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European Environment Agency
European Topic Centre on Urban, Land and Soil Systems

Task: 1.8.2.2 Copernicus peri-urban and grassland indicator proposals

D13 – Final report on methodology to define and map the sub-region entities urban, peri-urban and rural areas

Prepared by

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List of Abbreviations

JRC	Joint Research Centre
UA	Urban Atlas
IMD	Imperviousness Layers
ESM	European Settlement Map
EUROSTAT	European Statistics Service
FUA	Functional urban region

1 Introduction

AP2018 results showed the PLUREL subdivision into urban, peri-urban and rural areas is most promising to monitor urban dynamics, i.e. changes between urban, peri-urban and rural areas [1]. To apply the PLUREL approach [2] population dynamics are important. In 2018 population estimates were produced for Urban Atlas (UA functional urban region (FUA) polygons of Berlin and Madrid to capture **rural <-> per-urban <-> urban** dynamics in a prototypical manner [3].

Population estimates for UA were produced by the Joint Research Center (JRC) and are only available for 2012 [4]. Based on an updated/gap filling (including West Balkans) UA2012 dataset across Europe, JRC produced new population estimates per UA polygon. To monitor trends it is necessary to have comparable population estimates based on the same input data for different time steps which is why the approach of the JRC was re-implemented and applied to 2006 and 2012 UA data. In AP2019 the work of AP2018 is expanded to 20 FUAs to enable a broader investigation of **urban <-> peri-urban <-> urban** dynamics based on population data and land cover dynamics [5].

To develop a **rural <-> peri-urban <-> urban** indicator a methodology for mapping/labelling UA polygons as urban, peri-urban or rural within UA Functional urban areas (FUAs) on basis of population thresholds, land use/land cover and spatial configuration (i.e. contingency) is needed and has to be developed. Datasets needed for the approach are population data from 2006 and 2012, UA2006 and UA2012 datasets and probably Imperviousness Degree (IMD) datasets with reference years 2006 and 2012. The following steps are foreseen:

- disaggregation of population estimates to UA polygons for a representative subset of FUA for which UA2006 data is available [5]
- mapping of urban, peri-urban and rural areas in the selected FUAs for 2006 and 2012 according to extended PLUREL methodology
- overview of the dynamics between urban, peri-urban and rural areas for the period 2006-2012

The ultimate outcome of this sub-task will be an estimation of efforts needed to apply the methodology for all FUA where UA is available, as well as the comparison of cities on the basis of land cover flows and cluster analysis.

2 Population estimates of 20 cities for 2006 and 2012

A short summary on the different methodologies to estimate populations for UA polygons on basis of the EUROSTAT population grid is presented in this section of the interim report [5].

2.1 Selection of cities

On basis of the city typology [6] 20 representative FUAs were chosen for which UA data of 2006 and 2012 is available. The city typology is used as a guideline to represent differently structured FUAs/cities across Europe as evenly as possible. The typology contains 5 clusters and lists the distance of each city to the cluster centres. Cities with a distance as small as possible where are chosen for the evaluation. To enable an unbiased comparison of the developed procedures it is also necessary to use only FUAs for which JRC population estimates where obtained from the EUROSTAT population grid (see [4] for a listing of population inputs per country). This excludes the entire cluster B which contains FUAs from Italy, Spain and Portugal. See [5] for final list of cities chosen.

2.2 Estimates JRC and ETC

From the interim report [5] it can be concluded that difference between JRC estimates and ETC estimates based on European Settlement Map (ESM) for 2012 are relatively small. The results achieved by applying the ETC methodology approximates the JRC results so it make sense to estimate the population with the ETC approach for the 2006 situation.

The influence of different population data input was found to be of major importance with large deviation between EUROSTAT data and e.g. census tracts. If a close match between JRC 2012 estimates is required, only cities from countries in which the JRC used the EUROSTAT population grid should be used (see [2]).

2.3 Processing time

The analysis of the processing time needed for the chosen cities indicates a linear relationship with the number of relevant polygons inside the FUAs (UA classes 1.1.X.X, 1.2.3.0, 1.4.2.0 and 2.X.X.X). The land cover distribution inside UA FUAs governs processing times with roughly 0.025 seconds per polygon of class 1.1.X.X, 1.2.3.0, 1.4.2.0 and 2.X.X.X. Based on experiences with selected cities the average processing time per FUA should lie between 60 and 90 minutes (including 2006 and 2012 estimates). The spread of processing times is considerable ranging between 2 and 40 minutes and estimates might be revised during further processing efforts.

3 Development rural, peri-urban, urban typology based on UA polygons

The development of the typology is based on 2-4 cities selected out of the 20 that were processed in the previous step (chapter 2). Our analysis is mainly based on the cities of Berlin and Vienna with some initial processing regarding the cities of Munich and Lyon.

The population estimates based on the IMD2006 and IMD2012 and calculated per UA polygon (population layer) were attributed to the original UA2006 respectively UA2012 polygons for each city (see Table 1 for UA classes). These datasets were downloaded from https://land.copernicus.eu/local/urban-atlas. Missing UA polygons in the population layer are considered to have no population. For each of the UA polygons with population data the population density per polygon is calculated for the separate UA2006 and UA2012 data layers.

Table 1. Urban Atlas classes.

11100: Continuous Urban fabric (S.L. > 80%)	12210: Fast transit roads and associated land	21000: Arable land (annual crops)
11210: Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)	12220: Other roads and associated land	22000: Permanent crops
11220: Discontinuous Medium Density Urban Fabric (S.L.: 30% - 50%)	12230: Railways and associated land	23000: Pastures
11230: Discontinuous Low Density Urban Fabric (S.L.: 10% - 30%)	12300: Port areas	24000: Complex and mixed cultivation patterns
11240: Discontinuous very low density urban fabric (S.L. < 10%)	12400: Airports	25000: Orchads
11300: Isolated Structures	13100: Mineral extraction and dump sites	31000: Forests
12100: Industrial, commercial, public, military and private units	13300: Construction sites	32000: Herbaceous vegetation associations
	13400: Land without current use	33000: Open spaces with little or no vegetations
	14100: Green urban areas	40000: Wetlands
	14200: Sports and leisure facilities	50000: Water

3.1 Original PLUREL definitions for urban, peri-urban and rural areas

Each polygon was classified into rural-urban regions using population density and land use of UA layer according to the following definitions based on the PLUREL Rural Urban Region (RUR) definitions (Table 2):

1. Urban high density: UA classes 11100 or 11210 independent from population density
2. Urban low density: UA classes 11220 independent from population density
3. Peri-urban high density: population density between 75 and 1000 inhabitants/km^2 OR population density between 40 and 75 inhabitants/km^2 and UA class 11230

4. Peri-urban low density: population density between 40 and 75 inhabitants/km^2 OR population density between 10 and 40 inhabitants/km^2 and UA class 11240 AND within 300m distance to polygons labelled as urban high or low density
5. Rural high density: population density between 10 and 40 inhabitants/km^2 OR population density between 1 and 10 inhabitants/km^2 and UA class 11300
6. Rural low density: population density below 10 inhabitants/km^2

As an additional step, class 4 was reduced by excluding polygons which are not within the distance of 300 metres from classes 1 and 2, i.e. urban low and urban high density.

Table 2. Definitions and colours for the 6 RUR classes.

	Pop. Density + UA class + distance
1	11100 or 11210
2	11220
3	75 – 1000; 40 – 75 and 11230
4	40 – 75; 10 – 40 and 11240; dist <300m
5	10 – 40; 1 – 10 and 11300
6	<10

Based on the above definitions maps were produced for the cities of Berlin and Vienna. Figure 1 shows the spatial distribution of the RUR classes for 2006 and 2012 for a part of the Berlin FUA. Figure 2 shows a detail for the Vienna FUA.

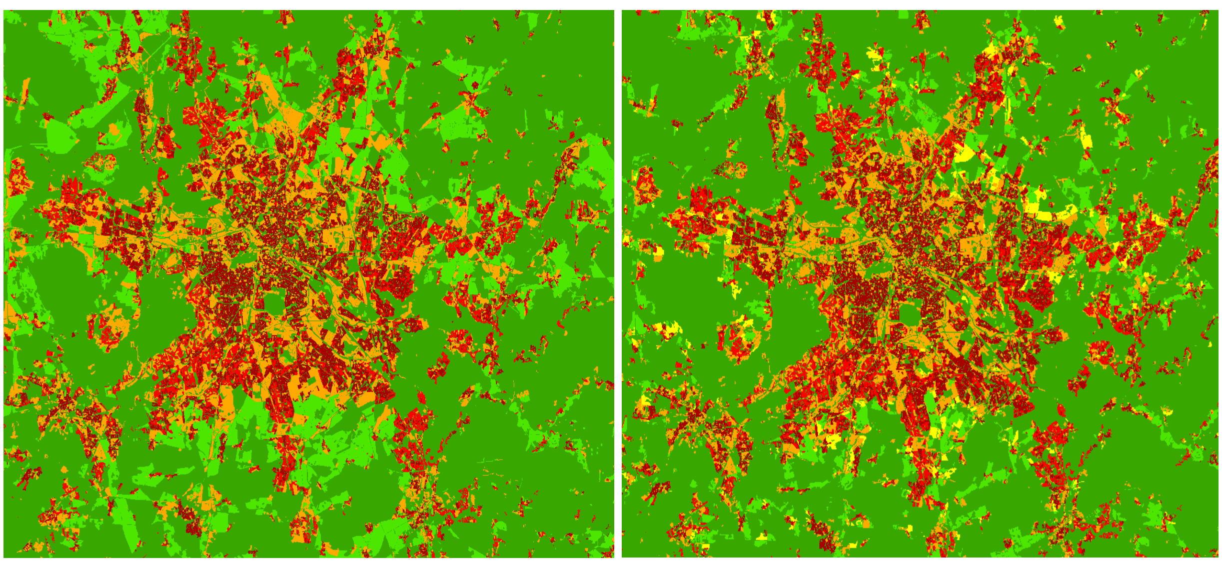


Figure 1. Berlin classified into rural (low and high density), peri-urban (low/high density) and urban (low/high density) for 2006 (left) and 2012 (right).

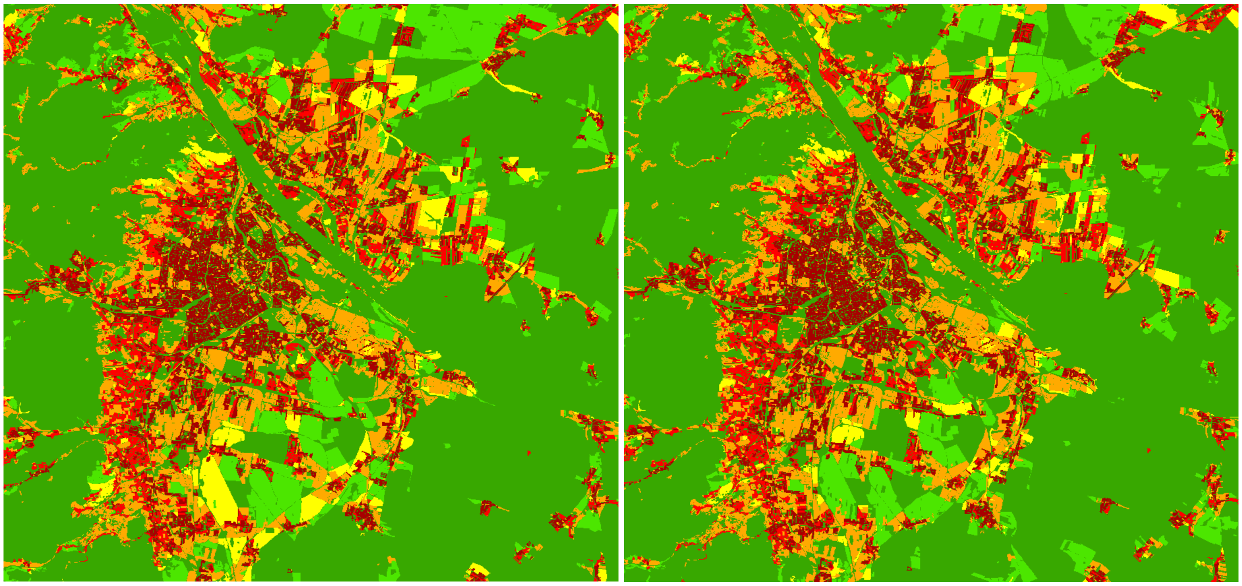


Figure 2. Vienna classified into rural (low and high density), peri-urban (low/high density) and urban (low/high density) for 2006 (left) and 2012 (right).

Both cities show a similar picture. A city centre with a high share of urban low and high density areas, adjacent to it the peri-urban areas within a matrix of rural areas. Around the city centre all over the FUA small, isolated urban areas surrounded with small peri-urban areas are encountered. The spatial distribution of rural, peri-urban and urban areas for 2006 and 2012 does not show large differences for both cities. Also in both cities and for both time steps there are still large rural areas present in the city centres. The urban and peri-urban areas in the centre of Berlin form a pattern like a star, while the Vienna city centre pattern is remarkable for a clear rural division and a south oriented finger tail visible if you zoom out to the complete FUA.

3.2 Adapted PLUREL class definitions for urban, peri-urban and rural areas

Due to the still large rural areas in the city centres of both Berlin and Vienna the class definitions were adapted. The class definitions for the urban low density (including class 14100) and peri-urban low density (including classes 12100 or 12210 or 12220 or 12230 or 12300 or 12400 or 14200) have been adapted compared to the original PLUREL classification (see 3.1) as green urban areas, industrial areas, infrastructure, port areas, airports and sport and leisure areas are tended to be part of the urban or peri-urban areas.

Each polygon was classified into rural-urban regions using population density and land use of UA layer according to the following definitions based on the (adapted) PLUREL Rural Urban Region (RUR) definitions (Table 3):

1. Urban high density: UA classes 11100 or 11210 independent from population density
2. Urban low density: UA classes 11220 or 14100 independent from population density
3. Peri-urban high density: population density between 75 and 1000 inhabitants/km^2 OR population density between 40 and 75 inhabitants/km^2 and UA class 11230

4. Peri-urban low density: population density between 40 and 75 inhabitants/km^2 OR population density between 10 and 40 inhabitants/km^2 and UA class 11240 OR UA classes 12100 or 12210 or 12220 or 12230 or 12300 or 12400 or 14200 independent from population density AND within 300m distance to polygons labelled as urban high or low density
5. Rural high density: population density between 10 and 40 inhabitants/km^2 OR population density between 1 and 10 inhabitants/km^2 and UA class 11300
6. Rural low density: population density below 10 inhabitants/km^2

As an additional step, class 4 was reduced by excluding polygons which are not within the distance of 300 metres from classes 1 and 2, i.e. urban low and urban high density. These polygons were then assigned to either class 5 or 6 based on population density (if higher than 40 – class 5) and UA class criteria according to Table 3.

Table 3. Definitions and colours for the 6 RUR classes.

	Pop. Density + UA class + distance
1	11100 or 11210
2	11220 or 14100
3	75 – 1000; 40 – 75 and 11230
4	40 – 75; 10 – 40 and 11240; dist <300m;
	12100 or 12210 or 12220 or 12230 or 12300 or 12400 or 14200
5	10 – 40; 1 – 10 and 11300
6	<10

Based on the above definitions maps were produced for the cities of Berlin and Vienna. Figure 3 shows the spatial distribution of the classes for 2006 and 2012 for a part of the Berlin FUA. Figure 4 shows a detail for the Vienna FUA.

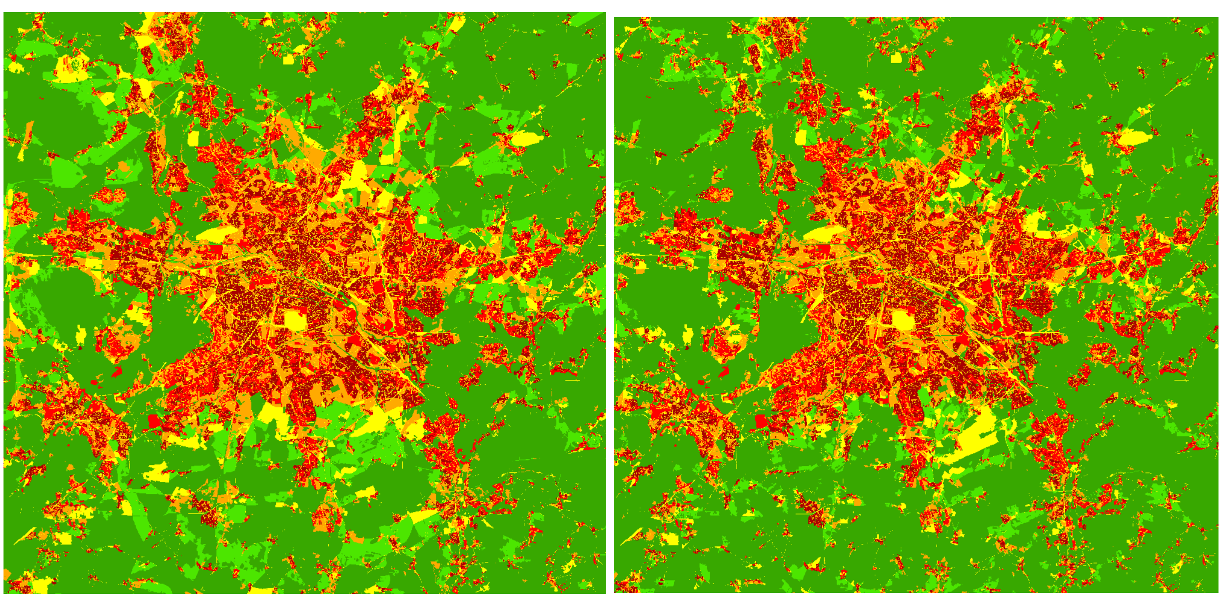


Figure 3. Berlin classified into rural (low and high density), peri-urban (low/high density) and urban (low/high density) based on adapted definitions for 2006 (left) and 2012 (right).

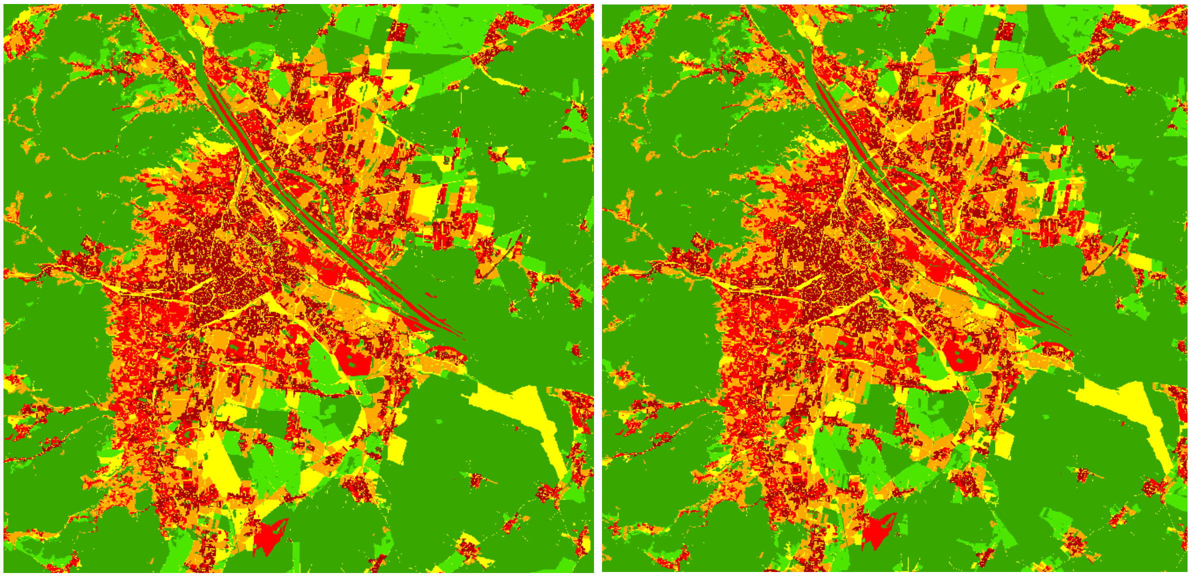


Figure 4. Vienna classified into rural (low and high density), peri-urban (low/high density) and urban (low/high density) based on adapted definitions for 2006 (left) and 2012 (right).

Large areas which were classified as rural areas are turned into peri-urban areas (infrastructure, airports and industrial areas) or into urban areas (green urban parks) due to the adapted definitions. On the map it's remarkable that line infrastructure classes (e.g. roads and railways) which are part of peri-urban areas are limited to 300m within to distance from urban classes while the rest of original UA polygons are classified into rural areas. Both cities show a similar picture. A city centre with a high share of urban low and high density areas, adjacent to it the peri-urban areas within a matrix of rural areas. City centres are for both cities more compact compared to the previous exercise (3.1). Around the city centre all over the FUA small, isolated urban areas surrounded with small peri-urban areas are encountered. Comparing the spatial distribution of rural, peri-urban and urban areas between 2006 and 2012 does not show large differences for both cities. The urban and peri-urban areas in the centre of Berlin form a pattern like a star, while the Vienna city centre pattern is remarkable for a clear rural division and a south oriented finger tail visible if you zoom out to the complete FUA.

3.3 Aggregated rural-urban regions at 1km^2 population grid

Rural-urban typology within the PLUREL project was developed at much coarser resolution than the minimum mapping unit of 1-5ha of land use/land cover units applied in the Copernicus local component Urban Atlas datasets. In order to test the methodology at a lower level of spatial detail in such a way that the mapped rural-urban regions are comparable with spatial detail applied in PLUREL, we made three type of aggregations for the Berlin FUA:

1. Majority of rural-urban region class within 1km^2 population grid
2. Rural-urban region class present in centre of 1km^2 population grid

3. UA polygons were first aggregated to the 1km^2 population grid. RUR classes were calculated afterwards

Ad. 1. In Figure 5 the most important RUR class within the 1km^2 grid is taken as value for the grid.

Ad. 2. In Figure 6 the RUR class in the centre of the 1km^2 grid is taken.

Ad. 3. The proportion of each UA class was calculated for each 1x1km population grid cell that was represented as a polygon. Then a new attribute was assigned to each of population polygons with the UA majority class. As a result, rural-urban regions were calculated using the same improved rules as at the UA polygon level (Table 3) (Figure 7). By this method we aggregated first UA classes to 1 km grid in contrast to aggregation of RUR classes as described in under 1 and 2. However, distance rule of 300m was skipped in this case due to lower resolution.

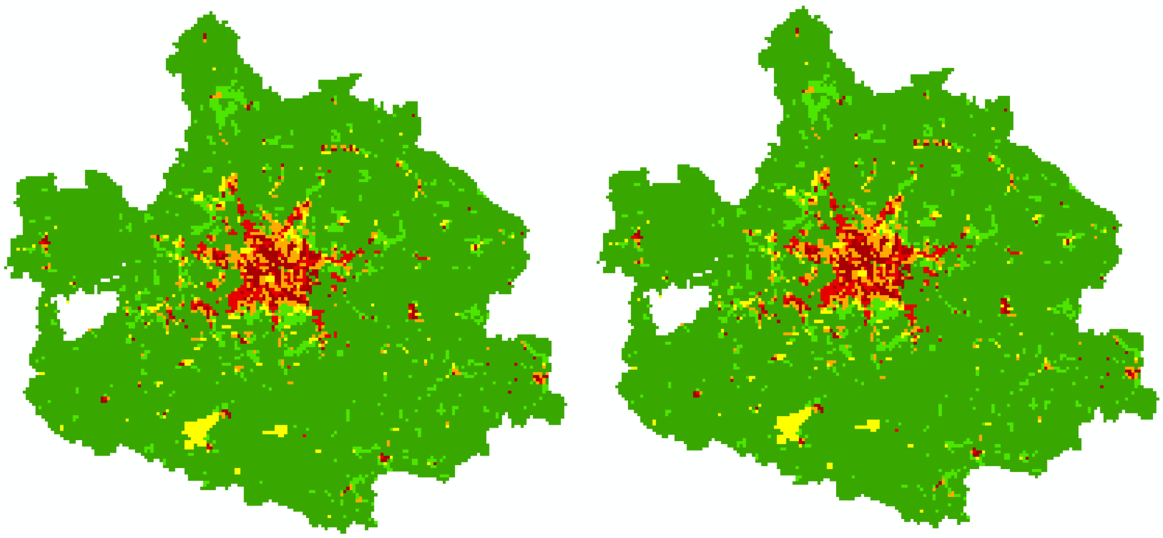


Figure 5. Aggregation of RUR class to 1km^2 grid based on majority class (maximum combined area) for 2006 (left) and 2012 (right).

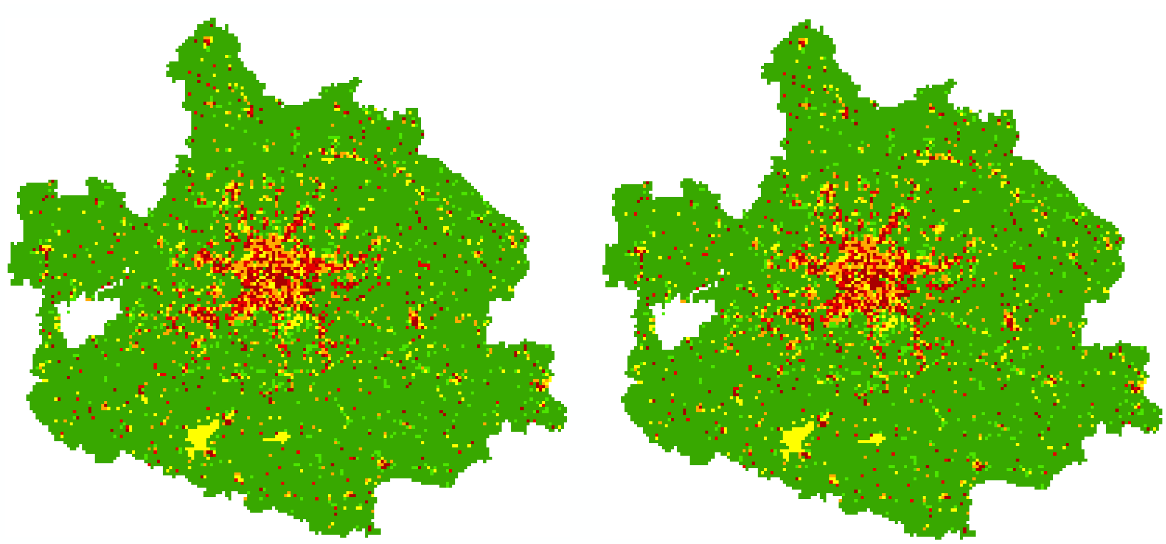


Figure 6. Aggregation of RUR classes to 1km^2 grid based on the class present in the centre for 2006 (left) and 2012 (right).

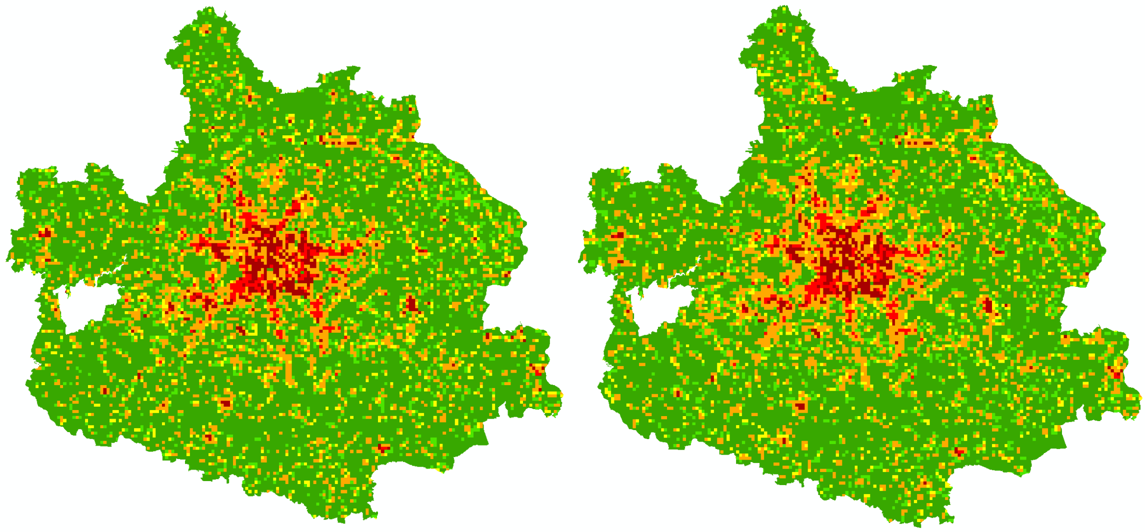


Figure 7. Aggregation of UA polygons to 1km^2 grid and classified into RUR classes for 2006 (left) and 2012 (right).

3.4 Rural <-> peri-urban <-> indicator

A rural <-> peri-urban <-> urban indicator could be calculated on basis of the classes as defined in section 3.1 and 3.2. Percentages of (low and high density) rural, peri-urban and urban areas over the total FUA area (or any other administrative subdivision) would give a degree of urbanisation or peri-urbanisation. Cities (FUAs) could be compared on basis of this indicator and dynamics in time can be monitored.

3.5 Discussion/conclusion

The adaptation of the RUR class definitions shows a better picture than the maps based on the original PLUREL definitions (section 3.1). The maps of section 3.2 reflect more our common understanding of urban, peri-urban and rural areas. The city centres are more compact and rural areas are nearly absent. Industrial areas, sport and leisure areas and airports e.g. should not be classified as rural areas. Also roads are no longer included as rural intrusions in the city centre.

The aggregation method ‘maximum combined area’ (majority) shows a city centre with only some small urban areas around it. The ‘pixel centre’ method shows a more scattered pattern of urban areas. Scattered pattern is also present in the third method. However, both urban and peri-urban areas are present within the rural area. The first method gives a more recognisable image of the distribution of urban, peri-urban and rural areas. In terms of area proportion per RUR class, urban and peri-urban classes have marginally smaller extent when they are aggregated (Table 4). A more significant difference is the large extent of peri-urban areas especially the peri-urban high density RUR class when using the method where UA was first aggregated to the population grid and then classified into RUR classes. The reason for this is still unknown.

Table 4. Overview of RUR areas and proportions for Berlin per different aggregation methodology.

	Urban high density		Urban low density		Peri-urban high density		Peri-urban low density		Rural high density		Rural low density		
	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	Total [km²]
UA polygons classified to RUR 2006	517	2.96	494	2.82	695	3.98	708	4.05	1168	6.68	13902	79.51	17484
UA polygons classified to RUR 2012	527	3.02	489	2.79	555	3.17	663	3.79	642	3.67	14609	83.55	17484
Aggregated RUR to pop. grid 2006 (max area)	357	2.04	323	1.85	504	2.88	369	2.11	1064	6.09	14858	85.02	17475
Aggregated RUR 2012 to pop. grid 2012 (max area)	357	2.04	323	1.85	504	2.88	369	2.11	1064	6.09	14858	85.02	17475
Aggregated RUR to pop. grid 2006 (center pixel)	522	2.99	501	2.87	587	3.36	666	3.81	648	3.71	14549	83.26	17475
Aggregated RUR 2012 to pop. grid 2012 (center pixel)	508	2.91	510	2.92	720	4.12	708	4.05	1187	6.79	13840	79.20	17475
Aggregated UA classified to RUR 2006	391	2.24	298	1.71	3133	17.93	886	5.07	1720	9.85	11047	63.21	17475
Aggregated UA classified to RUR 2012	424	2.42	327	1.87	2906	16.63	894	5.11	1607	9.20	11317	64.76	17475

The approach described in this chapter 3 (especially sections 3.2 and 3.3) can be used to define a rural, peri-urban, urban indicator that monitors dynamics in time. However, it can be questioned if the definition of urban, peri-urban and rural used is the correct one. So a kind of validation of the distribution of rural, peri-urban and urban areas would be helpful to make a statement about the accuracy of the results. In section 4 the RUR dynamics between 2006 and 2012 are compared with the Land Cover Flows (LCFs). The comparison with territorial typologies of Eurostat also give some insight in the validity of the RUR classes as defined in sections 3.1 and 3.2.

4 Comparing rural, peri-urban and urban dynamics with LCF

4.1 Typology for dynamics

The analysis of the dynamics of urban, peri-urban and rural areas is based on the classification thresholds used in section 3.1, i.e. the definitions as applied in the PLUREL project.

After the intersection of UA layers 2006 and 2012 attributed with population density data the dynamics between rural, peri-urban and urban (or Rural Urban Region (RUR) changes) were calculated. For this the 6 classes defined in the previous step were aggregated to the 3 classes rural, peri-urban and urban. Changes between these 3 aggregated classes were defined (Table 5).

Table 5. Type of changes between rural, peri-urban and urban areas.

	Type of change
1	no change
2	rural to periurban
3	rural to urban
4	periurban to rural
5	periurban to urban
6	urban to rural
7	urban to periurban

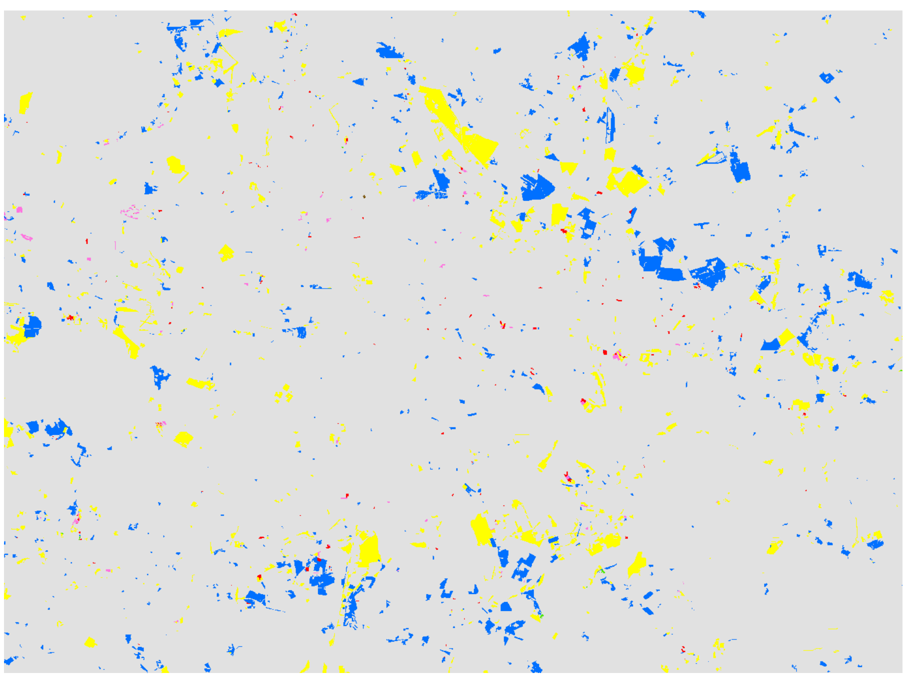


Figure 8. Changes between rural, peri-urban and urban regions (RUR changes) in Berlin between 2006 and 2012.

In figure 8 for a detailed area of Berlin different type of changes are presented. Most prominent are the changes from rural to peri-urban and vice versa. Other changes are relatively of minor importance. The matrix is formed by areas that did not change at all.

4.2 RUR vs LCF

For a comparison between rural, peri-urban and urban dynamics with land cover flows (LCF) as defined by the EEA [7] the UA change layer is attributed with LCFs. The LCFs are aggregated to main categories (see Table 6).

Table 6. Aggregated LCFs

LC flows
1 Urban land management
2 Residential sprawl
3 Sprawl of economic sites and infrastructure
5 Conversion from forest to agriculture
7 Forest creation and management
8 Water bodies creation and management
9 Changes of land cover due to natural and multiple causes

After intersection of the UA change layer with the rural, peri-urban and urban changes (or Rural Urban Region (RUR) changes) (see figure 9) an attribute is added showing the calculated combination RUR change and LCF.

Figure 9. Intersection of RUR changes and LCFs for a small area within the FUA of Berlin.

In total 486.4 km^2 RUR changes and 79 km^2 changes in UA (LCFs) were discerned in Berlin for the period 2006 -2012. Of those 79 km^2 only 21.8 km^2 show overlap with the RUR changes. Figure 10 presents for each combination of RUR change – LCF the area (km^2) covered in the Berlin FUA. A code 1-1 on the horizontal axis means that the area given is for the combination of RUR change type 1 (no change) (Table 5) and LCF1 (urban sprawl management) (Table 6). So 16.1 km^2 is not changed according to the RUR change typology and is classified as LCF Urban Land management. Not all combinations of RUR changes and LCF are obvious. For example, the combinations 4-1 or 4-3 (RUR change "Peri-urban to rural" vs LCF "Urban land management", respectively "Sprawl respectively sprawl of economic activities and infrastructure"). However, other combinations like 2-2 and 2-3 (RUR change rural to peri-urban vs LCF residential Sprawl respectively sprawl of economic activities and infrastructure) are to be expected or explainable.

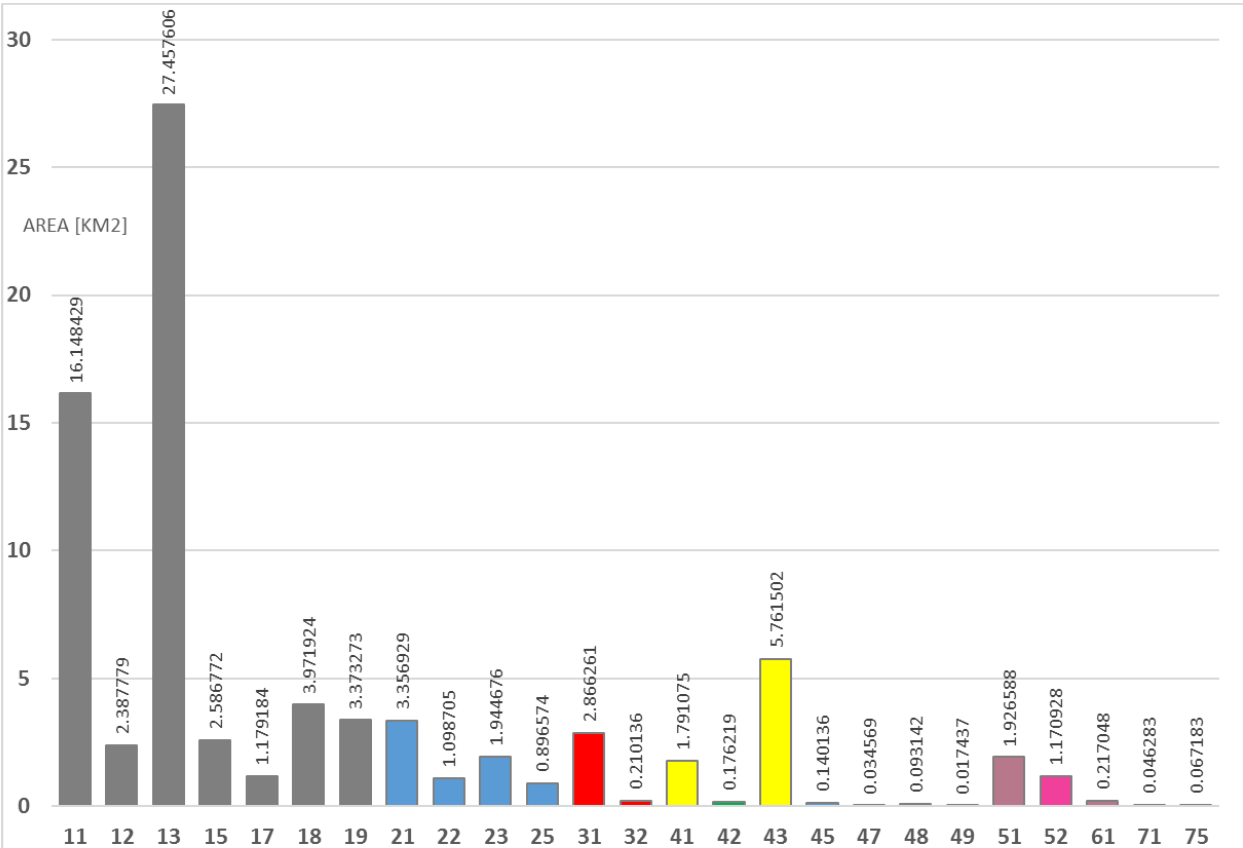


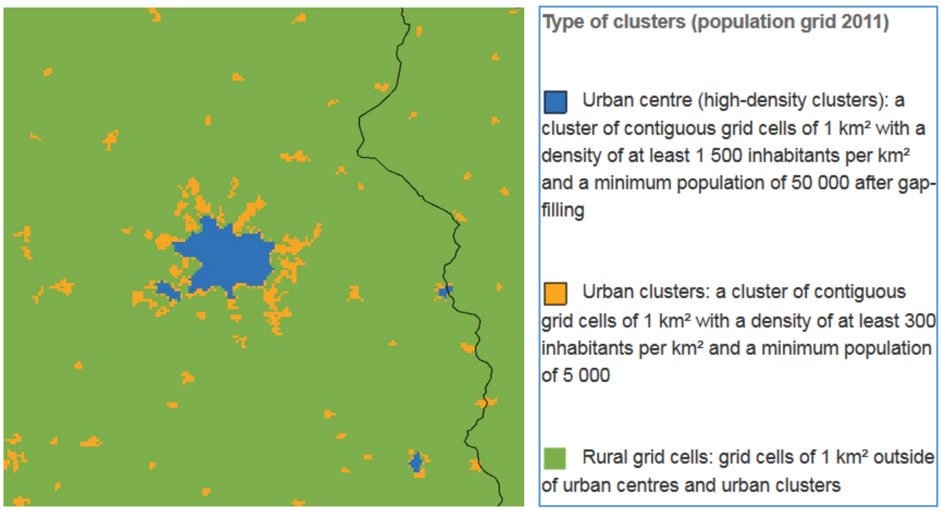
Figure 10. RUR changes compared to LCFs for Berlin.

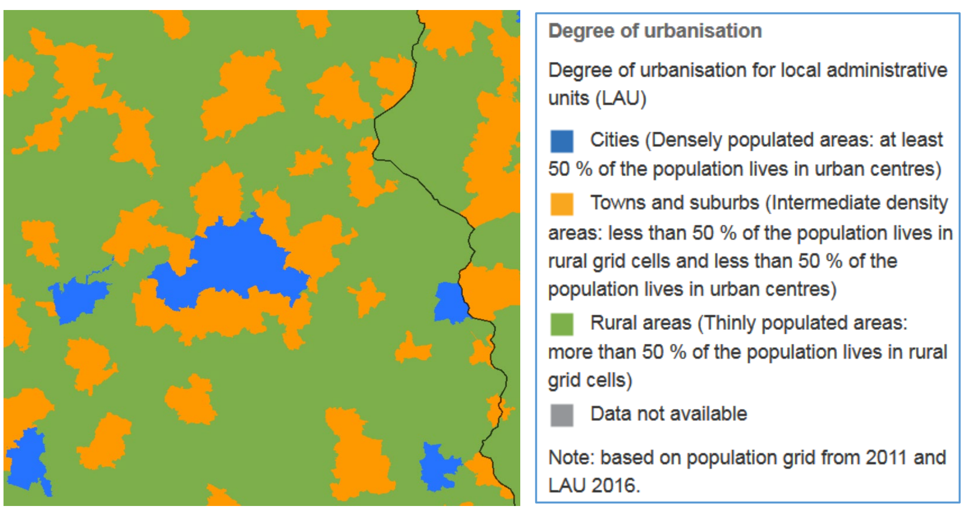
4.3 Discussion/conclusions

The comparison of RUR dynamics with land cover flows based on UA polygons provides a coarse assessment for validation of RUR typology mapping. The area of changes between 2006 and 2012 differs more than a factor 6 (486.4 vs 79 km^2) and the overlap between the changes between RUR (RUR dynamics) and LCF is only a fraction of the 79 km^2, i.e. 21.8 km^2. Both RUR dynamics and LCF presents different levels of thematic and spatial detail. RUR dynamics are often not reflected by changes in land cover (LCF) as land cover changes are aggregated to a high level in case of the LCF while for the RUR dynamics, next to changes in population density, changes between detailed Urban Atlas classes are important. So much more RUR dynamics then LCF can be expected. Furthermore the difference in spatial detail of population data (1 km^2) and the Urban Atlas data (1 ha) makes comparison difficult. The majority of LCFs/UA changes are too detailed/small to be accounted by the methodology applied to define RUR changes.

5 Comparison with EUROSTAT territorial typologies

The comparison with territorial typologies of Eurostat is presented in this chapter to give some insight in the validity of the RUR classes as defined in sections 3.1 and 3.2. The EUROSTAT typologies consists of three types: 1. Type of clusters (based on population grid 2011) defines urban centres, urban clusters and rural grid cells; 2. Degree of urbanisation recognises at local administrative units (LAU) cities, towns and suburbs and rural areas; 3. Urban – rural typology discerns predominantly urban region, intermediate regions and predominantly rural regions. Figure 11 and 12 show the different EUROSTAT typologies compared with the RUR regions as defined in section 3.2 for Berlin respectively Vienna.





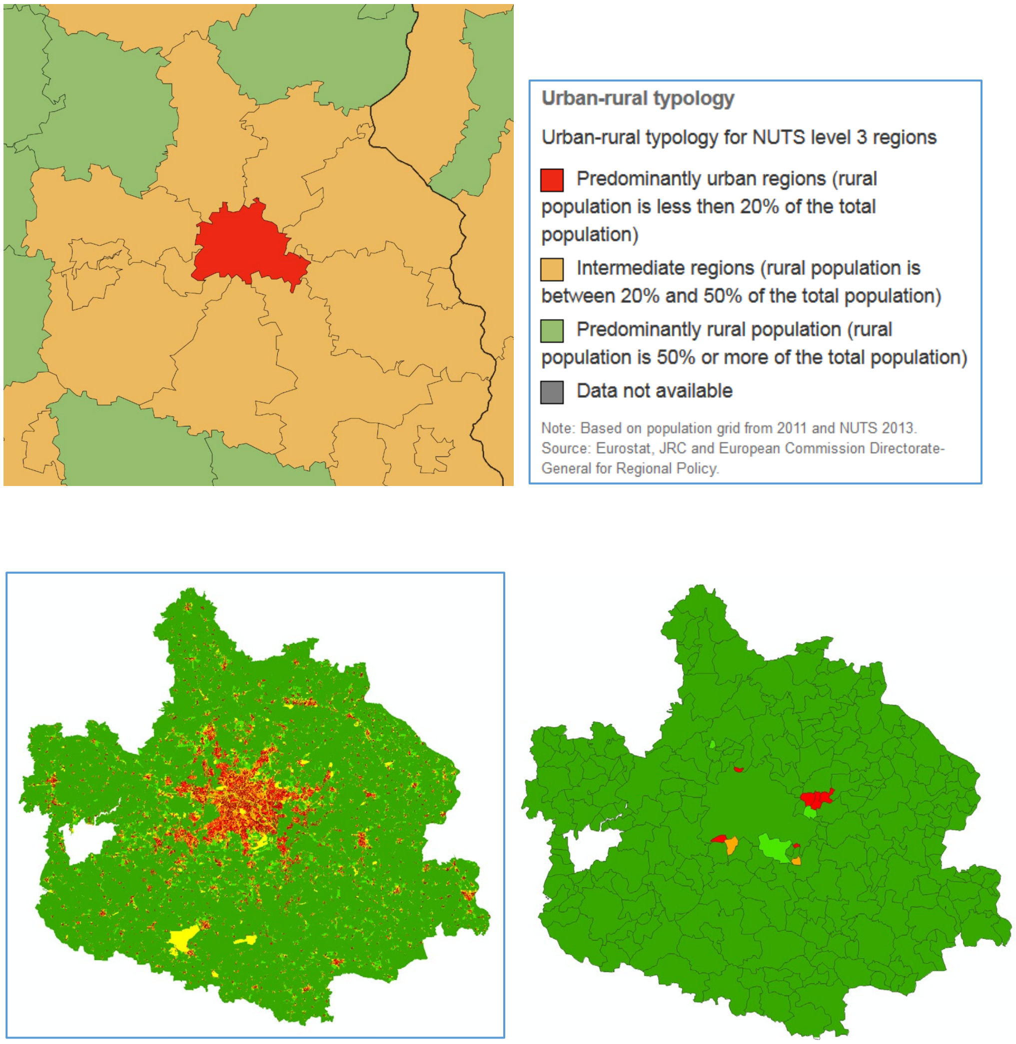
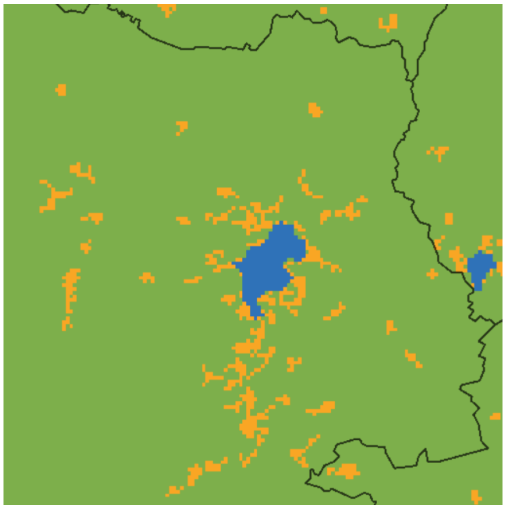


Figure 11. EUROSTAT typologies for the Berlin FUA compared with our RUR typology (Type of clusters, Degree of urbanisation, Urban-rural typology, RUR classification and RUR classification aggregated into LAU polygons).

The type of cluster typology (first figure) shows similarities with the pattern shown in our results (lowest figure). The location of the majority of the urban RUR classes (low/high density) are located in the predominantly urban region as defined in the Urban-rural typology. Using the LAU geometry to calculate the majority of RUR classes, most of the polygons turn into rural areas as the majority (>50%) is classified as low/high density rural areas. Possible solutions to overcome this problem could be to aggregate the six RUR classes into 3 classes (urban, peri-urban and rural) or to move the threshold of 50%.

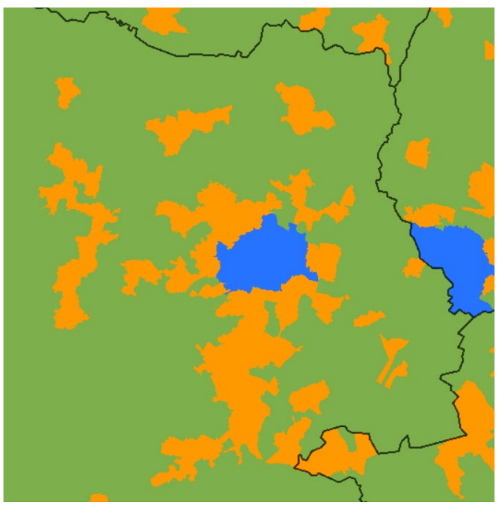


Type of clusters (population grid 2011)

Urban centre (high-density clusters): a cluster of contiguous grid cells of 1 km² with a density of at least 1 500 inhabitants per km² and a minimum population of 50 000 after gap-filling

Urban clusters: a cluster of contiguous grid cells of 1 km² with a density of at least 300 inhabitants per km² and a minimum population of 5 000

Rural grid cells: grid cells of 1 km² outside of urban centres and urban clusters



Degree of urbanisation

Degree of urbanisation for local administrative units (LAU)

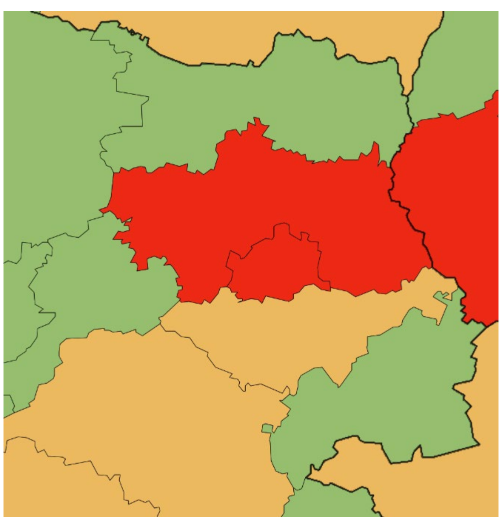
Cities (Densely populated areas: at least 50 % of the population lives in urban centres)

Towns and suburbs (Intermediate density areas: less than 50 % of the population lives in rural grid cells and less than 50 % of the population lives in urban centres)

Rural areas (Thinly populated areas: more than 50 % of the population lives in rural grid cells)

Data not available

Note: based on population grid from 2011 and LAU 2016.



Urban-rural typology

Urban-rural typology for NUTS level 3 regions

Predominantly urban regions (rural population is less then 20% of the total population)

Intermediate regions (rural population is between 20% and 50% of the total population)

Predominantly rural population (rural population is 50% or more of the total population)

Data not available

Note: Based on population grid from 2011 and NUTS 2013.
Source: Eurostat, JRC and European Commission Directorate-General for Regional Policy.

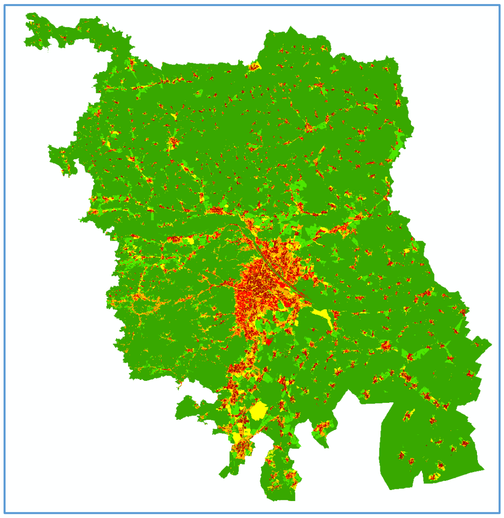


Figure 12. EUROSTAT typologies for the Vienna FUA compared with our RUR typology (Type of clusters, Degree of urbanisation, Urban-rural typology and RUR classification).

The type of cluster typology (first figure in Figure 12) and degree of urbanisation typology (second figure) both show similarities with the spatial pattern as presented in lowest figure (results RUR typology). The location of the urban RUR classes (low/high density) does not show much similarities with the Urban-rural typology. The NUTS 3 areas seems to be to coarse to make a comparison possible with the RUR typology results.

For both cities a possible future spatial analysis could be to aggregate our results based on the RUR typology to the LAU administrative level and compare the results with the "Degree of urbanisation" territorial typology.

6 Conclusions

6.1 Population data

On basis of a city typology 20 representative FUAs were selected for which UA data of 2006 and 2012 was available. The selected cities had to meet with the condition that only FUAs were used for which JRC population estimates where obtained from the EUROSTAT population grid. The difference between JRC estimates and ETC estimates based on European Settlement Map (ESM) for 2012 are relatively small. So it make sense to estimate the population with the ETC approach for the 2006 situation.

6.2 Rural <-> peri-urban <-> rural typology

In this task the rural – peri-urban – rural (RUR) typology as defined in PLUREL project was applied by using UA polygons and population estimates at 1 km^2 grid as input datasets. Most significant difference between original (PLUREL) assessment and approach used in this study is the spatial scale. While UA polygons provide high level of details in terms of land use entities, RUR - PLUREL typology considers more coarse feature inputs. In addition, combination of high resolution UA polygons and 1 km^2 population grid represents already spatial discrepancy. Despite of these facts, the general spatial pattern mapped within this study corresponds with earlier assessment done by Eurostat related to territorial typologies. Although UA gives added value in terms of mapped spatial details, it is suggested that the definition of RUR should be adapted or newly developed to correspond with the spatial scale of Urban Atlas.

The assessment of land cover flows (LCF) or changes in land cover between UA 2006 and 2012 and the RUR dynamics is hampered by differences in thematic and spatial detail. The area mapped as a change by comparing Urban Atlas 2006 and 2012 is much smaller as the area where RUR dynamics took place. LCFs aggregate changes to a level that makes comparison with more detailed land cover changes that define RUR dynamics difficult. Also the combination of land cover and population results in much more changes than mapped by Urban Atlas.

The ultimate outcome of this sub-task would be an estimation of efforts needed to apply the methodology for all FUA where UA is available, as well as the comparison of cities on the basis of land cover flows and cluster analysis. However, the results for Vienna and Berlin were not satisfactory to continue and expand it to other cities. So an estimation of costs does not make sense.

7 Literature

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[4] Batista e Silva F., Poelman H. (2016): Mapping Population Density in Functional Urban Areas. JRC Technical Report. - https://ec.europa.eu/jrc/en/publication/mapping-population-density-functional-urban-areas-method-downscale-population-statistics-urban-atlas

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