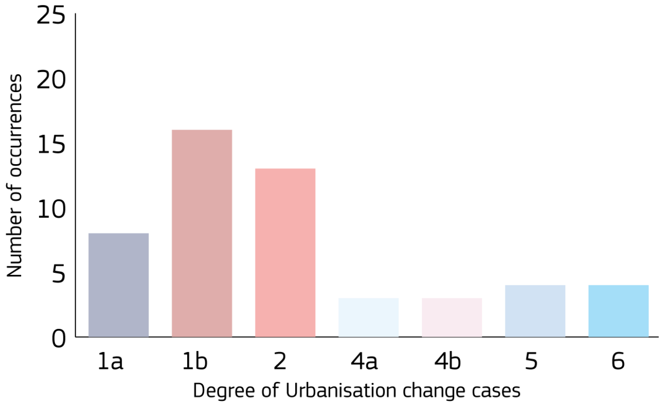


Figure 6 Frequency distribution of cases of degree of urbanisation variation in Europe between 1975 and 2015

Table 3 Classification of territories in Europe per case of degree of urbanisation change

Case	Name	Count	Territories (ISO A3)
1a	*Rural driven de-urbanisation and demographic growth*	8	AND, IRL, FRA, MNE,POL, RUS, SMR, SVK
1b	*Urban driven urbanisation and demographic growth*	16	ALA, BEL, DEU, DNK, ESP, FIN, GBR, GRC, IMN, LUX, MKD, NLD, NOR, SVN, SWE, XKO
2	*Urban polarised urbanisation and demographic growth*	13	ALB, AUT, BLR, CHE, GGY, GIB, ISL, ITA, JEY, LIE, MCO, MLT, PRT
4a	*Urban driven de-urbanisation and demographic decline*	3	BGR, HUN, UKR
4b	*Rural driven urbanisation and demographic decline*	3	HRV, ROU, SRB
5	*Rural resilient de-urbanisation and demographic decline*	4	BIH, EST, LTU, LVA
6	*Rural polarised de-urbanisation and demographic growth*	4	CZE, FRO, MDA, SJM

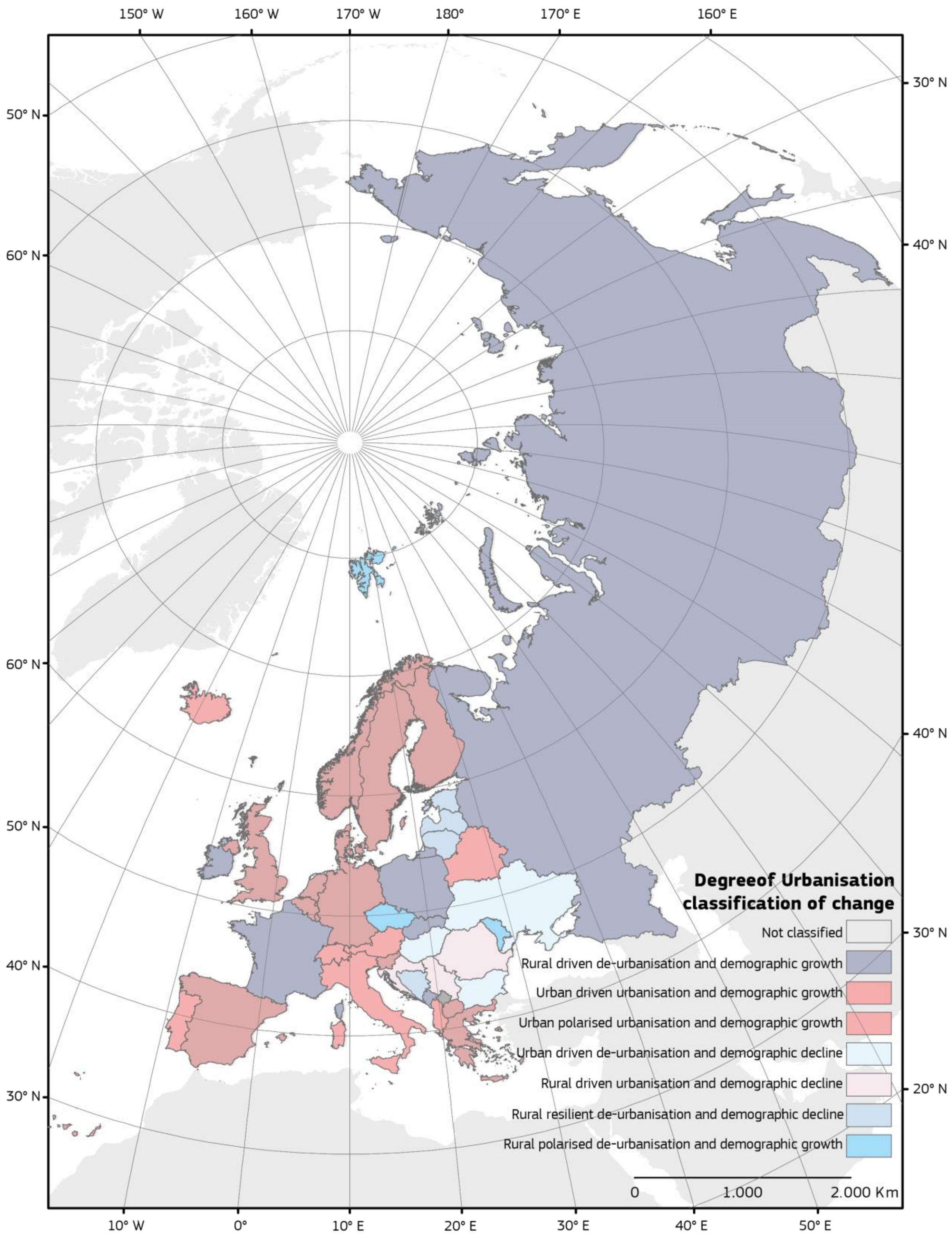


Figure 7 Classification map of the region Europe according to the *Demographic Factors of Change in National Degrees of Urbanisation model*

The degree of urbanisation change cases seem to have specific geographical distribution (Figure 7). In most countries in Eastern Europe the degree of urbanisation declines, most often due to *urban driven urbanisation and demographic decline* pattern, whereas both urban and rural population shrink. On the contrary, *urban driven urbanisation and demographic growth* is widespread across Central and Western Europe implying net population growth in both urban and rural areas (excluding France and Ireland, showing a *rural driven de-urbanisation and demographic growth* pattern).

4.2 Demographic changes across degree of urbanisation change cases

Figure 8 plots the territorial patterns of ΔP_r and ΔP_u (from which also ΔU can be derived) presented above. In comparative terms, the dynamics of urban and national population and of degree of urbanisation variations are rather different across the analysed area of interest.

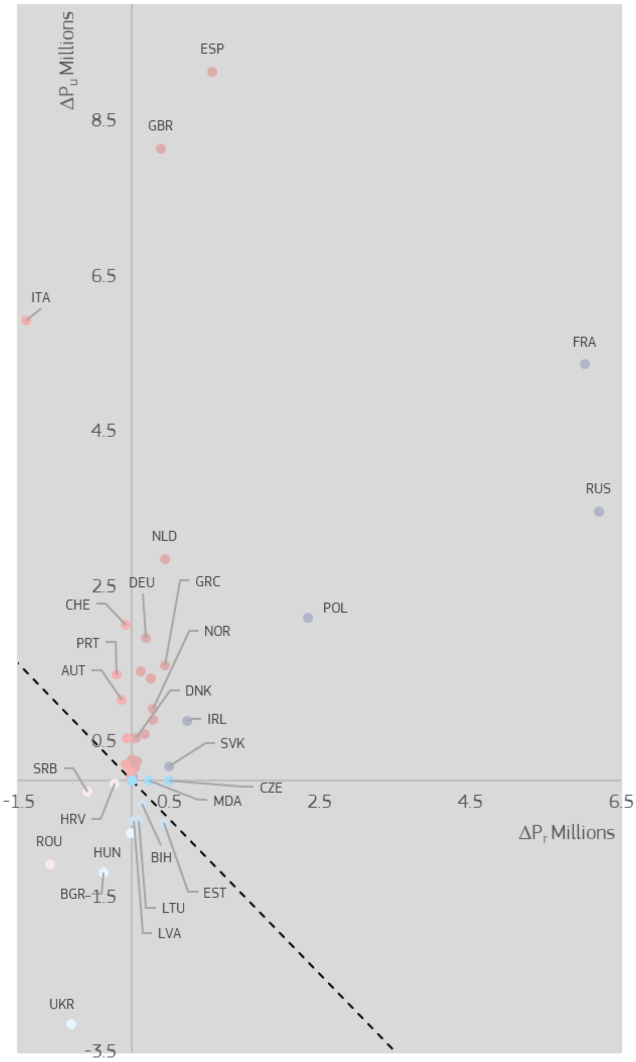


Figure 8. Cases of degree of urbanisation variation by changes of national and urban population in Europe 1975-2015 (right); and Countries in the Major Area Europe per case of degree of urbanisation change

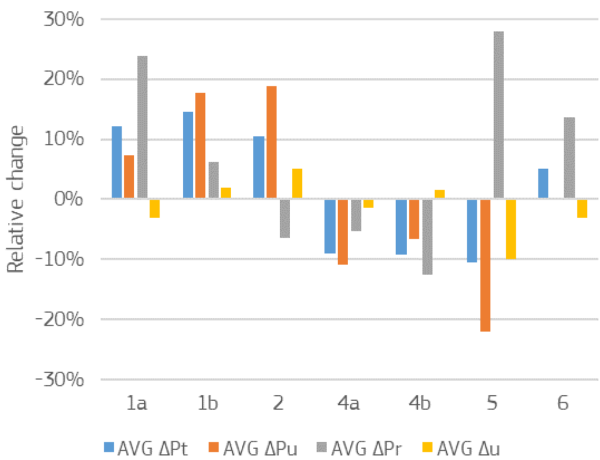


Figure 9. Average of national and urban population and degree of urbanisation per case of change

Figure 9 shows average changes in total, urban and rural population, and the related average degree of urbanisation variation per class. The chart is built summarising the national-level changes of the countries in the class. Although the model is not formulated on the basis of relative changes of P_r, P_u and the degree of urbanisation, ex-post classification highlights that the intensities of change varies. In case 1b and case 2, both of positive ΔU, the latter shows on average a higher relative change of the degree of urbanisation. This is due to the combination of positive demographic change in urban areas and net loss in rural ones. Table 4 summarises for the countries of the Major Region Europe, the observed absolute changes of total population, urban and rural components, the degree of urbanisation at *t* (1975) and *t+1* (2015), and the case of degree of urbanisation variation as per the classification with the presented model.

Table 4. Dataset of the observed variables for countries in the European Major Region, 1975-2015 (ΔP in thousands)

ISO A3	ΔP_t	ΔP_u	ΔP_r	U_t	U_{t+1}	case
ALA	8.63	4.60	4.03	40%	44%	**1b**
ALB	485.73	545.44	- 59.72	56%	66%	**2**
AND	39.71	24.81	14.90	67%	64%	**1a**
AUT	919.95	1,040.71	- 120.76	51%	58%	**2**
BEL	1,533.85	1,406.01	127.85	75%	78%	**1b**
BGR	- 1,561.49	- 1,191.84	- 369.65	60%	56%	**4a**
BIH	- 156.94	- 301.08	144.14	74%	69%	**5**
BLR	128.03	205.07	- 77.04	69%	70%	**2**
CHE	1,938.21	2,009.27	- 71.06	67%	76%	**2**
CZE	487.52	- 7.35	494.87	62%	59%	**6**
DEU	2,028.69	1,837.88	190.82	69%	70%	**1b**
DNK	607.83	542.74	65.09	59%	62%	**1b**
ESP	10,211.84	9,133.11	1,078.73	74%	77%	**1b**
EST	- 112.49	- 547.11	434.63	96%	63%	**5**
FIN	785.13	599.79	185.35	56%	59%	**1b**
FRA	11,382.88	5,360.50	6,022.39	64%	61%	**1a**
FRO	7.67	0	7.67	0%	0%	**6**
GBR	8,534.65	8,146.69	387.96	83%	85%	**1b**
GGY	4.86	5.21	- 0.34	89%	91%	**2**
GIB	6.22	6.22	0	100%	100%	**2**
GRC	1,925.17	1,479.91	445.25	66%	68%	**1b**
HRV	- 251.62	- 35.64	- 215.97	55%	57%	**4b**
HUN	- 684.98	- 678.19	- 6.79	65%	62%	**4a**
IMN	26.84	22.52	4.31	62%	69%	**1b**
IRL	1,508.90	762.88	746.02	55%	54%	**1a**
ISL	111.47	124.53	- 13.07	52%	72%	**2**
ITA	4,535.13	5,932.07	- 1,396.94	70%	74%	**2**
JEY	32.41	34.34	- 1.93	78%	87%	**2**
LIE	13.82	15.88	- 2.06	72%	88%	**2**
LTU	- 420.57	- 522.45	101.88	75%	67%	**5**
LUX	211.20	167.04	44.15	56%	65%	**1b**
LVA	- 485.85	- 523.13	37.29	73%	65%	**5**
MCO	12.42	12.42	0	100%	100%	**2**
MDA	224.33	- 4.73	229.06	62%	58%	**6**
MKD	275.25	266.97	8.28	69%	72%	**1b**
MLT	111.07	114.49	- 3.42	91%	95%	**2**
MNE	71.95	48.14	23.81	70%	69%	**1a**
NLD	3,305.43	2,857.22	448.21	81%	82%	**1b**
NOR	1,203.08	922.11	280.97	48%	54%	**1b**
POL	4,443.61	2,095.25	2,348.36	62%	60%	**1a**
PRT	1,163.50	1,363.69	- 200.18	61%	67%	**2**
ROU	- 2,160.38	- 1,084.32	- 1,076.05	54%	55%	**4b**
RUS	9,666.33	3,464.45	6,201.88	77%	74%	**1a**
SJM	1.58	0	1.58	0%	0%	**6**
SMR	10.51	8.57	1.95	83%	82%	**1a**
SRB	- 720.96	- 143.03	- 577.93	60%	64%	**4b**
SVK	679.76	180.73	499.04	56%	52%	**1a**
SVN	318.59	247.34	71.25	45%	50%	**1b**
SWE	1,585.34	1,319.21	266.13	60%	64%	**1b**
UKR	- 3,935.61	- 3,144.97	- 790.63	70%	69%	**4a**
XKO	1,064.01	782.50	281.50	55%	65%	**1b**

5 Conclusions

With the global debate increasingly bound to urbanisation figures and analysis, it is key to inform policymaking on the basis of reliable, accurate, updated and consistent data. To support the endeavours of the European Commission and its institutional partners (OECD, the World Bank and FAO) committed to developing a people-based global definition of cities and settlements, this technical report has introduced a methodology to analyse the changes in the degree of urbanisation considering demographic factors: urban and rural population, and total national population.

The mathematical formulation of the methodology demonstrates that the degree of urbanisation variations should be analysed taking into consideration the dynamics of its components, namely urban, national and rural population. In the abstraction of the change cases, it was highlighted that equal variations of the degree of urbanisation may be due to opposite demographic trends. Therefore, in order to consider the degree of urbanisation as indicator, it is necessary to characterise it and be aware of the different drivers of its variation.

The abstract classification proposed in Table 2 (Classification of positive and negative degree of urbanisation changes between epochs, national population and urban / rural population variables) has been tested in the 51 countries forming region Europe as per the classification of the UNDESA World Urbanization Prospects 2018 Revision (the institutional and scientific reference in the domain). The application demonstrated that it is needed to differentiate and classify national cases of degree of urbanisation variation to capture actual demographic dynamics (absolute changes) and shifts (urban rural transitions, and vice versa), as these dynamics require substantially different policy responses especially in the framework of the Future of Cities (European Commission Joint Research Centre 2019).

The presented methodology is capable of supporting policy design and policy implementation monitoring at European level and at international one. In particular, the model could be applied to classify smaller territorial units (i.e. NUTS or regions). In particular it could help to better identify the territorial and demographic dynamics determining urbanisation processes. Such information is of particular importance to conceive and analyse policies addressing the specific requirements of the different processes. In a broader context, the classification schema is also useful as sampling attribute to group and identify specific economic, social, development and environmental indicators. For example the classification can be deployed to characterise the risk assessment for humanitarian crises and disasters index of JRC (INFORM) (Marin Ferrer, Vernaccini, and Poljansek 2017), and to inform development and cooperation actions, that could underpin the assessment and the focus of disbursement among beneficiaries in DEVCO intervention (European Commission , Directorate-General for International Cooperation and Development 2018).

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List of abbreviations and definitions

GHS-BUILT	Global Human Settlement Layer Built-up grid
GHS-POP	Global Human Settlement Layer Population grid
GHS-SMOD	Global Human Settlement Layer Settlement Model grid

Annex

Table 5 Colour coding

Classification	Name	RGB
1a	*Rural driven de-urbanisation and demographic growth*	176, 181, 201
1b	*Urban driven urbanisation and demographic growth*	223, 172, 171
2	*Urban polarised urbanisation and demographic growth*	245, 176, 175
3	*Urban resilient urbanisation and demographic decline*	249, 208, 209
4a	*Urban driven de-urbanisation and demographic decline*	233, 245, 253
4b	*Rural driven urbanisation and demographic decline*	247, 234, 238
5	*Rural resilient de-urbanisation and demographic decline*	208, 225, 241
6	*Rural polarised de-urbanisation and demographic growth*	164, 221, 247

Table 6 *Demographic Factors of Change in National Degrees of Urbanisation model* nomenclatures and abbreviations, specific cases are reported in brackets

Classification	Name	Abbreviation
1a	*Rural driven de-urbanisation and demographic growth*	RDG
1b	*Urban driven urbanisation and demographic growth*	UDG
2	*Urban polarised urbanisation and demographic growth* *(Pure urban growth)*	UPG (PUG)
3	*Urban resilient urbanisation and demographic decline* *(Pure rural decline)*	URD (PRD)
4a	*Urban driven de-urbanisation and demographic decline*	UDD
4b	*Rural driven urbanisation and demographic decline*	RDD
5	*Rural resilient de-urbanisation and demographic decline* *(pure urban decline)*	RRD (PUD)
6	*Rural polarised de-urbanisation and demographic growth* *(Pure rural growth)*	RPG (PRG)

Table 7 Demographic Factors of Change in National Degrees of Urbanisation model nomenclatures and abbreviations of special cases

Name	Abbreviation
Rural to urban shift	R2U
Urban to rural shift	U2R
Stable urbanisation with demographic growth	SUG
Stable urbanisation with demographic decline	SUD

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