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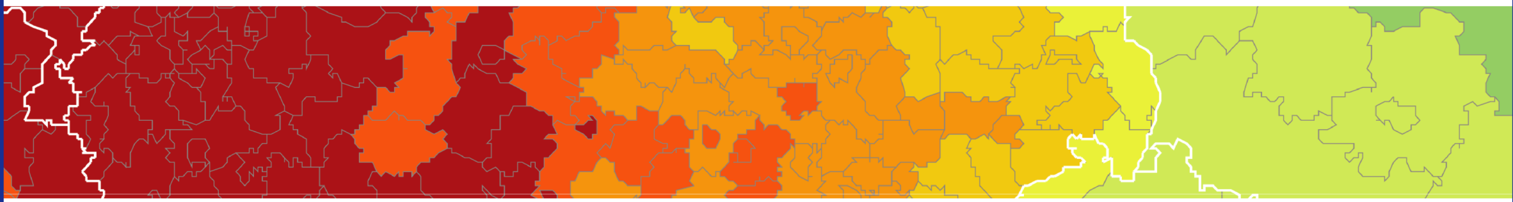

SUPER – Sustainable Urbanisation and Land Use Practices in European Regions

Applied Research

Annex 1 – Evidence on developments

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Annex 1 – Evidence on developments

SUPER – Sustainable Urbanisation and Land Use Practices in European Regions

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Abbreviations

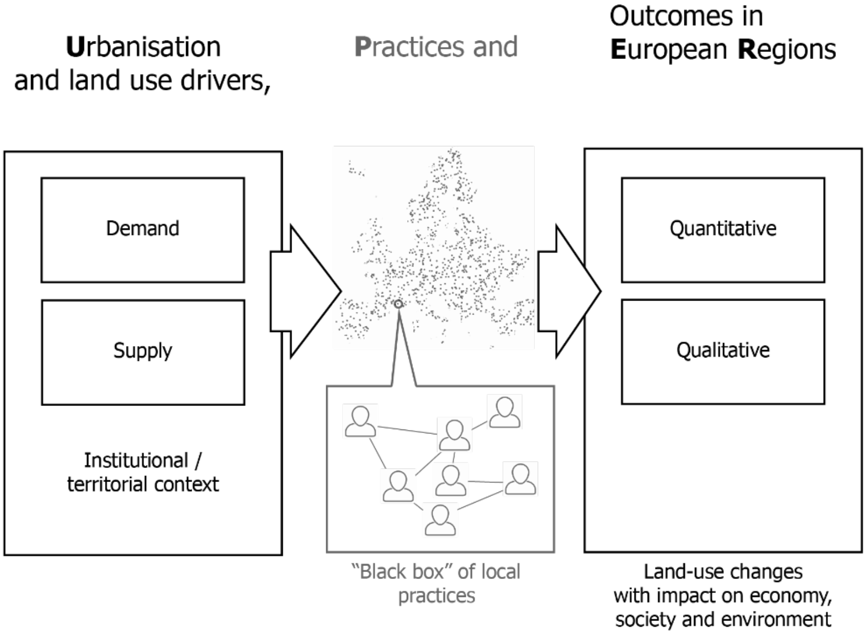
AESOP	Association of European Schools of Planning
ARTS	ESPON Assessment of Regional and Territorial Sensitivity
BBSR	Bundesinstitut für Bau-, Stadt- und Raumforschung (Federal Institute for Research on Building, Urban Affairs and Spatial Development)
CEMAT	Council of Europe Conference of Ministers Responsible for Spatial/Regional Planning
CLC	Corine Land Cover
COMPASS	ESPON Comparative Analysis of Territorial Governance and Spatial Planning Systems in Europe
EC	European Commission
ECP	ESPON Contact Point
ECTP	European Council of Town Planners
EEA	European Environmental Agency
ERDF	European Regional Development Fund
ESPON	European Territorial Observatory Network
ESPON EGTC	ESPON European Grouping of Territorial Cooperation
EU-LUPA	ESPON European Land Use Patterns
EU	European Union
GVA	Gross Value Added
ISOCARP	International Society of City and Regional Planners
ITI	Integrated Territorial Investments
JRC	EU Joint Research Centre
LCC	(Corine) Land Cover Change
LUE	Land Use Efficiency
MCA	Multi-Criteria Assessment
NUTS	Nomenclature of Territorial Units for Statistics
PBL	Netherlands Environmental Assessment Agency
POLITO	Politecnico di Torino
PCG	Project Coordination Group
SCBA	Societal Cost Benefit Analysis
SDG	Sustainable Development Goal
SPIMA	ESPON Spatial Dynamics and Strategic Planning in Metropolitan Areas
SUPER	ESPON Sustainable Urbanization and Land Use Practices in European Regions
TANGO	ESPON Territorial Approaches for New Governance
TIA	Territorial Impact Assessment

1 Introduction

This Annex to the Draft Final Report provides background information about drivers of land use change and actual land use changes for the ESPON SUPER project. Specifically, it provides information about how data was collected and methodological information about the analysis. It also presents an overview of the findings in the form of maps, tables and charts.

The focus of the ESPON SUPER project is on measuring and explaining urbanization in Europe with respect to sustainable urbanization and land use. A conceptual framework has been designed to this end based on previous own research as well as other recent literature. This framework illustrates the main relevant cause-effect relationships governing urbanization and land-use change according to the SUPER project (Figure 1.1).

Figure 1.1: Conceptual framework of ESPON SUPER. Practices will not be addressed in this Annex and are de-emphasized.



The purpose of this Annex is to present (mostly) quantitative evidence on urbanization and land-use change in Europe in the 2000-2018 period. Therefore, only some *drivers* (mainly demand-side) and some *outcomes* are considered here. The *practices*, or decision-making processes governing the conversion of land use, are not specifically considered in this annex.

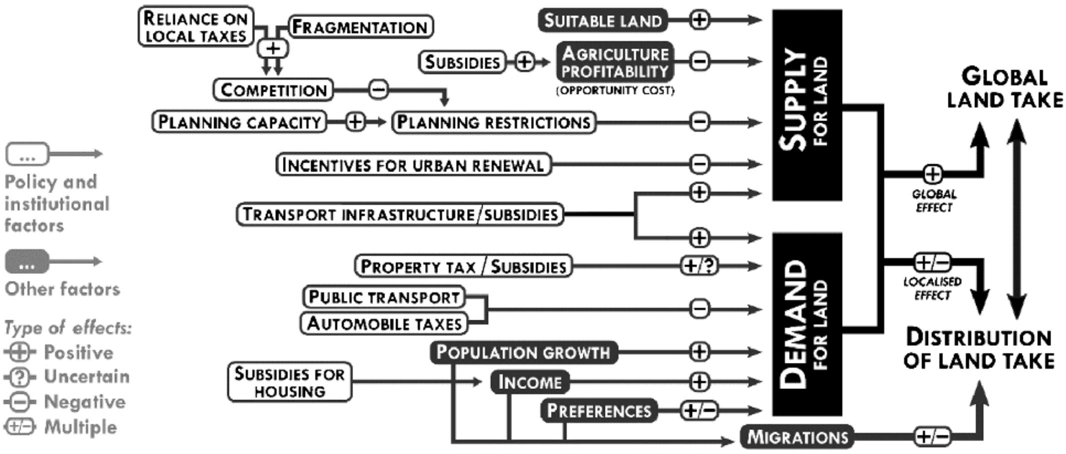
Drivers will be discussed in Chapter 2 and the outcomes in Chapter 3. Relationships between drivers and outcomes will be explored in Chapter 4, which assesses the evidence on developments. Finally, Chapter 5 places 'European regions' at the forefront by examining how urbanization and land-use change occurs within existing regional typologies and how new typologies can be constructed using the relevant quantitative and qualitative methodologies.

2 Evidence base on land use drivers and outcomes

2.1 Introduction & overview

Behind anthropogenic land use changes are socio-economic driving forces such as demographic and economic growth. In a recent meta-analysis Colsaet et al. (2018) surveyed journal articles on urbanization, land take and urban expansion. The results, based on 193 sources, are summarised in Figure 2.1, which illustrates how policy and institutional factors (interventions) and other (autonomous) factors produce pressures for land take (urbanization).

Figure 2.1: Main determinants of land take



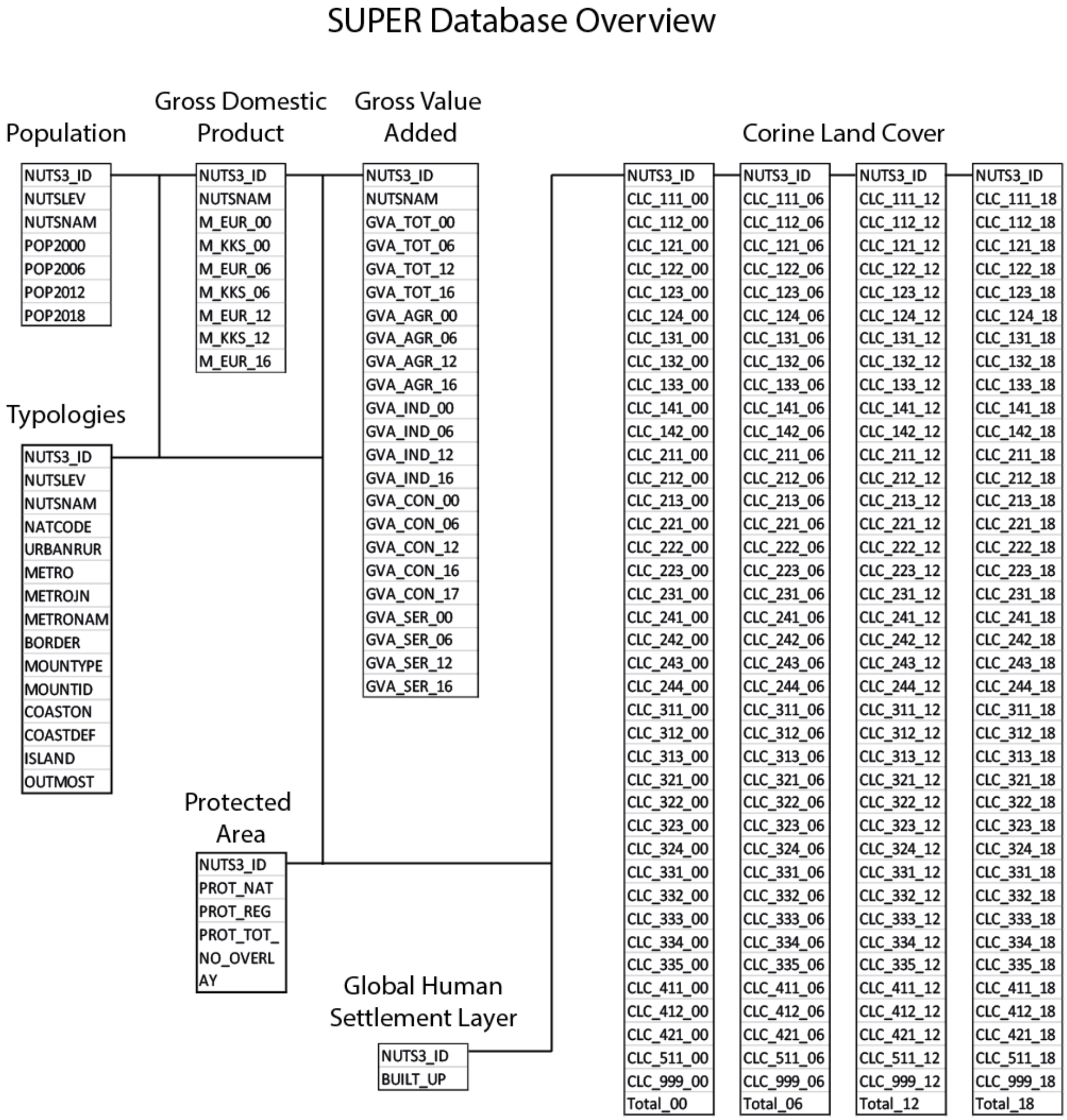
Source: Colsaet et al. (2018)

Colsaet et al. (2018) grouped drivers of urbanization into supply and demand factors. Supply-side factors, such as the profitability of land-use conversion (Couch et al. 2007), strategic land ownership and legal rights to develop, can play an important role in land use change. These factors are considered in the ESPON SUPER project in the analysis of interventions and case studies and are not collected at the pan-European level. This Annex concentrates solely on quantifiable demand-side drivers (more qualitative demand-side variables such as socio-cultural attitudes and adoption of technology are explored in the scenarios).

2.2 Data structure for ESPON SUPER

In order to perform the required analyses, the SUPER project created a tailor-made database which combines socioeconomic, environmental and land-cover data from various sources into a single Excel workbook to ensure maximum comparability, compatibility and ease of use. The table below provides a short overview. As far as possible, all data has been collected or converted into NUTS 3 (2016 boundaries) for the four Corine Land Cover measurement dates (2000, 2006, 2012 and 2018). The database has been adapted to allow for user-generated queries via the pivot table function.

Figure 2.2: Main structure of the SUPER quantitative database

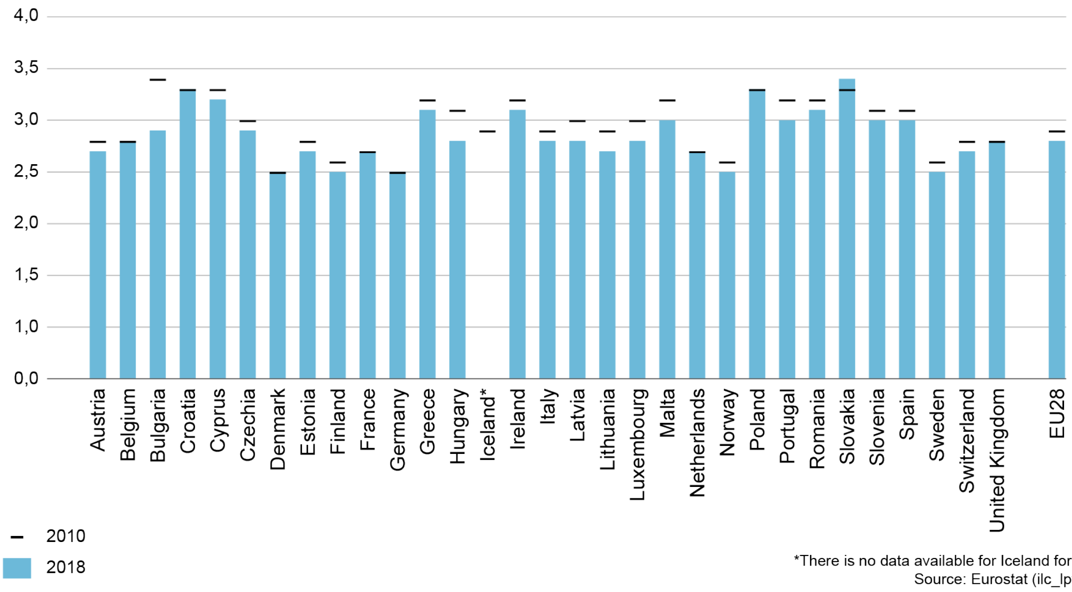


2.3 Drivers of land use change – statistical data & sources

2.3.1 Population

One of the main drivers of urbanization is residential development. It is the main component of 'discontinuous urban fabric' the largest urban indicator in terms of surface area in the land cover dataset. Homes are built for people, so their growth is obviously linked to population development. However, this driver is not linear as there are various intervening variables at play, such as housing affordability, cultural attitudes regarding cohabitation and second homes. A more appropriate indicator for predicting demand for homes would arguably be household development, but this is not as widely available as raw population data. Household sizes are decreasing in most European countries, mainly as a consequence of an increasing proportion of single-person households (Eurostat 2020), and is seen increasing only in Slovakia. Declining household size results in an increasing demand for housing even if the population size remains stable (see Figure 2.3).

Figure 2.3: Average household size in 2000 and 2018



*There is no data available for Iceland for 2018
Source: Eurostat (ilc_lpvh01)

As regards the data itself, the ESPON database includes relevant indicators at the NUTS 3 level on population and economic performance from 2000 to 2016. Unfortunately, the data refers to NUTS 2013 and not NUTS 2016. Eurostat population data estimates at the NUTS 3 level are currently only available for 2014 to 2018 and has significant gaps for many countries. To remedy these deficiencies, the ESPON SUPER project compiled a NUTS 3 population dataset using 2016 NUTS 3 units that correspond to the Corine reference years. This was done by processing existing Eurostat data, BBSR data of older Eurostat datasets, PBL data for the Netherlands and data from respective national statistical offices. In the end, all NUTS 3 regions, including the Western Balkan Countries and Turkey could be covered.

2.3.2 Economic growth

One of the main drivers of urbanization is economic. More economic growth creates demand for more industrial areas, warehouse space, shops and offices. This development can be quite independent of population development and follows a different logic in terms of the location and space requirements. Hairdressers and bakeries tend to locate near their customers, financial institutions near city centres or airports whereas shipping companies establish themselves near port facilities. More recent examples are large distribution centres being built at highway interchanges to accommodate the shift to online retail and data centres in areas with access to cheap electricity and internet centrality. Economic growth can also produce extra demand for residential development, for example, on second homes.

Data from the ESPON database and Eurostat comprised the basis for gross domestic product (GDP) and gross value added (GVA) data collection. Due to recent recalculations from Eurostat, the respective data no longer match those in the ESPON database. At the same time, some countries lack data for several years in the Eurostat tables. In this case, ESPON database information was used to fill gaps in the data.

2.3.3 Employment

Another measure for explaining land cover is employment, which usually bears a more direct relationship to demands for space than GVA. A financial or online company can earn phenomenal profits (GVA) with a very small physical footprint, whereas employees need a minimum amount of space to work and ancillary facilities, amenities and infrastructure. Given this, we should expect a direct relationship between employment growth and the development of land cover categories related to work.

The data on employment in the ESPON database originate from Eurostat and refer to the Labour Force Survey at the NUTS 2 level. Eurostat NUTS 3 employment data, however, proved to be rather complete, but missed data from many countries including France and the Netherlands. Older Eurostat datasets at the BBSR allowed some of missing information to be patched. A dataset on employment data for the Corine reference years now exists for the EU Member States. More efforts are required to expand this to EFTA countries, the Western Balkans and Turkey.

2.4 Outcomes in terms of land use changes – Land cover data

The physical outcome of land-use decisions is readily measurable due to the availability of increasingly accurate data based on satellite imagery. Thanks to the Corine Land Cover (CLC) dataset, we can ‘see’ the changing landscape of Europe over the past 18 years with a reasonable level of accuracy. It is also possible to make aggregate analyses of how the land is being converted in Europe and represent this e.g. in the form of a Sankey-diagram.

There has been earlier research in the ESPON programme focusing on land use and land use change, most importantly the ESPON European Land Use Patterns project (EU-LUPA, 2013). Since then, there have been several updates to the Corine Land Cover (CLC) dataset[1], including releases for 2012 and 2018 and a freely available separate dataset for land use changes at a higher resolution.

The CLC change maps provide information on land use changes at a minimal mapping unit of 5 hectares. This is important to keep in mind in the context of urbanization, which especially in the case of diffuse urbanization may take place at much smaller scale. In order to assess the consequences of this characteristic of the CLC dataset, we have run comparisons with other data sources: DLR's Global Urban Footprint (GUF) and JRC's Global Human Settlement Layer (GHSL). The results of these comparisons can be found in paragraph 2.5. These comparisons provide some nuance in interpreting CLC data. Because the temporal overlap between the GUF/GHSL and CLC is limited, it was not possible to make this combination a structural element of the data analysis for ESPON SUPER.

2.4.1 CLC data characteristics

The Corine Land Cover data provided by Copernicus, the earth observatory programme, coordinated and managed by the European Commission in partnership with the European Space Agency (ESA), comprises the basis for the analysis of the land-use structure, urbanization and land use dynamics in time in the SUPER project.

Corine data is offered in both raster and vector format. In this project, the vector format has been used for both the Corine land cover (CLC) and the Corine land cover changes (LCC) datasets. Using both the Corine land cover (CLC) and the Corine land cover changes (LCC) datasets from Copernicus for 2000, 2006, 2012 and 2018, both the state and flux were calculated at the NUTS 3 level using Corine vector datasets, ensuring high resolution output. Structural changes, but also flow analysis of land use, including the expansion of artificial areas – similar, but not exactly the same as the EEA indicator on 'land take' – for settlement purposes, can easily calculated at the NUTS3 level and for all Corine reference years and the time periods.

The minimal mapping unit for the Corine state data is 25 hectare, for the change data it is 5 hectare[2]. This means that land cover units with a contiguous area that it smaller than these MMU's are underrepresented. This has consequences for e.g. small-scale urbanization, which is underrepresented in the data. In one example, CLC measures an average urbanization rate for Belgium that is three times as low as figures based on smaller mapping units[3]. This is problematic for the measurement of urban sprawl, which often consists of small-scale developments and which is systematically underrepresented by Corine data. The effects of this data characteristic on reporting urbanisation vary from country to country, depending on e.g. the typical grain size of new urbanisation (see e.g. Tennekes, Harbers &

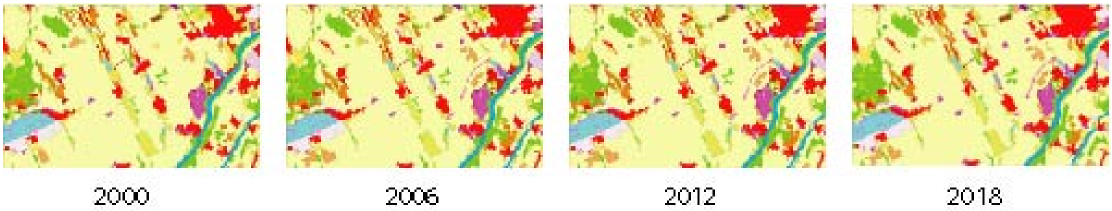
[1] ESPON SUPER uses CLC version 20 (dated 12/2018), whereas the most recent version available at the time EU-LUPA started was version 13 (dated 05/2010).

[2] https://land.copernicus.eu/pan-european/corine-land-cover

[3] See e.g. https://statbel.fgov.be/nl/themas/leefmilieu/grond/bodemgebruik

Buitelaar (2015). A further consequence of the difference in mapping units between state and change data is that totals for change data do not correspond with totals for differences in state data.

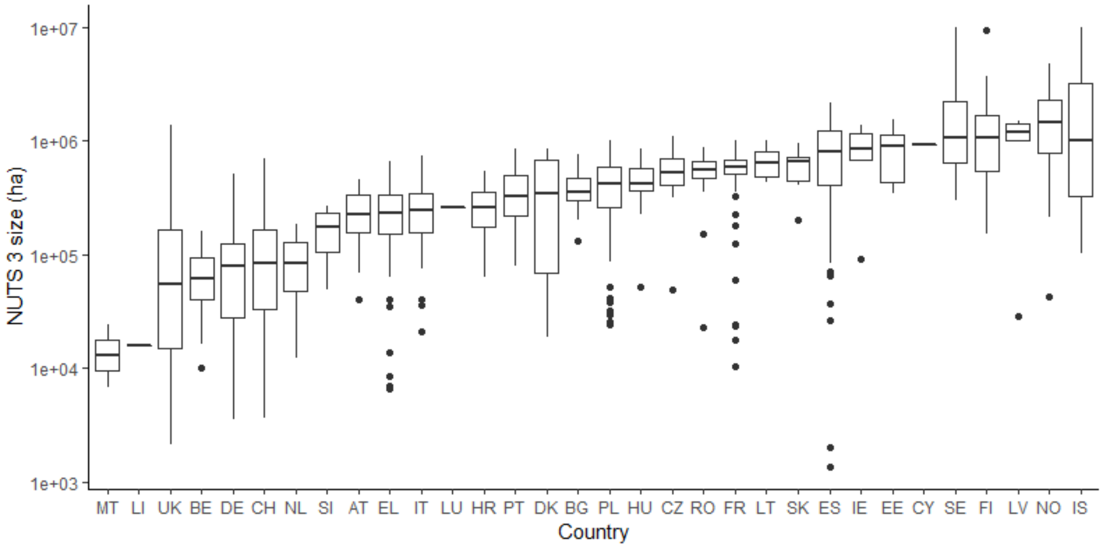
Figure 2.4: Corine reference years



2.4.2 CLC data aggregation – regions and land use classes

Data in SUPER has been collected and aggregated at the NUTS3 level, to allow for the combination of statistical information on drivers and geographic data on land use changes. The use of NUTS3 (or any pan-European nomenclature) has implications that should be taken into account. As can be seen in Figure 2.5, NUTS3 have variable sizes, ranging from 1,359 hectare (Melilla, Spain) to 10,029,160 hectare (Landsbyggd, Iceland). This is partially country-specific, as can be seen in the graph below. This means that absolute land use change, as well as land use change as percentage of the total area, gives a distorted image. Where possible, this is taken into account in the representation of data in this report, e.g. by reporting relative changes, e.g. urban land use change in the period 2000-2018 relative to urban land use in 2000.

Figure 2.5: Boxplot distribution of NUTS3 sizes per country



Corine works with 44 land cover classes, organized into 5 main categories: 'artificial surfaces', 'agricultural areas', 'forest and semi natural areas', 'wetlands' and 'water bodies'. For our analysis of sustainable land use, we have predominantly looked at these classes in 11 groups, distinguishing several types of urban and non-urban use (Table 2.1). Mineral extraction sites and dump sites are artificial areas that are not considered urban. Construction sites should be analysed with some care as this land cover type can indicate a transition towards either urban or non-urban use, but in this analysis are included in urban land. Green urban areas and sport and leisure facilities are not a form of soil sealing, but they are for urban use. This leads to five main groups: urban, non-urban artificial, agriculture, terrestrial nature and water-related nature.

Table 2.1: CLC land use classes as categorised in the SUPER project

Urban use		Urban use	
Urban – Urban fabric		**Urban - Industrial**	
111	**Continuous urban fabric**	121	Industrial or commercial units
112	**Discontinuous urban fabric**	**Urban – Infrastructure**	
Urban – Construction sites		122	Road and rail and associated land
133	**Construction sites**	123	Port areas
		124	Airports
Non-urban artificial		**Urban use**	
Artificial – Mineral extraction sites		**Urban – Urban green**	
131	**Mineral extraction sites**	141	Green urban areas
Artificial – Dump sites		142	Sport and leisure facilities
132	**Dump sites**		
Agriculture		**Agriculture**	
211	**Non-irrigated arable land**	231	Pastures
212	**Permanently irrigated land**	241	Annual crops with permanent crops
213	**Rice fields**	242	Complex cultivation patterns
221	**Vineyards**	243	Agriculture with natural vegetation
222	**Fruit trees and berry plantations**	244	Agroforestry areas
223	**Olive groves**		
Terrestrial nature		**Terrestrial nature**	
Vegetated		**Non-vegetated**	
311	**Broad-leaved forest**	331	Beaches, dunes, sands
312	**Coniferous forest**	332	Bare rocks
313	**Mixed forest**	333	Sparsely vegetated areas
321	**Natural grasslands**	334	Burnt areas
322	**Moors and heathland**	335	Glaciers and perpetual snow
323	**Sclerophyllous vegetation**		
324	**Transitional woodland-shrub**		
Wetlands and water bodies		**Wetlands and water bodies**	
411	**Inland marshes**	511	Water courses
412	**Peat bogs**	512	Water bodies
421	**Salt marshes**	521	Coastal lagoons
422	**Salines**	522	Estuaries
423	**Intertidal flats**	523	Sea and ocean

2.5 Comparison of CLC with other sources of land use information

Combined with other sources, the Corine data allow for an in-depth analysis of land-use developments that go beyond land cover but provides insight into potential land use, density and other qualities. Still, there are some problems with this data. For example, the so-called minimal mapping unit for the Corine state data is 25 ha, but the change data is measured at the 5 ha level. This means that land cover units with a contiguous area smaller than these minimal mapping units are underrepresented, which, in turn, means that small-scale urbanization is also underestimated. For example, the Corine database measures an average urbanization rate for Belgium several times lower than nationally collected data based on smaller mapping units.[4] Another consequence of the difference in mapping units for state and change data is that totals for change data do not correspond with totals for differences in state data, as some development observed in the high-resolution change data vanish when aggregated to the change-state data.

Given that no suitable alternative to Corine exists, we must accept that the analyses in some cases will be skewed in this manner. We can however quantify the skew inherent in CLC by comparing it with data from other sources. As every dataset has its own biases this does not resolve the problem completely, but the comparison can help us interpret the data with more nuance.

2.5.1 Global Urban Footprint (GUF)

Description of the data

The Global Urban Footprint data was collected for the ESPON countries excluding overseas territories. The data (GUF_DLR_v02) is a binary product in tiles of 5 degrees by 5 degrees; with a pixel size of in 0.4 arcsec from the equator up to 55˚N, increasing up to 1.2 arcsec from 85˚N northwards. The data seeks to register built-up area, where "built-up area is defined as a region featuring man-made building structures with a vertical component". The Global Urban Footprint database provides information on built-up areas for 2011 at approximately 12 m resolution.

Method for combining GUF with CLC

The GUF raster tiles were combined in a catalogue and converted into polygons. The polygon file was then combined with the CLC polygon data (function: union). The combined CLC-GUF file was then combined with geometries for NUTS3 areas (NUTS3 2016). The attribute table of this combined file was exported and recast as a table with each entry providing a surface area for a unique combination of NUTS3, CLC class and GUF urbanization class.

[4] This has important policy implications, as the current ambition of 3ha/day would entail cutting land-take in half from a national perspective, but from our perspective using Corine, allow for a significant increase in land take.

Figure 2.6: GUF urban footprint data for Europe and surroundings

Source: GUF website

Analysis

When using CLC to draw conclusions on urbanization, we can identify two types of errors. In the first case, CLC presents urban areas where there is no urban footprint. This leads to an overrepresentation of actual urbanised area, and may result in underestimations of new urbanization if this takes place in areas already designated urban. This phenomenon is especially prominent in Belgium, which had a fine-grained urbanization pattern in 2000 (Figure 2.7 below). In the second case, CLC does not register urban areas even though there is an urban footprint. This leads to an underrepresentation of actual urbanised area, and may result in overestimations of new urbanization, e.g. when an existing small urban area crosses over the registration threshold due to relatively liminal new construction. An example of such underrepresentation can be seen in the eastern outskirts of Warsaw. This distinction can be illustrated further by considering Figure 2.7 (Liège). This urban area has considerable spaces to the East and south which are very low in concentration. The ribbon development to the East could continue along the same roads without being noticed by Corine, for example. When combined with population data this could result in an erroneous finding that new urbanization is highly efficient and sustainable because it makes use of existing built-up areas. In fact, homes are still being built, but just not registered. Rather than urban containment, diffusion is occurring.

Spurious conclusions could also be drawn in instances of low concentration, as the example of Warsaw shows (Figure 2.9). To the east of the city, the urban form in Corine seems more compact that it really is because the very diffuse urbanization is still being registered as agricultural. When combined with population data, this would give the impression of a vital rural area, where in fact it may be a rural area losing its function due to development pressure. Moreover, the amount of buildings in this rural area – even if they are devoted to agricultural use – still has implications for soil sealing, water retention, and hence sustainability.

Figure 2.7: CLC-GUF comparison for Liège and surrounding area. GUF in black, CLC main classes in coloured overlay: urban (red), industry/commerce (purple), infrastructure (grey), agriculture (yellow), nature (green), water (blue). The approximate position of Figure 2.8 is shown in black outline.

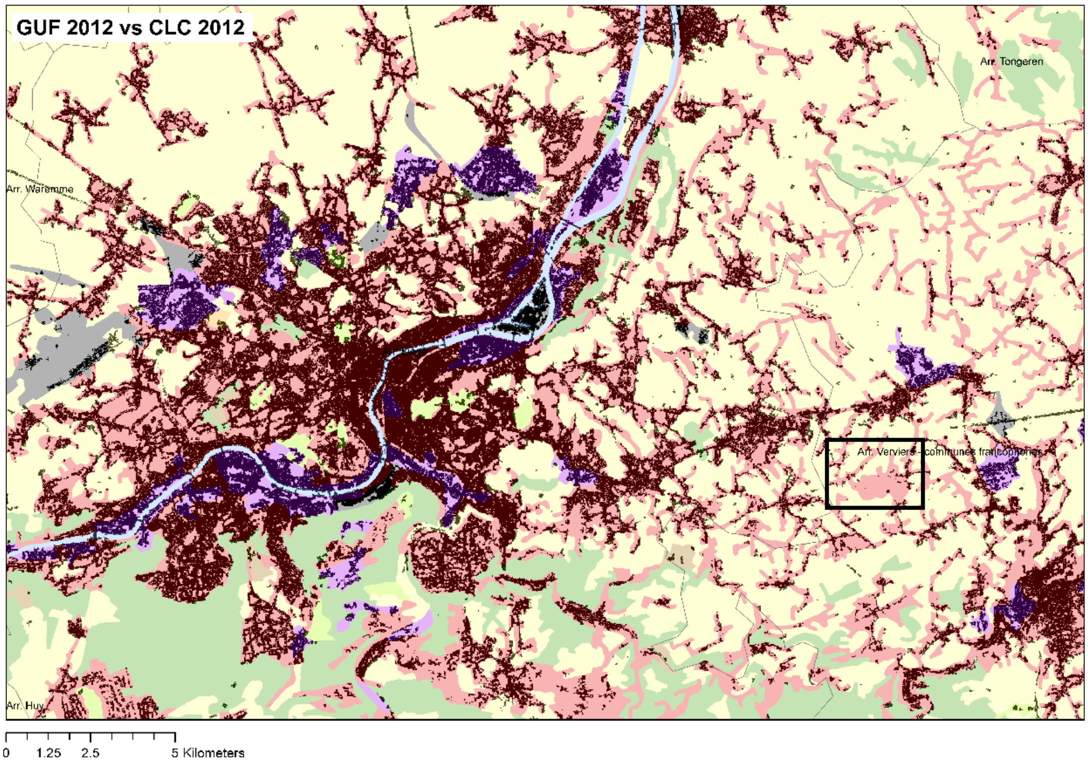
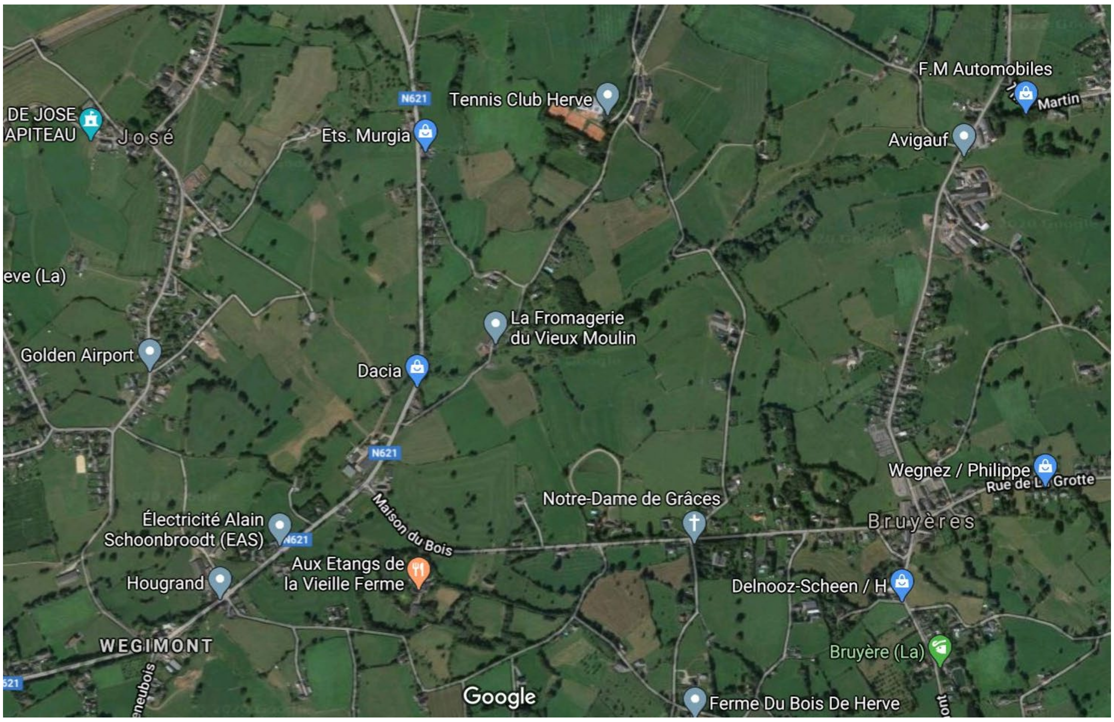


Figure 2.8: Google maps screenshot for a sample area where CLC shows linear urbanisation with limited GUF footprints



In order to assess both these phenomena, we calculated two indicators for each NUTS3, based on the comparison between CLC and GUF. The first indicator shows, at the level of an administrative area, how much of CLC urban use areas contains an urban footprint according to the GUF data: this indicator is called *saturation*. The second indicator shows, at the level of an administrative area, which proportion of the urban footprint lies within CLC urban use areas: this indicator is called concentration. For ease of interpretation, we sometimes use the inverse of these figures, reporting how much of CLC urban use areas do not register an urban footprint, or how much of the urban footprint in a region lies outside of CLC urban areas (e.g. Map 2.1).

This distinction can be illustrated further by considering Figure 2.7 (Liège). This urban area has considerable spaces to the East and south which are very low in concentration. The ribbon development to the East could continue along the same roads without being noticed by Corine, for example. When combined with population data this could result in an erroneous finding that new urbanization is highly efficient and sustainable because it makes use of existing built-up areas. In fact, homes are still being built, but just not registered. Rather than urban containment, diffusion is occurring.

Spurious conclusions could also be drawn in instances of low concentration, as the example of Warsaw shows (Figure 2.9 - Figure 2.11). To the east of the city, the urban form in Corine seems more compact than it really is because the very diffuse urbanization is still being registered as agricultural. When combined with population data, this would give the impression of a vital rural area, where in fact it may be a rural area losing its function due to development pressure. Moreover, the amount of buildings in this rural area – even if they are devoted to agricultural use – still has implications for soil sealing, water retention, and hence sustainability.

Figure 2.9: CLC-GUF comparison for eastern Warsaw and surrounding area. GUF in black, CLC main classes in coloured overlay: urban (red), industry/commerce (purple), infrastructure (grey), agriculture (yellow), nature (green), water (blue). The approximate position of Figure 2.10 is shown in black outline.

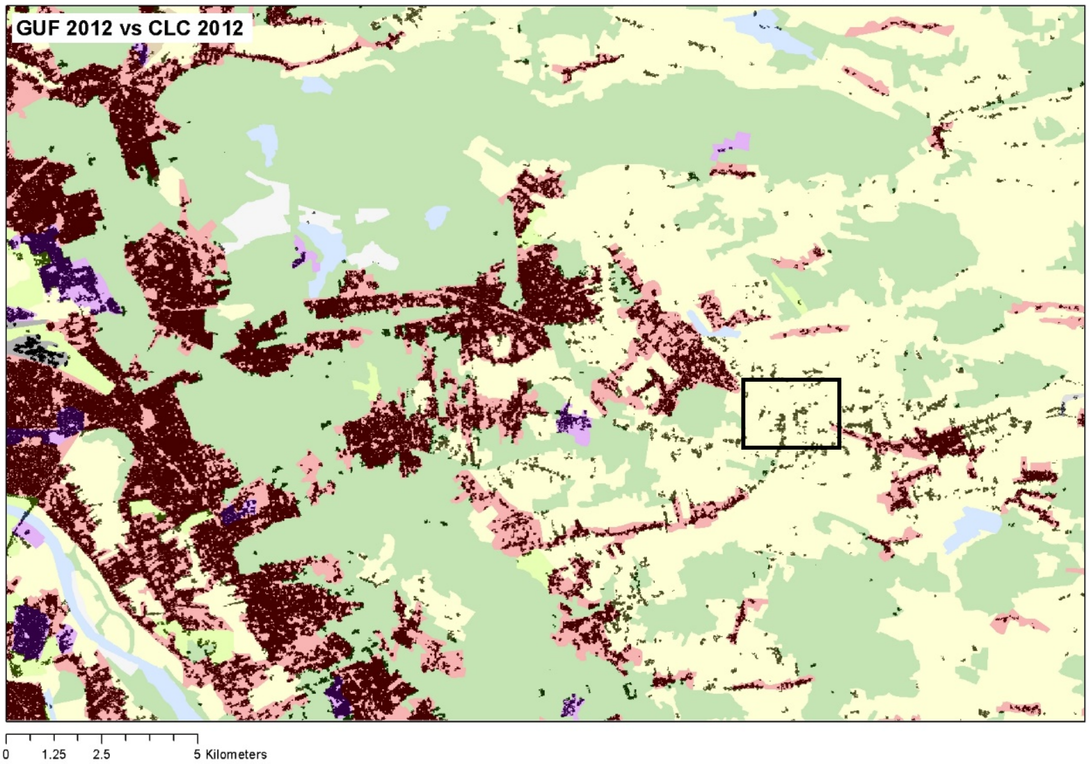


Figure 2.10: Google maps screenshot for a sample area where CLC does not register urbanisation.

Figure 2.11: Google streetview screenshot from the Wielgolas Brzezinksi area in Figure 2.10.

Results

The GUF saturation and concentration information provide nuance with respect to the interpretation of Corine Land Cover data. Across the territory covered (ESPON space on the European continent), 21% of all urban footprint lies outside of CLC urban use areas, or in absolute terms, 29,220 km^2 of GUF urban fabric situated outside of CLC urban land classes. Of the area that lies within CLC urban use classes, 45% does not register an urban footprint (some of this concerns urban green and empty lots). Map 2.1 shows for each NUTS3 region the overall saturation and concentration in combination. Shades of brown show underestimation of urban footprint by CLC, shades of blue show overestimation of urban footprint by CLC. When there is both a low saturation and a low concentration, errors in representing the amount of urban land use may balance each other out (grey-black), but the spatial distribution of urban area based on GUF and CLC will differ.[5]

There are clear differences between highly urbanised NUTS3 regions and rural regions on these two indicators (see Table 2.2). The average concentration in predominantly urban regions is 89%, whereas in rural regions it is 72%, indicating that urban areas have less diffuse development than rural areas. For saturation, these numbers are 72% and 50% respectively: urban areas are more ‘filled in’ than rural areas. There are also clear national differences. National saturation figures range from 23% (Finland) to 77% (Malta), and concentration figures from 55% (Portugal) to 93% (Bulgaria). It is unclear whether these

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[5] All datasets have their errors, and therefore not all differences between CLC and GUF should be attributed to CLC: the GUF also shows inaccuracies in registering buildings, e.g. not registering all buildings in wooded areas.

differences stem from differences in classification between national classification teams for Corine, or whether they stem from actual differences in urban morphology. Whatever the reason, these differences demonstrate that the utmost care should be taken when interpreting differences between countries in urban land cover based on Corine data.

Map 2.1: Representation of Global Urban Footprint data in CLC urban use at the NUTS3 level.

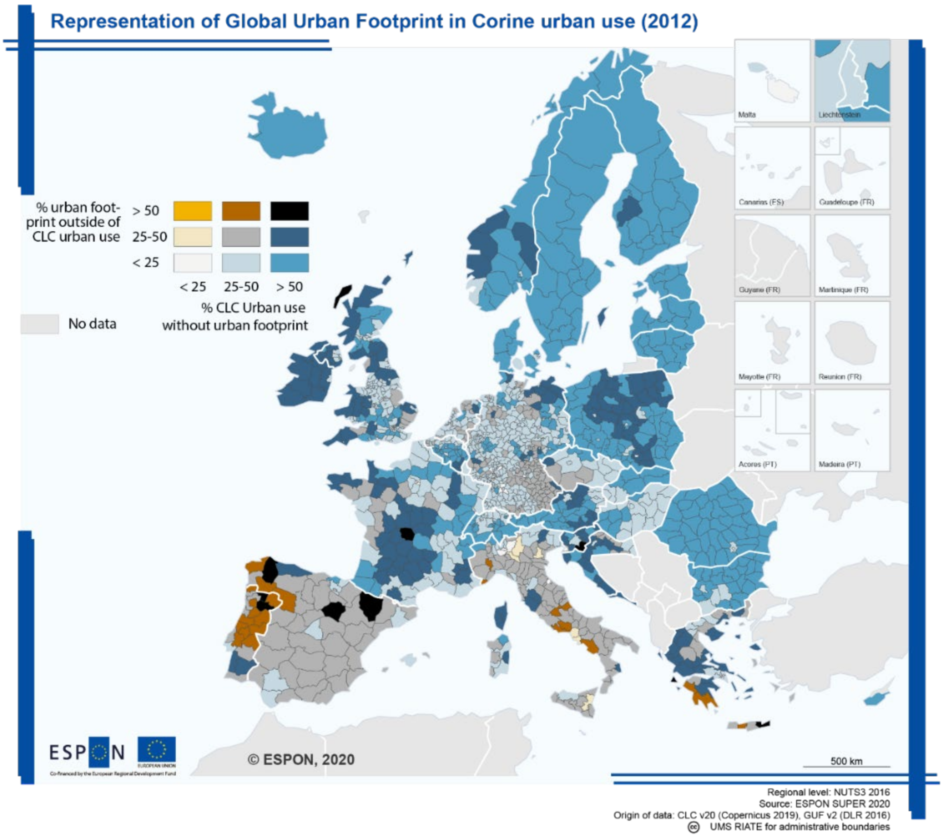


Table 2.2: National figures for saturation and concentration split according to Eurostat NUTS3 urban-rural typology

Satu-ration	Urban	Inter-mediate	Rural
AT	61%	49%	38%
BE	56%	50%	34%
BG	67%	43%	36%
CH	59%	49%	41%
CY		60%	
CZ	66%	55%	55%
DE	72%	63%	60%
DK	74%	56%	53%
EE	30%	34%	24%
EL	74%	70%	63%
ES	70%	65%	60%
FI	32%	22%	20%
FR	65%	57%	49%
HR	60%	52%	48%
HU	85%	61%	53%
IE	70%	51%	51%
IS	73%		36%
IT	75%	67%	64%
LI	49%		
LT	44%	36%	34%
LU		55%	
LV	53%	29%	24%
MT	77%		
NL	74%	68%	68%
NO	51%	45%	35%
PL	55%	40%	38%
PT	64%	57%	64%
RO	74%	39%	34%
SE	38%	39%	30%
SI		59%	50%
SK	63%	51%	51%
UK	74%	65%	55%
Europe	68%	54%	45%

Concen-tration	Urban	Inter-mediate	Rural
AT	94%	86%	76%
BE	90%	84%	79%
BG	95%	92%	93%
CH	91%	85%	84%
CY		83%	
CZ	80%	83%	71%
DE	92%	83%	74%
DK	98%	81%	76%
EE	92%	77%	81%
EL	84%	63%	63%
ES	78%	63%	47%
FI	92%	88%	82%
FR	88%	81%	71%
HR	91%	76%	71%
HU	98%	89%	90%
IE	95%	72%	59%
IS	98%		83%
IT	73%	65%	59%
LI	89%		
LT	76%	85%	84%
LU		86%	
LV	98%	86%	80%
MT	80%		
NL	80%	73%	74%
NO	91%	79%	77%
PL	90%	79%	72%
PT	76%	55%	43%
RO	93%	92%	91%
SE	90%	86%	83%
SI		75%	66%
SK	91%	89%	88%
UK	90%	77%	65%
Europe	85%	78%	72%

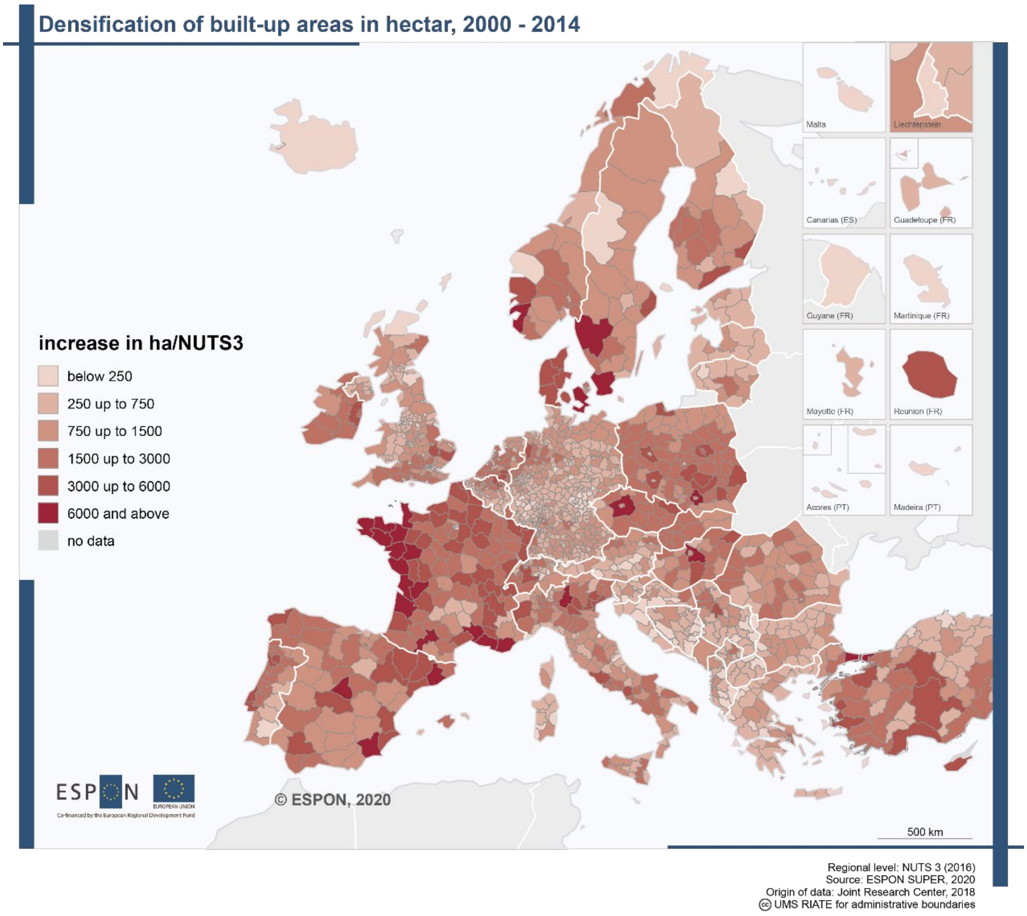
2.5.2 Global Human Settlement Layer (GHSL)

Another dataset offering information relevant for urbanisation is the Global Human Settlement Layer (GHSL) built-up presence dataset. A map offering GHSL densities was produced for SUPER so that it might be compared with CLC data. As a result of this processing, land-use developments should be visible at a greater morphological sensitivity.

Methodology

The Global Human Settlement (GHSL) framework produces global spatial information on built-up areas, population density and settlements for 1975, 1990, 2000 and 2014. For our analysis, the built-up area density data (GHS-BUILT) with the 250m raster resolution[6] of the years 2000 and 2014 have been used for comparison with CLC in the urban use categories. The GHSL information percentage of built-up area per raster cell was recalculated in absolute figures (see Map 2.2). Because absolute figures were chosen for the map below, larger areas will also tend to show more new built-up area.

Map 2.2: Densification in terms of GHSL built-up area.



[6] This means each pixel covers 6.25 hectares (2.5^2).

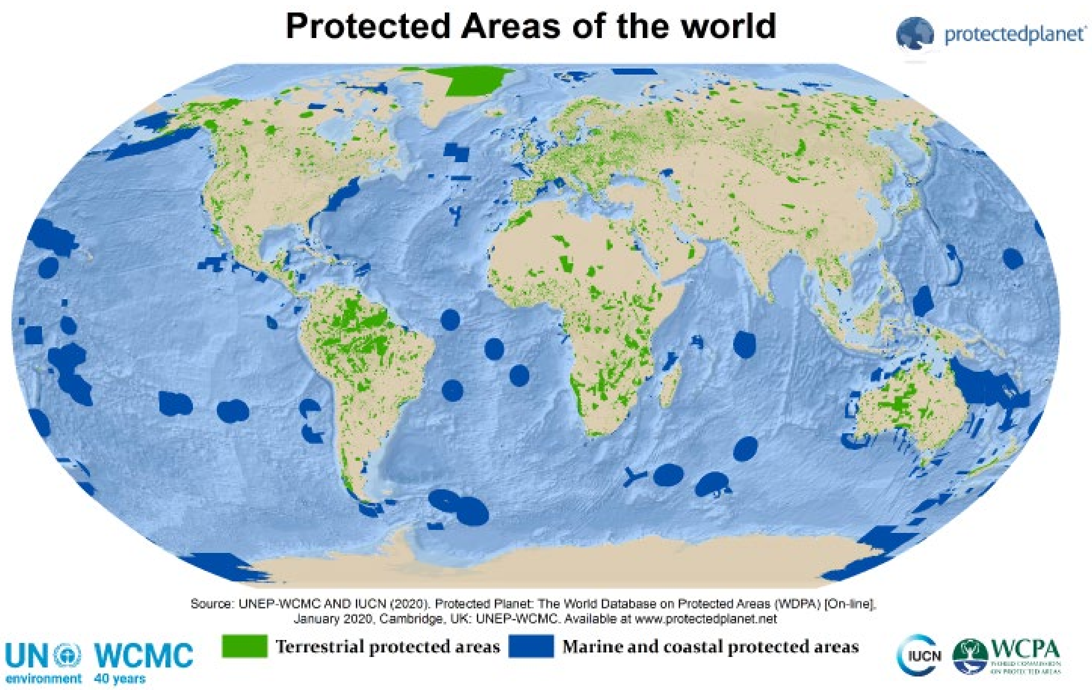
2.5.3 The Word database of Protected Areas

The worldwide database of protected areas results from a joint activity of the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas (WDPA).

The WDPA information is based on detailed geographical vector data. It includes both national protected landscapes and national parks as well as internationally designated protected areas. In Europe this for example covers the Natura 2000 areas. Multiple designations are part of this dataset, which can in cases overlap with one another.

In order to gain an overall picture of protected area in quantitative terms, the overlapping areas (e.g. both a national landscape park and Natura 2000) have been subtracted in the total amount of protected areas via a symmetrical difference function in GIS. Analysis of this data is done in paragraph 4.2 where land use changes in protected areas are discussed.

Figure 2.12: Coverage of world database on protected areas



Source: UNEP-WCMC

3 Evidence on land-use developments

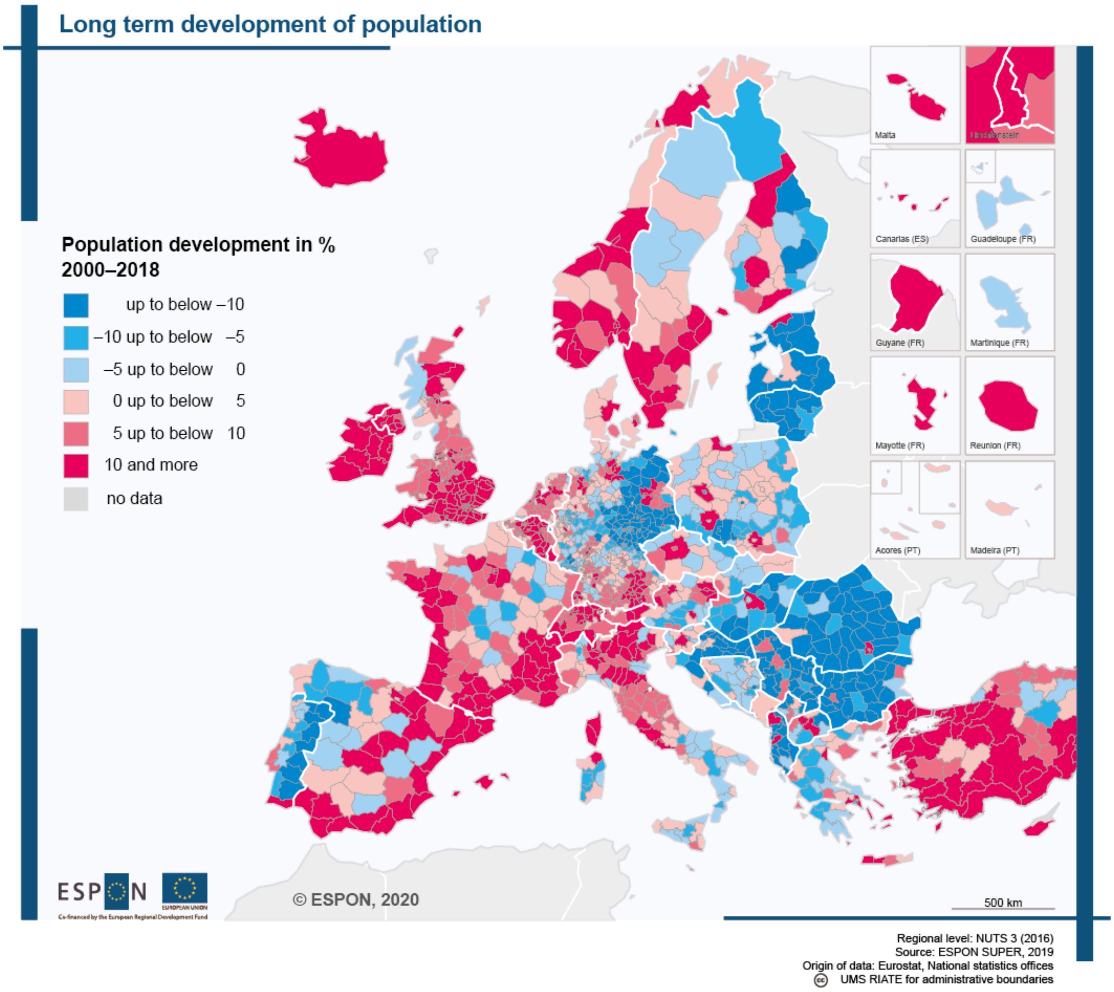
3.1 Structures and trends of drivers of land use changes

3.1.1 Population

Population change is one of the key drivers for urbanisation. Although other factors such as number of households and real-estate markets play an important modifying role on the effect of population on urban land use change, data on these factors was not available at the NUTS3 level across the ESPON space, and could not be used. Only population data is therefore used here for demographic analysis. Aside from aggregated population change we zoom in on migration later in this paragraph.

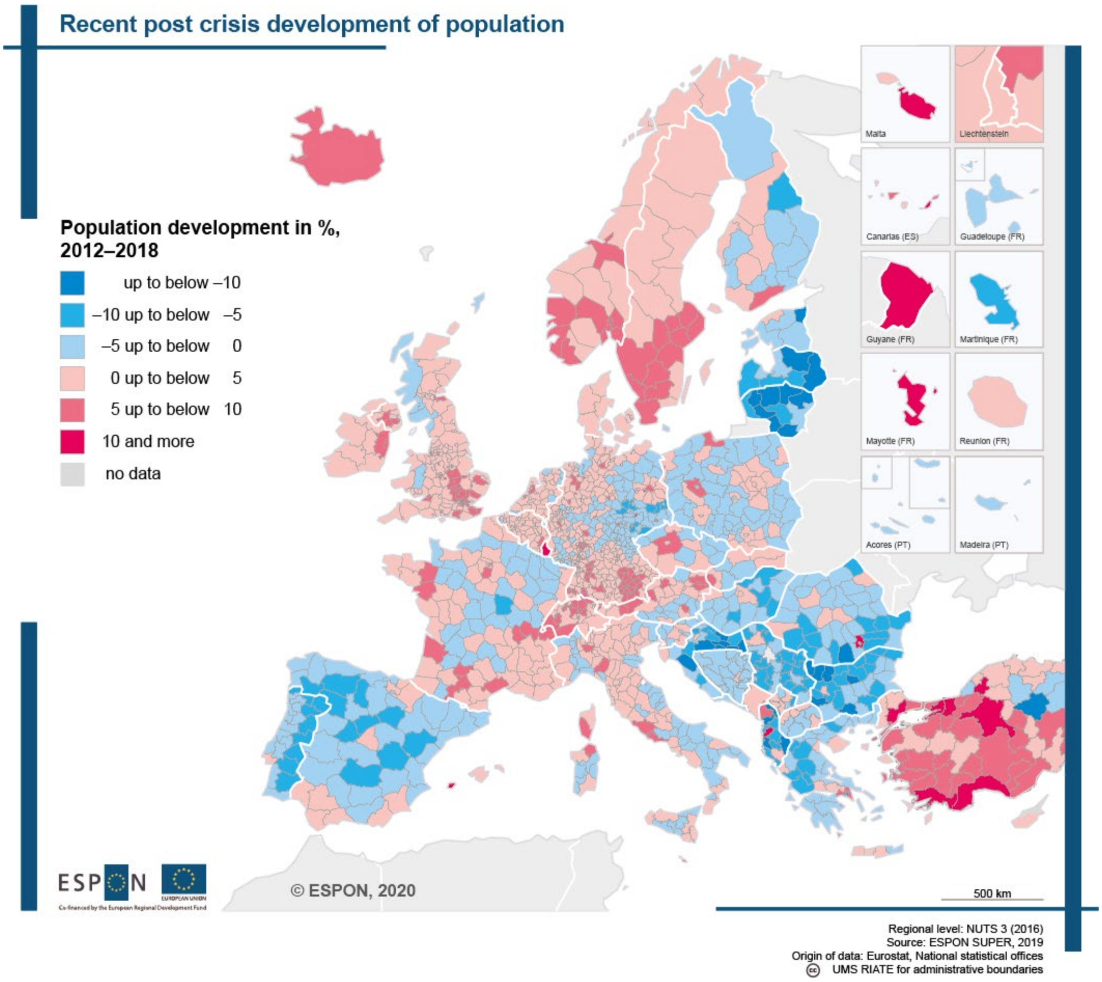
The regions with the highest growth rates in population in a long-term perspective over the period from 2000 to 2018 are definitely the metropolitan und urban regions followed e.g.in France and Spain by the coastal regions. Almost every country shows distinct regional concentration of growth and unbalances between growth and shrinking areas.

Map 3.1: Long term development of population



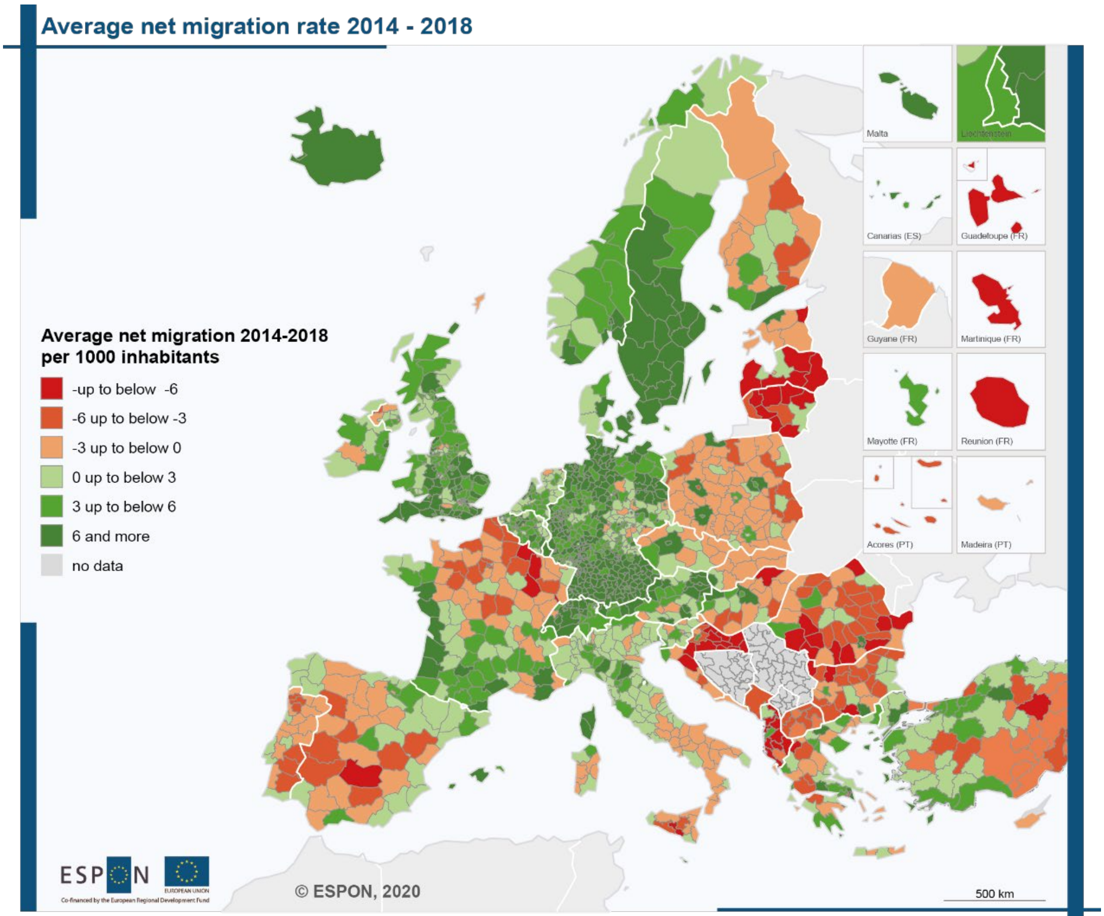
A more focused view on the last years underlines the speed at which demographic trends might change due to economic factors and migration patterns. Changing demographic trends also raise the question on the sustainability of observed land-use changes, for example in regions growing in population in the past but decreasing in population in recent years. Spain is the most striking example in this respect, but depopulation in metropolitan regions, for example, does not just reduce potential demand on land, they also raise questions on the sustainability of land use changes related e.g. to infrastructure.

Map 3.2: Recent post-crisis development of population



Migration is integral to demographic trends, and plays a role both within and between countries, as Map 3.3 shows. It increases regional contrasts between source and target regions. Migration amplifies demands on land use especially in destination regions and might impact societal demands for land. Out-migration can be seen in many East European areas outside the urban context, but also in parts of France and Spain. High in-migration rates as part of the demographic trends point to hotspots of potential high pressure on land mainly in the broader urban context, but also in many regions outside of urban areas.

Map 3.3: Recent post-crisis net migration rate



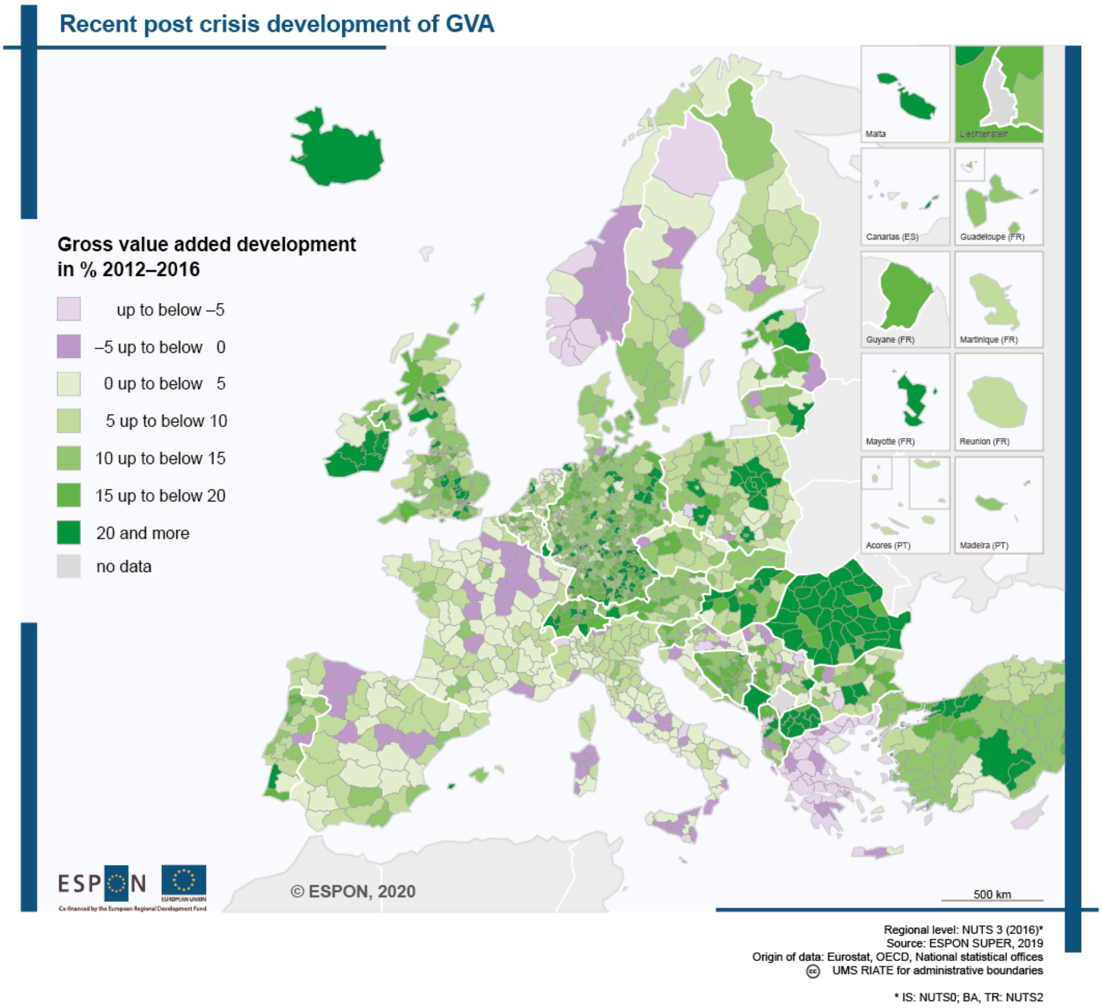
Regional level: NUTS 3 (2016)
Source: ESPON SUPER, 2020
Origin of data: Corine Landcover, 2019
© UMS RIATE for administrative boundaries

3.1.2 Economic growth

One of the main drivers of urbanization is economic development. Growth creates demand for industrial areas, warehouse space, shops and offices. This development can be quite independent of population development and follows a different logic in terms of the location and space requirements. Hairdressers and bakeries tend to locate near their customers, financial institutions near city centres or airports whereas shipping companies establish themselves near port facilities. More recent examples are large distribution centres being built at highway interchanges to accommodate the shift to online retail and data centres in areas with access to cheap electricity and internet centrality.

Economic growth can produce additional demand for residential development through demand for second homes. Second homes and tourism can be an important factor of urbanisation regionally, especially in rural areas, although unfortunately pan-European data at the NUTS3 level for this driver of land use change is still lacking.

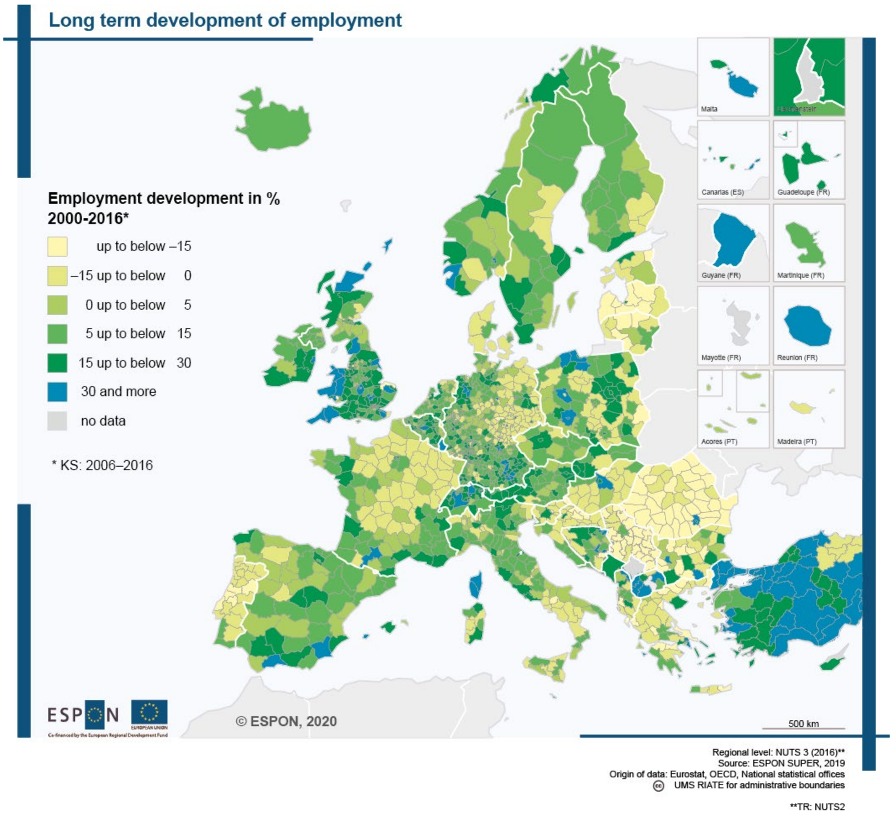
Map 3.4: Recent post-crisis development of GVA (nominal GVA at current market prices)



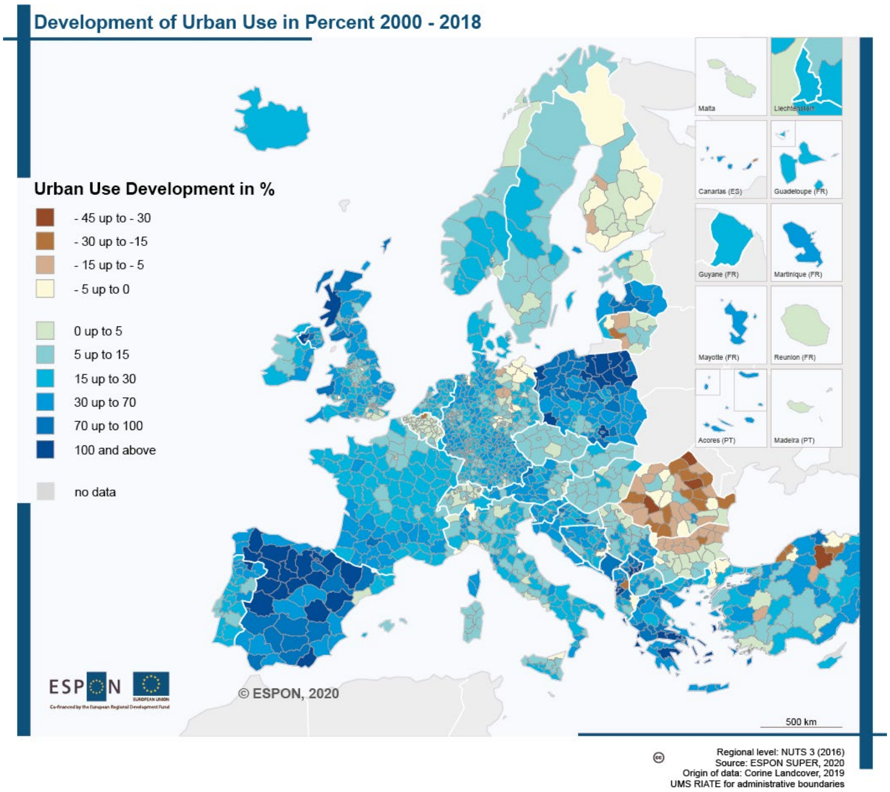
3.1.3 Employment

Another measure for explaining land cover is employment, which usually bears a more direct relationship to demands for space than GVA. A financial or online company can earn phenomenal profits (GVA) with a very small physical footprint, whereas employees need a minimum amount of space to work and ancillary facilities, amenities and infrastructure. Given this, we should expect a direct relationship between employment growth and the development of land cover categories related to work. This can be seen if we compare Map 3.5 and Map 3.6).

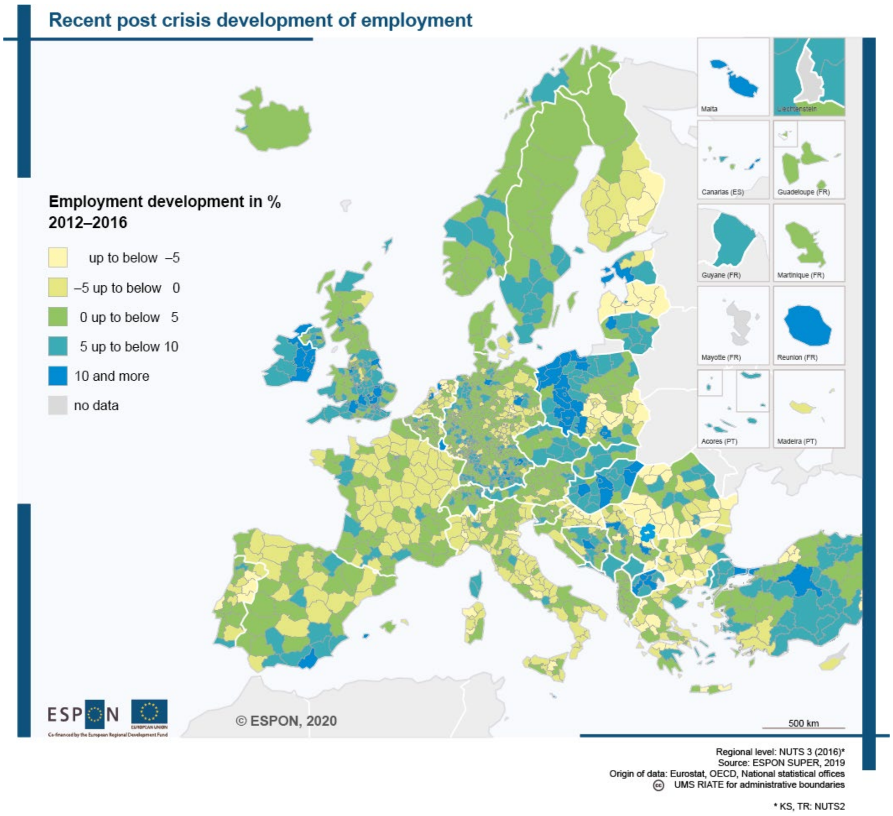
Map 3.5: Long-term development of employment



Map 3.6: Long-term development of urban use



Map 3.7: Recent post-crisis development of employment



3.2 CLC land cover changes

Central to understanding the land-use developments is the analysis based on the Corine Land Cover data provided by the Copernicus Institute. We have made use of the data for 2000, 2006, 2012 and 2018, and the land use changes in between these periods. Total land use state and change data has been calculated for all CLC classes per NUTS3 (2016) region. To simplify the presentation of the Corine data, we grouped the various classes into five main categories: urban, non-urban artificial, agriculture, terrestrial nature and water-related nature (see Table 2.1). At times, these were grouped further to just urban, agriculture and terrestrial nature (which contain all categories).

3.2.1 Aggregate land-use change

In 2000, excluding water and across the ESPON countries, urban areas took up 4.0% of all territory, other non-urban artificial areas 0.2%, agriculture 45.3%, nature 50.6%. In 2018 these proportions were respectively 4.8%, 0.2%, 44.1% and 50.9%. Countries that stand out with a high proportion of urban area (in 2000) are Malta (28.2%), Belgium (20.4%), the Netherlands (13.4%) and Lithuania (11.3%). The countries with the highest share of agricultural land are Ireland (82.7%), Denmark (79.2%), the Netherlands (74.6%) and Hungary (69.4%). For natural areas, the highest proportions are found in Iceland (96.9%), Norway (93.1%), Sweden (88.1%) and Finland (88.0%).

The Corine data allows us to track changes in land use across the ESPON territory over the 2000-2018 period. During this time, a little under 2.87 million hectares of land changed from one main category to another (see Table 3.1). Almost half (1.26 million ha or 44%) concerned a conversion to urban land. As a result, artificial land cover increased from 19.2 million to 22.6 million hectares, the vast majority of which (18.5 million in 2000 and 21.8 million in 2018) concerned urban use; the rest regarded mineral extraction and dump sites. New urban land mostly came from agricultural land (78%), although in Scandinavian countries (except Denmark), Croatia, Greece, Iceland and Portugal this was terrestrial nature. Some NUTS3 in Austria and the UK (Scotland) also saw a majority of new urban land coming from natural areas. Only in Romania (-0.8%) and Bulgaria (-0.1%) did the share of urban land decrease between 2000 and 2018. With respect to possible deurbanization, approximately 176,000 ha concerned transitions away from urban or other artificial land, with the latter in the majority (69%). This land has been converted in equal proportions to agriculture and terrestrial nature, and a smaller part to water-related nature. Over half of these conversions took place in four countries: Germany (21%), Spain (15%), the UK (10%) and Poland (9%). In total, 8.6 times more land was converted to urban/artificial use than vice versa. Finally, 8,800 ha of artificial land was converted to urban use, mainly in Spain (19%), Germany (16%) and the UK (16%).

Table 3.1 Sum of land-use change (ha) in ESPON countries between 2000 to 2018

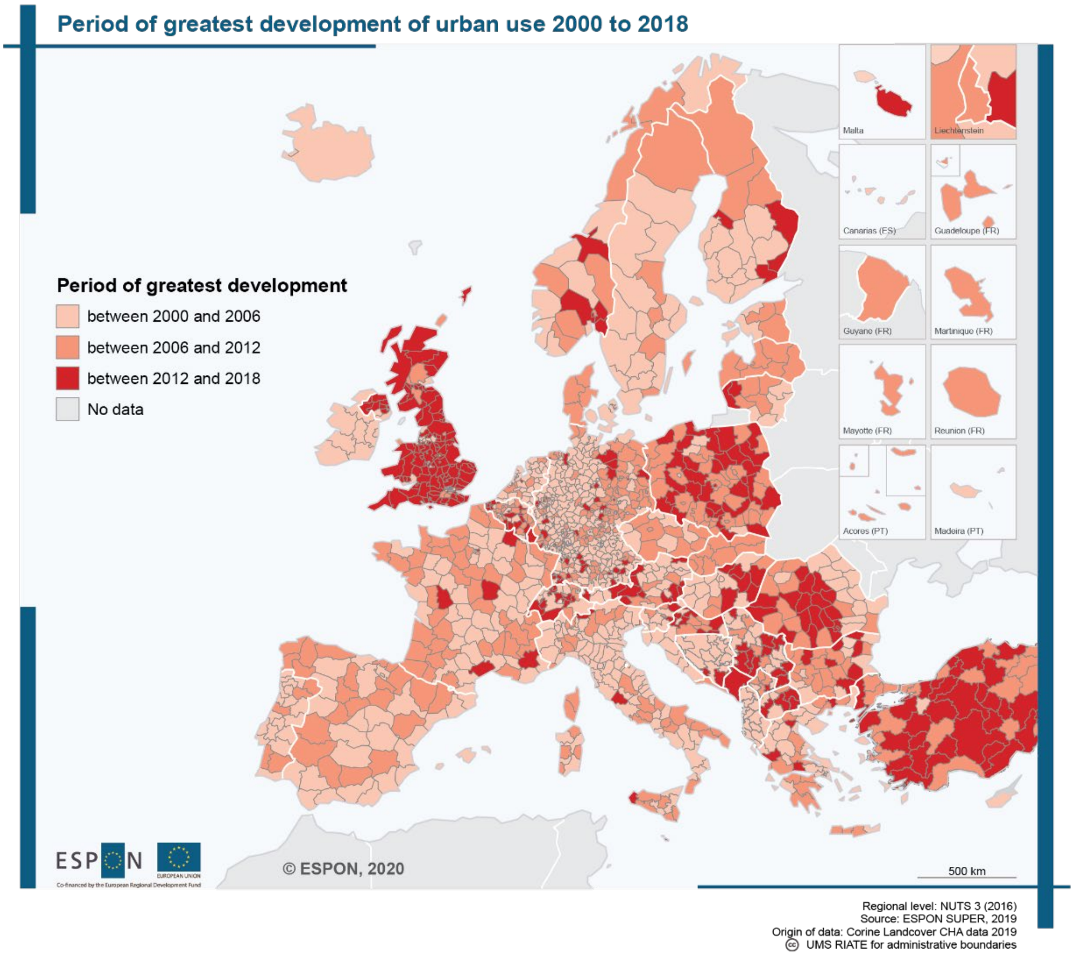
From \ To	Urban	Artificial (not urban)	Agri-cultural	Terrestrial nature	Wetlands & water bodies	Total
Urban		3,041	33,003	12,116	9,034	57,194
Artificial (not urban)	8,763		52,399	50,033	19,819	131,014
Agricultural	990,538	162,331		456,676	97,316	1,706,861
Terrestrial nature	246,969	97,801	325,142		125,904	795,816
Wetlands & water bodies	16,301	4,616	45,134	111,499		177,550
Grand Total	1,262,571	267,789	455,678	630,324	252,073	2,868,435

Map 3.11 shows the growth in the share of urban areas at the NUTS 3 level, revealing that there are some parts of Europe which also saw a decline, most notably in Romania and Bulgaria. The territorialisation of urbanization can be further explored by using the standard urban/rural typology. As Figure 3.1:, shows, the most dynamic regions tend to be urban and intermediate, which reflects the general trend in much of Europe (Dembski et al. 2019).

Finally, we can identify those NUTS3 regions which converted the most land to urban use with respect to the European average, the national average or both. Map 3.12 shows the outcome of this analysis, which can be considered a first step at mapping out potential ‘hotspots’ of absolute levels of urbanization in Europe. Many regions in Spain, Poland and the UK can be identified where relatively great swathes of land was urbanized in the 2000-2018 period.

Over time, the rate of urbanization has decelerated somewhat (see Map 3.8). This can partially be explained by the EU expansion in 2004 and the 2008 economic crisis: 44% of all conversions to urban use took place in 2000-2006, 35% in 2006-2012, and 21% in 2012-2018. This can be seen in the overal predominance of pre-crisis development (the lightest shade in the map) Some countries were exceptions, with almost all of the UK showing developments predominantly after 2012, as well as many regions in Poland and Romania, the east of Hungary and Croatia, the west of Austria, parts of the Western Balkans a few other regions throughout Europe.

Map 3.8: Period of the greatest development of urban use (2000-2018)



3.2.2 Urban land use change

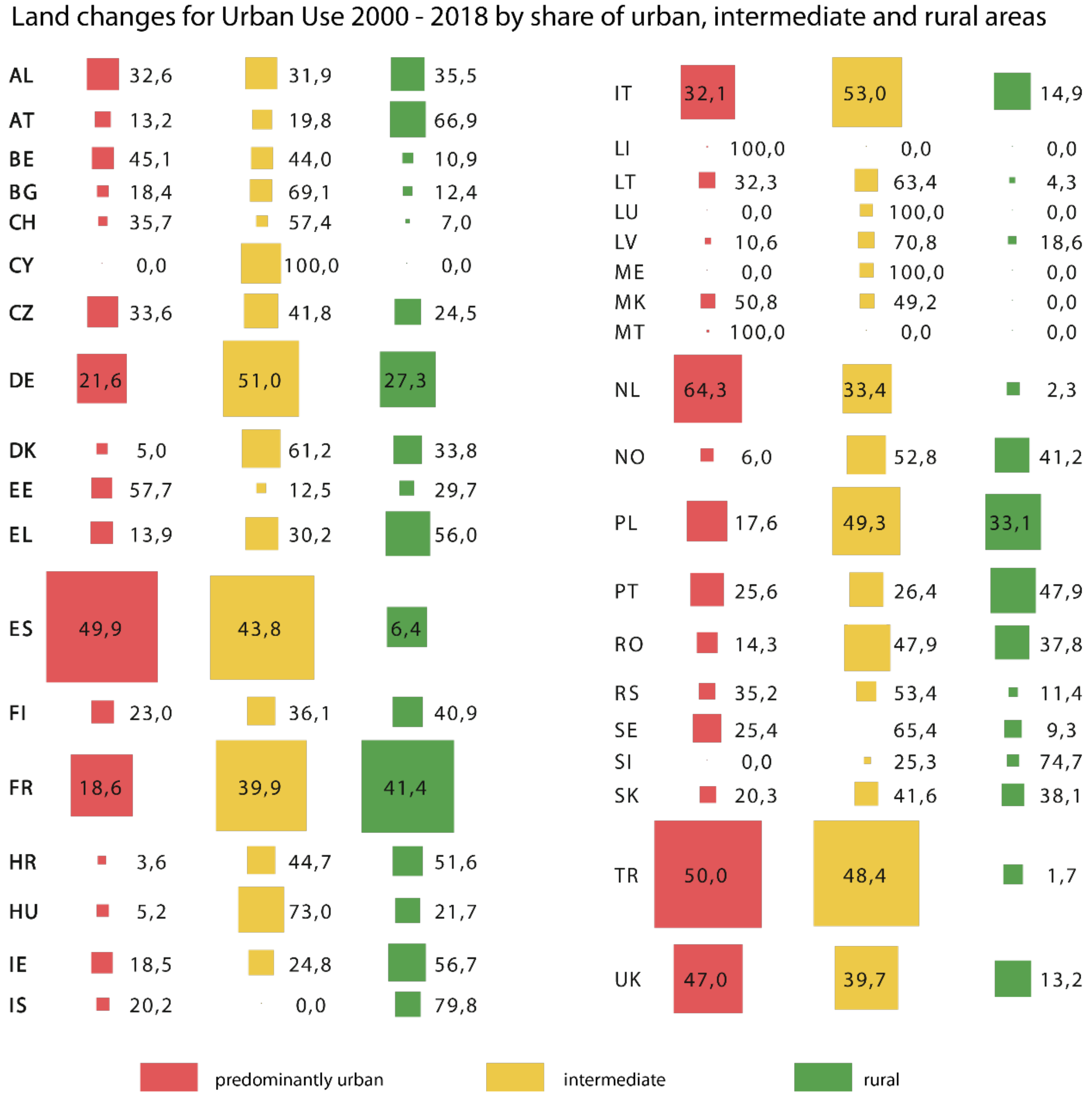
As stated, approximately 1,263,000 ha were converted to urban use in the 2000-2018 period. Of this, 450 thousand hectares were first registered as construction sites. In the same period

353 thousand hectares of construction site was converted to other urban uses. Of the 1,166,000 ha thus converted to some form of urban use, 35% became urban fabric (predominantly residential), 37% industrial (including business parks and offices), 17% infrastructure (including airports) and 11% urban green (Table 3.2). From this land cover data, we can get a general picture of common land-use categories: living, working, mobility and recreation. The following pages show a number of maps displaying urban land use change (Map 3.9 - Map 3.13).

In Liechtenstein, Bulgaria, Slovenia, Belgium, Croatia, Luxembourg, and Italy the conversion to industrial areas (work) was twice that as urban fabric (living). In Norway, Finland, Denmark, Malta, Latvia, Cyprus, Lithuania and Ireland the proportion was the inverse; in the case of Cyprus (3.2), Latvia (3.4) and Ireland (4.6) the urban fabric/industry ratio was even greater. Growth in infrastructural land cover was predominant in in Portugal (32%), Poland (42%), Greece (47%), Slovenia (47%) and Croatia (64%). Finally, urban green was the predominant new land cover type in Norway (44%), Iceland (45%) and Austria (48%). Changes also occurred within the categories of urban land use: 34,810 hectares. Half of this (17,187) became construction sites. The most common shift regarding the rest concerned a conversion of urban green (50%) to urban fabric (38%) and industrial areas (34%). It bears remembering however that all numbers do not include small-scale land cover changes, as stated above.

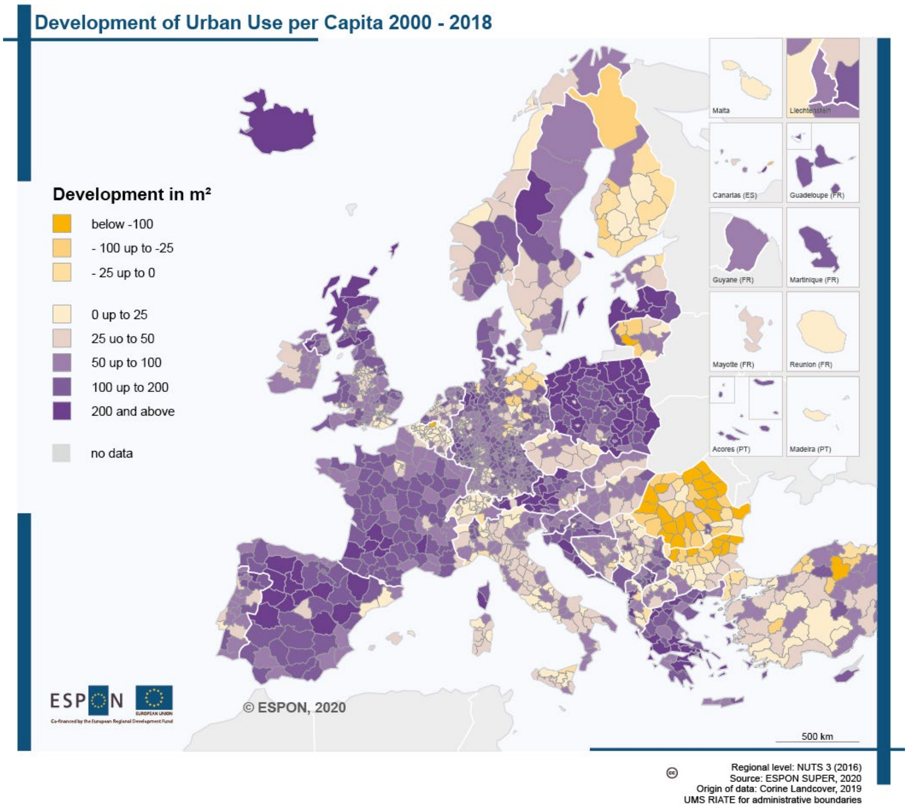
The combination of land use change figures per NUTS3 with the Eurostat typology for rural, intermediate and urban NUTS3 shows some national patterns in new urbanisation, corresponding largely (but not entirely) with expectations (Figure 3.1). Highly urban countries like the Netherlands, Belgium and the UK show a clear concentration of urbanisation in urban or intermediate NUTS3; the same goes for Spain, which is known to have a relatively compact pattern of urbanisation. Many countries have a more spread out distribution of urbanisation, with notable cases such as Germany and Italy. Some countries show a preponderance of new urban areas in rural NUTS3, such as Austria and France.

Figure 3.1: Size and typological location of new urban development by country (2000-2018)

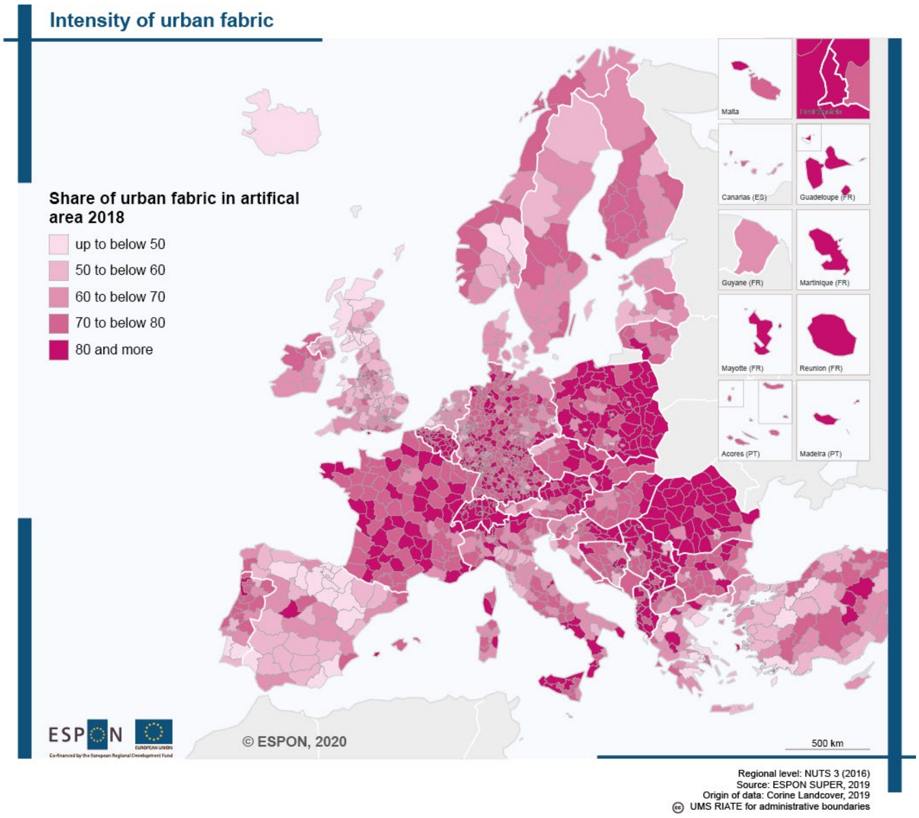


Origin of data: Corine Landcover CHA data 2019, Eurostat for urban-rural typology

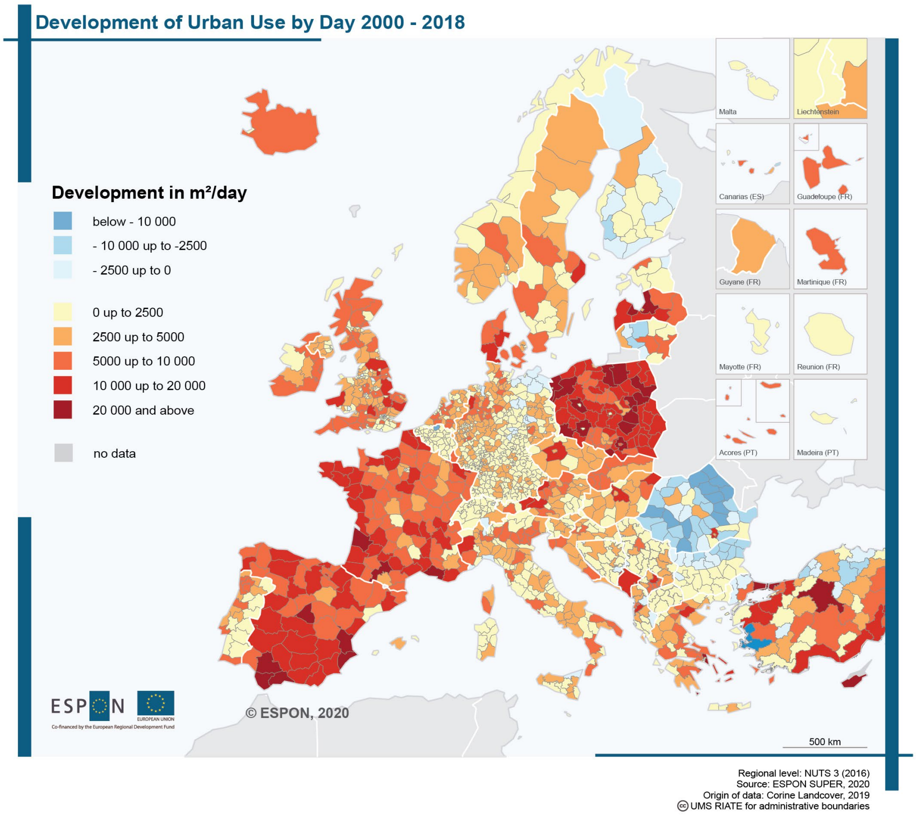
Map 3.9: Development of urban use areas per capita in the period 2000-2018



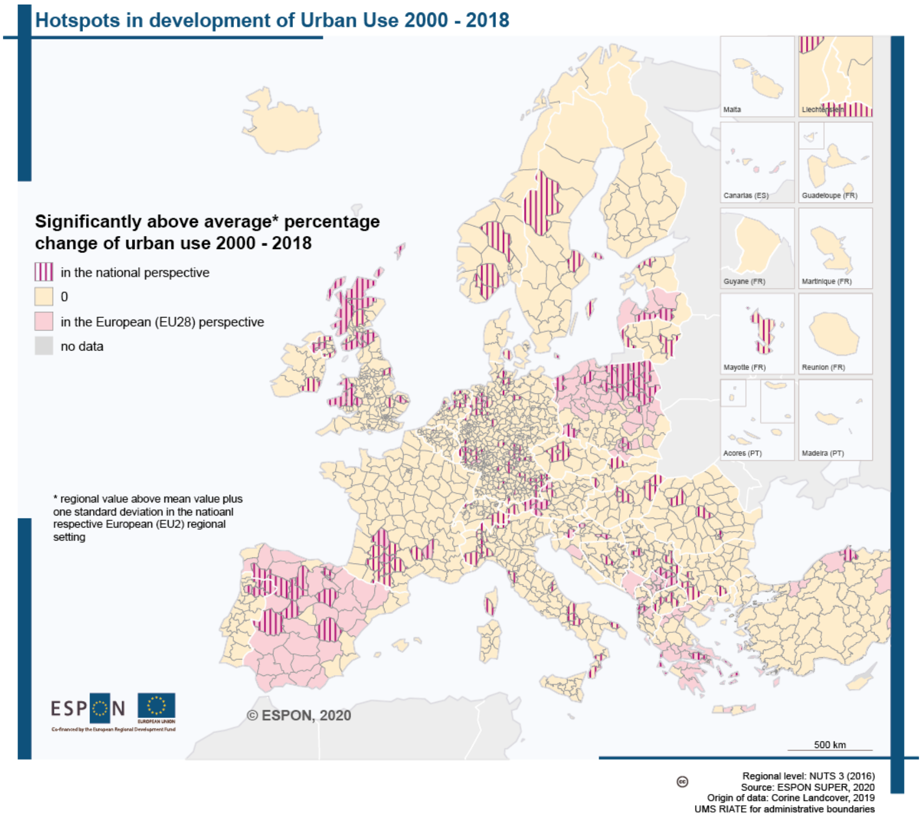
Map 3.10: Intensity of urban fabric



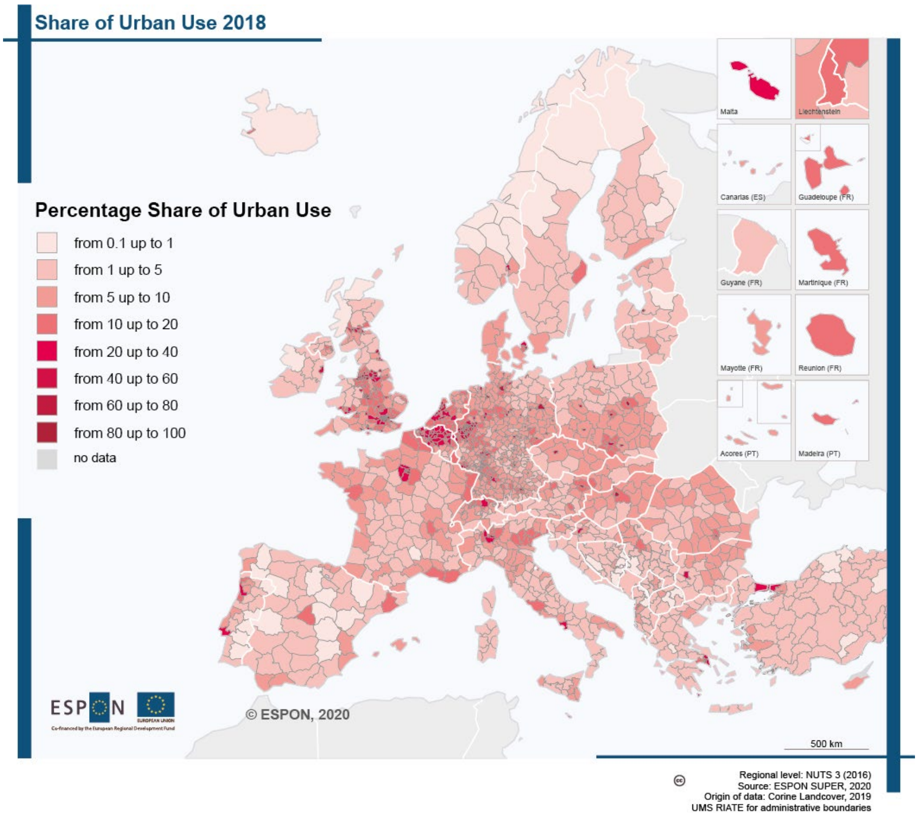
Map 3.11: Development of urban use areas per day in the period 2000-2018



Map 3.12: Hotspots of urban use development in the period 2000-2018



Map 3.13: Urban use as a proportion of total surface area in 2018



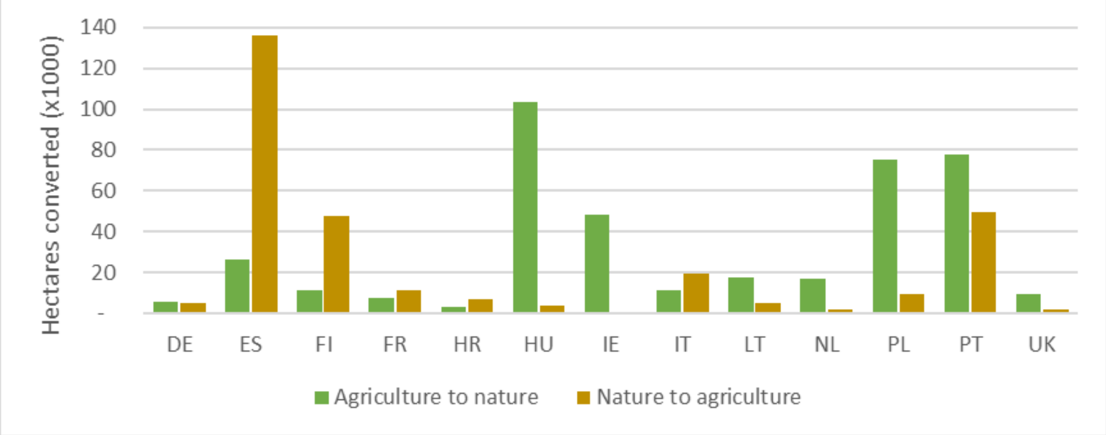
3.2.3 Non-urban land use change

Finally, with regard to non-urban land cover, the biggest source for new agricultural land was terrestrial nature (71%) and the biggest source for new terrestrial nature was agriculture (72%), although 1.4 times more agricultural land was converted to terrestrial nature than vice versa. As a result, agricultural areas decreased from 208.8 million to 202.7 million hectares while natural areas have stayed largely stable (233.2 million hectares in 2000 and 234.0 million hectares in 2018). Other major conversions included agriculture to mineral extraction (150 thousand ha), terrestrial nature to mineral extraction (84 thousand ha) and agriculture to wet natural areas (97 thousand ha).

Table 3.2 Land use changes of SUPER main classes other than urban

	Added (ha)	Removed (ha)
Mineral extraction sites	240,536	102,829
Dump sites	24,211	19,422
Agriculture	422,675	716,323
Terrestrial nature – vegetated	543,429	469,815
Terrestrial nature– bare	74,779	79,032
Aquatic nature	243,039	161,248

Figure 3.2: Conversion of agriculture to nature and nature to agriculture per country in the period 2000-2018 (for countries with a total conversion of more than 10.000 ha)



From Figure 3.2, we see that the relatively stable balance between agriculture and nature at the European level belies significant territorial differences. Most of the dynamics occurred in just a handful of member states: Spain, Hungary, Poland and Portugal. Moreover, the dynamics were one-way in several cases: Spain (and to a lesser degree, Finland) showed a significant shift from nature to agriculture, whereas this was the opposite in Hungary and Ireland.

4 Support for the assessment of urbanization and land use change

Aside from describing developments from the perspective of drivers and outcomes of urbanisation and land use change, the ESPON SUPER project also considers the sustainability of urbanisation and land use changes. A detailed discussion of sustainable urbanisation can be found in Annex 4, which consists of both a scenario study for three types of urbanisation (compact, polycentric and diffuse) as well as a literature study on the sustainability of these three forms. Sustainability is considered in this project along the lines of social, economic and environmental sustainability, as well as temporal and institutional sustainability. In the following paragraphs, some macro-level trends are discussed by considering the combination between trends in drivers (such as demographic changes) and trends in land use changes. This data is provided along the three dimensions of social, economic and environmental sustainability. These macro-level trends may provide support and context for the assessment of urbanisation and land use change across Europe; by providing geographic context and information on how European regions differ in relation to drivers for and outcomes of land use change.

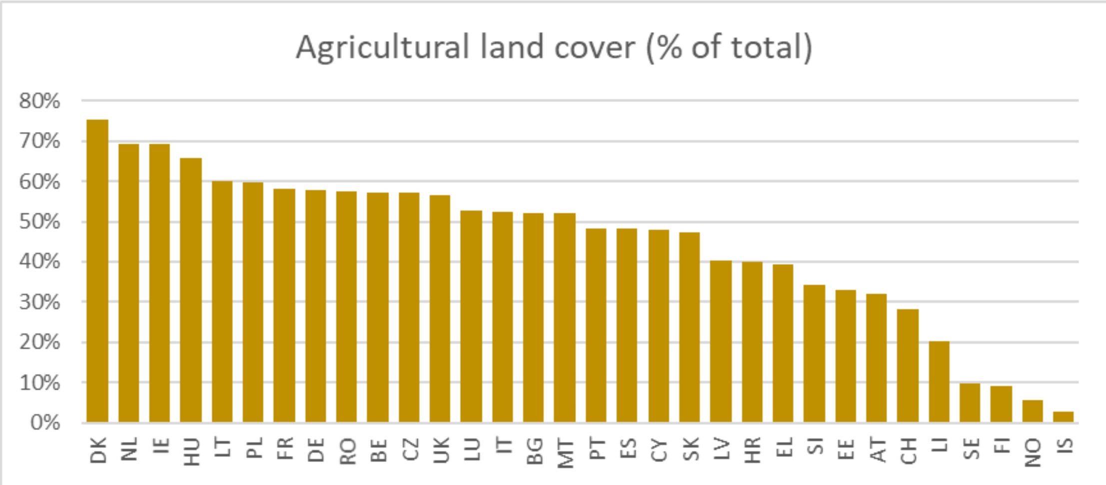
4.1 Economic functionality

Land is used to produce economic gains, but it also has an economic value. This analysis only considers the use of land for economic gain, not its value as measured in land prices. In order to understand the economic productivity of land, we have access to data on land cover classes, gross value added for industry, services, construction and the combination of agriculture, forestry and fisheries. This data offers a basis to reflect on certain predefined land use categories and their intensities of use. We will discuss forms of extensive and intensive land use, changes over time, the geographic distribution and provide some suggestions for how these findings relate to sustainable land use.

When we look how land is used for economic functions, we can discern both intensive and extensive land use. Intensive land use derives economic value from utilising a small piece of terrain very intensively, extensive land use derives economic value from utilising large swathes of land. Under extensive land use we include agriculture (CLC main class 200), mineral extraction sites (CLC class 131) and dump sites (CLC class 132). A clear example of intensive land use is the provision of services, where the amount of people working on a plot of land can be increased tremendously by increasing density, as is done in office buildings. In Corine, commercial and industrial land use is grouped (CLC class 121) even though this combination contains land uses that differ significantly – at the extremes, this (unfortunately) puts an oil refinery or seaport in the same category as a central business districts.

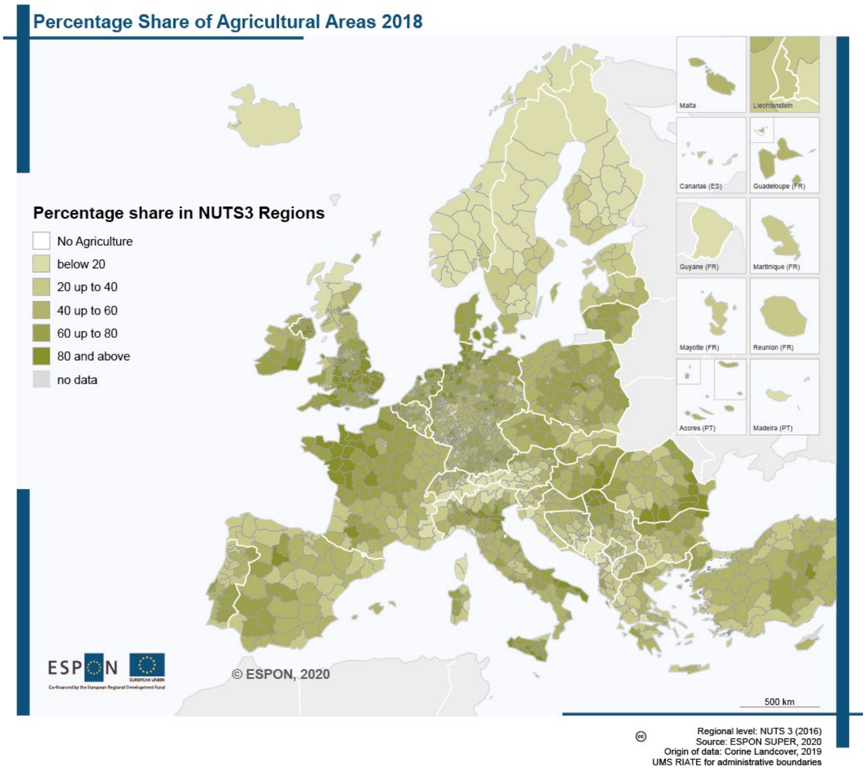
Land use in Europe (here referring to EU28+EFTA to include the entire ESPON space) is dominated by the economic sector of agriculture. Although 49% of the European territory is covered by natural land use (with a relatively large proportion in the Nordic countries), 43% is covered by agriculture. Agricultural land use ranges from 75% in Denmark to 3% in Iceland (see Figure 4.1 and Map 4.1).

Figure 4.1: Agricultural land use as % of total land area



Source: Corine land cover 2019

Map 4.1: Agriculture as a percentage of total land use in 2018

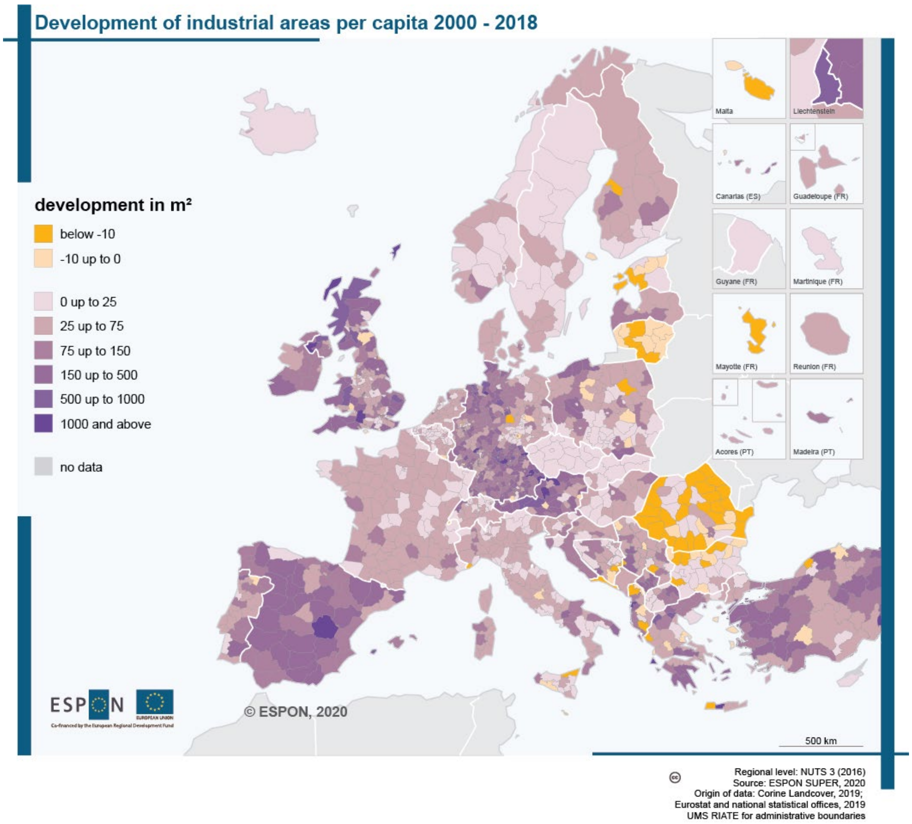


Industrial land use and mineral extraction or dump sites cover a much lower proportion of land: respectively 0.6% and 0.2% of the total European land area. These numbers can vary significantly from region to region: for example, Seine-Saint-Denis, extending in the north-east of Paris from the Périphérique to the Charles de Gaulle airport, has 18,5% of its total land used for commercial/industrial purposes. Quite a few Kreisfreie Stadte (German cities with their own NUTS3) have high proportions of industry/commerce, partially due to their small size. A number of German regions also top the list with mineral extraction or dump sites as a proportion of total land use, as a consequence of the large-scale lignite surface mining taking place in places like Cottbus and its environs, near the Polish border, and Düren to the west of Cologne. Aside from these exceptions, even in areas where the proportion of artificial land use is relatively high, commercial/industrial land cover is typically less than 2% of the total NUTS3 surface area.

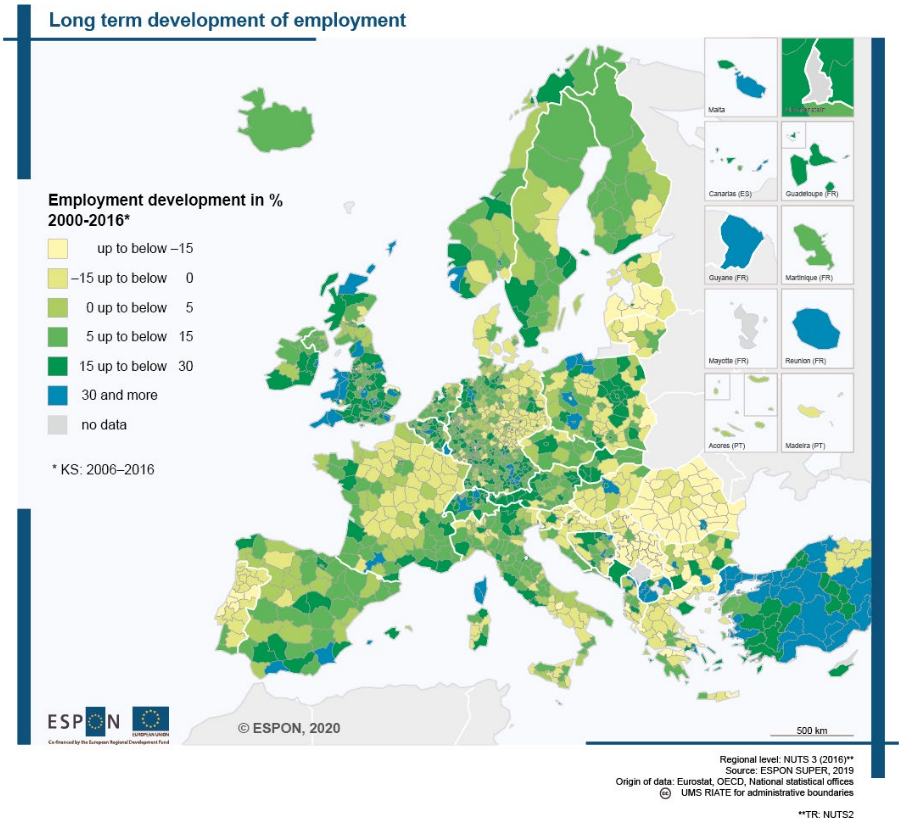
Overall image

Overall, the period 2000-2018 has seen the largest increase in industrial area per capita in the UK, Spain, Germany, Austria, Western Poland, the Western Balkans, Greece and Turkey; and a decrease in only a few regions but including most of Lithuania and Romania (see Map 4.2). This development is largely related to developments in employment (Map 4.3), although the relation does not hold in eastern Germany and Portugal (increase in industrial/commercial land, decrease in employment); Greece and central France (decrease in employment, no decrease in industrial/commercial land); and Norway (increase in employment, limited increase in industrial/commercial land). The relation between industrial land use developments and development of GVA (Map 4.4) is far less straightforward, with a surge in GVA development in Eastern Europe, Norway and Ireland, as well as Switzerland and the Western Balkans.

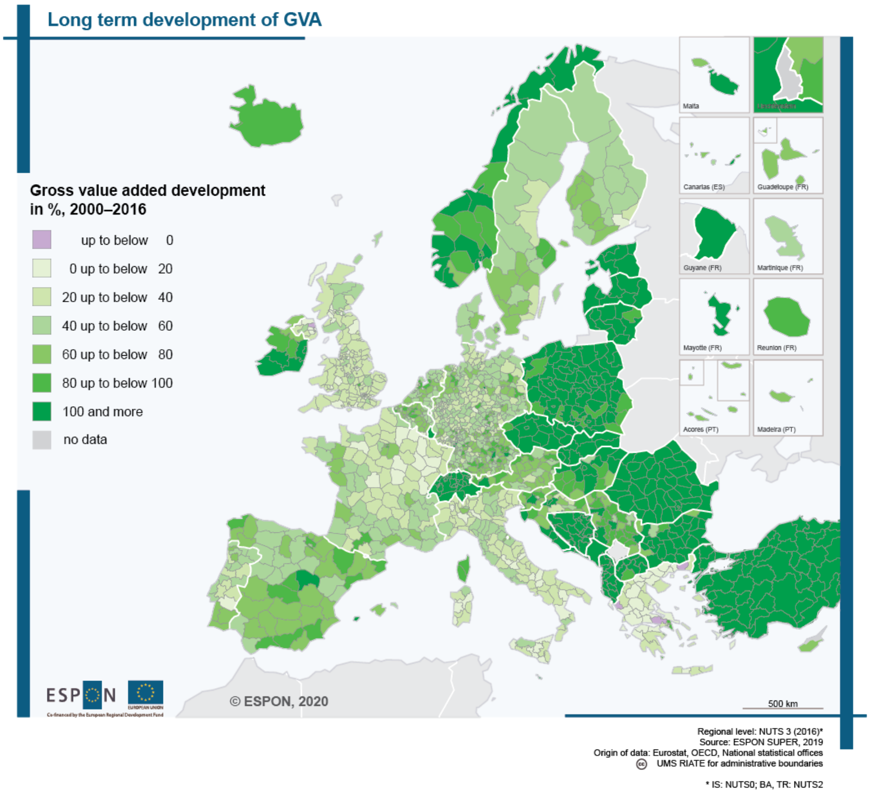
Map 4.2: *Long-term development of industrial area per capita (2000-2018)*



Map 4.3: *Long-term development of employment (2000-2018)*



Map 4.4: Long term development of GVA at basic prices (nominal GVA at current market prices) (2000-2016)



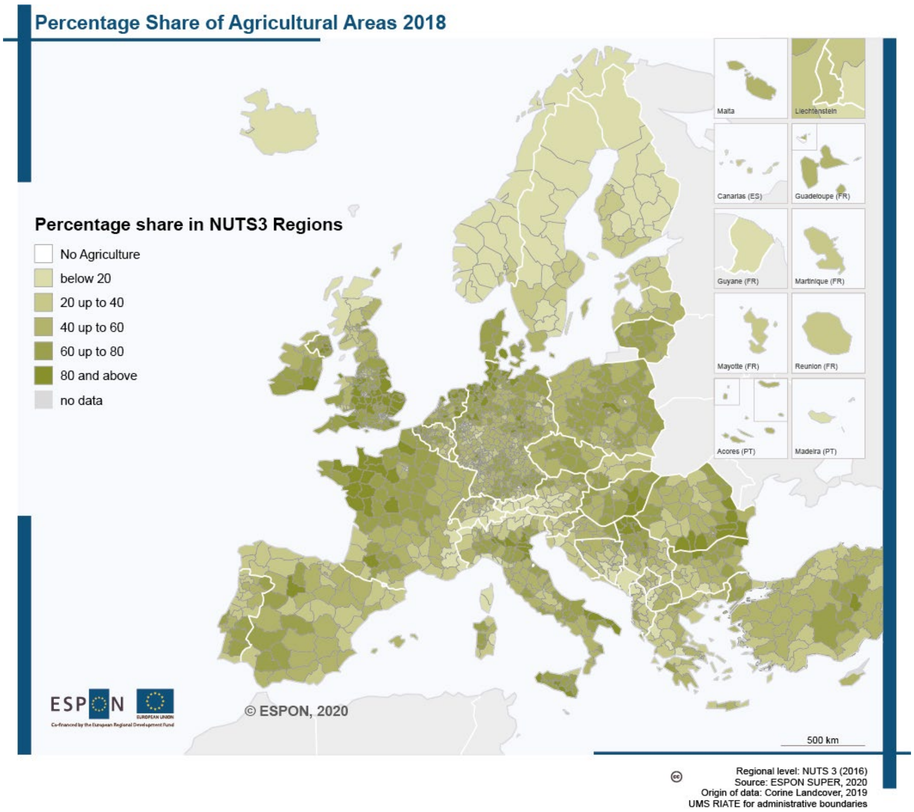
4.1.1 Efficiency

The sustainability of land use is dependent on many variables. Here we consider only how much economic value is derived from different types of land use, and how this has changed over the period 2000-2018.

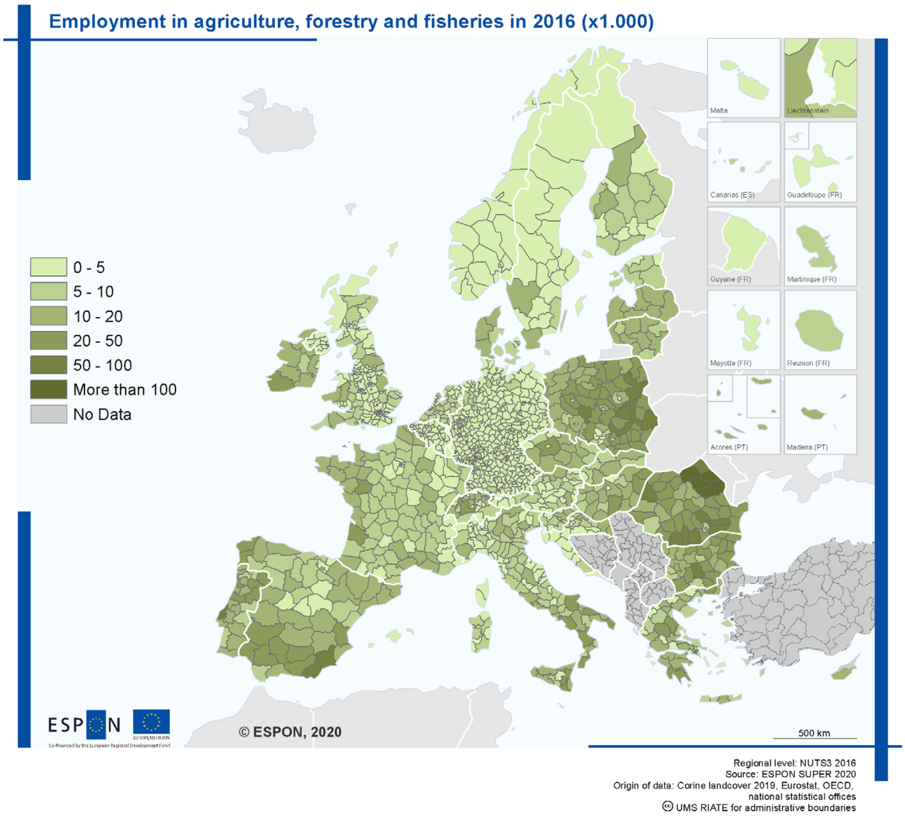
Agricultural intensity

Employment and GVA are reported by Eurostat for the combination of agriculture, forestry and fisheries (NACE category A). For employment, this regards 10.6 million jobs in Europe in 2016. Fisheries are only a very small part of these figures. In 2015, the sector employed roughly 150,000 people across Europe, with ca 35,000 in Spain, 30,000 in Greece, 23,000 in Italy and 15,000 in France. Only the workforce in Malta reaches a significant proportion in this category: approximately 30% (EC 2017). Forestry employs about 540,000 people in Europe, mainly in Poland (77,200), Italy (53,400) and Romania (47,500). This represents more than 10% of the total workforce in NACE category A in Slovakia (28%), Sweden (28%), Estonia (24%), Finland (22%), Czechia (21%), Latvia (16%), Switzerland (12%) and Bulgaria (11%) (Eurostat 2016). Geographical patterns in agricultural areas and NACE A employment are found in the following maps (Map 4.5 - Map 4.8). If we compare these figures to agricultural land use to construct a measure of agricultural intensity, low employment numbers may regionally inflate numbers; as can be seen for example along the coast of Spain (see Map 4.8).

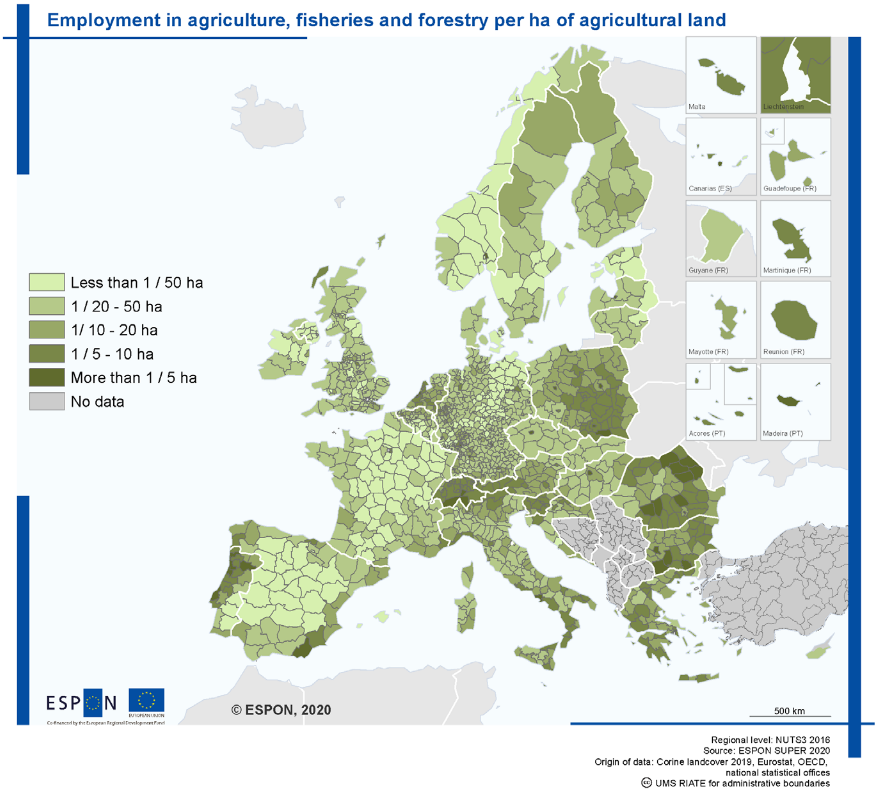
Map 4.5: Percentage share of agricultural areas in 2018



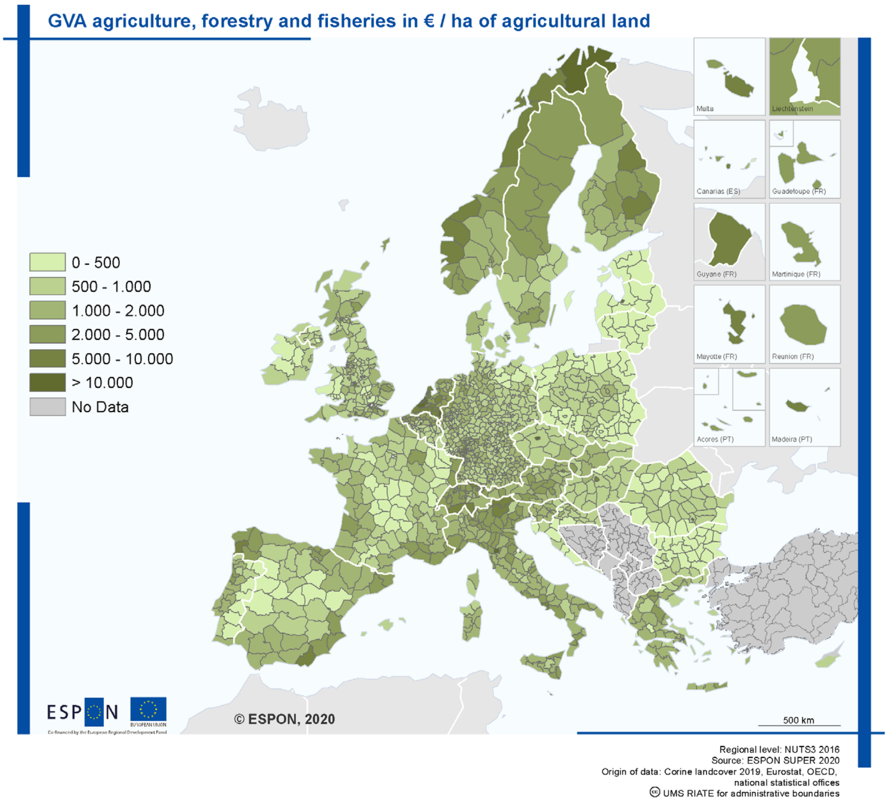
Map 4.6: Employment in agriculture, forestry and fisheries in 2016



Map 4.7: Employment in agriculture, fisheries and forestry per ha of agricultural land (2016)



Map 4.8: GVA in agriculture, forestry and fisheries per ha of agricultural land (2016)



Agriculture and land use efficiency

Agriculture as the major type of land use in most European countries, cannot be left out of an analysis of land use and land use changes; but the relationship between agriculture and (intensity or sustainability) of land use is as complex one. It involves, among other things, nutrient or pesticide pollution, changes in the availability of habitat for flora and fauna, and the displacement of livelihoods through intensification. It is beyond the scope of the SUPER project to address these issues, limiting the analysis to trends in the relation between agricultural land and total land area in general (Map 4.9), and the relation between agricultural land and employment (Map 4.10).

These maps show a decrease in agricultural employment (per ha of agricultural land) almost everywhere in Europe, showing an intensification of the sector across the continent, with the exception of Western Germany, the majority of the UK, Bulgaria, parts of Italy and northern Sweden. In the case of northern Sweden, this is likely to be more closely related to forestry than to agriculture. Decreases in agricultural area are most pronounced in the northern half of Europe with the exception of Norway, Sweden and the north of Finland; the UK, the Czech republic, Greece, and all of Spain except along the Portuguese border. Stable areas such as Norway, Sweden and Austria are likely stable due to the relatively small proportion of agricultural land to begin with.

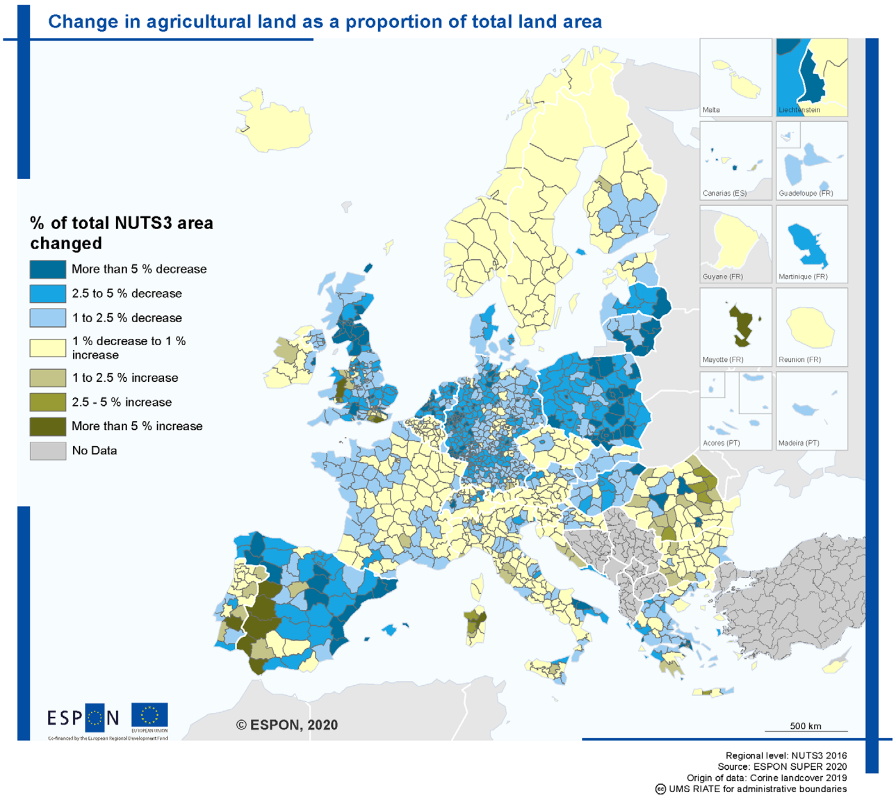
Intensive land use

To get a basic understanding of the way industrial/commercial land is used, we can first look at how the industrial and service sectors are related, for example by comparing the ratio of jobs and GVA between industrial and services (Map 4.11 and Map 4.12 respectively) A first observation is that the ratio of service to industry jobs rises faster than the ratio of GVA because some areas have very few industrial jobs. It is also worth noting that although only 4 regions in Europe have more jobs in industry than in services (three in Germany, one in Romania), there are 36 NUTS3 regions where industry outperforms services in terms of GVA.

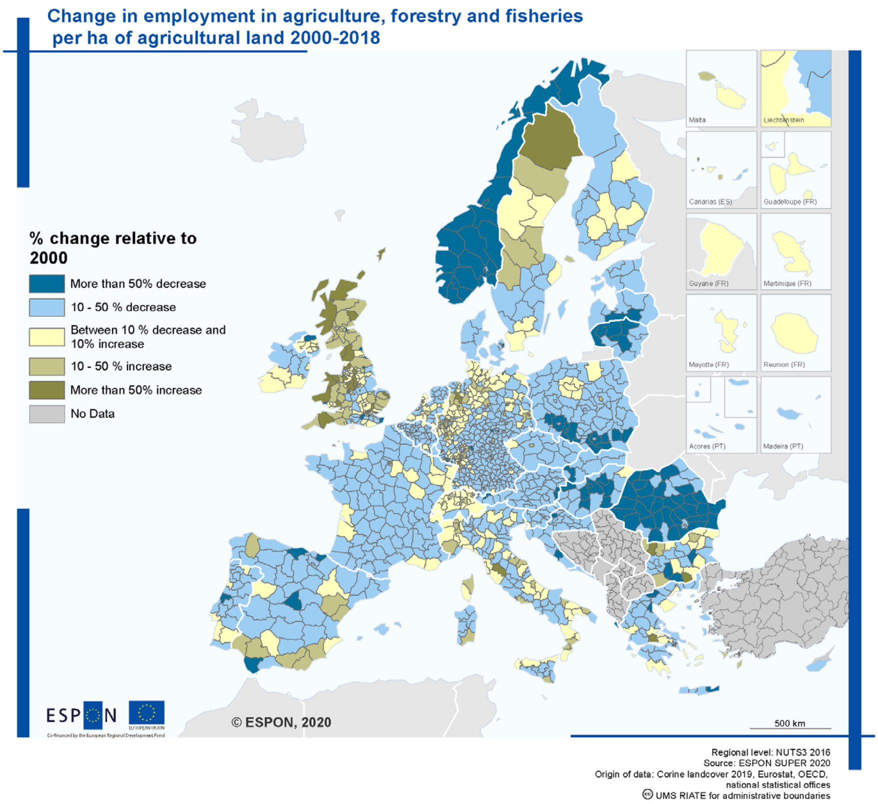
From these analyses, we can observe that service employment and GVA is especially dominant in high-density regions and touristic areas (e.g. Sicily and the French Riviera). These extreme ratios make it difficult to say much about the relationship between industrial/commercial land use and industrial or service performance separately, and the above maps will need to be taken into account when interpreting the aggregated data (services plus industry).

When the efficiency of work-related land use is mapped out at the NUTS3 level, namely by displaying the ratio of economic production (GVA) of the combined services/industry sectors against the Corine service/industry land use, a familiar geographic distribution emerges. This map looks quite similar to the map of GVA in general, suggesting that the variation in economic performance is the most important variable.

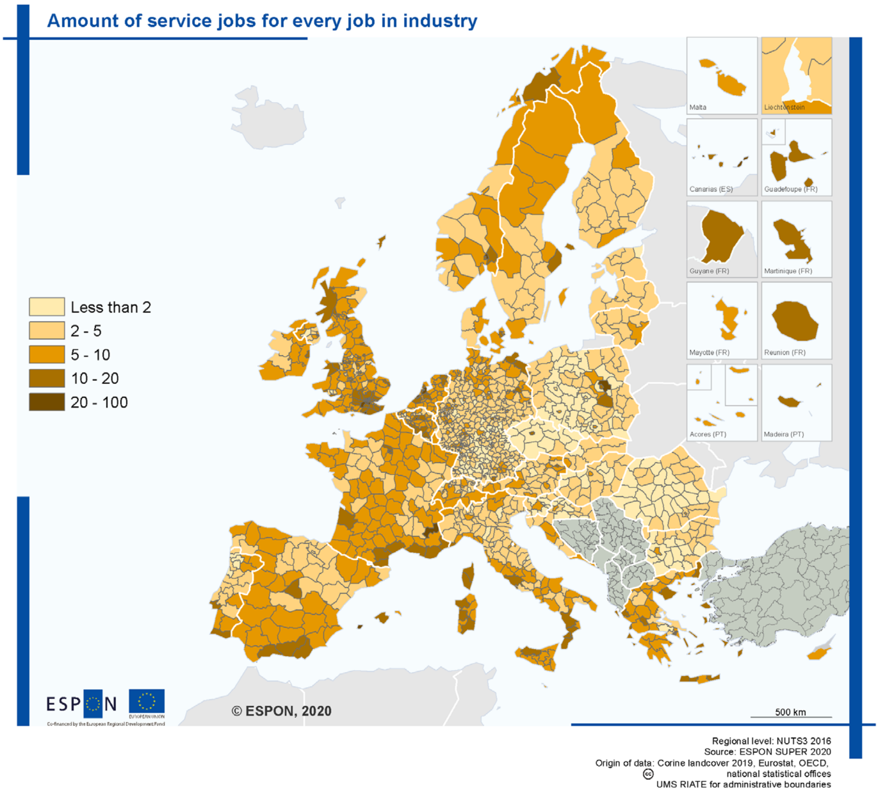
Map 4.9: Change in agricultural land as a proportion of total land area (2000-2018)



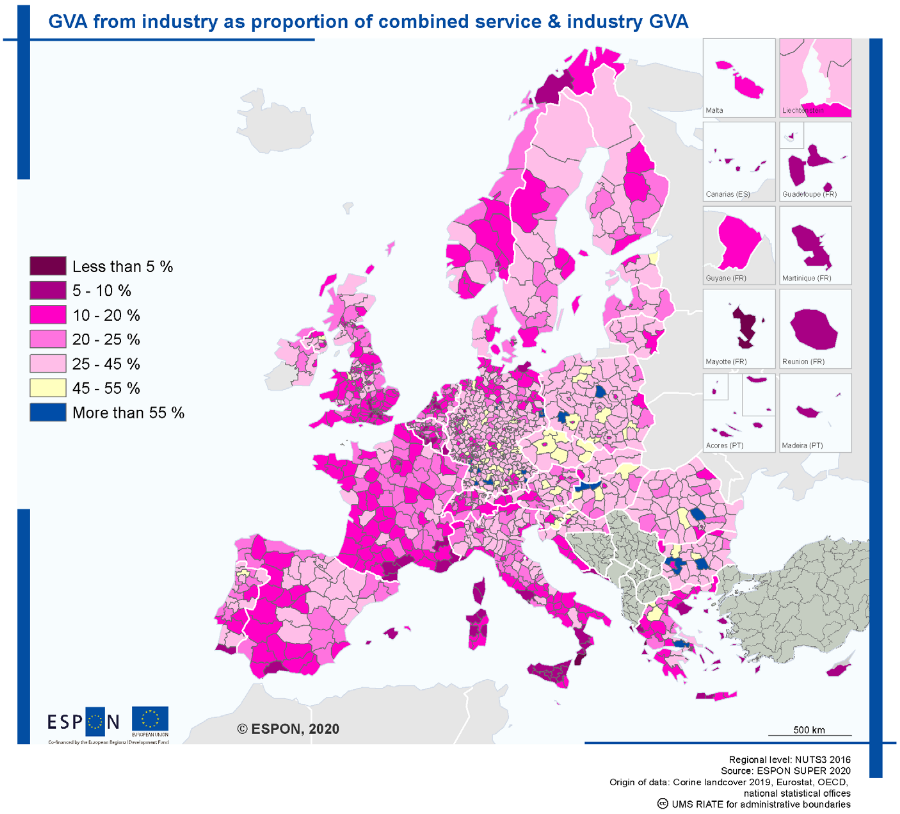
Map 4.10: Change in employment in agriculture, forestry and fisheries per ha of agricultural land (2000-2018)



Map 4.11: Number of service jobs for every job in industry (2016)



Map 4.12: GVA from industry as a proportion of combined service & industry GVA (2016)



Areas with high performance also have high efficiency. On the one hand this could mean that a hectare of business parks in areas such as South West England, the Randstad, Switzerland and Austria, office space is being used more intensively than elsewhere. Obviously this is true for areas with large financial centres and high-rise office towers versus areas with extensive back-office business parks and light industry. However, it can also be an artefact of the Corine data. In dense cities, much economic production occurs within the urban fabric, such as law firms or consultancies in or near city centres. Finally, this is probably related to the national or regional economy. A flourishing economy will most likely exhibit higher economic production per hectare than struggling economies.

4.1.2 Trade-offs

Trade-offs for extensive land use

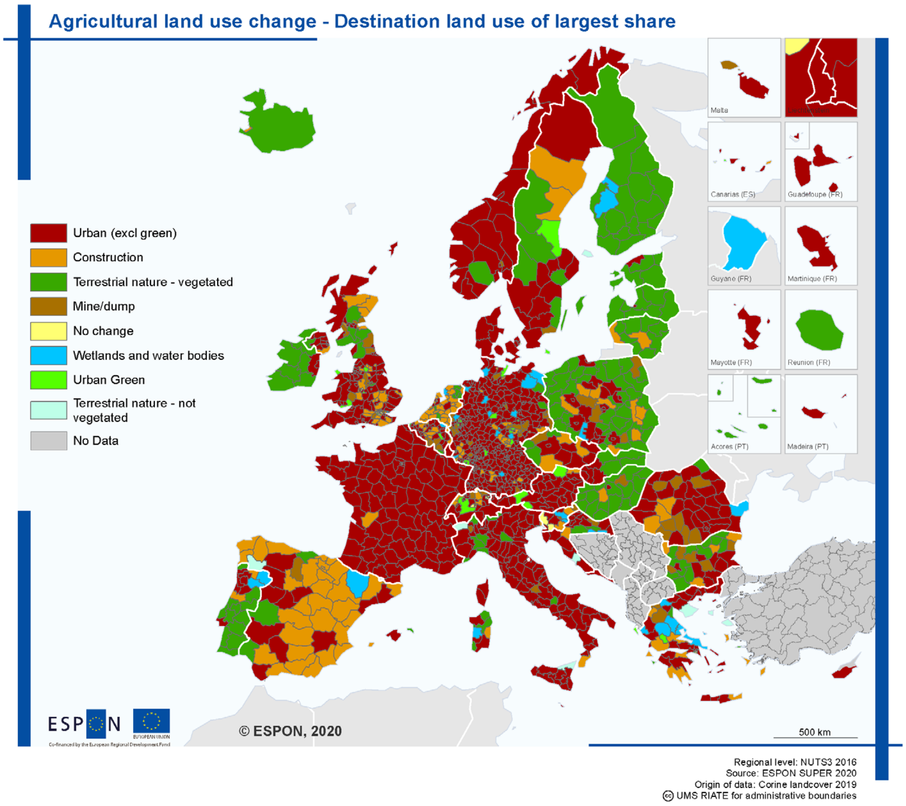
In classical economic geographic theory (e.g. Alonso), more productive functions displace less productive ones at prime locations. As the economy of Europe grows, this should be observable as well. Looking the land use changes over 2000-2018 period we see that agriculture has lost the most hectares to other functions. When mapped out we can see distinct geographic distributions in the kinds of land uses which succeeded agricultural land use (see Map 4.13). The most common destination for agricultural land is either urban uses or construction (presumably future urban use), which is in line with economic theory. In some cases, agriculture is being transformed into urban green, which while not built-up, is in the service of more productive (in terms of GVA) or valuable land. Interestingly, parts of Eastern Europe, some islands (Ireland, Iceland and parts of Sardinia) and Portugal show agriculture transforming into nature. It is unclear what processes are behind this.

Trade-offs for industry-commerce

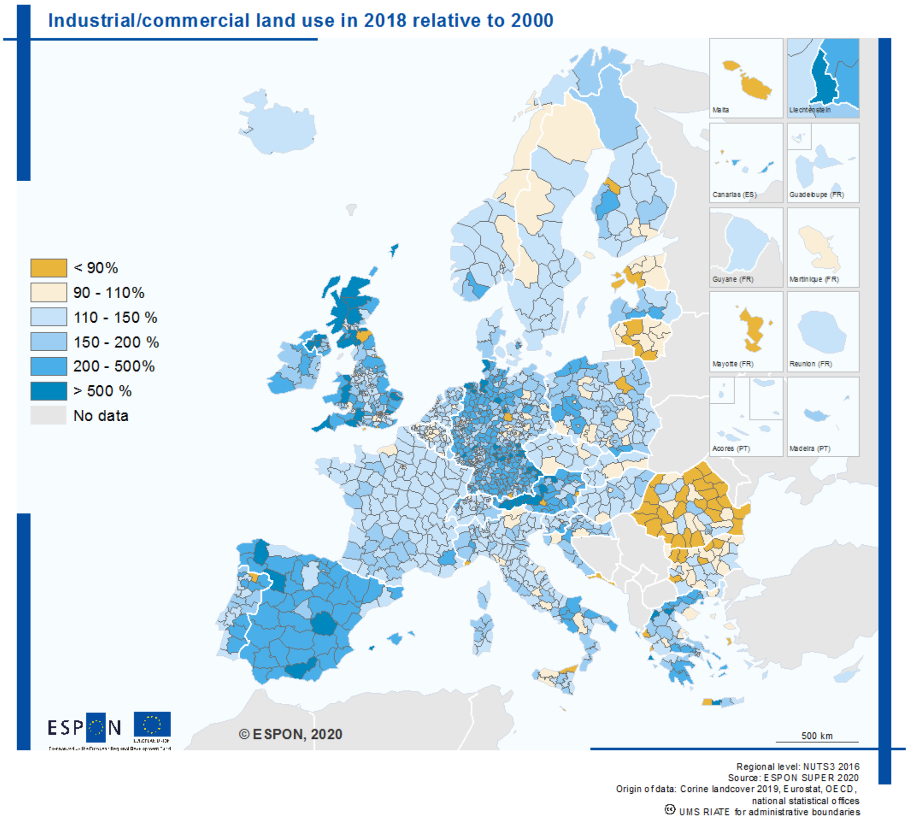
Land reserved for commercial or industrial use is a relatively low proportion of total land in almost every part of Europe: as a proportion of urban land use, it is only 14% (see Table 5.6). These approximately three million hectares of land (or 0.6% of all land) is are not all the land used for production of GVA, but still account for a large share of the 93% of GVA in industry & commerce and 89% of the jobs across the ESPON space in 2016. Although countries do not run on industry and services alone, these sectors do get efficient economic returns from land.

Zooming in further, services take up 74% of both GVA and employment totals across the ESPON space; but there are important regional differences both in the predominance of services (Map 4.11 and Map 4.12), and in trends over time (Map 4.13- Map 4.16). The latter show an increase in industrial/commercial land use almost everywhere; and a strong increase in the proportion of jobs everywhere except for the north-western parts of Europe, which already had a high proportion of services in 2000. Somewhat surprisingly, they also show a decrease across the majority of the UK and in Sweden; which is due to a (slightly) larger decrease in jobs in industry than there was an increase in jobs in services.

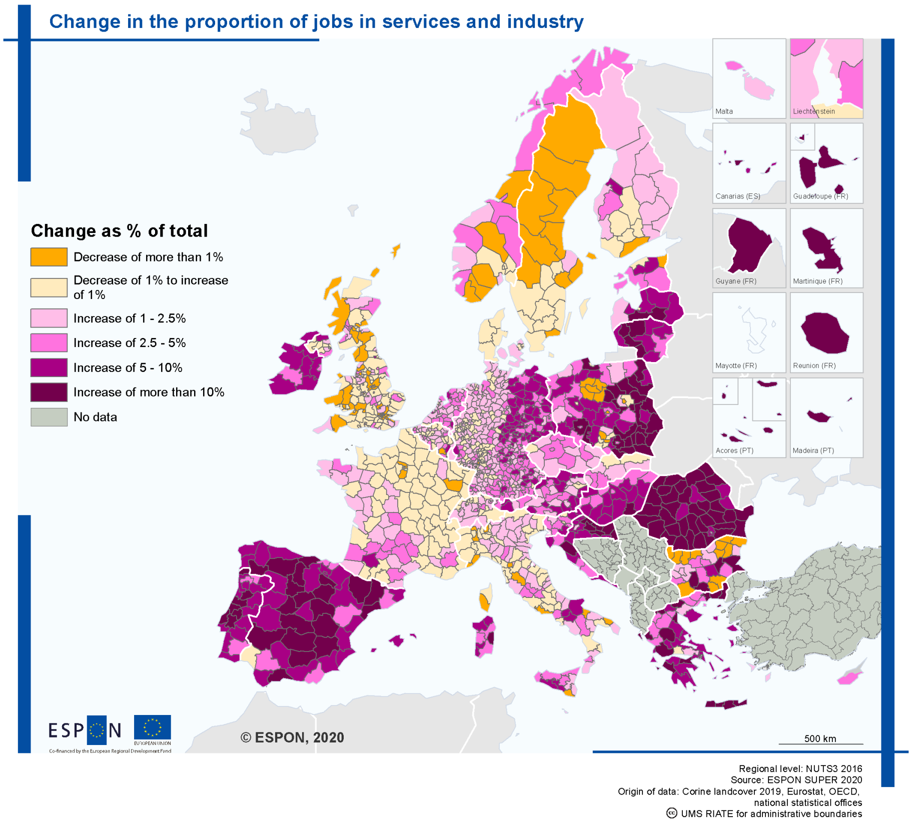
Map 4.13: Agricultural land use change: destination land use of largest share (2000-2018)



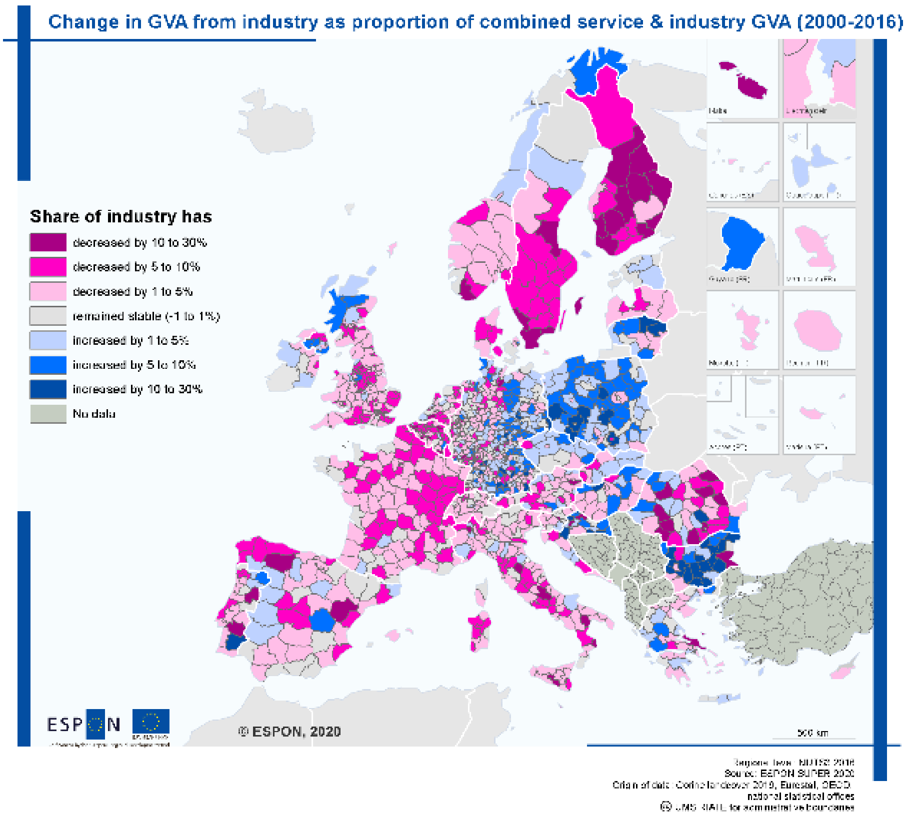
Map 4.14: Growth in industrial/commercial land use 2000-2018



Map 4.15: Change in the proportion of jobs in services and industry relative to all employment



Map 4.16: Change in GVA from industry as a proportion of combined service & industry GVA



4.2 Environmental

The ecological dimension of sustainability has been under strain as a result of various land-use changes, especially urbanization processes (see Figure 4.2). Much of the land being converted to urban use was previously agricultural, particularly arable land. Still, it is not sufficient to only consider changes towards artificial areas to understand environmental impacts of land-use change. If one looks at the total picture, it becomes clear that a large part of environmentally relevant conversion regards other land uses. Many near-natural areas are being converted into agricultural land, for example (see Figure 4.4).

Figure 4.2: Sankey diagram of land use changes towards urbanization in ESPON territory for 2000-2018

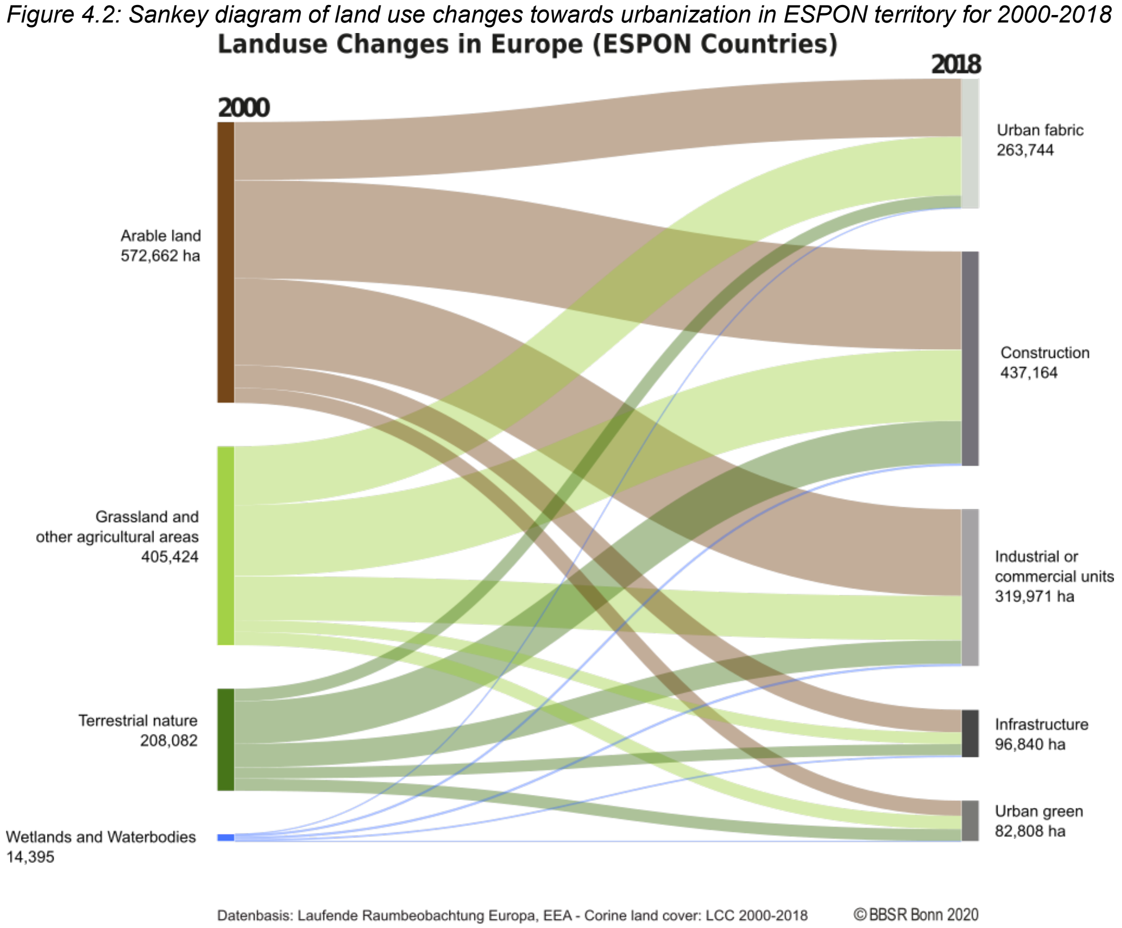


Figure 4.3: Sankey diagram of land use changes towards urbanization in ESPON territory split out for 2000-2006, 2006-2012 and 2012-2018

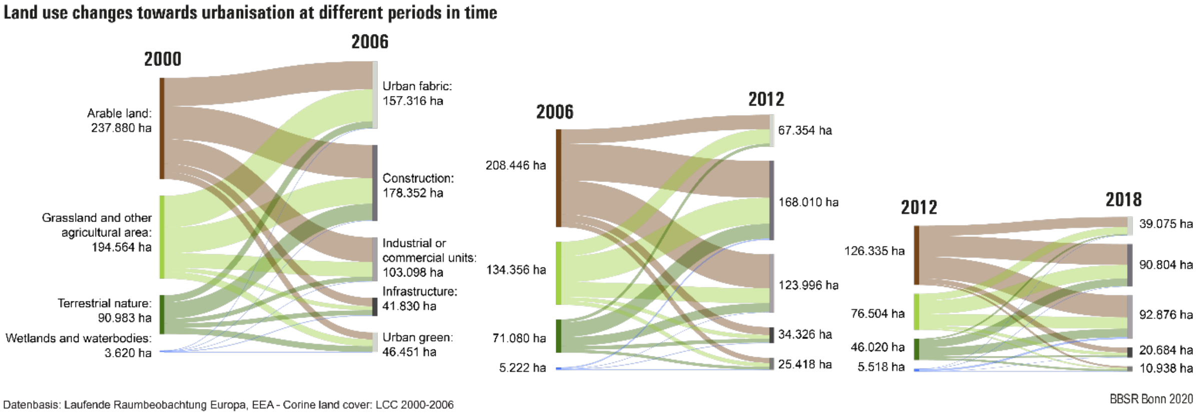
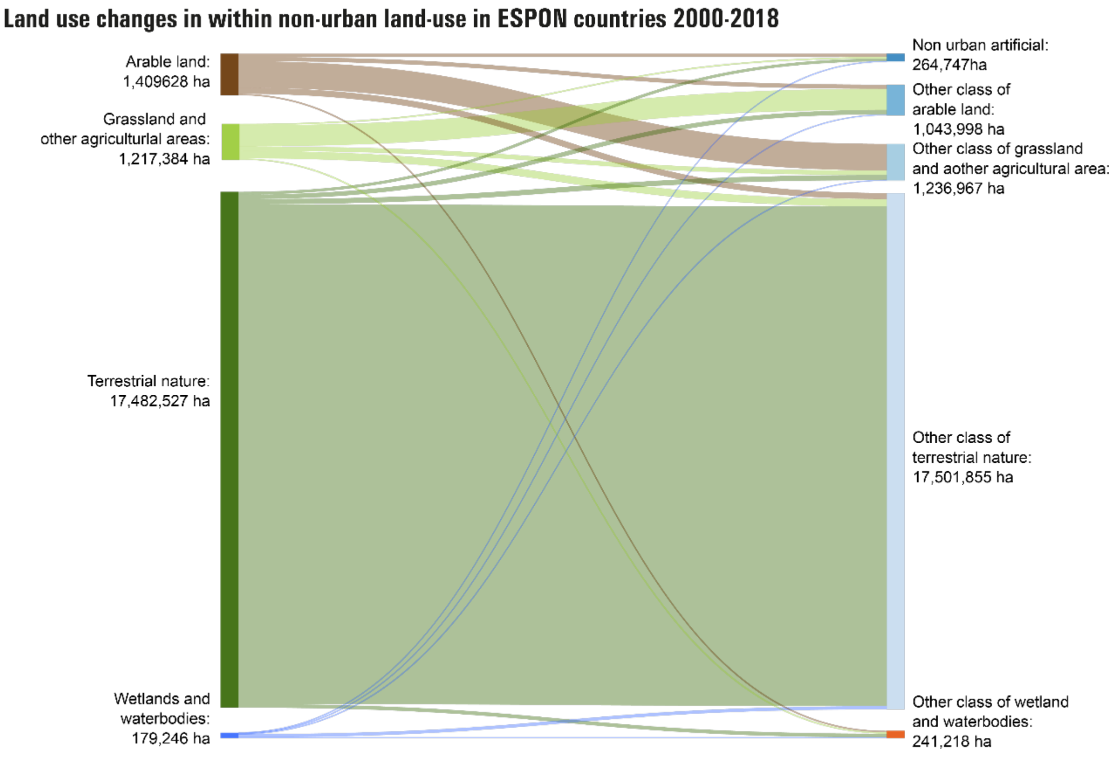


Figure 4.4: Sankey diagram of reclassifications of terrestrial nature, agriculture and arable land to other categories (2000-2018)

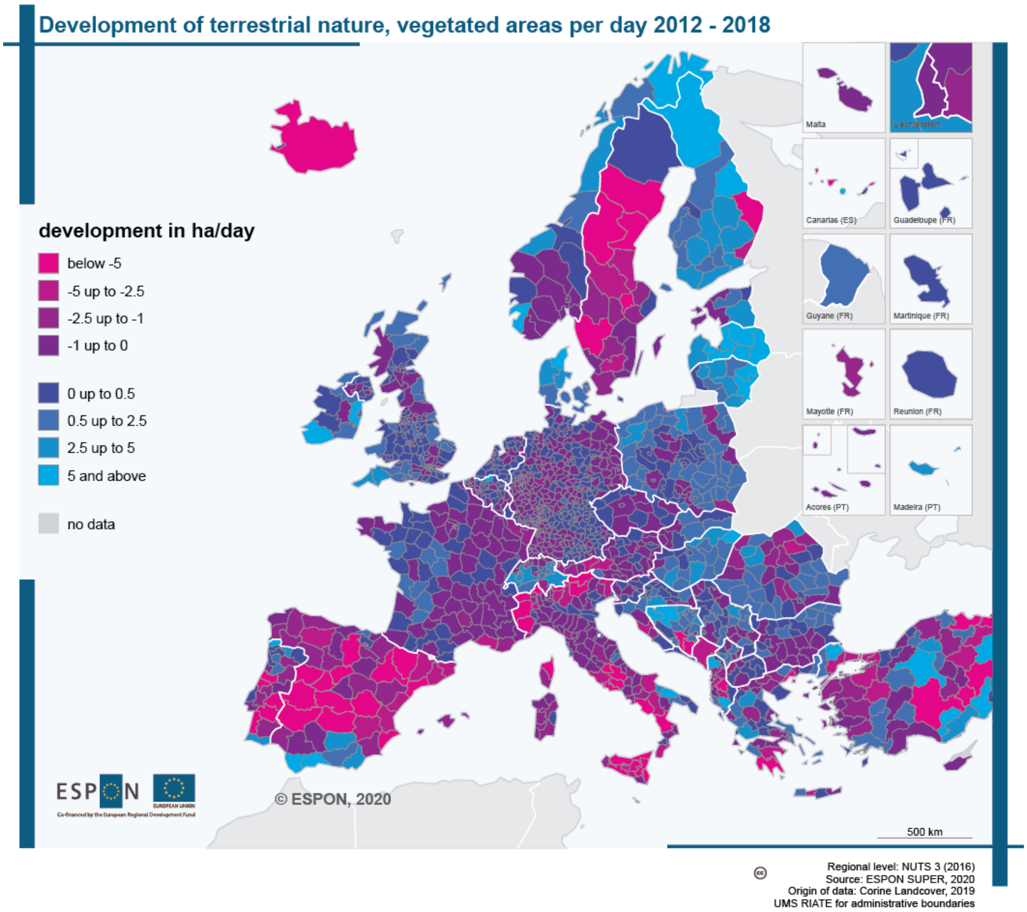


Data source: Laufende Raumbeobachtung Europa, EEA - Corine land cover: CHA data 2019 BBSR Bonn 2020

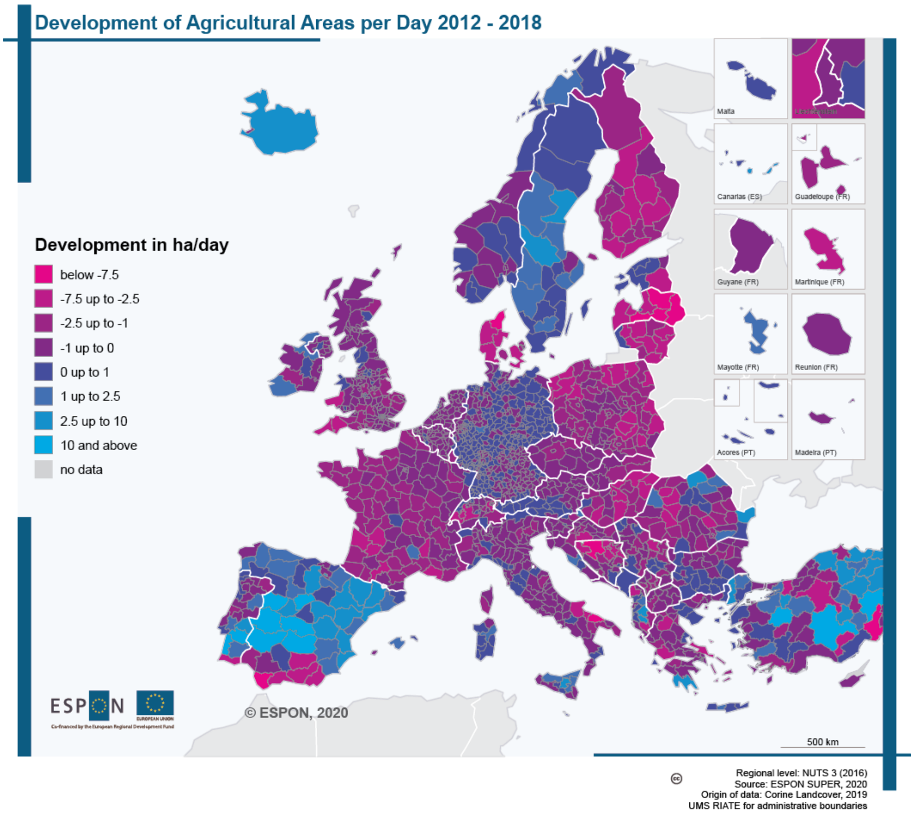
In the entire observation period (2000 to 2018), about 17.7 million hectares of land were converted from terrestrial nature. About 96% of these are changes regarding other near-natural uses, leaving 795,000 hectares which changed to non-natural functions. Of this, 22% were used for agriculture and grassland and 19% for arable land. Another 12% of the area was converted to non-urban artificial, 7% to industrial areas, 5% to urban green areas, 12% to construction sites and 4% each to urban fabric and infrastructure. The developments of the past years (2012-2018) show a decrease in conversion from nature to artificial areas (36% in total) while agriculture (22%) and arable land (26%) slightly increased. During this period, about 220,000 ha were transferred from terrestrial nature to other categories. Conversely, during the same period, about 12% of the total changes in agricultural land (495,000 ha) and 8% of arable land (440,000 ha) became terrestrial nature, reducing the actual loss of near-natural land to agriculture to about 15,000 ha between 2012 and 2018.

The changes between semi-natural areas and agricultural areas have a distinct geographical distribution. Especially in Spain, Sweden and some regions in the Balkans and Turkey, strong losses of terrestrial nature are accompanied by an increase in agricultural land, whereas in Finland and parts of Eastern Europe the opposite trend can be seen. Developments in Central Europe are rather moderate, but France and Italy have recorded losses in both categories (see Map 4.17 and Map 4.18).

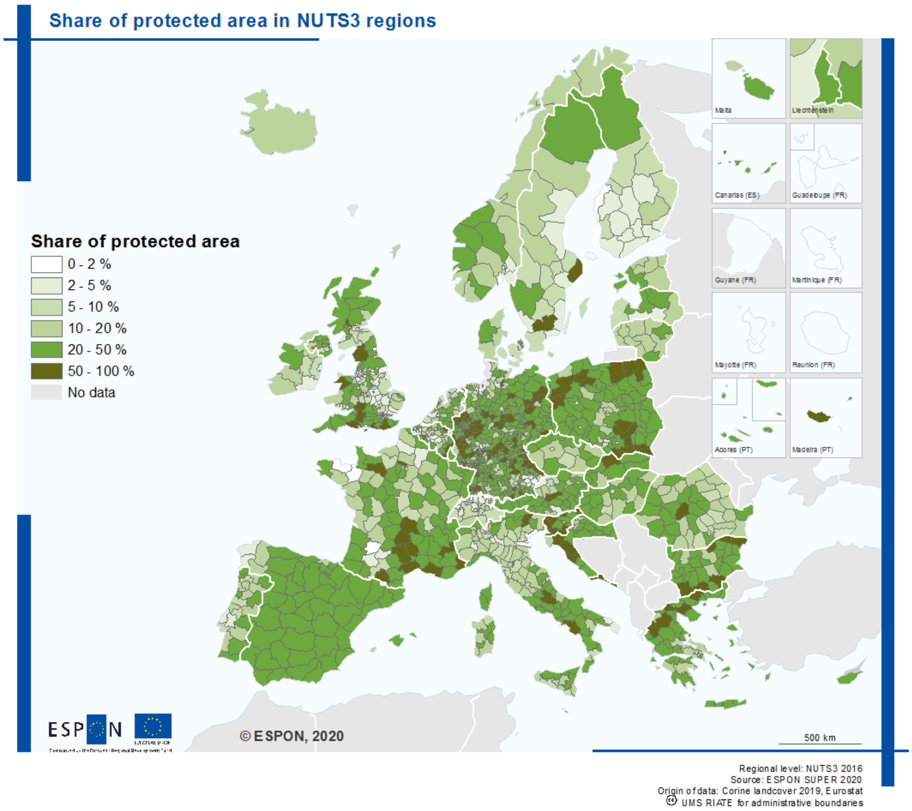
Map 4.17: Development of terrestrial nature (vegetated) per day in the period 2012-2018



Map 4.18: Development of agricultural area per day in the period 2012-2018



Map 4.19: Share of protected areas in NUTS3 regions



4.2.1 Efficiency

Land-use in Protected Areas

The negative effects on the ecosystem caused by the loss of natural areas are manifold, which is why protected areas are designated. This was analysed based on the WDPA data (see paragraph 2.5.3 and Map 4.19 above). Protected areas subject to the EU habitat and bird directives (Natura 2000) often have a significantly higher protection status than those protected by nations. Land use within these protected areas differs significantly from the averages for the entire ESPON space (Figure 4.5 and Figure 4.6). In countries with a high level of urban land use (MT, BE, NL) or agricultural use (DK; IE, NL) as well as in countries where the share of natural areas is already very high (IS, NO, FI), the share of natural land cover is even higher in protected areas and shares of urban and agriculture are correspondingly lower.

Although urban and agricultural uses within protected areas are significantly lower than those in the surrounding areas at the national level, there are some regions in which the share is still 50% and higher. Protected areas dominated by agriculture are found mainly in the south of England, Poland, the north-east and north-west of Germany, Bretagne in France, and individual regions in Eastern Europe and on the Iberian Peninsula (see Map 4.20). These areas in Spain and Portugal correlate with the strong increase in agricultural land in recent years (see Map 4.18 above). Some of these agricultural areas also have significant urban use, particularly in England, Poland and France. Mainly urban areas within protected areas are found in Belgium, the Netherlands, western Germany, England, eastern Austria and the Czech Republic (see Map 4.21).

Figure 4.5: Share of CLC land uses per country in 2018

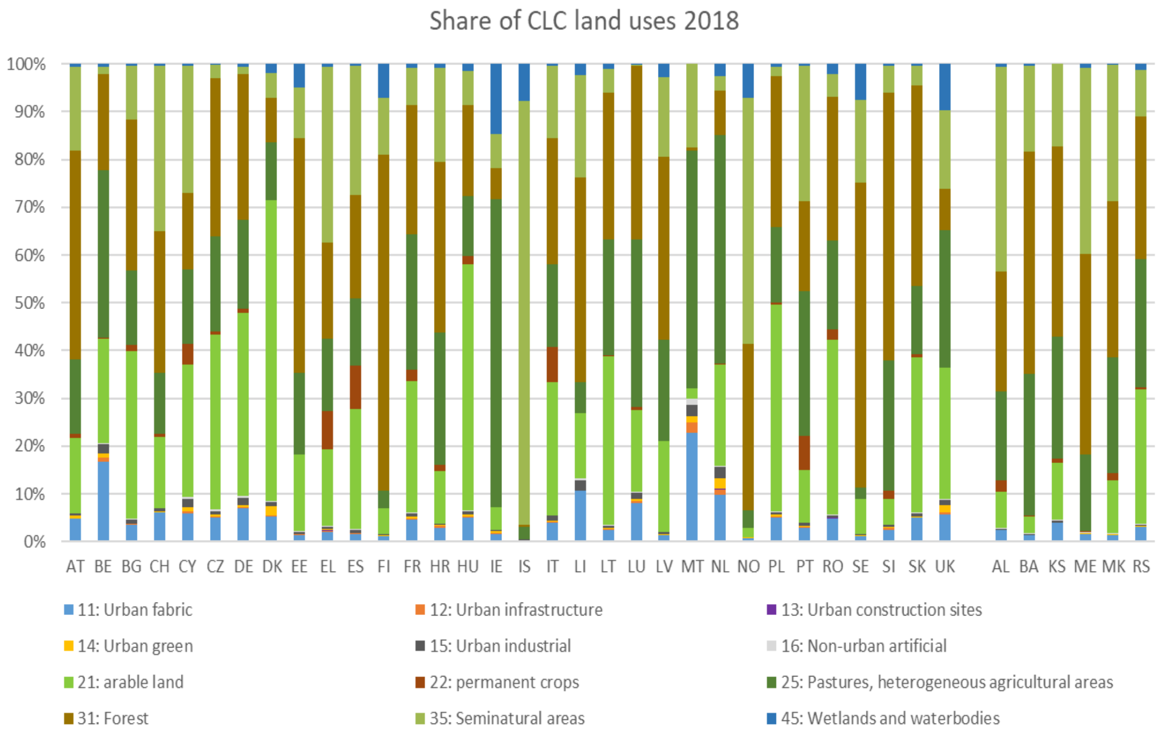
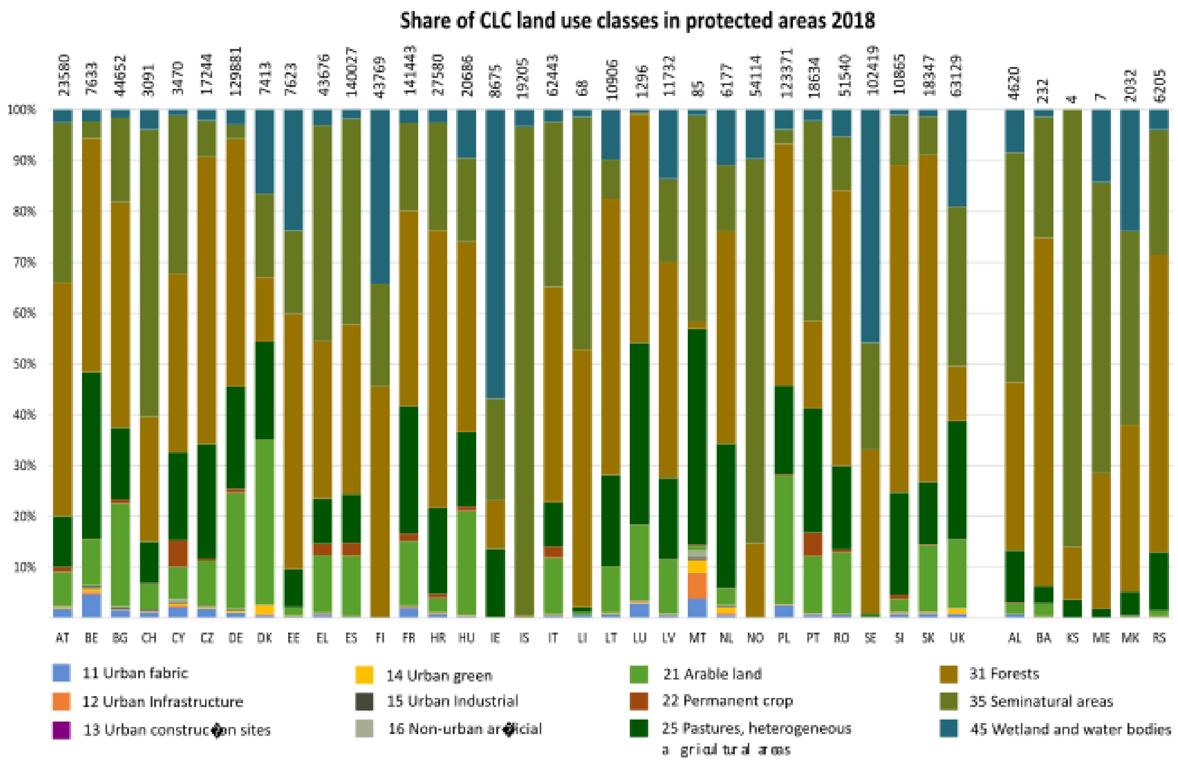
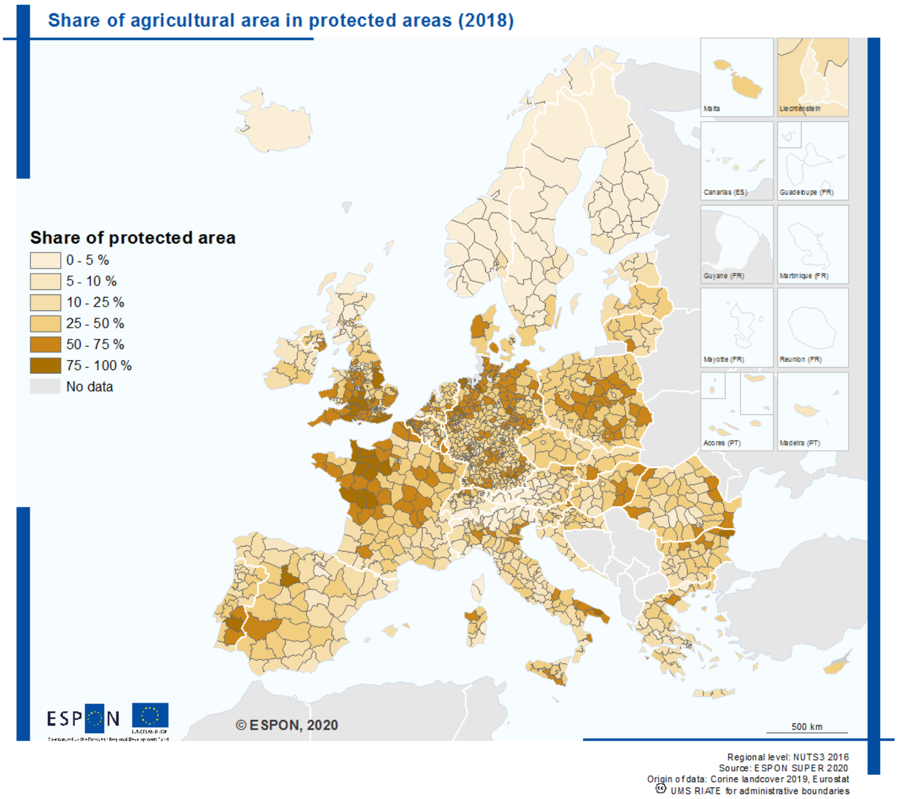


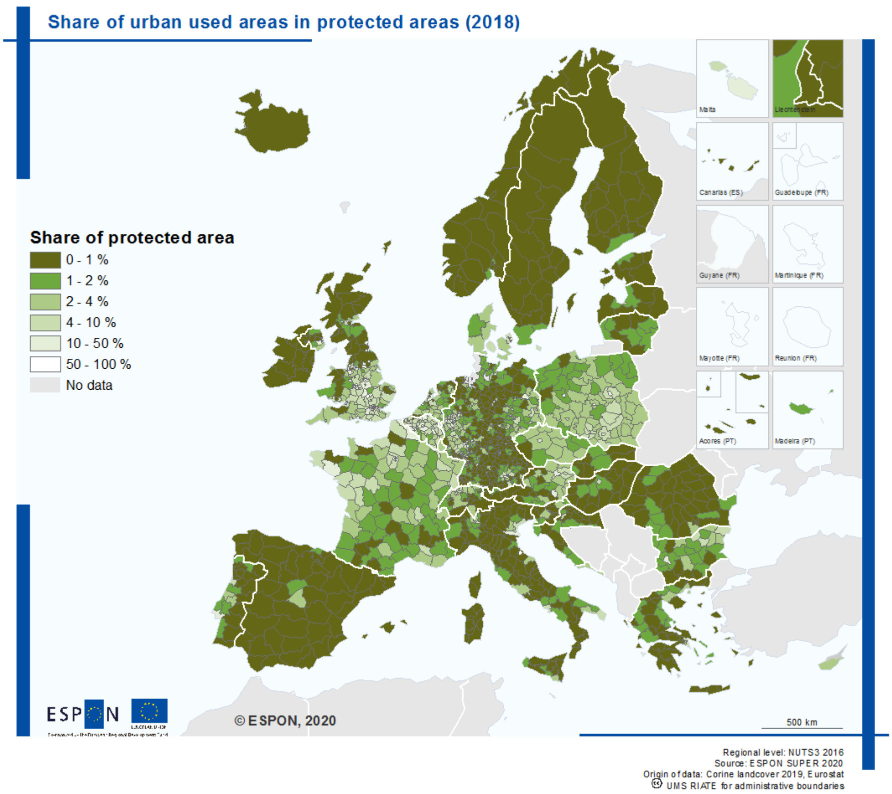
Figure 4.6: Share of CLC land use classes in protected areas per country in 2018. Numbers on top are total area in km2



Map 4.20: Share of agricultural areas in protected areas (2018)



Map 4.21: Share of urban use areas in protected areas (2018)



Land use changes regarding nature and protected areas

To understand whether the trends are sustainable, we examined how nature developed over time. In the entire time of observation (2000 to 2018), about 17.7 million hectares of land were rededicated to terrestrial nature, but about 96% of these regard changes to other near-natural uses. This leaves 795,000 hectares, of which 22% were used for agriculture and grassland and 19% for arable land in 2018. In addition, 12% of the area was converted to non-urban artificial, 7% to industrial areas, 5% to urban green areas, 12% to construction sites and 4% each to urban fabric and infrastructure.

The developments in recent years (from 2012 to 2018) show a decrease in direct rededications to artificial areas (36% in total) while rededications to agriculture (22%) and arable land (26%) have slightly increased. During this period about 220,000 ha transferred from terrestrial nature to other categories. Conversely, during the same period, about 12% of the total changes in agricultural land (495,000 ha) and 8% of arable land (440,000 ha) became terrestrial nature, reducing the actual loss of near-natural land to agriculture to about 15,000 ha between 2012 and 2018.

The changes within the Protected Areas in the period from 2012 to 2018 were over 1 million hectares, 86% of these changes were due to changes within and to terrestrial nature, 3% to changes within (20%) and to artificial areas and 8% to changes within (66%) and to agricultural areas. Overall, the share of urban and agricultural changes in Protected Areas was thus significantly lower than in the area as a whole.

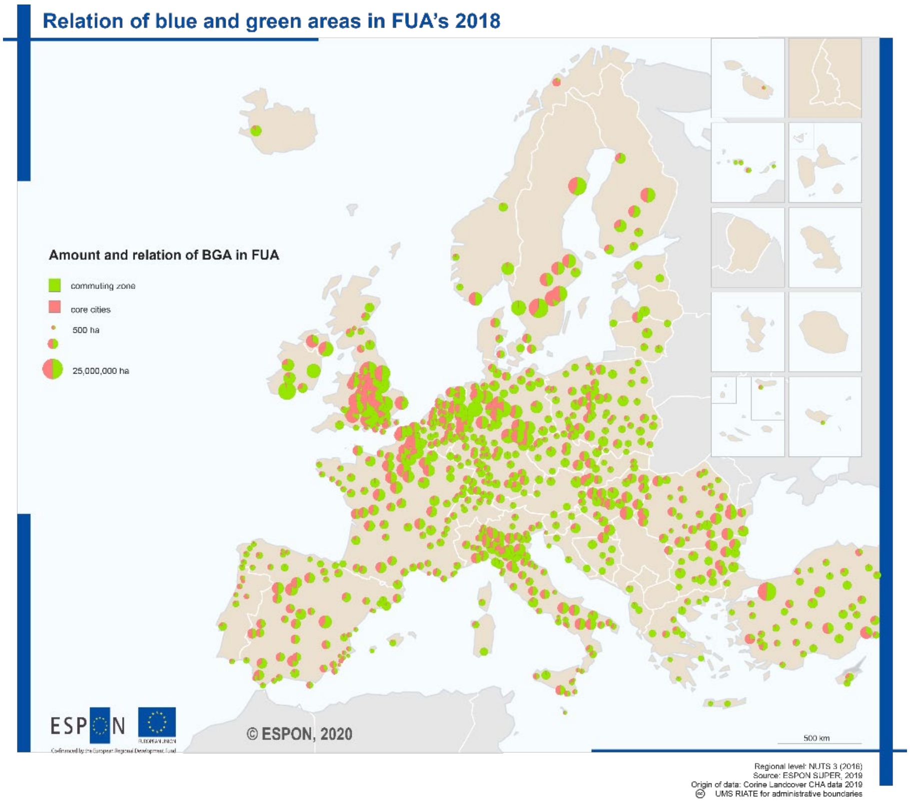
4.2.2 Trade-offs

A clear intensification of agricultural land use is visible from the CLC data: from 2012 to 2018, about 65% of changes were from grassland and agriculture to arable land, which corresponds to an area of over 300,000 ha. This intensification should increase production per hectare, but also carries with it various ecological consequences, especially in cases of simultaneous losses in semi-natural land. In addition to the loss of biodiversity there is an increased risk of soil erosion, loss of retention areas, and higher pollution by pesticides and fertilizers (especially nitrate) in soil and groundwater.

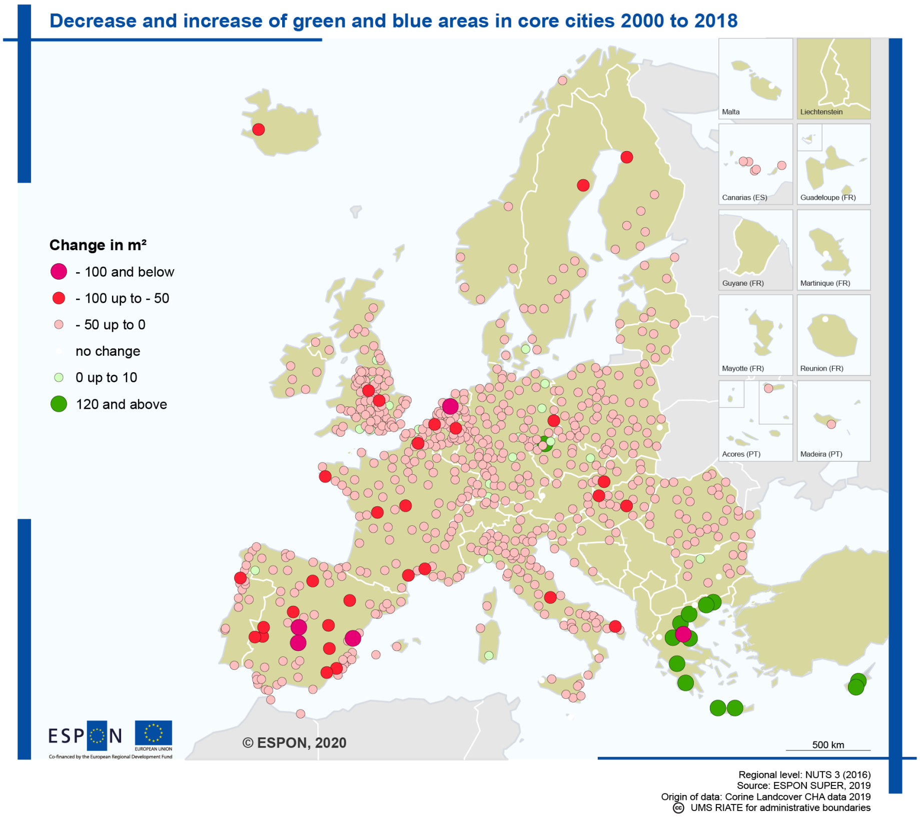
Green Urban Areas

With respect to climate change and growing cities, it is not only necessary to preserve open space for anthropocentric reasons such as recreational use, cooling (anti-heat island), and water retention (anti-flooding), but it is also necessary to maintain and develop urban green infrastructure areas to promote a healthy urban ecosystem. Despite this, only about 30 cities have a higher share of green urban areas than their surrounding areas. These are relatively evenly distributed across Europe, but most are located in Spain and Great Britain. In about 100 other cities, the proportion of urban green in the cores is roughly equal to the surrounding area (Map 4.22)

Map 4.22: Relation of blue and green areas between the core city and its commuting zone



Map 4.23: Changes in urban green areas inside the core city between 2006 and 2012



4.3 Social equity

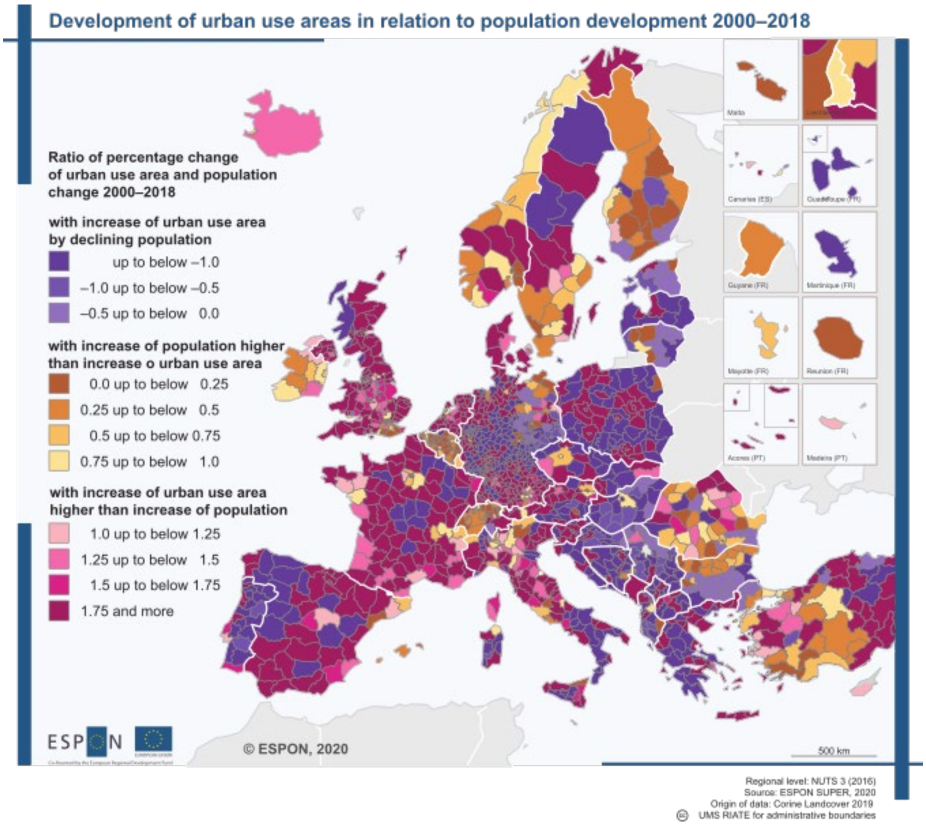
Social aspects comprise one of the three pillars of sustainability. With respect to land use, land-use changes related to housing is paramount, both in terms of providing sufficient and appropriate supply of housing stock as well as affordability. Urban and suburban development is driven and counterbalanced by income, level and developments of rents, interest rates, land and house prices and the related real-estate development. Exploring the kinds of data to create an evidence base on these elements at the European level reveals a potpourri of unharmonized regional level data with great gaps in between. Given this, simple proxies will need to suffice as a provisional information base until better data becomes available.

One of the most important starting points is population development and migration, which can be used to identify regional urbanization processes. Demographic change in combination with economic development and the resulting asymmetric geographical distribution can reveal differences between economically growing and shrinking regions versus demographically growing and shrinking regions as this provides insight into regional housing pressure. In this respect, the SDG indicator 11.3.1, the ratio of land consumption rate to population growth rate (also mentioned e.g. in the UN-GGIM: Europe report) seeks to measure inclusive and sustainable urbanization (social dimension).

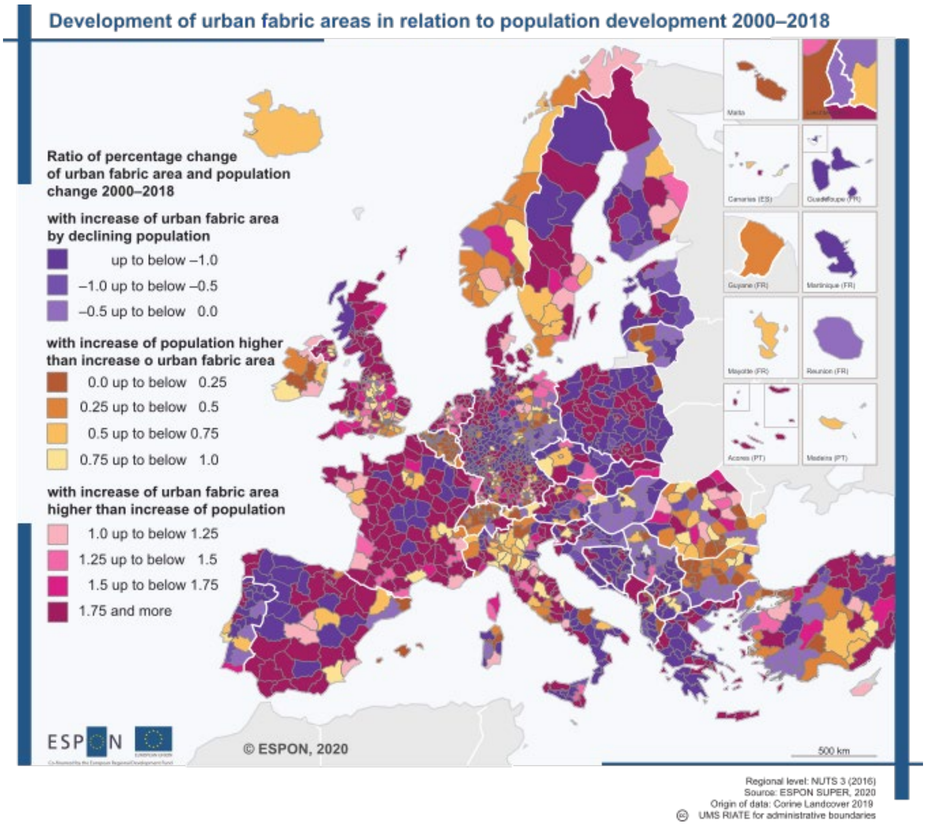
Urban areas and, more specifically urban fabric, can be measured in relation to population growth in the 2000-2018 period. The resulting map seeks to reveal regions with housing markets under pressure (see Map 4.24). According to this calculation, a value of one indicates a balanced development in which settlement developments more or less follows the development of population proportionally. With a value of 0.5 – bright orange in Map 4.24 – the percentage change of population is twice that of urban development (increasing density), with the value of 2.0 – which would be dark purple in Map 4.24 below – it is vice versa (decreasing density). As expected, pressure is higher in and around main urban centres, but not everywhere in Europe. Regions with population growth 4 times higher than that of urban use area characterize metropolitan regions like South East England, large parts of Belgium and Switzerland. The opposite trend is common in more non-metropolitan regions: growth of urban use areas in the surroundings of city regions like in Poland and Spain. There are also regions with bigger cities like in France or Mid-England that show this trend as well.

This warrants a closer view of urban fabric only, leaving the other elements of urban use, industrial and construction areas, urban infrastructure and green areas aside (see Map 4.25). Although this map shows largely the same pattern there are some differences, notably in regions around large cities. The capital cities in Eastern Europe show the strongest differences, with the exception of Poland where the increase of urban fabric indicates suburbanization processes.

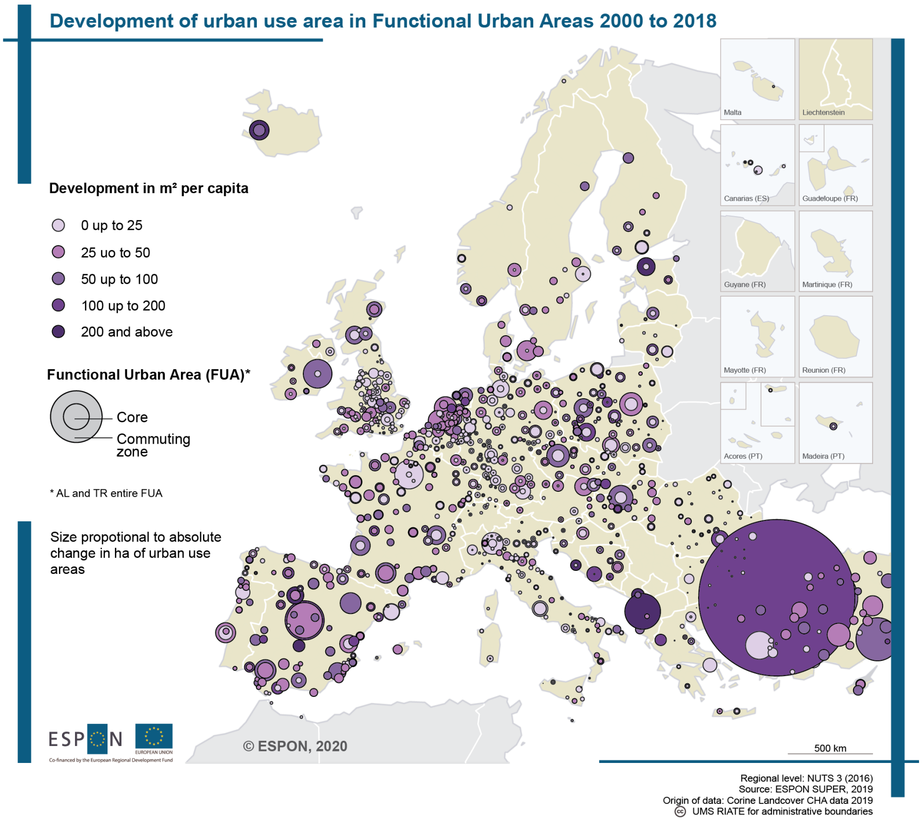
Map 4.24: Development of all urban uses in relation to population development (2000-2018)



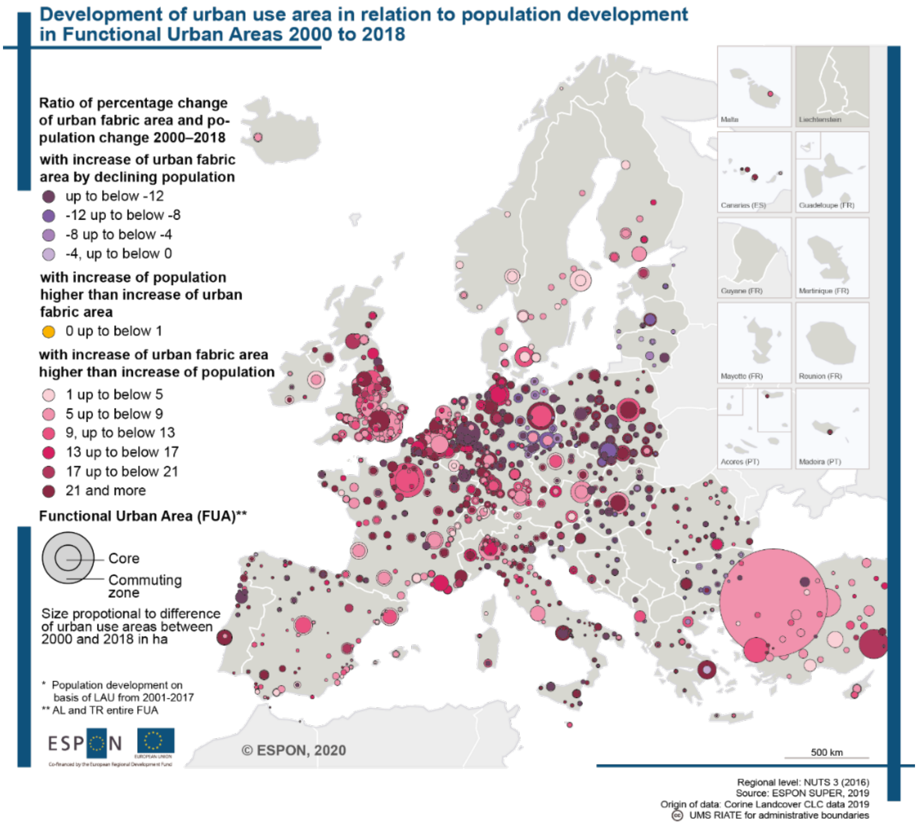
Map 4.25: Development of urban fabric in relation to population development (2000-2018)



Map 4.26: Development of urban use per capita in 2000-2018 per FUA



Map 4.27: Development of urban use relative to population for the period 2000-2018 per FUA.



Functional urban areas

From the development of cities and their environs in this analysis, we can infer that in many countries, the pressure of population growth has reached the NUTS3 areas surrounding core metropolitan regions (this is more or less visible depending on how a country has defined its territories). If true, the development of prices should then follow suit. This effect might minimise real-estate development, but it might be also possible that this will lead to a distinct socially unbalanced movement to the inner-suburbs and an increased pressure on inner-city property. This particularly affects parts of the population depending on affordable housing. Furthermore, urban development might increase in an extended circle around cities.

In this light, we have extended our analysis to Functional Urban Areas (FUA), zooming in on the division between core area and periphery, which also reveals geographic variation across Europe (Map 4.26 & Map 4.27). At the level of the whole FUA, the main pattern is an increase of urban use areas. Within the FUA, increase in urban use per capita is usually higher in the surrounding areas. This visible on the map with a small core dot and a big "donut" surrounding it. Areas with a predominant urban use growth in the core area stand out in Spain (large core circle, small "donut"). In absolute terms Turkish FUAs like Istanbul, Ankara or Adana-Mersin showed the highest absolute changes in hectares. Within the EU, Madrid, Paris and Dublin, Budapest, and Warsaw stand out.

Typologies of the relation between demography and urban land use

In order to operationalise these development trends and deepen the analysis using different indicators, a typology of population and urban fabric development was created on basis of a regression analysis. Four regional types were then discerned on the basis of below-average and above-average development with respect to the EU average. Below follows a short discussion, which is supplemented with a scattergram (Figure 4.7) and a map (Map 4.28).

The first group of regions have below-average growth in population and above-average growth of urban fabric (top left quadrant, salmon-coloured). This group is geographically concentrated in more rural and peripheral areas of Europe. These are regions with potential oversupply, where urbanization processes might thus be linked to more strongly to supply side drivers than elsewhere. The question remains to what extent this increase of urban fabric is related to local population dynamics (e.g. the population might not be increasing much, but households are[7]) or economics (e.g. second home development) and in which field of activity these developments are taking place (urban fabric contains more than just housing).

The second group of regions have both population and urban fabric development trends above average (top right quadrant, red). These regions mainly lie outside core cities in

[7] Many of the countries with these trends (Greece, Croatia, Poland) do not however show decreasing household sizes (see Figure 2.3).

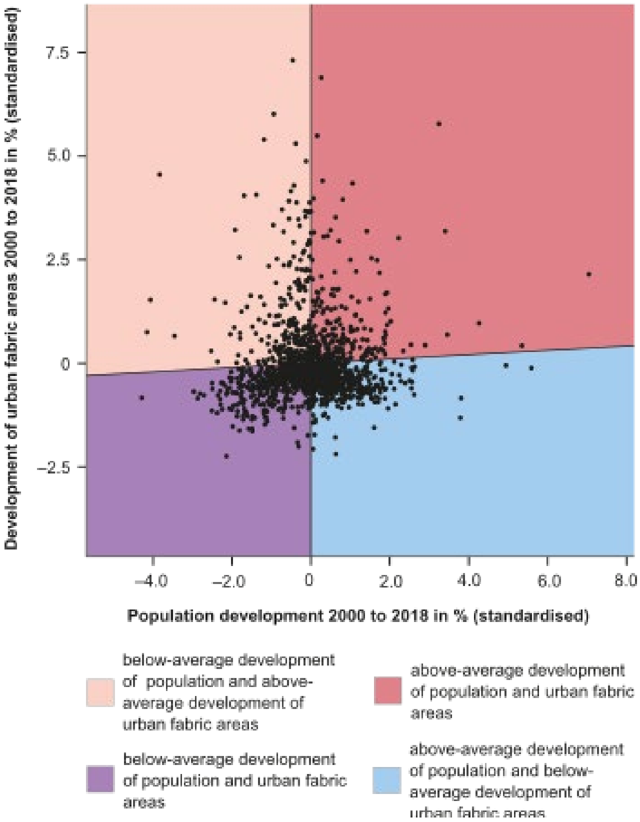
urbanized regions. Areas like the South and West of France, South of Spain and East England are regions with distinct development potential for outside population. Urbanization strategies in these regions may need to pay more attention to spatial coordination than development.

The third group of regions has above-average development in population and below-average urban fabric growth (bottom right quadrant, blue). This is a mixed group, consisting of highly urbanised regions (the Netherlands, the southern UK) but also regions with large amounts of natural areas (Norway, Austria, Switzerland, rural Iceland), for which the statement of a single issue or trend in urbanization dynamics is likely to skip over important differences.

The last group of regions have below-average development of both population and urban fabric (bottom left quadrant, purple). These are usually rural regions, that also stand out as areas of population decrease. Here sustainability issues are in fact likely to be social, and the question is less how to organise urbanization processes, and more how to safeguard urban systems and foster development.

A comparable typology was drawn up that measures the average net migration rate in the last 5 years to the development of urban areas (Figure 4.8 and Map 4.29). This analysis provides some nuance and is a potential indication of at least short-term economic trends. Of note in this analysis are both the difference within the group of high net-migration regions (red and dark blue; e.g. in Germany and the UK), and the differences within the group of low net-migration regions (orange and light blue; e.g. Spain vs northern France or Romania).

Figure 4.7: Scattergram of the interrelation between development of urban fabric areas and population



Map 4.28: Geographic distribution of urban fabric versus population typology

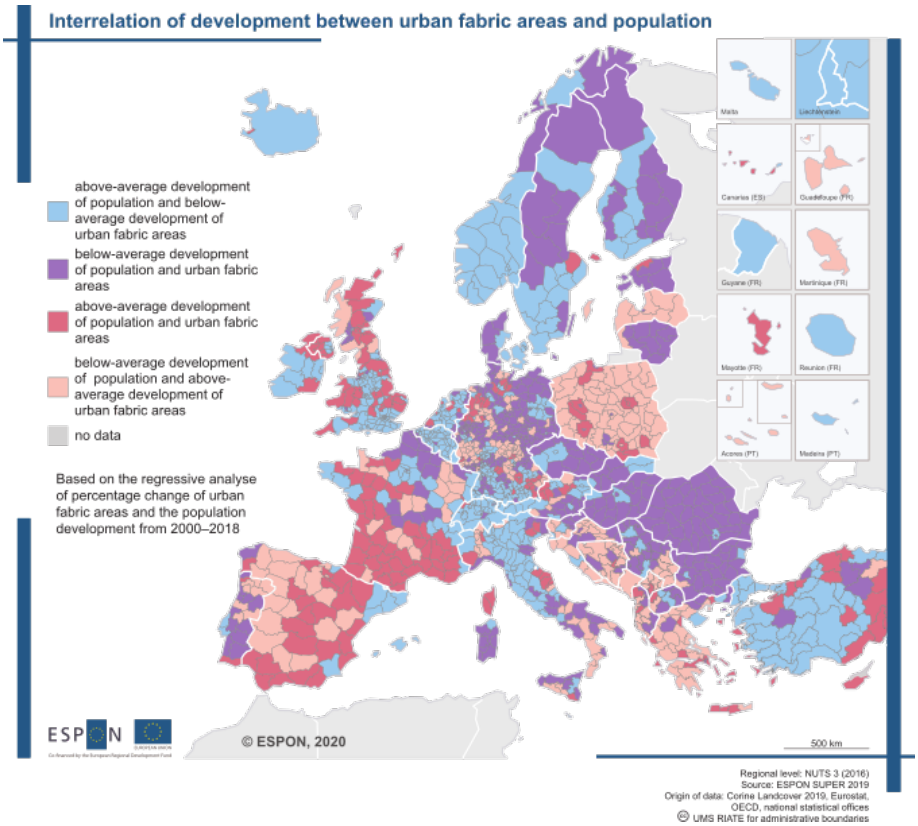
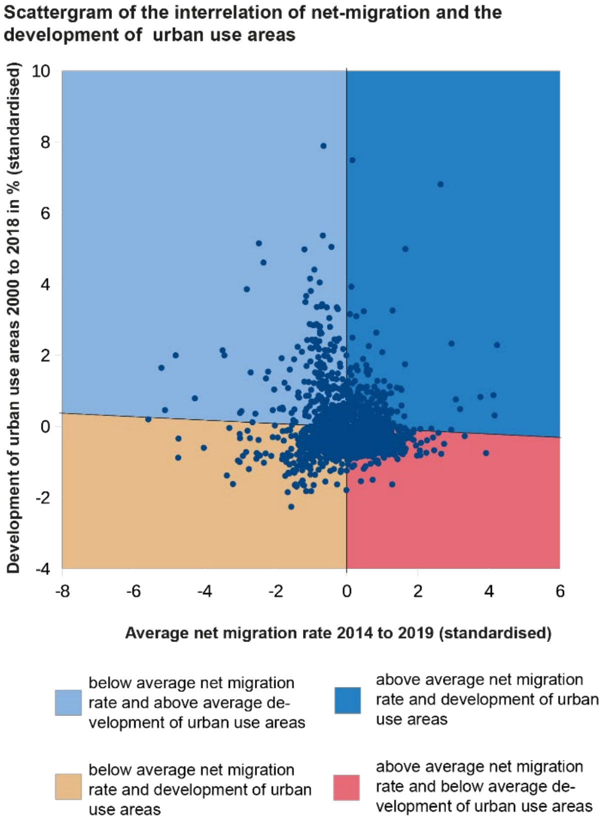
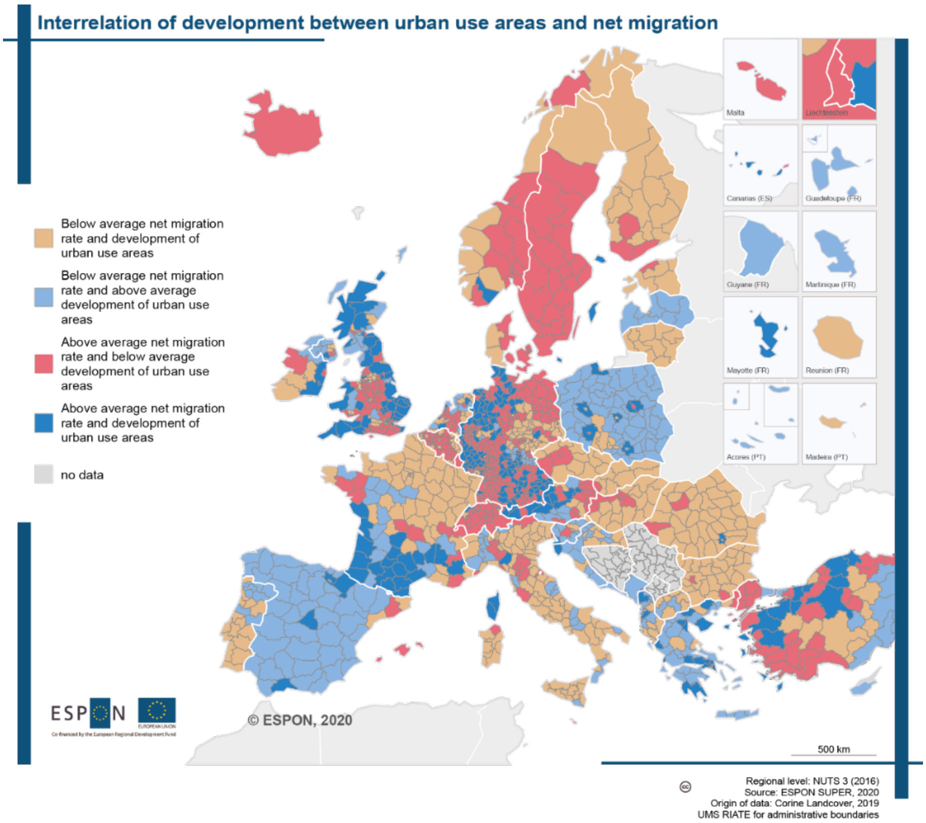


Figure 4.8: Scattergram of the interrelation of migration and the development of urban use areas



Map 4.29: Geographic distribution of urban use areas versus migration typology



5 Developments in European regions

Territory matters. The great number of land-use changes presented in this Annex are highly heterogeneous and multifaceted. The SUPER project has only begun to scratch the surface of the potential of what the rich datasets currently available provide in terms of analytical possibilities.

In order to assist future research, the SUPER project is making this information readily available to other researchers or anyone interested in browsing the data. Specifically, we produced a pivotable database from which information can be extracted in combination with a number of pre-existing typologies. Some key statistics for such typologies are presented below. These typologies, made by Eurostat and/or other ESPON projects (e.g. ESPON GEOSPECS) can be found in the following tables. This data is presented for all ESPON territory excluding Liechtenstein and Iceland, for which no GVA and employment data was available.

In addition, the SUPER project constructed two typologies to help understand urbanization in Europe better.

- **Composition of urban use**: this presents a picture of urban land-use types according to a standard clustering methodology. Performing this on multiple periods provides insight into which regions, if any, have moved from one type to another.
- **Urban form:** this examines the shape and structure of urban areas within their respective regions. This provides insight into whether urban use in an area is compact or diffuse and how it is evolving over time.

This final chapter presents the data on the ESPON typologies from our database, underlining the diversity of European regions (Section 5.1). Section 5.2 presents our construction of a typology based on land-use and other key indicators by way of a cluster analysis. Section 5.3 presents our construction of an urban form typology based on a manual visual reading of regional morphology.

5.1 ESPON typologies

5.1.1 Urban-rural

Table 5.1: Key statistics for urban-rural typology

		Predominantly urban	Intermediate	Predominantly rural
State	Population 2018	233,387,059	194,725,423	97,552,283
	GVA 2016 (M€)	7,757,081	4,587,608	1,833,993
	Employment 2016 (1000s)	115,602	86,274	40,133
	Total land area (2018)	48,116,422	200,577,952	212,133,363
	Urban use (2018)	6,441,202	9,370,122	6,052,276
	Urban fabric (2018)	4,521,481	7,066,340	4,870,307
	Agricultural land (2018)	24,169,475	91,448,387	86,722,201
	Natural vegetated (2018)	16,021,398	89,753,889	99,983,987
% of ESPON space	Population	44%	37%	19%
	GVA	55%	32%	13%
	Employment	48%	36%	17%
	Land area	10%	43%	46%
	Urban use	29%	43%	28%
	Urban fabric	27%	43%	30%
	Agricultural land	12%	45%	43%
	Natural vegetated	8%	43%	48%
% of territory	Urban use	13%	5%	3%
	Urban fabric	9%	4%	2%
	Agricultural land	50%	46%	41%
	Natural vegetated	33%	45%	47%
% change relative to 2000	Population	110%	104%	98%
	GVA	156%	158%	161%
	Employment	114%	108%	98%
	Urban use	115%	119%	119%
	Urban fabric	109%	115%	114%
	Agricultural land use	96%	97%	98%
	Natural vegetated	99%	101%	100%

5.1.2 Coastal regions

Table 5.2: Key statistics for coastal regions

		Coastal regions (≥ 50 % of population lives within 50 km of the sea)	Coastal regions bordering the sea	Island
State	Population 2018	33,451,014	187,138,806	22,485,273
	GVA 2016 (M€)	1,012,573	5,093,160	576,660
	Employment 2016 (1000s)	15,556	80,903	8,520
	Total land area (2018)	9,999,999	179,131,587	20,193,848
	Urban use (2018)	1,049,465	7,128,515	783,494
	Urban fabric (2018)	747,153	5,042,430	580,548
	Agricultural land (2018)	5,767,622	62,727,296	11,029,937
	Natural vegetated (2018)	2,912,833	87,460,858	6,026,467
% of ESPON space	Population	6%	36%	4%
	GVA	7%	36%	4%
	Employment	6%	33%	4%
	Land area	2%	39%	4%
	Urban use	5%	33%	4%
	Urban fabric	5%	31%	4%
	Agricultural land	3%	31%	5%
	Natural vegetated	1%	42%	3%
% of territory	Urban use	10%	4%	4%
	Urban fabric	7%	3%	3%
	Agricultural land	58%	35%	55%
	Natural vegetated	29%	49%	30%
% change relative to 2000	Population	110%	110%	115%
	GVA	138%	155%	180%
	Employment	111%	111%	114%
	Urban use	117%	120%	123%
	Urban fabric	110%	116%	119%
	Agricultural land use	98%	97%	100%
	Natural vegetated	96%	99%	90%

5.1.3 Mountainous areas

Table 5.3: Key statistics for mountainous areas

		> 50 % of population and 50 % of surface are in mountain areas	> 50 % of population live in mountain areas	> 50 % of surface are in mountain areas
State	Population 2018	49,728,179	715,058	66,172,362
	GVA 2016 (M€)	1,352,353	19,847	1,428,976
	Employment 2016 (1000s)	22,094	333	28,085
	Total land area (2018)	67,576,472	469,086	68,376,252
	Urban use (2018)	1,989,723	20,538	2,310,613
	Urban fabric (2018)	1,569,581	15,328	1,685,183
	Agricultural land (2018)	18,742,937	325,420	22,361,671
	Natural vegetated (2018)	36,414,093	121,504	37,358,481
% of ESPON space	Population	9%	0%	13%
	GVA	10%	0%	10%
	Employment	9%	0%	12%
	Land area	15%	0%	15%
	Urban use	9%	0%	11%
	Urban fabric	10%	0%	10%
	Agricultural land	9%	0%	11%
	Natural vegetated	18%	0%	18%
% of territory	Urban use	3%	4%	3%
	Urban fabric	2%	3%	2%
	Agricultural land	28%	69%	33%
	Natural vegetated	54%	26%	55%
% change relative to 2000	Population	103%	108%	107%
	GVA	179%	145%	157%
	Employment	109%	111%	105%
	Urban use	119%	116%	119%
	Urban fabric	111%	108%	110%
	Agricultural land use	97%	98%	96%
	Natural vegetated	99%	102%	100%

5.1.4 Border zones

Table 5.4: Key statistics for border zones

		Land border	Land border within 25 km	Outmost
State	Population 2018	130,823,118	37,998,894	4,840,925
	GVA 2016 (M€)	2,993,796	1,077,609	86,509
	Employment 2016 (1000s)	56,850	18,238	1,663
	Total land area (2018)	195,223,121	22,924,387	2,450,306
	Urban use (2018)	6,846,005	1,538,801	151,499
	Urban fabric (2018)	5,373,637	1,200,843	125,956
	Agricultural land (2018)	70,261,051	11,216,003	513,610
	Natural vegetated (2018)	99,737,029	9,497,521	1,282,340
% of ESPON space	Population	25%	7%	1%
	GVA	21%	8%	1%
	Employment	23%	8%	1%
	Land area	42%	5%	1%
	Urban use	31%	7%	1%
	Urban fabric	33%	7%	1%
	Agricultural land	35%	6%	0%
	Natural vegetated	48%	5%	1%
% of territory	Urban use	4%	7%	6%
	Urban fabric	3%	5%	5%
	Agricultural land	36%	49%	21%
	Natural vegetated	51%	41%	52%
% change relative to 2000	Population	101%	106%	122%
	GVA	171%	162%	175%
	Employment	105%	111%	122%
	Urban use	115%	118%	125%
	Urban fabric	111%	113%	124%
	Agricultural land use	98%	96%	95%
	Natural vegetated	100%	103%	83%

5.2 Evidence on urban composition: cluster analysis

5.2.1 Introduction

The speed of urbanization in terms of land use is related to the composition of urban land use, which differs from region to region and from country to country. Although almost all forms of urban land use (urban fabric, industrial/commercial, infrastructure, urban green, construction sites) are present everywhere, their compositions vary. In order to find patterns in these compositions, we have performed a cluster analysis on the composition of land use in 2018, supported by additional variables on population and jobs to compute density statistics. In doing so, we arrive at a data-driven typology of urban land use at the regional level.

5.2.2 Methodology

Data preparation

We used 8 variables from the SUPER database on Corine Land Cover at the NUTS3 level: the urban uses categorised as urban fabric, industrial land use, infrastructure (including ports and airports), construction sites, and urban green (including sports and leisure facilities), as well as the non-urban artificial land uses of mineral extraction and dump sites. We combined this with Eurostat data on population, and data on jobs in four sectors: agriculture, industry, construction and services. Land use variables for the year 2018 were expressed as proportion of the total area of all forms of urban land use (including mineral extraction and dump sites). Urban population density for 2018 computed as population divided by urban area. Job density information was available for 2016 and computed as number of jobs in urban sectors (industry, construction and services) divided by urban area; sector composition of jobs in urban sectors for the same year, expressed as percentages of total number of urban jobs.

Principal Component analysis

Using these variables, we first selected the 1370 regions for which all data were available. Then we performed a Principal Component Analysis to solve any multicollinearity problems and extract the most important dimensions. Five components had an Eigenvalue larger than 1, but since the share of construction sites was very poorly represented in these 5 components, we decided to use the 6 components with the largest Eigenvalues. The component matrix was rotated (varimax with Kaizer normalization), resulting in the table below (Table 5.5). We have highlighted all components with component loadings (absolute values) above 0.5.

Component 1 is clearly associated with a high percentage of service jobs and a large proportion of urban green; it is negatively associated with jobs in agriculture and industry. Component 2 is associated with high population and job densities. Component 3 is associated with a high proportion of industrial land use, 4 with mineral extraction and dump sites, 5 with infrastructure, and 6 with construction sites.

Cluster selection

Using these components we performed a hierarchical cluster analysis using Ward's Method with all variables standardized. To determine the number of clusters, we used the cluster coefficient, which indicates the amount of lost information after each step in the clustering process. The general principle is to stop before a large increase in the clustering coefficient. In this case, this principle leads to 2, 7 or 9 clusters. We opted for 7 clusters, because all clusters had a clear interpretation, which was not the case if we had chosen 9 clusters.

Table 5.5: Rotated Component Matrix for cluster analysis

Component	1	2	3	4	5	6
pUrbFab	-.472	.092	-.579	-.437	-.196	-.375
pInd	-.089	.017	.906	.079	.020	.035
pInfra	.166	-.066	.124	.033	.807	.227
pMine	-.053	-.131	-.109	.782	.281	.027
pDump	-.063	.007	.103	.757	-.202	.028
pConstr	-.017	.049	-.020	.044	.175	.899
pGreen	.815	-.053	.030	-.013	-.352	.275
Popdens	.166	.881	.109	-.085	.022	.015
Jobdens	.103	.888	.077	-.021	-.086	.033
pjobind	-.859	-.231	.066	.068	-.290	.114
pjobcon	-.090	-.355	-.637	.157	-.082	.129
pjobser	.836	.299	.080	-.100	.293	-.137

5.2.3 Results

The first four clusters are all similar in size, ranging between 277 and 402 regions each. Taken together, they comprise over 90% of all regions included in the analysis. The last three clusters are much smaller, between 15 and 41 regions each. The 7 clusters are presented here, accompanied by a table with key characteristics (Table 5.6) and a map showing the geographic distribution of clusters (Map 5.1).

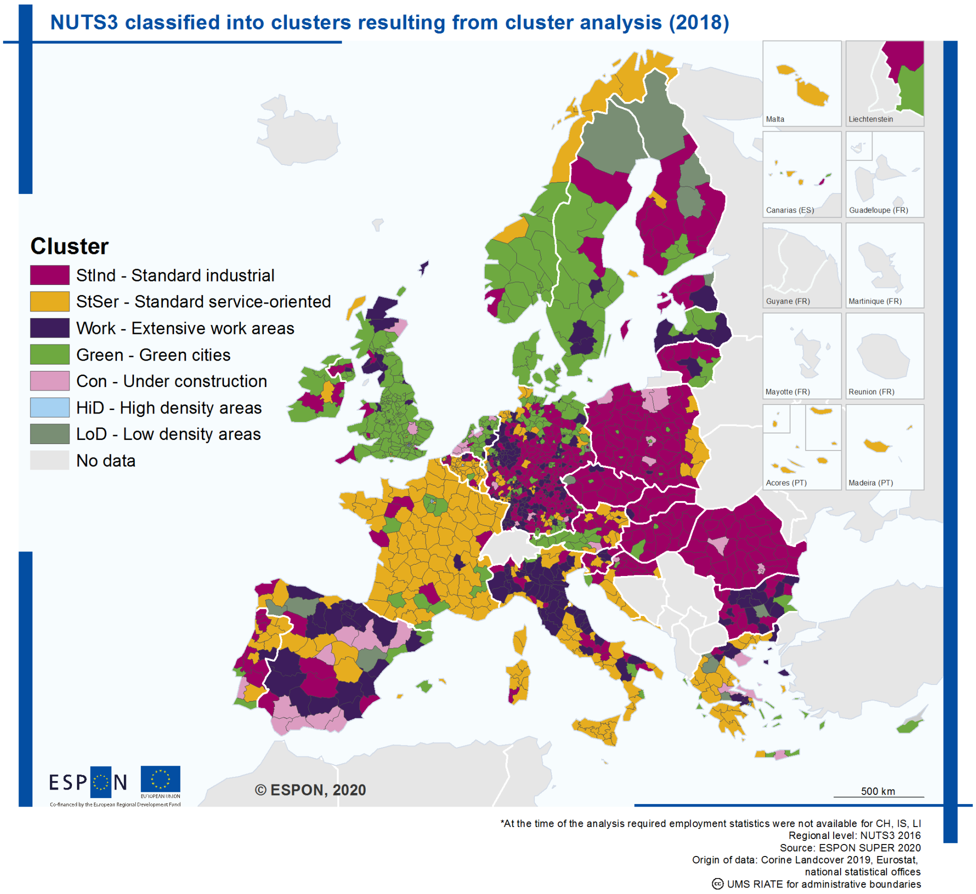
Table 5.6: Cluster composition with cluster averages for key variables

Cluster	StInd	StSer	Work	Green	Con	HiD	LoD	Overall
Number of NUTS3	402	277	281	338	41	15	16	1370
% Urban fabric	78%	77%	66%	68%	61%	79%	48%	72%
% Industry/ commercial	11%	11%	22%	12%	15%	8%	13%	14%
% Infrastructure	2%	6%	3%	3%	6%	2%	3%	3%

% Mines	3%	3%	2%	2%	4%	0%	27%	3%
% Dump sites	1%	0%	0%	0%	1%	0%	5%	0%
% Construction	0%	0%	0%	0%	5%	0%	1%	0%
% Urban Green	4%	3%	5%	15%	8%	11%	4%	7%
Population density	19	23	29	28	28	119	13	25
Job density	7	9	16	12	12	109	4	12
% jobs in industry	26%	13%	22%	11%	19%	4%	22%	18%
% jobs in construction	9%	7%	6%	7%	7%	4%	8%	7%
% jobs in services	65%	79%	72%	82%	75%	92%	70%	74%

- **Cluster 1, 'Standard industrial cities (StInd)',** is characterized by a large proportion urban fabric and a large industrial sector, albeit with a small proportion industrial and commercial areas. Because this cluster is in many respects close to the average for all European regions, and because it is the most abundant type, we refer to it as 'Standard', with the addition of 'industrial' to distinguish it from cluster 2. This type is dominant in central and eastern Europe.
- **Cluster 2 'Standard service-oriented cities (StSer)',** is quite similar to cluster 1 with respect to urban land use, which is why we also refer to it as 'Standard'. It differs from cluster 1 in that is has a large service sector and an above average proportion of infrastructure. This is the dominant type in France, Belgium, parts of southern Europe and northern Norway.
- **Cluster 3, 'Cities with extensive work areas (Work)',** is characterized by a high proportion of land devoted to Industrial and commercial areas; it also has a large industrial sector. We find this type in western Germany, northern Italy, parts of Spain, Bulgaria and Latvia.
- **Cluster 4, 'Green cities (Green)',** is characterized by a high proportion of urban green and a large service sector. This is the dominant type in north-western Europe, and in parts of Austria.
- **Cluster 5, 'Cities under construction (Con)',** is characterized by high proportions of construction areas and infrastructure. This is the dominant type in Southern Spain.
- **Cluster 6, 'High density areas (HiD)'** is made up of 15 small, highly urbanized NUTS3 regions, and is therefore difficult to spot on the map. These have by far the highest densities of population and employment, the highest proportion urban fabric as well as the largest service sector. We find these areas in the metropolitan areas of London, Paris, Brussels and Athens. The fact that they occur here, and not in other metropolitan areas, may be an artefact of the different sizes of metropolitan NUTS3 regions in different countries.
- **Cluster 7, 'Low density regions (LoD)',** is characterized by the highest proportions of mineral extraction and dump sites, as well as the lowest densities of population and employment and a relatively large industrial sector. It consists of 16 regions, 4 of which are located in northern Scandinavia.

Map 5.1: NUTS3 regions classified into the clusters resulting from cluster analysis



Clusters as typology

We can use the clusters to look at their importance in the ESPON space (EU28+EFTA). The first four clusters are the most important ones: together they contain around 90% of the land mass, population and economic activity (see Table 5.7). It should also be noted that the three clusters ‘Standard industrial’, ‘Standard service-oriented’ and ‘Green cities’ seem to represent three different urban cultures which are dominant in Central, Southern and Northwestern Europe, respectively. The largest land area and the largest artificial land area are occupied by the cluster Standard Industrial, whereas the largest population, most jobs and the largest share of GDP are found in the cluster Urban green.

The other three clusters are related to very specific types of land use. The cluster High density is remarkable because it occupies only 0.02% of the total land mass (0.4% of all urban land), but still houses 2% of the population and over 3% of all jobs, and produces ca. 6% of the total GDP in the study area. The Construction cluster indicates either stalled construction or areas in flux (as the construction land cover type is also a transition type, typically to some form of urban land use). The Low density cluster has large amounts of artificial areas that are not directly related to urban land use, with by far the lowest population and job densities of all clusters.

Table 5.7: Relative importance of urban types in the cluster analysis across variables of land area, artificial area, population, employment and GDP.

CLUSTER	Land area	Artificial land area	Population	Employment	Gdp
StInd	32.1%	32.1%	23.8%	21.7%	16.5%
StSer	23.4%	23.4%	21.8%	19.0%	19.0%
Work	13.3%	15.1%	19.6%	21.9%	22.5%
Green	20.8%	23.8%	26.7%	28.0%	30.5%
Con	4.0%	3.9%	5.4%	5.4%	5.4%
HiD	0.02%	0.4%	2.0%	3.4%	5.7%
LoD	6.4%	1.3%	0.6%	0.6%	0.4%

If we look at a few other territorial statistics (Table 5.8), we see that the High density cluster has by far the largest percentage of urban land, the largest population density, employment ratio and GDP per worker. In all other clusters except the Low density one, the percentage of urban land is similar, around 5%. There are clear differences in population density and number of jobs per inhabitant, in both cases the numbers for clusters Extensive Work areas, Green Cities and Construction are higher than those for the two Standard urban and the Low density cluster. The GDP per worker is similar in the Standard Service, Extensive Work and Green cluster and (along with the High density cluster) higher than in the other clusters. This probably reflects the differences in wealth within Europe.

Table 5.8: Proportion of urban land, population density, employment ratio and GDP/job per cluster

CLUSTER	% Of territory urbanised	Urban pop/ha	Urban jobs/cap	GDP (thousands euro/worker)
StInd	4.8%	17	0.39	45
StSer	4.9%	22	0.38	70
Work	5.5%	30	0.49	71
Green	5.6%	26	0.47	73
Con	4.6%	32	0.44	64
HiD	90.1%	119	0.75	112
LoD	1.0%	11	0.38	57

Non-urban land use types per cluster

The question remains how these urbanization types correlate with non-urban land use types. Table 5.9 is based on the 5 main Corine land cover classes, with wetlands and water bodies aggregated for the sake of simplicity.

This table shows that the two Standard clusters, together with the Extensive work and Construction cluster have similar average land use characteristics: around 5% artificial land use, around 50% agriculture and around 45% (dry and wet) nature, which is similar to the average but with agriculture and nature switching percentages. These clusters are mostly found on the mainland of Europe, which by its temperate climate is very suitable for agriculture.

The Green cities cluster has a similar percentage of artificial land use, but clearly less agriculture and more nature. This is caused by the fact that a large proportion of all land for this this cluster is located in central Scandinavia where the climate is less favourable for agriculture, even though most of England and the Netherlands are also part of this.

The High density is almost entirely urbanized: 89% of land has an artificial land use. The rest is mostly forest or other dry nature. The Low density cluster on the other hand is the least urbanized: just 1% of land has an artificial land use, 9% is agriculture and 90% is nature. The largest part of this cluster is located in northern Scandinavia, where population is sparse and agriculture unfeasible.

Table 5.9: Share of non-urban uses per urban type

CLUSTER	Urban	Agriculture	Dry nature	Wetlands & water bodies
StInd	5%	49%	44%	1%
StSer	5%	48%	46%	1%
Work	6%	50%	42%	2%
Green	6%	37%	53%	5%
Con	5%	51%	43%	1%
HiD	89%	0%	9%	1%
LoD	1%	9%	80%	10%
Total	5%	43%	50%	3%

Table 5.10: Size of the largest city per urban type.

CLUSTER	Metropolitan region	Mid-size cities region	Small-sized cities region	Regions without cities over 25.000 inhabitants
StInd	0%	6%	46%	48%
StSer	2%	9%	43%	45%
Work	6%	12%	53%	28%
Green	8%	11%	48%	33%
Con	17%	15%	41%	27%
HiD	50%	0%	50%	0%
LoD	0%	0%	56%	44%
Total	4%	9%	47%	39%

Table 5.11: Primacy in terms of mono/polycentricity per urban type

CLUSTER	Poly-centric	Mono-centric
StInd	57%	43%
StSer	54%	46%
Work	76%	24%
Green	65%	35%
Con	70%	30%
HiD	67%	33%
LoD	100%	0%

Table 5.12: Urban GUF saturation and concentration per urban type

CLUSTER	GUF saturation	GUF concentration
StInd	49%	79%
StSer	51%	73%
Work	61%	83%
Green	52%	83%
Con	53%	74%
HiD	82%	100%
LoD	41%	70%

City size and mono/polycentricity

Finally, we can compare the clusters with information on population size and primacy rate (represented here as monocentricity/polycentricity). As it turns out, there is a clear order in the typology from the most rural Low density cluster via Standard Industrial, Standard Service, Extensive Work, Green Cities, then Construction to High-Density which is of course the most metropolitan cluster.

If we look at the primacy rate (Table 5.11, based on the population of the largest LAU2 as a proportion of the total population of the NUTS3) we see that all categories are predominantly polycentric, although in the two Standard urban clusters polycentric and monocentric regions are almost equally common. None of the regions in the Low Density have a clear major municipality, and the Extensive work cluster has an above average proportion of polycentric regions. This is in line with general idea that many polycentric urban regions have their origin in the rapid development of mining and industry during the industrial revolution (e.g. Freeman & Snodgrass 1975:2).

Comparison of CLC and GUF per urban type

One might expect that the comparison between CLC and GUF urban areas (see section 2.5.1) would give different results for different urbanization types. Apart from some obvious cases, the differences are not large (see Table 5.12). Urban GUF saturation (percentage of artificial land according to CLC that is actually built up according to GUF) is by far the highest in the High density cluster and the lowest in the Low density cluster. Generally, the saturation seems to correlate with urban population density, which is as would be expected. Urban GUF concentration (percentage of built up land according to GUF that is located within an area of artificial land use according to CLC) is 100% for the High density cluster. This is almost tautological because the regions in this cluster consist almost exclusively of urban areas (artificial land use).

Dynamics in land use since 2000 per urban type

This part of the analysis reflects on land use changes in the identified clusters. Unsurprisingly, artificial land use has hardly grown at all in the High density cluster, because the regions in this cluster had already over 90% artificial land use in 2000. The large percentual changes in industrial land use, infrastructure, mineral extraction and construction sites are misleading, because the initial areas of these land uses were very small. Small areas of these land uses have been converted to urban green.

Perhaps also unsurprisingly, the Construction cluster has the largest growth of artificial land use. All artificial land use type have grown more than average in these regions.

The Standard Industrial cluster had below average growth of artificial land use. This may be because of the low population growth in many Central/Eastern European countries. More specifically, the growth of urban fabric and industrial and commercial areas was below average. Other land uses such as infrastructure, construction sites and urban green, showed a relatively large increase. This suggests improvements in the urban structure.

Table 5.13: Land-use changes in the period 2000-2018 per cluster*

Land Use Change 2000-2018	StInd	StSer	Work	Green	Con	HiD	LoD	total
Urban Fabric	11.1%	18.4%	9.8%	10.4%	33.2%	-0.8%	11.4%	13.1%
Industrial	27.3%	40.0%	55.0%	43.9%	81.1%	17.8%	46.9%	42.1%
Infrastructure	50.7%	40.9%	31.4%	5.0%	70.0%	-13.4%	13.3%	32.2%
Mine	14.1%	-4.7%	7.9%	-2.9%	36.2%	-95.8%	18.1%	7.7%
Dump	-6.5%	4.3%	29.0%	12.3%	27.6%	n/a	34.5%	8.5%
Construction	61.1%	-58.3%	-32.9%	-7.7%	72.3%	-50.8%	-18.9%	8.6%
Green	35.6%	23.7%	37.1%	28.5%	60.1%	3.9%	52.1%	31.2%
Total	14.3%	20.5%	19.3%	15.5%	44.9%	0.5%	19.2%	17.7%

** based on Corine state data, not change data*

The Urban Green also had below average growth of artificial land use. This may be because of the relatively strong tradition of spatial planning in many north western European countries. No type of urban land use has grown substantially more than average in this cluster. The growth of infrastructure was particularly small with only 5 percent.

The other clusters had slightly above average growth of artificial land use. The Standard Service cluster had above average growth of urban fabric and infrastructure. The Extensive work had above average growth of industrial and commercial areas, as well as urban green. The Low density cluster had above average growth of industrial and commercial areas, mineral extraction and dump sites, and urban green.

Dynamics between urban types

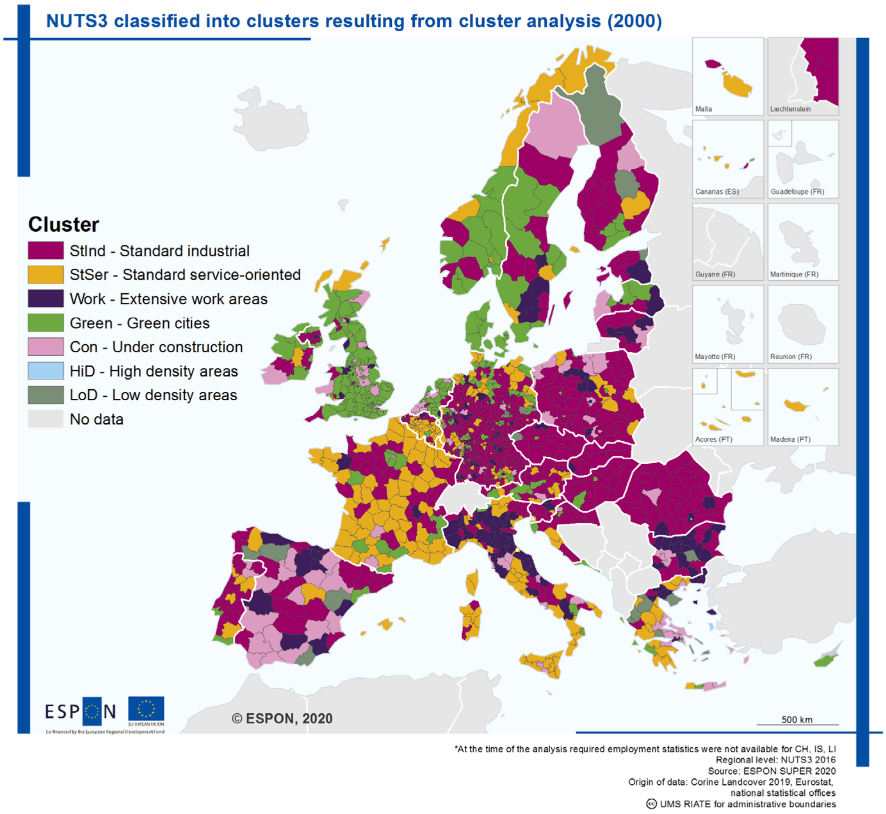
So what would Map 5.1 look like in the year 2000, using the same typology? We performed a discriminant analysis to derive classification functions based on all input variables; then we re-classified the regions applying those functions on the data for 2000. The resulting clusters can be seen in Map 5.2, with Table 5.14 showing changed clusters and their new clustering in 2018. Since in most regions, the area of construction sites was substantially larger in 2000 than in 2018, this resulted in more than half of all regions being classified into the Construction cluster in the year 2000. We therefore derived new classification functions, leaving out the percentages mineral extraction, dump sites and construction sites. This resulted in a reasonable fit for 2018, with 78% of all regions correctly classified. Unsurprisingly, the percentage correctly classified was much lower (41%) for regions in the Construction cluster, but for all other clusters it was 75% or better. Taking into account only the 1067 regions that were correctly classified in the 2018 data based on this method, 304 or 30% of those were in a different cluster in the year 2000.

Table 5.13 shows the results of this change analysis, with the percentage of clusters staying the same greyed out. Most of the areas that would be classified as Construction in 2000 have changed in the period 2000-2018. In the year 2000, there were more regions in Standard Industrial, Construction and Low Density than in 2018. The other clusters (Standard Service, Extensive Work and Urban Green) have grown since 2000, mainly because of regions changing from Standard Industrial. The location of regions that changed between clusters is shown in Map 5.3.

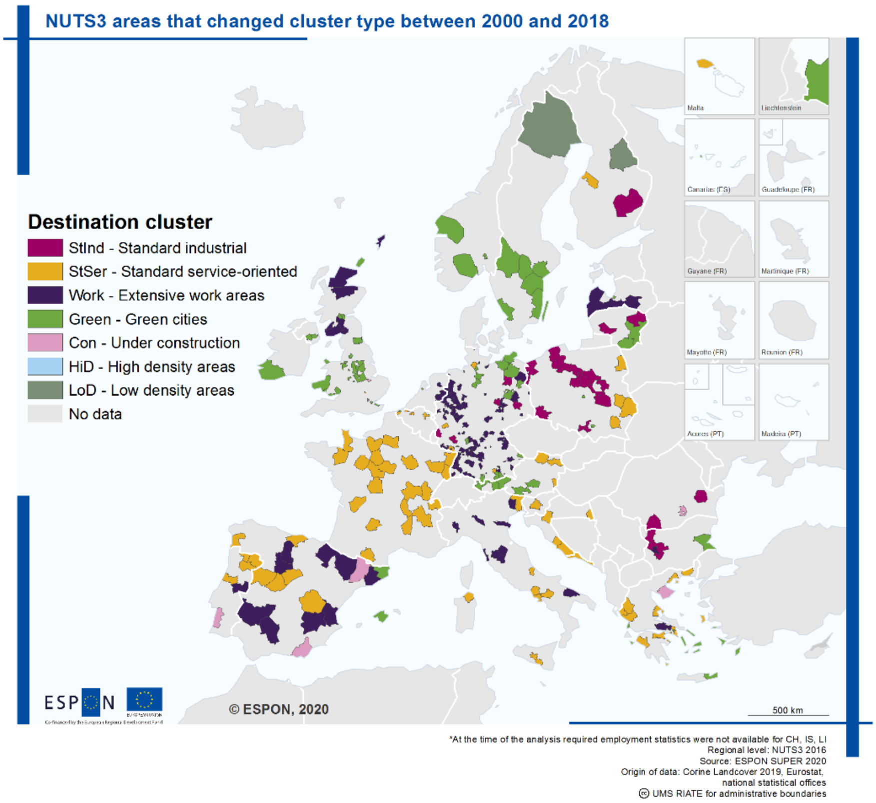
Table 5.14: Changes in typology between 2000 and 2018 as percentage of source category (2000) for correctly identified clusters

2018 2000	StInd	StSer	Work	Green	Con	HiD	LoD	Total
StInd	66%	13%	15%	6%	0%	0%	0%	415
StSer	4%	76%	9%	11%	0%	0%	0%	202
Work	7%	1%	85%	6%	1%	0%	0%	136
Green	0%	2%	7%	90%	0%	1%	0%	211
Con	11%	19%	26%	26%	16%	0%	3%	70
HiD	0%	8%	8%	0%	0%	83%	0%	12
LoD	5%	10%	10%	10%	10%	0%	57%	21
Total	301	227	232	264	17	12	14	1067

Map 5.2: NUTS3 clustered according to 2000 data



Map 5.3: Destination cluster of NUTS3 areas that changed typology between 2000 and 2018



5.3 Evidence on urban form: morphological analysis

5.3.1 Introduction

Much of the literature on sustainability of urban regions makes a distinction between a relatively sustainable compact urban form versus unsustainable urban sprawl. However important this morphological distinction is to policymakers and academics may be, it is difficult to impossible to shed light on this discussion using data used elsewhere in this report and project. This is largely because the data available regard socioeconomic and land-cover statistics that do not directly address the shape of urban areas. Using such quantitative data, it is notoriously difficult to define, operationalize let alone measure urban form, and studies that attempt to do (e.g. EEA & FOEN 2016, OECD 2018), invariably raise as many questions as they do answers. In general, the more sophisticated quantitative analyses become, the less intelligible the methods become to policymakers.

The SUPER project feels that it is important to contribute to the societal debate on the sustainability of urban form. An important step is being carried out elsewhere (see Annex 4) by a literature review of the impacts on different kinds of modes urbanization (compact, polycentric and diffuse) using our broad definition of sustainability. This resulted in a matrix of pros and cons on myriad indicators for each of the three modes. The next step is to identify these modes in real life: which regions in Europe are more compact, which more polycentric and which more diffuse? And in which direction are they heading? The answers to these questions will help to determine the sustainability of developments of individual regions.

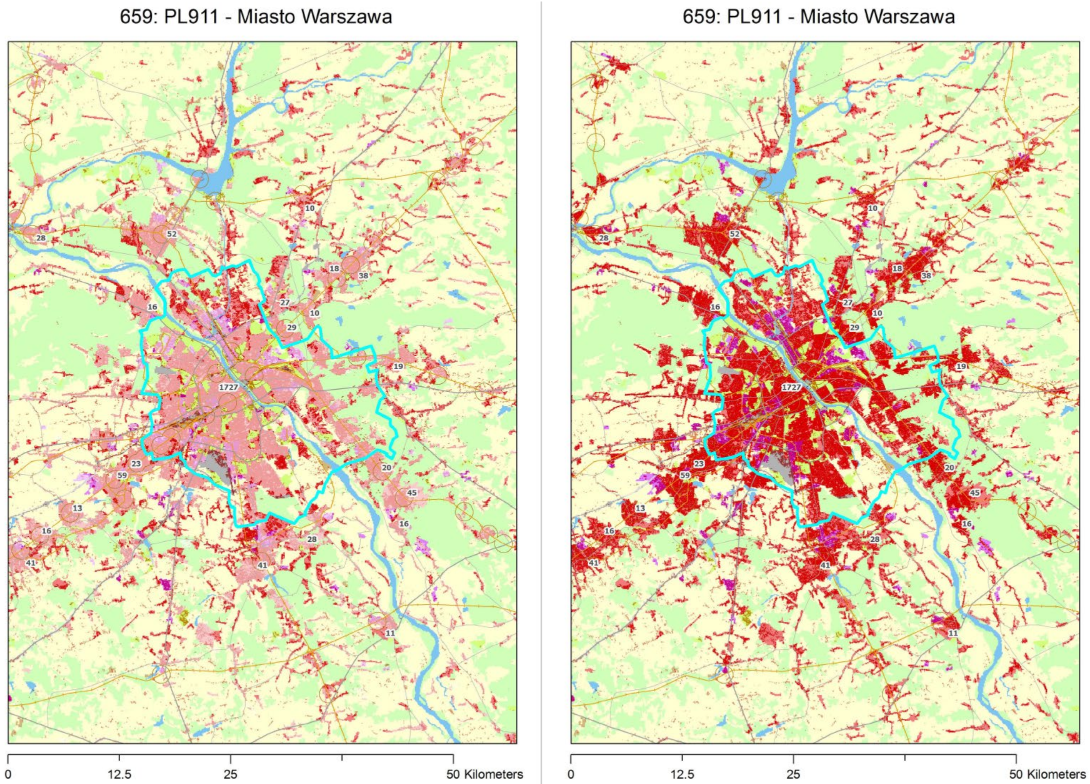
To answer these crucial questions, the SUPER project has endeavoured to classify NUTS 3 regions in terms of their urban form, using those in the sustainability matrix as far as possible (compact, polycentric and diffuse). The basic philosophy is similar to that of the book *A Field Guide to Sprawl*, which uses visual information – in that case aerial photography – to identify different urban forms (Hayden 2004). In other words, the expression “I know sprawl when I see it” comprises the point of departure. Therefore, the methodology employed was to manually evaluate images of NUTS3 regions on urban form on the basis of expert judgement using a categorization that corresponds to the SUPER sustainability assessment framework. Even though expert judgement can be accused of being untransparent and nonreproducible by definition, the criteria used to arrive at this judgment can certainly be stated in a clear and transparent manner. This is the intent of the SUPER morphological analysis. Still, it is an experimental and unorthodox methodology and should be thus considered as indicative and preliminary. If it results in interesting insights, it could be refined further or even be automated.

5.3.2 Methodology

Data preparation

The first step was to produce clear images of each NUTS3 region in Europe in order ease the interpretation of urban form. This was done by automating the export of maps, containing information about land cover, territorial boundaries and supplementary data, for each NUTS3 region in random order. This was done by using a Python script operating from the ArcGIS Python console. Two images were produced per NUTS3 region. The first image was used to understand the urban form and presented all urban fabric in bright red, industry in bright purple, urban green in bright green and infrastructure in grey, with other (non-urban) functions displayed less prominently. In addition, population information was given where available using gazetteer data, and major road and rail networks were drawn as well as circles of one kilometre in radius around train stations to ascertain the level of transit-oriented development. The second map exactly the same as the first, but presented all urban use in 2000 less prominently, thus highlighting changes in the 2000-2018 period (see Figure 5.1).

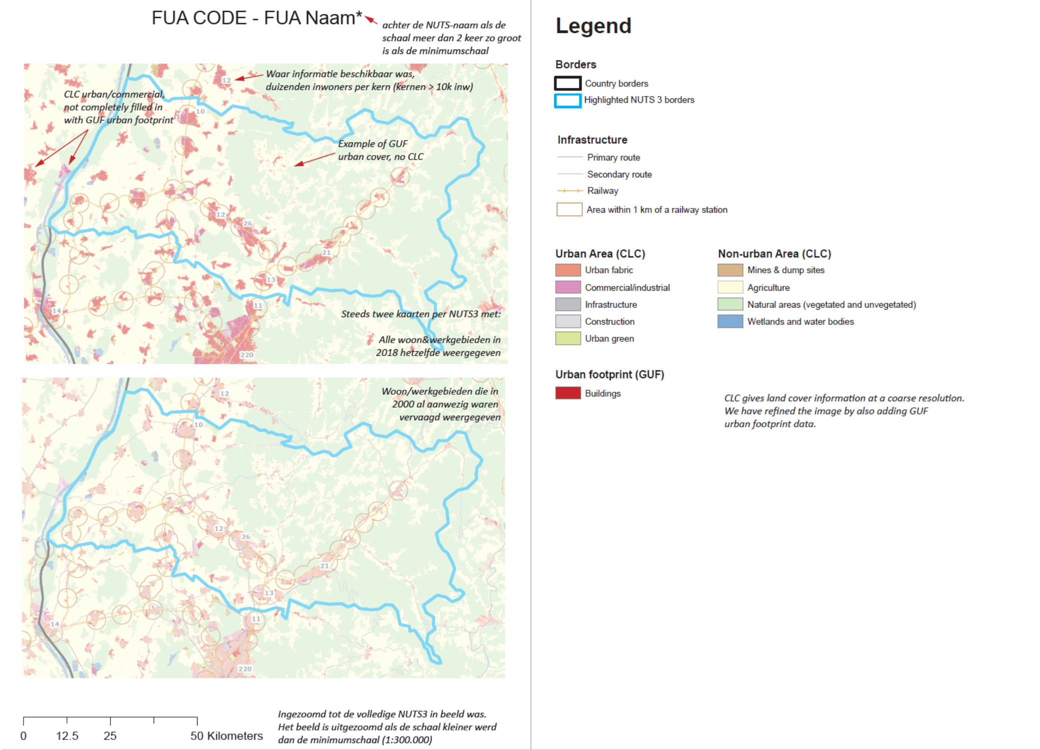
Figure 5.1: Sample screenshot showing region to be evaluated on recent urbanisation (left) and urban form in 2018.



Qualitative assessment

The next step was to determine a classification system for evaluating the NUTS3 regions. This was performed in a workshop at PBL Netherlands Environmental Assessment Agency on 13 February 2020 with participants with backgrounds in architecture, urban design and spatial planning. The intent was to agree on and test a classification system that could be easily communicated to third parties. Each member received instructions on how to read the maps (see Figure 5.2) and were briefed on the three modes of urbanization identified in the SUPER project.

Figure 5.2: Screenshot of instructions to evaluators



The work proceeded as follows. First, the participants began deductively evaluating the randomized NUTS 3 regions by attempting to put them into one of the three categories. After approximately 30 minutes the results were discussed to reflect on the methodology. First, it was clear that the three types could be distinguished and that they formed a continuum. Second, it became very clear that more categories were required between the three extremes. This resulted in the creation of five morphological categories: compact, compact/polycentric, polycentric, polycentric/diffuse and diffuse. This could be read as a Likert scale on compactness. An additional category for no urbanization was also added.

A second round of evaluation commenced. After approximately one hour, it became clear that further modification was needed because most regions exhibit multiple types which could not be explained by merely averaging out the morphological classification. For example, some regions had a single compact city but very diffuse surroundings, which is a completely different than polycentric (which could also be multiple compact centres). To account for this, a distinction was created in terms of ‘main structure’ and ‘substructure’. The main structure records the shape and distribution of the most prominent urban centres in the region, whereas the substructure records the rest. This is displayed in Figure 5.3.

The same was applied to the evaluation of changes in urban form in the 2000-2018 period. Here it was agreed not to judge the magnitude of the changes (unless zero) because this is already known from the land-use data, but the *shape* these changes were taking. This is shown in Figure 5.4. Finally, it was also decided to note the type of area in which the NUTS3 region was located. In some cases, the region was part of a larger polycentric urban region, while in others it was the only urban area in that part of the country.

After testing this method for a few hours and entering the results into an Excel sheet, the workshop was ended. The selected categories were compiled into the above schematic to allow this methodology to be carried out by third parties. The scoring was carried out by members of the SUPER project team together with spatial planning students at the University of Amsterdam. A messaging group was set up so that evaluators could quickly discuss issues regarding scoring of difficult cases. Rarely were differing opinions regarding scores more than one step removed, so this can be construed as a margin of error.

Figure 5.3: Urban form evaluation guide

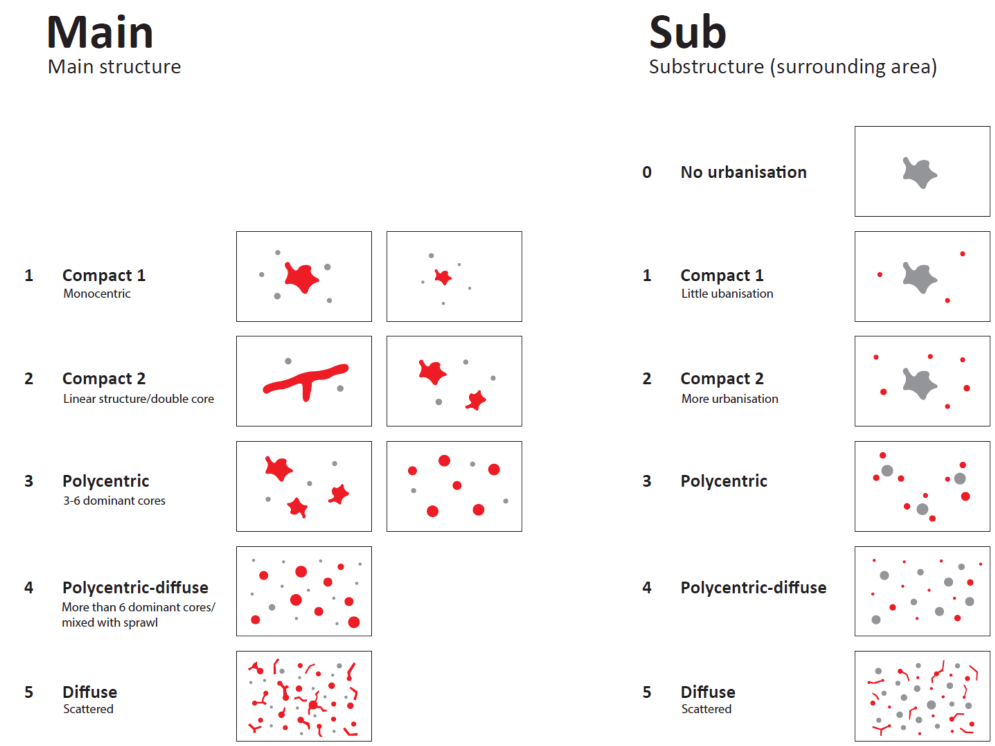
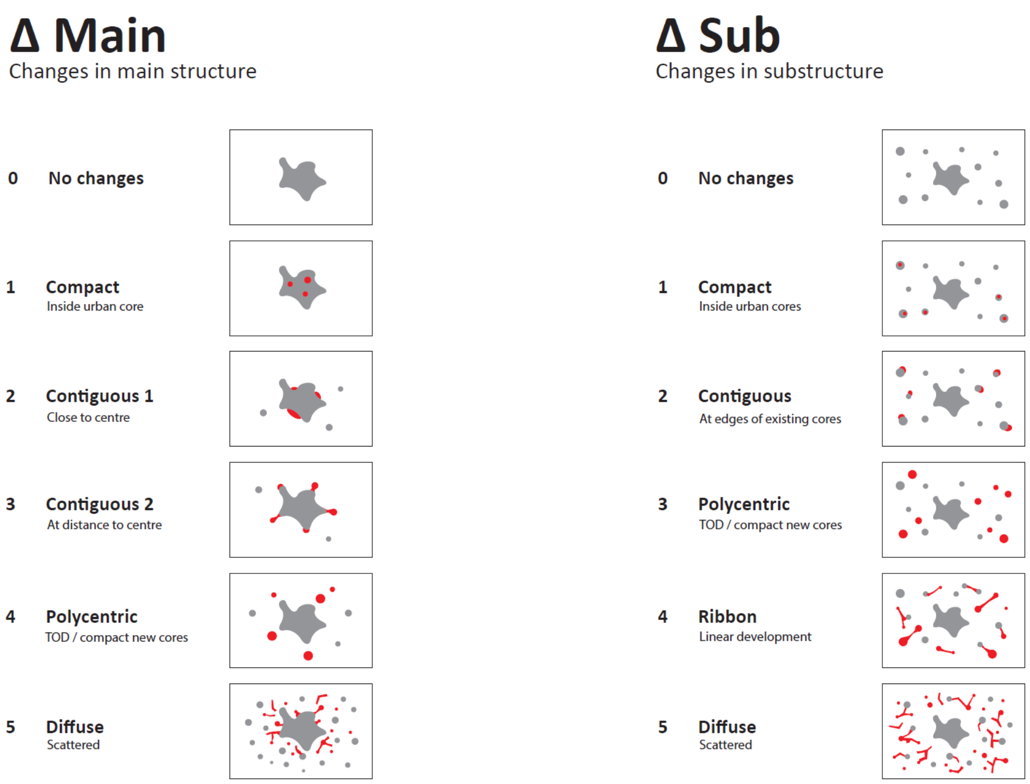


Figure 5.4: Change in urban form evaluation guide



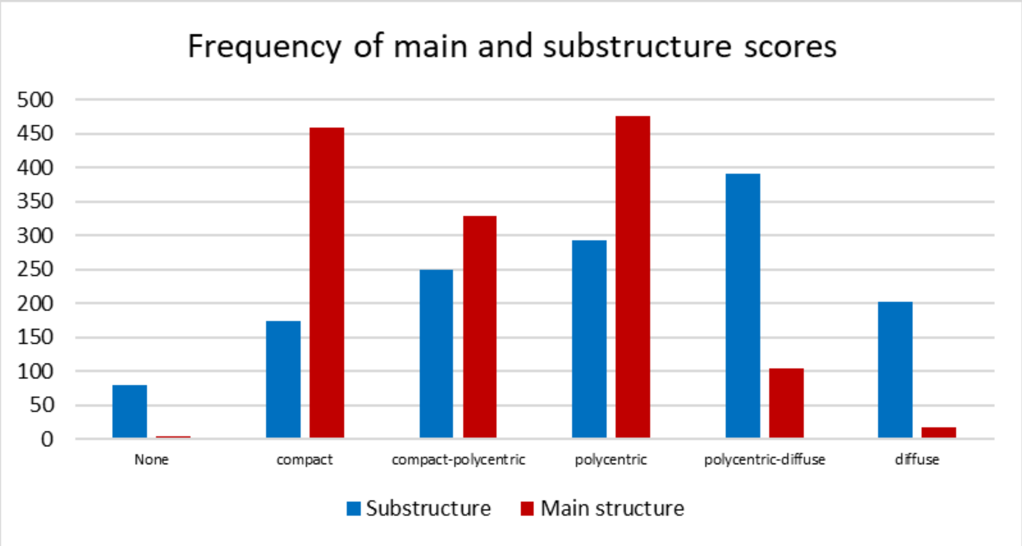
5.3.3 Results

Morphological analysis of urban form

In order to gain an impression of the most common urban forms in Europe a frequency distribution of the scores was performed (see Figure 5.5). Here it is clear that, not surprisingly, the main structure was judged more compact than the substructure. For the main structure, the most common urban forms were compact (generally monocentric) and polycentric (generally 3-5 urban clusters); relatively few main structures were classified as diffuse. In the substructure we see consistently higher frequencies as the urban form becomes more diffuse; only the final category 'diffuse' was lower than the category preceding it. Taken together, the number of polycentric scores (n= 772) was the highest, followed by compact (n= 636), compact-polycentric (n= 580), polycentric-diffuse (n= 499) and finally diffuse (n= 226). The most common pairing was a polycentric main structure with a polycentric-diffuse substructure (n= 169), followed by polycentric/polycentric (n= 138).

For some regions, no urban structure could be identified (n= 84). Excepting four occurrences in the main structure (e.g. extremely sparsely populated areas such as in Iceland), this pointed to the absence of a substructure, generally indicating an extremely compact urban form with no building outside the main urban area(s) or very tight administrative boundaries.

Figure 5.5: Frequency of main and substructure scores



Looking in more detail, Figure 5.6 below how the two structures interrelate. For the sake of clarity, we excluded the cases where the main structure could not be detected. The analysis tells that that the more diffuse categories (4 and 5) in the substructure – often labelled as urban sprawl – most often occurs when the main structure is also relatively diffuse. Interestingly, the first three main categories show roughly equal levels of diffuse substructures. In other words, the chance that a compact (monocentric or dual/linear structure) region has a diffuse substructure is roughly the same as that for polycentric regions. For example, there were monocentric regions with very compact or no development outside the core city (e.g. Oslo, Berlin, Coventry and Budapest: sometimes explained by tight NUTS3 borders) as well as ones with very diffuse development (e.g. Gliwicki, Milan and Braşov). Still, outside this relatively small diffuse category, we clearly see a pattern where, as the main structure becomes more diffuse, so too becomes the substructure.

Figure 5.6: Combinations of main structure and substructures

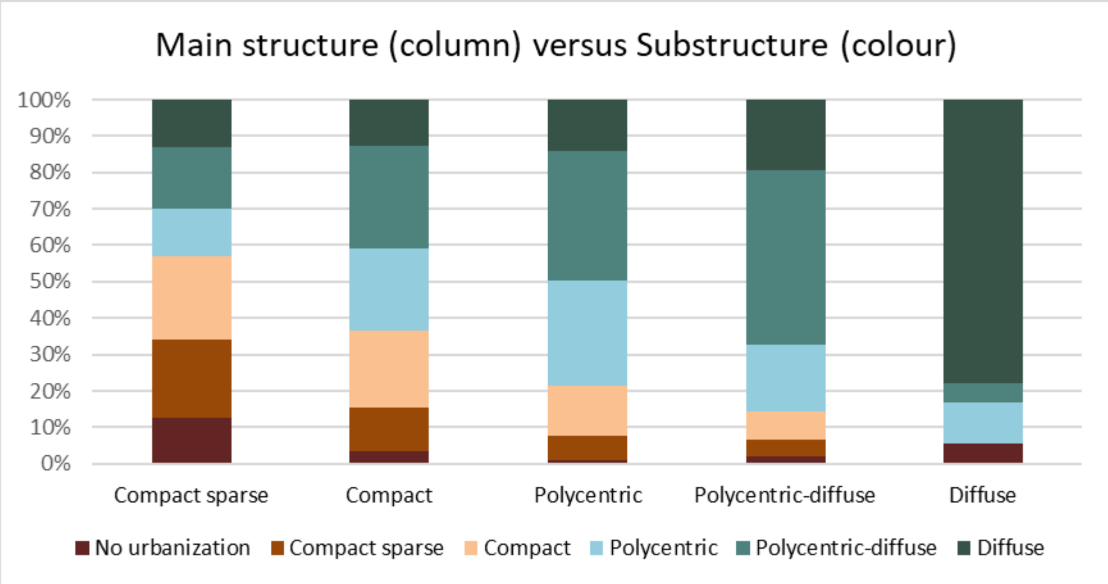
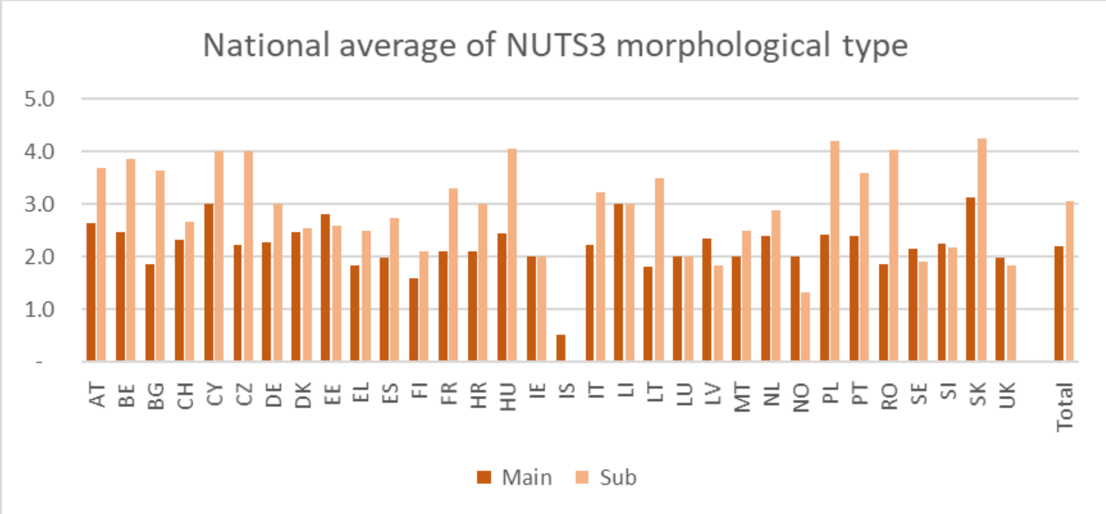
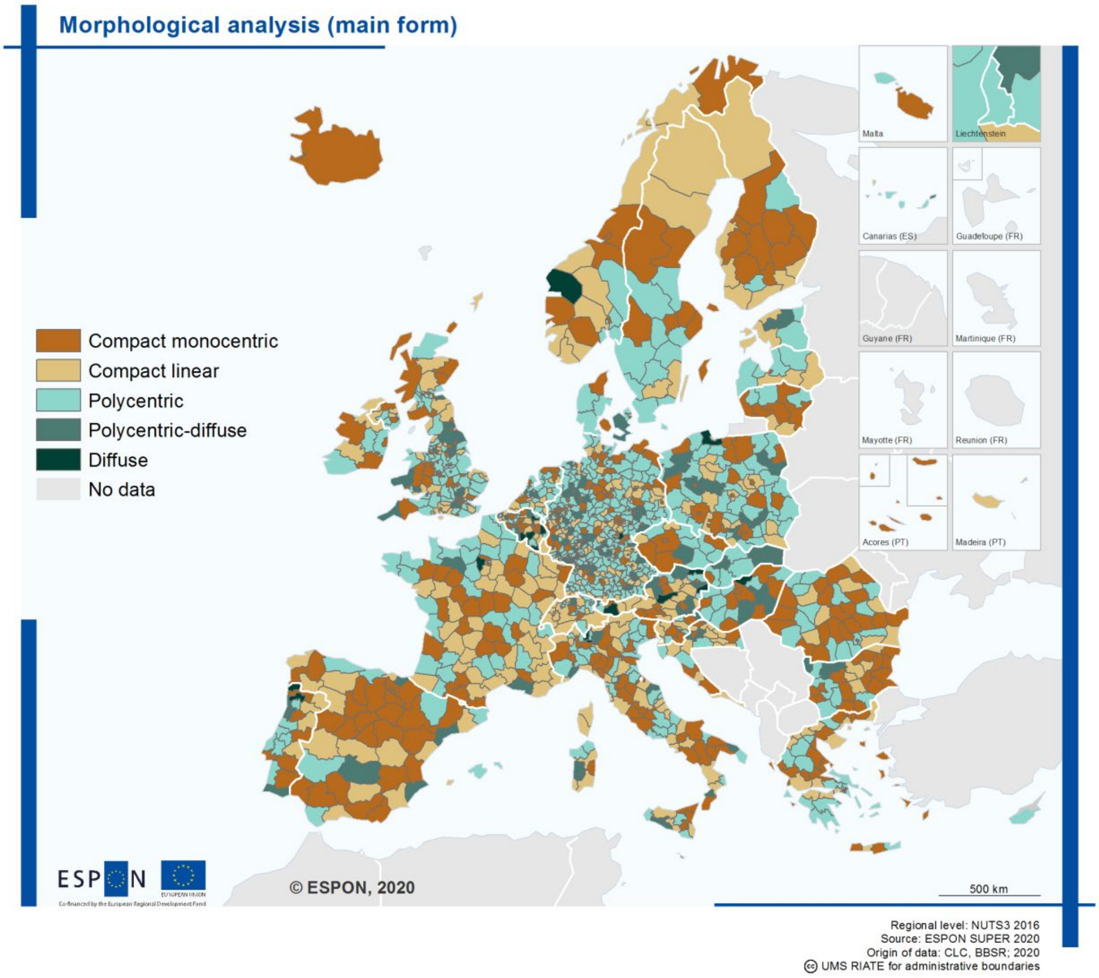


Figure 5.7 provides an indication of which countries have the most compact or diffuse structure. Given the averaging of scores of individual regions will gravitate towards the mean, it is mainly the outliers that are interesting. Austria, Lithuania and Slovakia show a relatively dispersed main structure and Iceland, Romania and Norway have relatively concentrated main structures. Perhaps more interesting is the substructure, because this is often where the urbanization often referred to as sprawl manifests itself. Here we see Poland and Slovakia heading the list in terms of diffuse substructure and Ireland, Latvia and the United Kingdom as having relatively compact substructures. In Iceland neither of the two NUTS3 regions had a discernible substructure.

Figure 5.7: National averages of NUTS3 morphologies with 1 being compact, 3 polycentric and 5 diffuse

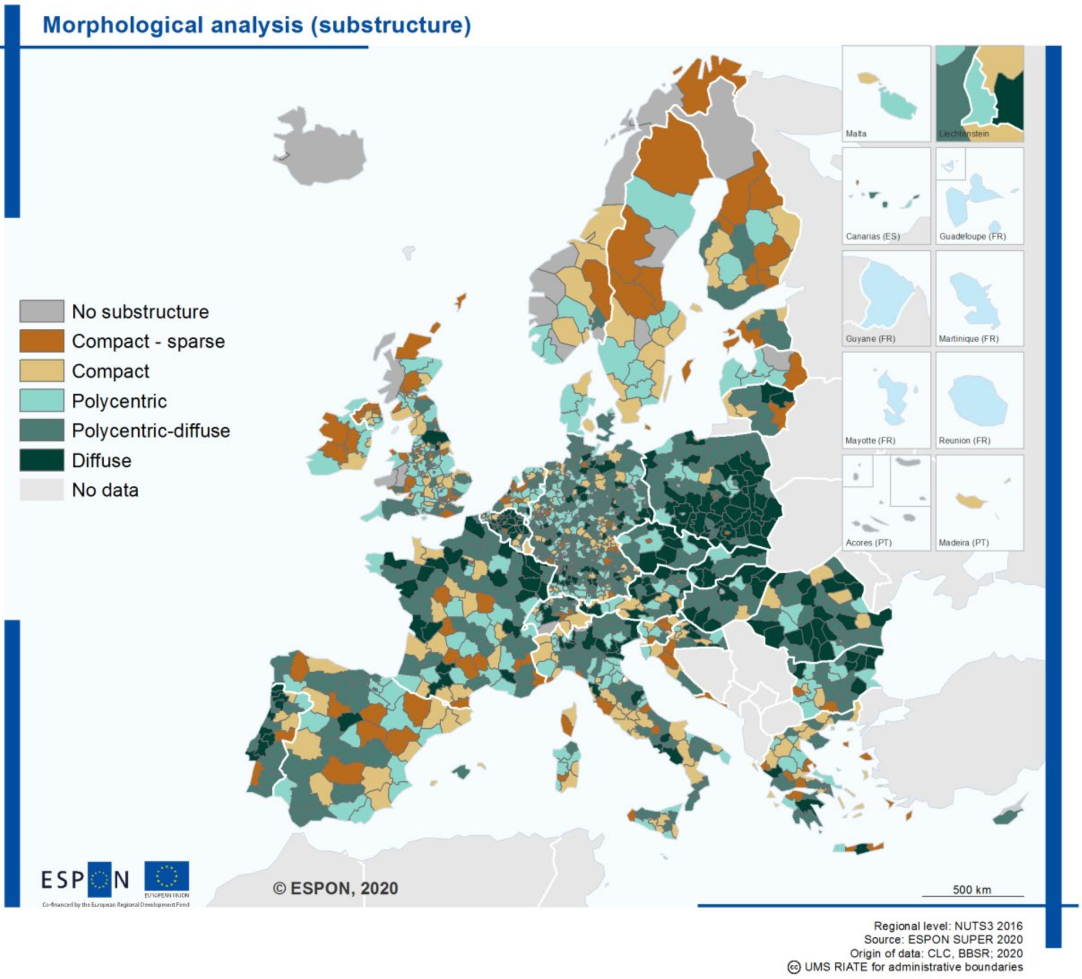


Map 5.4: Morphology of main structure for NUTS3 analysed



The territorial diversity of Europe is brought into view even better when the two structures are mapped out at the NUTS3 level, the scale at which the morphological analysis was carried out. Examining Map 5.4, national differences can be observed in the main structure, with Iceland, Norway, Finland and Spain generally having compact main structures and the Netherlands, Germany, Denmark and Slovakia being more polycentric. Still, the differences within countries is marked. France, Romania, Bulgaria, Belgium, Italy, and Poland are all quite heterogeneous. Sweden is divided between a compact north and polycentric south while Portugal and the Czech Republic have an east/west divide. These results challenge the conventional wisdom of a traditional compact Mediterranean urban form versus dispersed development in the more northern regions, or stereotypes of idyllic compact Italian cities versus urban sprawl in Belgium. According to this analysis, the distribution of main urban form is quite diverse across the ESPON space.

Map 5.5: Morphology of substructure for NUTS3 analysed

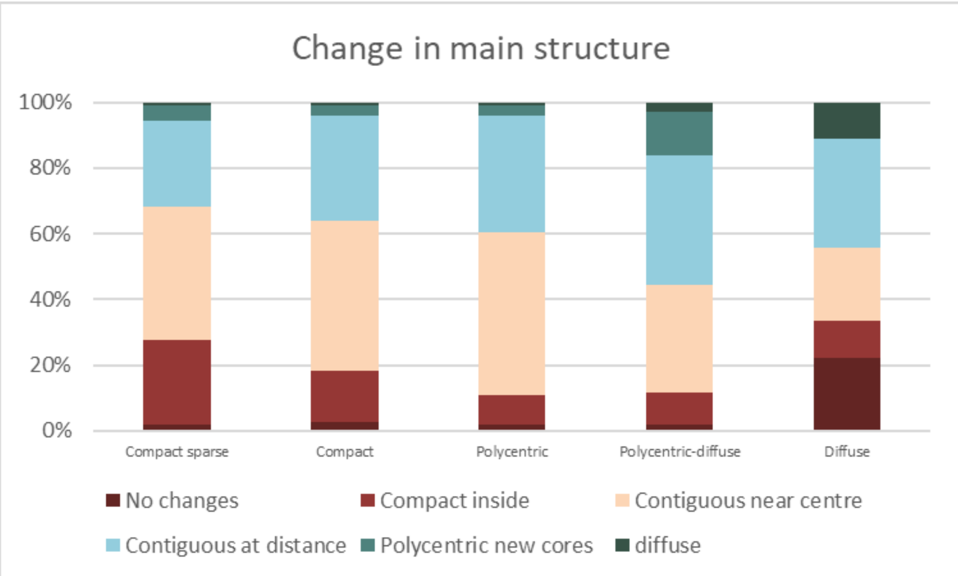


The diversity of Europe is still apparent, but less so, when examining the distribution of substructures in Map 5.5. The observation at the European level that the substructure is more diffuse than the main Figure 5.5 is immediately apparent in the large share of polycentric-diffuse and diffuse categories. Northern France, northern Italy, Ireland, much of central and eastern Europe (particularly Poland, Hungary and the Czech Republic and Slovakia) have comparably diffuse substructures. More compact substructures are found in Spain, central France, Croatia, central Italy, the Netherlands, and northern Scandinavia. As noted in the sustainability assessment framework (see Annex 4), urban form has distinct but complex implications for sustainability given inherent trade-offs. On the other hand, it is also something that has gradually evolved over a long period of time and is difficult to manage; much of Europe's current urban structure is the result of seeds planted hundreds, if not thousands, of years ago. This has implications for the capacity of certain territories to become more sustainable.

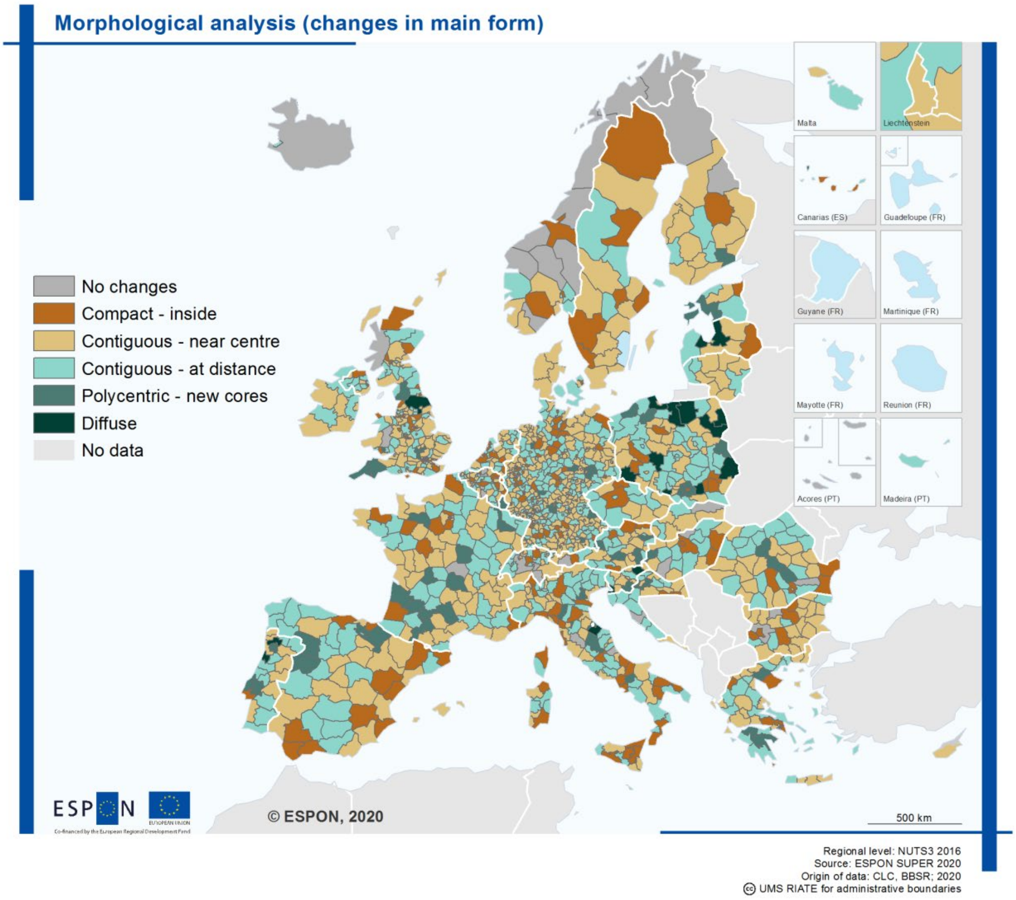
Morphological change over the 2000-2018 period

Given that urbanization is a dynamic phenomenon, it is important to measure changes in urban form over time. This has been done by looking at the location and form of new urbanisation in the period 2000-2018, as described in paragraph 5.3.2. This also provides insight into whether urban form is becoming more or less sustainable. The changes to the main structure in the 2000-2018 period are presented in Figure 5.8. From this, we can see that the developments in the main structure can replicate the main structure. However, this tendency is not particularly strong: the first three categories are relatively similar with slightly over half of new development taking place within or very near the existing urban fabric. Diffuse main urban structures seem to break with this pattern, but these are few in number (n=18) and can be considered an outlier. By far the predominant kind of urbanization is contiguous: either close by or on the urban fringe. Development at a distance or diffuse are less frequent. Still, contiguous development in a diffuse main structure is not likely to create a more compact structure, but instead reproduce fragmentation.

Figure 5.8: Type of change of main class per main class



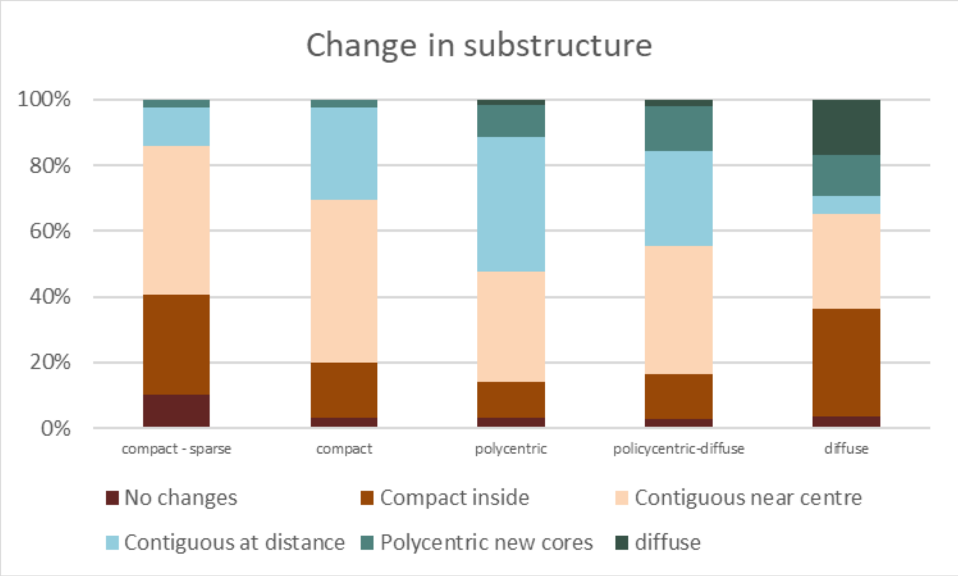
Map 5.6: Change in main structure (2000-2018)



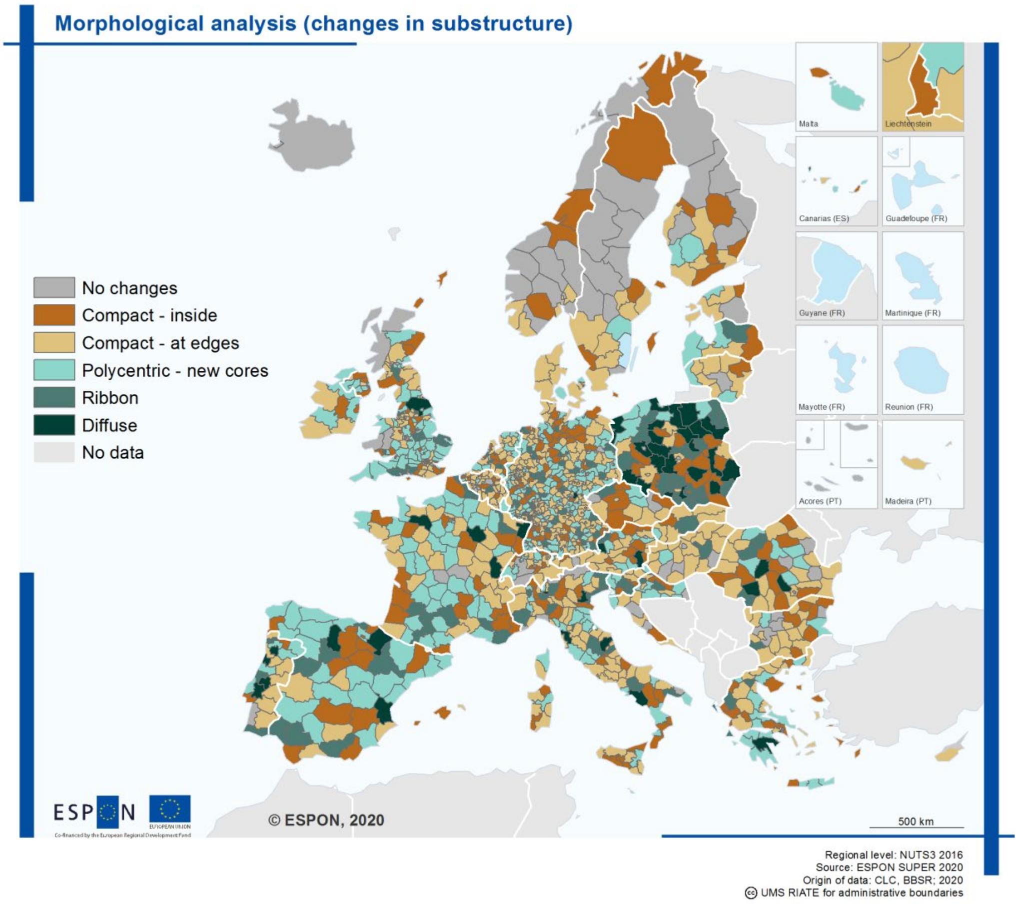
Map 5.6 helps localize these developments. At first glance, few spatial patterns are immediately apparent, especially at the national level: almost all countries had regions developing more compactly and less compactly. Two hotspots can be identified of diffuse development in the main structure: this signals situations where the edges of towns and cities scatter outwards: Poland (various regions) and northern England. Interestingly, Spain which has the most urban development in absolute terms, urbanizes in a comparatively compact way. This is also the case in the Netherlands, Bulgaria and Sweden.

Finally, given that much of urban development occurs in the substructure, and that this is where the sprawl debate is generally focussed, this was analyzed with interest (Figure 5.9). Again, for the first three categories we see more compact substructures growing in slightly more compact ways than polycentric regions. For these three categories, infill or contiguous development constituted the vast majority of urbanization in the 2000-2018 period: 90% and more. For compact substructures virtually all new development was infill or contiguous. Diffuse development only really occurred in already diffuse substructures, although the line is quite blurry between this category and polycentric new areas (scattered development). As with the main structure, if new development in relatively diffuse substructures occurs contiguously, this does not necessarily imply that a more compact structure is being created.

Figure 5.9: Type of change of substructure per substructure



Map 5.7: Change in substructure (2000-2018)



Map 5.7 displays the geographic distribution of changes in the substructure. This reveals similar hotspots of diffuse development as the main structure: Poland and north England. Now, however, these areas are in good company: most countries have a region where the

substructure is urbanizing in a diffuse way (either scattered or along roadways). Scandinavia and the Baltic states seem to be an exception to this rule. It is also worth noting that some countries such as Hungary and the Czech Republic and Slovakia \which had fairly diffuse substructures are urbanizing in more compact ways, while Poland is not. If nothing else, this finding reveals that 'urban sprawl' is a very complex phenomenon and not necessarily path dependent. This suggests that targeted interventions could be effective in redirecting developmental trajectories towards more sustainable urbanization.

Morphology in relation to primacy rate

Finally, one can compare the urban form to a similar measure: the primacy rate. The latter measures the ratio between the largest urban unit (measured at the municipal/LAU level) compared to the total population in the NUTS 3 region. This analysis seems to suggest that the population of a NUTS 3 region is positively correlated to compact urban form (see Table 5.15). Both the main and the substructure are, on average, more compact in NUTS3 with larger populations. Interestingly, NUTS3 with a higher primacy rate (here referred to as 'poly' under primacy) tend to have more compact urban forms than NUTS3 with a clear dominant LAU2 area. The same goes for developments in either the main or the substructure. The predominance of small and sparsely populated NUTS3 regions biases the pan-European average. Finally, with respect to change over the 2000-2018 period, it appears that more populous NUTS3 regions are growing more compactly than smaller ones.

Table 5.15: Urban type according to primacy rate

			Urban form		Change	
Population (x1000 people)	**Primacy rate**	N	Main	Sub	Main	Sub
Metropolitan (>500)	Mono	17	1.5	3.2	1.7	2.3
	Poly	39	1.2	1.5	1.8	1.4
	Total	56	1.3	2.0	1.8	1.7
Mid-sized (200-500)	Mono	15	2.3	3.8	2.5	2.5
	Poly	104	1.5	2.7	2.1	2.0
	Total	119	1.6	2.8	2.1	2.1
Small (50-200)	Mono	255	2.6	3.6	2.3	2.4
	Poly	364	1.8	2.8	2.2	2.1
	Total	619	2.1	3.1	2.3	2.2
Sparsely populated (<50k)	Total	501	2.5	3.2	2.3	2.2
	Grand total	1305	2.2	3.0	2.2	2.2

* This was calculated on the basis of the primacy rate, which is the share of the population of the largest settlement (LAU2) in the NUTS 3 region to the total population of the region. A rate higher than 50% is considered monocentric in regions with a large population (>500k inhabitants), in regions with fewer inhabitants this limit was set at 25%.

5.3.4 Reflection on developments and typologies

Given the rich and nuanced analysis of land-use developments in European regions in this Annex, it is very difficult to make blanket judgements about sustainability at the pan-European level because the distribution of developments is so heterogeneous. For example, we see signs of agricultural intensification in some European regions and agricultural abandonment in others. We see strong urban growth in some European regions, slower development in others and even deurbanization in some instances. We see sharp rises in infrastructural land-use in some areas (also per capita), whereas others remain stable. We see some monocentric cities expanding by means of contiguous or clustered development while others display profound urban diffusion. Finally, we see that some regions shifted from one urban type to the other as their urban composition changed.

The application of existing typologies and the creation of new ones provides a lens by which to understand this heterogeneity and draw appropriate conclusions. We can analyse the importance of certain drivers in certain types of regions to understand certain phenomena, for example. Do demographic developments have a greater impact on land use in urban or rural regions? Or we can use typologies to isolate the significance of territorial context: how do drivers produce urban development differently in island regions, metropolitan FUAs and sparsely populated regions? When corrected for factors such as GDP and household development, do compact monocentric regions exhibit more or less urban diffusion than polycentric regions? Is there a link to be made between types of regions and territorial challenges such as environmental pressure, housing affordability and economic development? Finally, we can explore the correlations between typologies by indicating ways in which European regions fall into different typologies: are ‘urban green’ regions more likely to be compact/monocentric? Which types of regions show the most growth of urban diffusion?

As stated in the introduction, the SUPER project has amassed a great deal of evidence and provided many of the tools to answer such questions. It is the task of future research to answer them.

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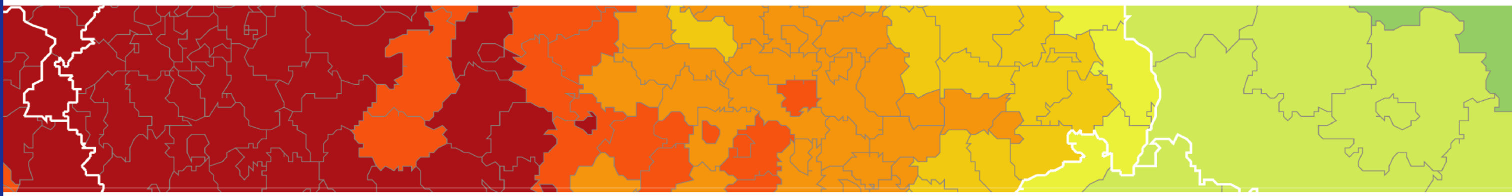

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