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What is Urban Sprawl in Flanders?

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1 ABSTRACT

At the country level, Belgium was found to be the European country with the highest degree of urban sprawl (EEA report on Urban sprawl in Europe, 2016). The phenomenon is most pronounced in Flanders, the highly populated northern part of the country. No less than 32.6% of its territory is taken in by settlement area, and, its landscapes are highly fragmented by ribbon and scattered development. An increase of ribbon development in Flanders from 3612 km in 1989 up to 4155 km in 2012 was calculated by Verbeek et al. (2014). This means an increase of 15% over 23 years. Given this urban fragmentation of the landscape, concerns and discussions rise about the pros and cons of this development and strategies to mitigate or stop urban sprawl.

Urban sprawl can refer to both a state (level of sprawl at a certain point in time) and a process (evolution of the level of sprawl in time). To gain better insights in the state of urban sprawl, detailed data of high quality are necessary. Several measures have been used in the literature to quantify (different aspects of) urban sprawl. Depending on the measure, but also on the type of input data used, different results can be obtained which in turn can lead to completely different interpretations and conclusions regarding the level of urban sprawl in Flanders. In this paper we analyse the effect of alternative input data on the outcome of the quantitative sprawl measure "WUP" (weighted urban proliferation) (EEA, 2016). Using sealed surfaces as an input to calculate WUP leads overall to an underestimation of the space taken in by urban settlements, hence of the importance of urban sprawl. Using the total settlement area of Flanders (including sealed surfaces, but also gardens, parks, etc.) leads to a much better representation of the phenomenon of urban sprawl.

The process of urban sprawl in Flanders is analysed by means of a temporal analysis using Landsat images of 1976, 1988 and 2000. The images are processed into urban settlement maps and urban sprawl is measured by means of WUP for the different time steps. Difference maps show the temporal and spatial dynamics of urban sprawl throughout the region.

Finally, in order to make measures of urban sprawl, and hence the phenomenon itself, easier to interpret and understand for a wider public, and, to answer the question "What is urban sprawl and where is it affecting Flanders?", the WUP-maps are translated into an urban sprawl typology map with characterizing examples and typical spatial configurations for each type. These will be used to stimulate the public awareness and debate with respect to sprawl and the generally devastating effects that it has on the Flemish landscapes.

Keywords: Flanders, spatial analysis, mapping, measures, urban sprawl

2 INTRODUCTION

Landscapes in Flanders are highly fragmented by ribbon and scattered development. In 2014 Verbeek, Boussauw and Pisman calculated an increase of ribbon development in Flanders from 3612 km in 1989 up to 4155 km in 2012, hence, an increase of 15% over 23 years. At the country level, Belgium was found to be the European country with the highest degree of urban sprawl together with the Netherlands (EEA, 2016). With this urban fragmentation of the landscape, the concern and discussions rise about the pros and cons of this development. The monetary cost of sprawled development is entering the public and political debates. This causes the need for a sound quantification and monetization of urban sprawl in Flanders and to gain better insights in the societal gains and losses of policy measures aimed at limiting and counteracting urban sprawl. With a view to get a better understanding of the nature and cost of urban sprawl, the Flemish Department of Environment & Spatial Development ordered a scientific study. In this paper results of the first phase of the study are reported.

3 QUANTIFYING URBAN SPRAWL IN FLANDERS

3.1 The state of urban sprawl

The EEA report of 2016 on urban sprawl in Europe reported on the recently developed WUP-method (Schwick et al, 2010) to quantify and compare urban sprawl between different regions and/or periods. This method combines measurements of the proportion of built-up areas (PBA – percentage of built-up), the degree of urban dispersion (DIS), and the land uptake per person (LUP) to give an overall – weighted – quantification of the degree of urban sprawl. The European sprawl analysis was done at the level of 1km² cells, based on sealed surface information derived from remote sensing (Copernicus) and population data at a 1km² resolution for 2011. When further analysing the results for Flanders, use can be made of available spatial data with a higher level of detail. Population, employment and land use (built-up) information are available at a 1ha resolution thus enabling a more precise quantification.

The input for carrying out WUP-calculations are:

- Number of inhabitants and jobs in 2013: derived from a population and employment map at 1ha resolution (Poelmans et al., 2016)
- Built-up areas: The definition of 'built-up', or better, what should be mapped as 'built-up' in order to fully grasp urban sprawl can be quite divergent. Three different definitions of 'built-up area', using four different data sources, are used and compared:
    - Buildings in Flanders
    - Sealed surfaces at a 5x5m² resolution
    - Sealed surfaces from the European Copernicus dataset at a 20x20m² resolution
    - Settlement areas, representing all land uses occupied by socio-economic functions, including residential and economic land uses, infrastructure, recreational grounds, gardens, etc.

Table 1 gives an overview of the input maps of the corresponding four 'runs'.

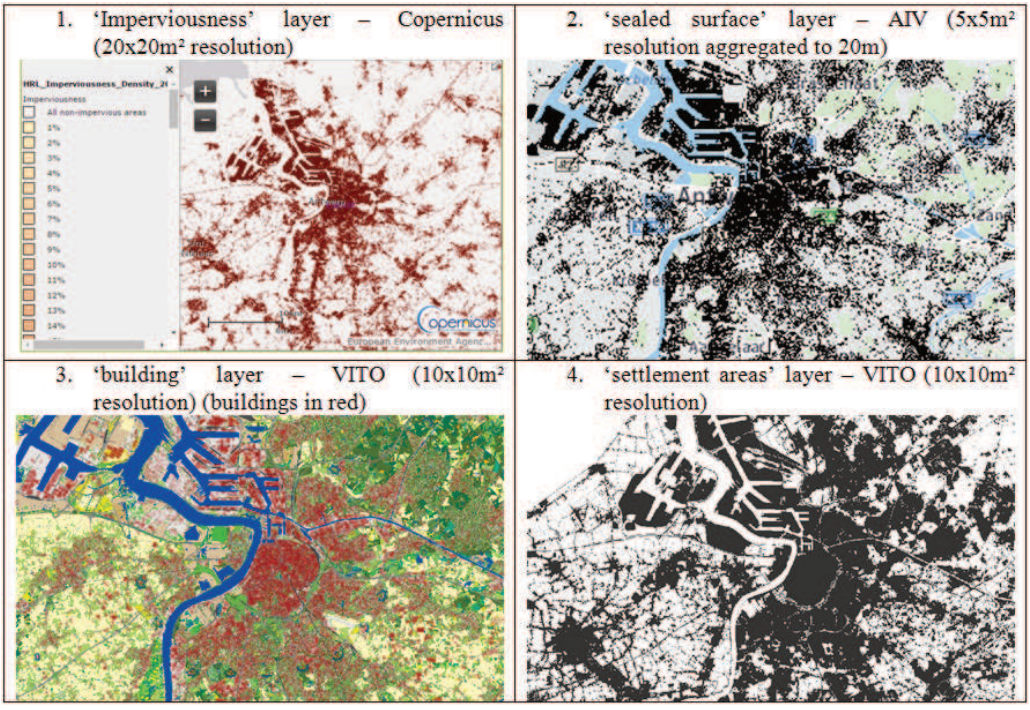

Table 1: Alternative input 'built-up' layers to calculate WUP (zoom on Antwerp)

Figure 2 shows the resulting WUP-scores in the four runs, summarised over the whole of Flanders. WUP-scores are on average the lowest when using 'buildings' as a proxy for built-up area, since WUP strongly correlates with percentage built-up. The settlement areas run shows significantly higher WUP values (Figure 2) due to the fact that it includes the complete plots occupied by buildings as well as infrastructure, recreational grounds, gardens, etc.

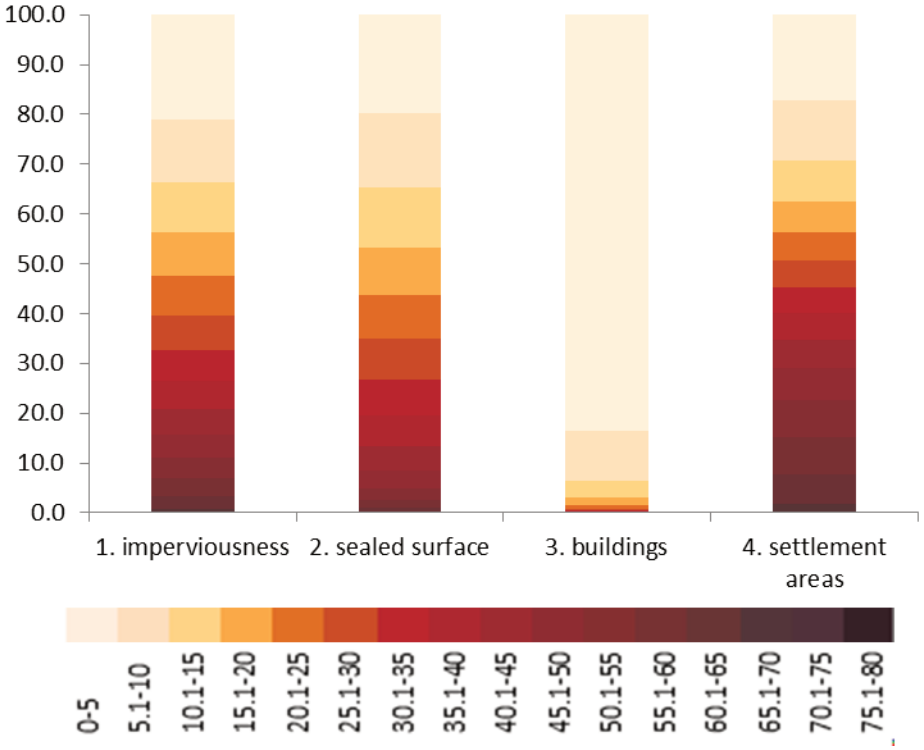

Figure 2: cumulative relative division of WUP values of 1ha-cells of four runs

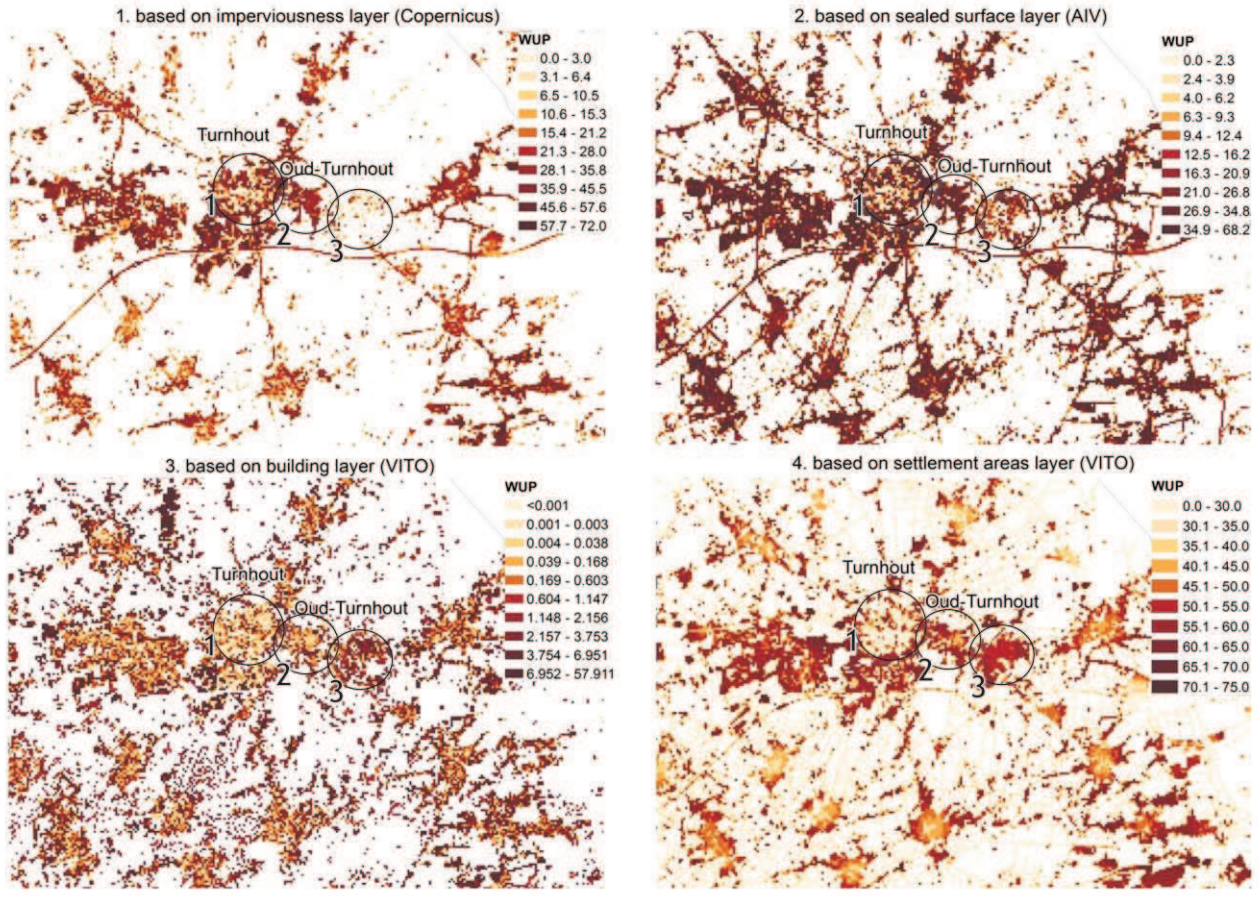

Figure 3: results of four alternatives, zoom on region Turnhout - Oud-Turnhout

Figure 3 shows the resulting WUP-maps zooming in on a region in which a – to Flemish standards - high density city centre (Turnhout, circle 1) is located next to a medium density suburban centre (Oud-Turnhout,

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circle 2) with a high income residential neighbourhood to its east (circle 3). This high income residential neighbourhood developed in green surroundings and is characterised by large plots with leafy park-like gardens. Since the average WUP is highly different in the four alternatives, the legends to map the WUP values are slightly adapted for each run, in order to be able to discern regional differences on the map.

In Figure 3 both alternatives using 'sealed surface' as a proxy for built-up area (top) show a relative low WUP in the high-income residential quarter since the garden plots are not counted for in the square meters of land used per inhabitant. When using 'buildings' as a proxy, the result is a highly scattered image with on average lower WUP values since only individual buildings, a subset of the sealed surfaces, are accounted for. The result of the 'settlement areas' alternative corresponds most to the perception of urban sprawl in Flanders: relatively low WUP values in the city centres (Turnhout) and at the countryside, slightly higher values in smaller city centres (Oud-Turnhout), and, high values in the suburban areas radiating out from the centres.

As all of the maps in Figure 3 show a rather scattered appearance, filtering these maps can help to discern more clearly zones with high versus low WUP values. Figure 4 shows the filtered version of the WUP-map based on 'settlement areas'. On this map the suburban areas and urban fringes of large cities appear as highly sprawled areas. Also residential areas with high average land uptake due to large parcels containing luxurious housing accompanied by large gardens, among others to the Northeast of Antwerp, stand out on the map.

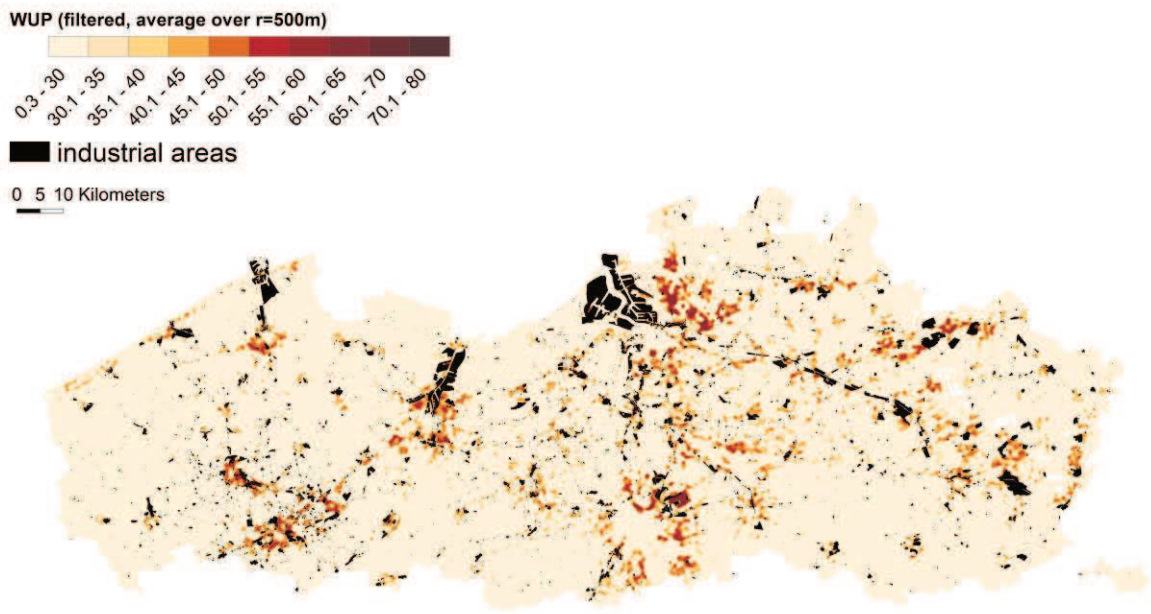

Figure 4: zones of urban sprawl – at 1ha resolution – based on settlement areas map

3.2 Urban sprawl as a process

The process of urban sprawl in Flanders is analysed by means of a temporal analysis using land-use maps of 1976, 1988 and 2000, based on Landsat images readily available from earlier work by Poelmans & Van Rompaey (2009). The land-use maps distinguish 5 land-use types at a 1 ha resolution: built-up land, arable land, grassland, forest and water. The built-up category is used in the calculations of WUP. In comparison the alternatives discussed so far, this holds somewhat the middle between 'sealed surface layer' and 'settlement areas'. Estimates of the historical number of inhabitants per ha are based on (Crols et al., 2017).

Figure 5 shows the resulting WUP-maps for each year. In general, an increase of WUP, and thus of urban sprawl throughout time, is observed. Differences can be analysed both in absolute and relative terms (Figure 6). In absolute values (Figure 6, top), WUP is mainly increasing in the surroundings of large cities and alongside roads. Also a strong increase is observed in the Southwest of Flanders, more in particular in the Roeselare-Kortrijk-Waregem conurbation (black triangle, figure 5). Rural areas, on the other hand, experience a strong relative increase (Figure 6, bottom) due to the urban development which is slowly

intruding in the landscape. In absolute terms, however, WUP values are still rather low at present. Medium relative increase (<10%) in WUP is observed in suburban areas around large cities. A decreasing WUP is only observed in the centre of Brussels, meaning that the city centre is densifying over time (higher population densities).

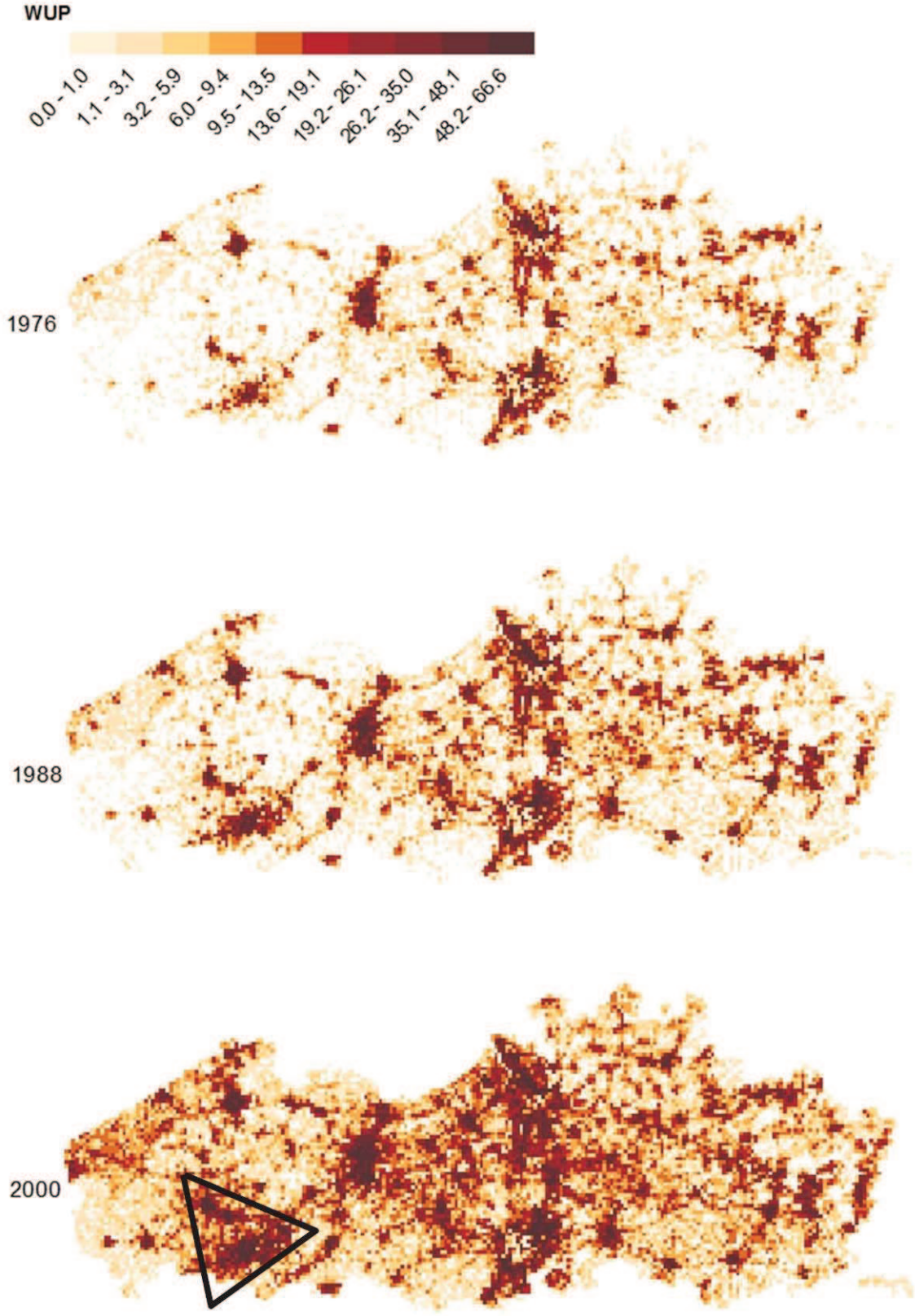

Figure 5: historical time series of WUP for years 1976, 1988 and 2000

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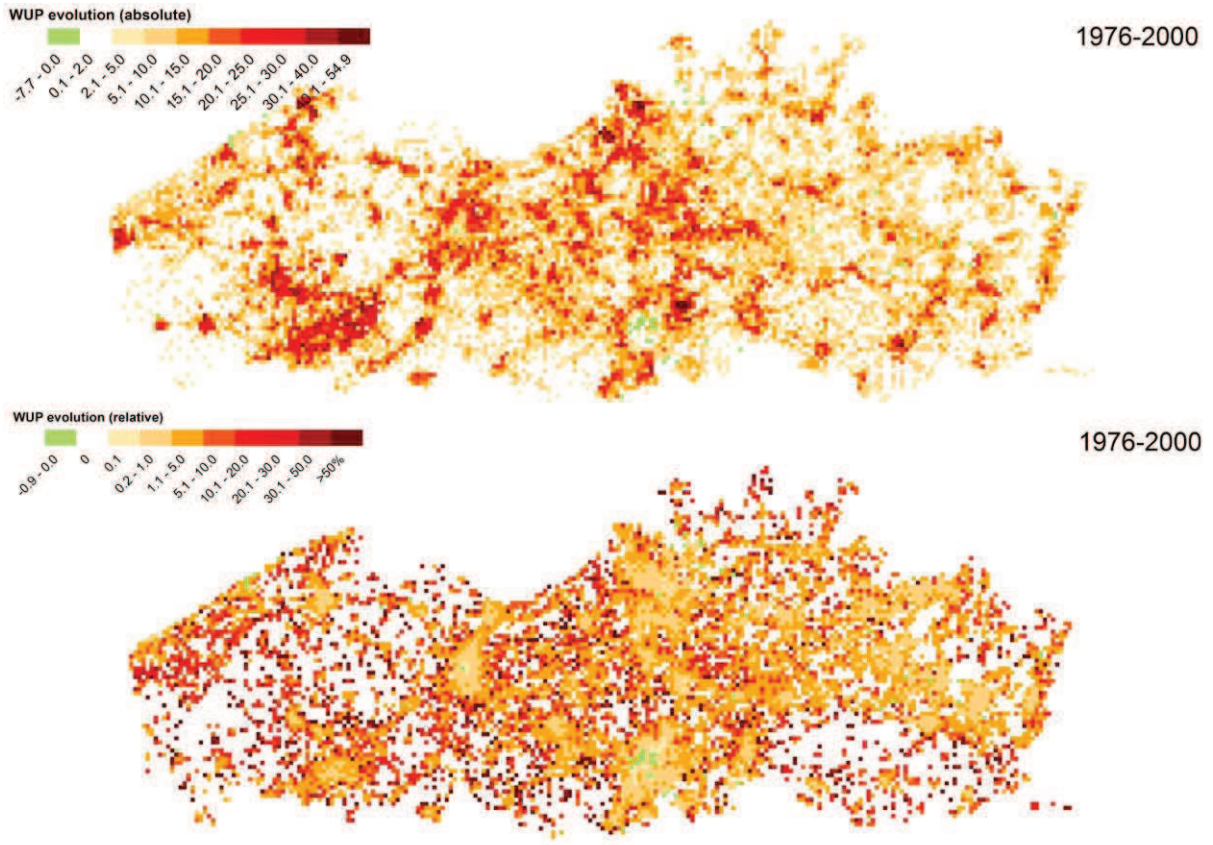

Figure 6: absolute (top) and relative (bottom) evolution of WUP 1976-2000

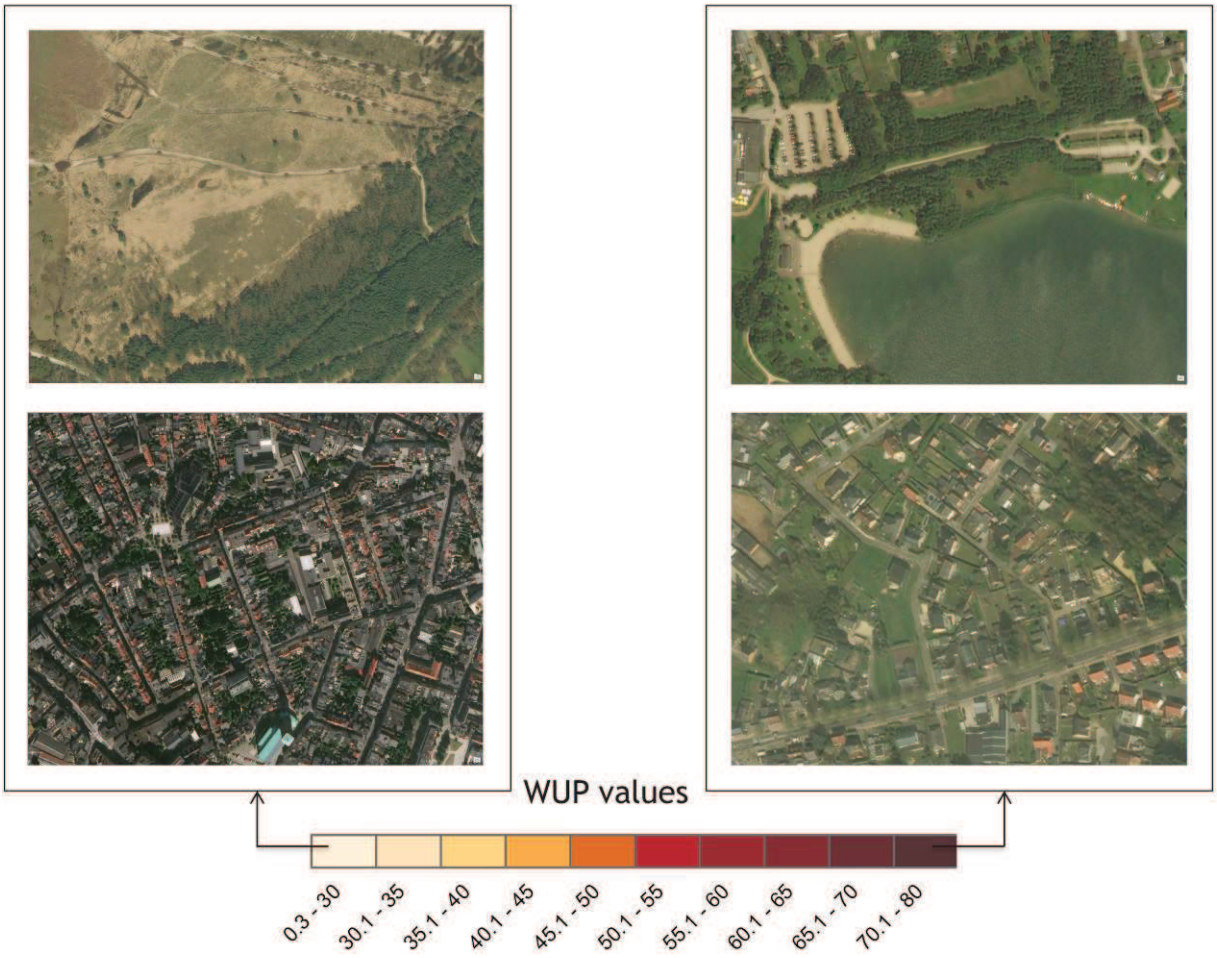

Figure 7: diverse profile of extreme values of WUP

4 URBAN SPRAWL TYPOLOGY

Although WUP is a highly valuable measure to objectively quantify urban sprawl, the measure is overly complex to use in a communication strategy for a broader public. In part this is so because it is not unambiguous. For example, low WUP-scores can be related to both open green areas as well as dense city centres. Figure 7 shows a set of four Google Earth screenshots (of 300 by 300 meters) with similar WUP-scores for the pairs left and right, but, with very contrasting building morphology types. Both low as well as high WUP values occur in locations with varying built-up density and population or employment density. Therefore, in this study, a more intuitive urban sprawl typology was created based on WUP, which can be used to encourage and inform public and political debate on the topic in Flanders.

To make WUP more transparent, the filtered WUP-map (see Figure 4) is crossed with a filtered activity map (summed number of inhabitants and number of jobs). First, both the WUP- and the activity map are categorized in four categories (very low – low – high – very high) according to natural breaks. These categorical maps are then crossed to create a 16-classed typology map. Figure 8 shows for each of the 16 classes a Google Earth tile which represent the typical building morphology.

Finally, classes similar to each other are aggregated in order to obtain a limited number of distinct building morphology types. This results in a final sprawl typology class map with six distinct building morphology types (Figure 9).

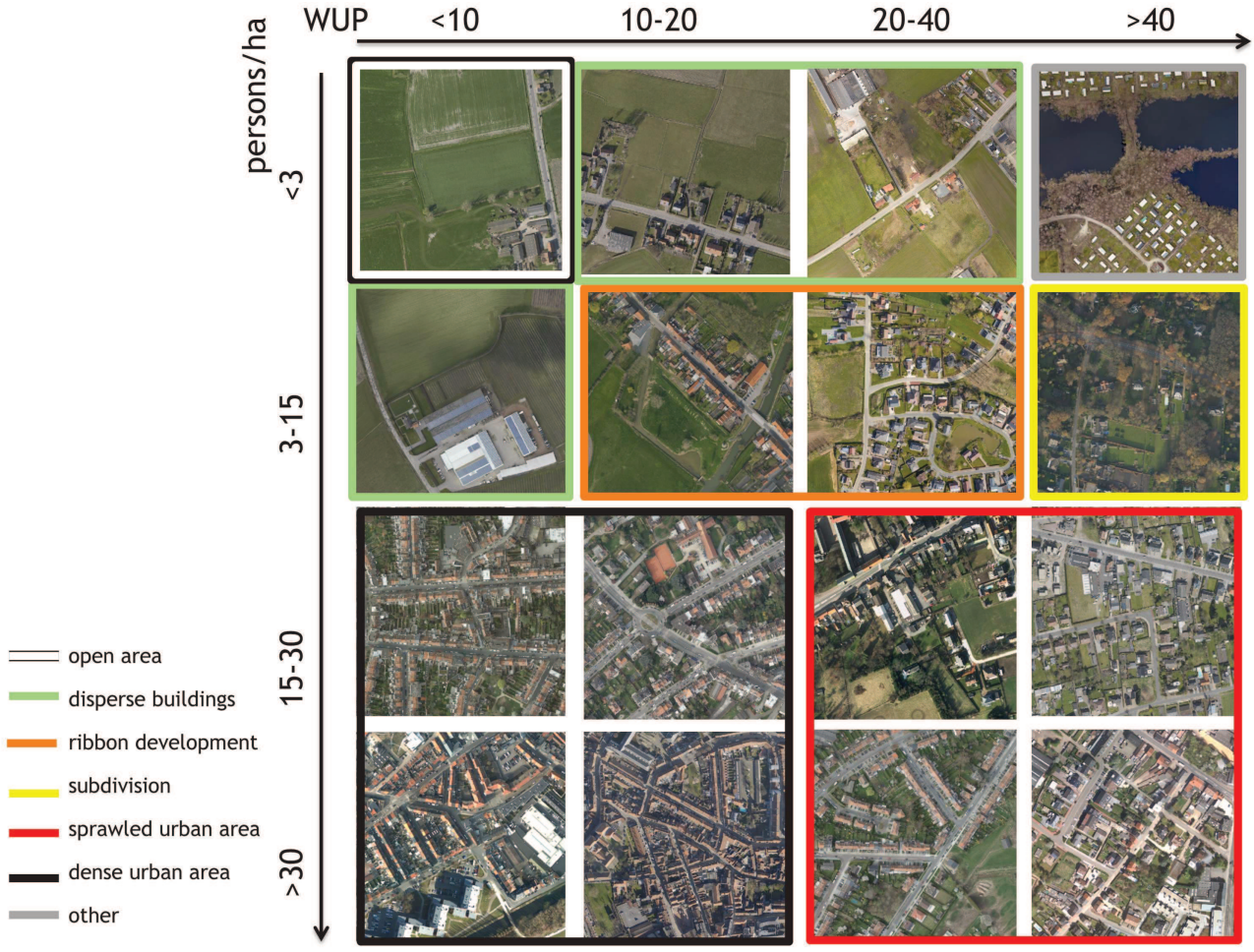

Figure 8: profile of sprawl typology classes

The least sprawled and most dense (in terms of activity) type consists of dense urban areas. These inner zones of Flanders largest cities (marked in black in Figures 8 and 9) refer to densely populated areas where multiple households reside in relatively small terraced houses or residential apartment buildings. Land used per capita and distances between buildings is lowest at these locations resulting in low WUP values.

Zones with higher WUP-values but comparable activity density, are marked in red on Figure 8 and 9. These sprawled urban areas are found either in the suburban fringe of the largest cities as well as in the centres of

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intermediate to small cities. Such areas consist of mainly single-household dwellings surrounded by gardens, thus increasing the average land use per person.

Ribbon development (orange in Figures 8 and 9), which is often associated with 'sprawl', is found almost everywhere in Flanders, but with a clear concentration in the centre (Figure 9). The typical 'allotments' in Flanders are also interpreted as a specific form of ribbon development. The activity density is low to very low in such areas. On average the WUP-values vary between low and high in these regions. The reason for the low WUP-values of this 'sprawled' morphology is that some forms of ribbon development consist of rather compact linear structures in the countryside. The rather low percentage of built-up thereof in a 1ha-cel is causing the relatively low WUP-values.

Disperse buildings (grey in Figures 8 and 9) score low to very low on WUP as well as on activity density. A high concentration of this building morphology is found in the West of Flanders. The percentage built-up in these areas is too low to result in high WUP-values. Areas with a dominance of disperse buildings are not perceived as sprawled areas, which is also explained in the European urban sprawl report (EEA, 2016).

On the other hand, subdivisions (yellow in Figures 8 and 9), are characterised by relatively large parcels with moderate sized to large buildings and large gardens. Most of these areas originate from a subdivision of large – previously agricultural – parcels into multiple residential parcels. Such a subdivision is in fact a 'grid of ribbon development'. Large yellow spots in Figure 9 indicate areas where these subdivisions spread out widely due to very large parcels with large buildings and very large gardens, accommodate higher socio-economic classes. Land use per person is very high in these areas (i.e. low activity level). Therefore WUP-values are high, hence contributing to urban sprawl.

One remaining sprawl type consists of remaining areas occupied by human activities but without residents nor significant employment (i.e. very low activity level). This other category (pale grey in Figures 8 and 9) gathers recreational areas, camping grounds, infrastructure, secondary home areas, …

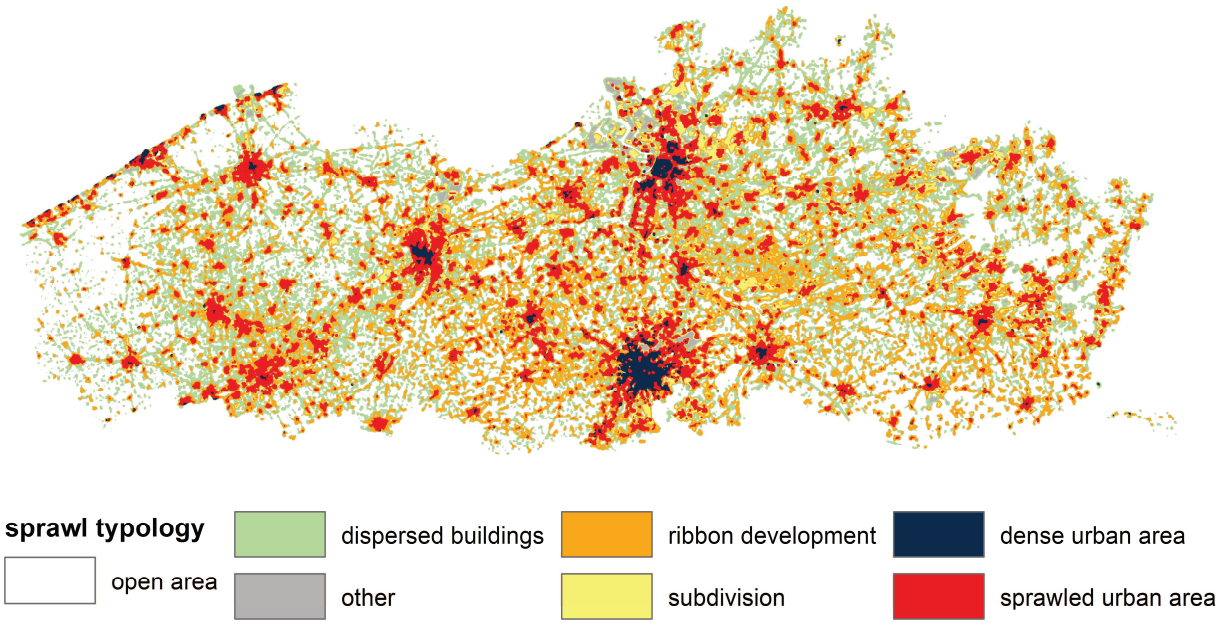

Figure 9: sprawl typology map of Flanders

The map in Figure 9 and the accompanying profiles in Figure 8 have the potential not only to assist urban policy makers in developing and putting into practice measures to reduce or at least to prevent further expansion of urban sprawl, but also, to increase the awareness of urban sprawl for a wider audience.

5 DISCUSSION

Urban sprawl is a complex phenomenon. Measuring urban sprawl as well as understanding what urban sprawl means in terms of building typology is challenging. This study shows that, in measures like WUP, the input data have a strong impact on the quantification of urban sprawl. Results show that using the impervious area, as has been the case in the EEA-study in 2016, leads to a clear underestimation of the problem of sprawl in Flanders since many green areas (gardens) solely fulfil a residential function. Using settlement area as an alternative input encompases the complete residential areas in the WUP and leads to a better measure to quantify sprawl in a Flemish context. It is therefore important to take into account the type of input data used to analyse and compare the results of sprawl measures.

Another drawback of the WUP-measure is its conflict with the common sense of what urban sprawl means in terms of building morphology. By applying this measure in Flanders, small to medium urban centres appear as highly sprawled areas (high WUP), while in the Flemish context these areas perform as urban centres with an increased concentration of population and buildings compared to their surroundings. The typical Flemish ribbon development, on the other hand, does not always score high on WUP, while they appear as urbanized tentacles reaching out into rural and open areas. They are therefore perceived as urban sprawl by the public opinion in Flanders. The urban sprawl typology implemented in this study tries to remedy these effects by translating the WUP-measure into a more intuitive sprawl measure. Both the spatial and historical analyses and maps of sprawl deliver useful insights and even steering handles to guide policy and the public debate. While the maps indicate the ‘hotspots’ of present as well as past urban sprawl, the images give ‘face’ to sprawl and initiate the debate on how and where to prevent sprawl from increasing.

In the remainder of the study, more effort will go in the development of scientific material to feed the public debate and produce practical levers for planners and policy makers. To begin with, the types developed will be an input to compute monetary costs and benefits of urban sprawl. This will involve costing public services associated with each urban sprawl-type: dwellings, energy, roads and other infrastructure, services provided to inhabitants, transportation, etc. It is expected that high sprawl will involve high public costs, but, this relation is not unambiguous. Next, land use scenarios will be developed and run using RuimteModel Vlaanderen (White et al., 2015) to explore the development of urban sprawl towards 2050. Detailed land use maps at the 1ha resolution will extend the time series discussed in section 3.2, hence, allow to compute the evolving WUP-values associated with each scenario. Scenarios will implement expected demographic and economic growth alongside various sets of policy measures aimed at combatting urban sprawl, and, it is expected that the analysis will reveal inputs for policies to deal with urban sprawl in Flanders.

With these instruments at hand, understanding and controling urban sprawl should be closer.

6 REFERENCES

CROLS, T., VANDERHAEGEN, S., CANTERS, F., ENGELEN, G., POELMANS, L., ULJEE, I. & WHITE, R. (2017). Downdating high-resolution population density maps using sealed surface cover time series. Landscape and Urban Planning 160 (2017) 96-106.

POELMANS, L., VAN ESCH, L., JANSSEN, L. & ENGELEN, G. (2016). Landgebruiksbestand voor Vlaanderen, 2013. VITIO Report 2016/RMA/R/0846.

POELMANS, L. & VAN ROMPAEY, A. (2009). Detecting and modelling spatial patterns of urban sprawl in highly fragmented areas: a case study in the Flanders-Brussels region. Landscape and Urban Planning 93(1) 10-19.

VERBEEK, T., BOUSSAUW, K. and PISMAN, A. (2014) Presence and trends of linear sprawl: Explaining ribbon development in the north of Belgium, Landscape and Urban Planning 128 (2014) 48–59

EUROPEAN ENVIRONMENT AGENCY (2016) Urban sprawl in Europe - Joint EEA-FOEN report, EEA Report No 11/2016..

SCHWICK, C., JAEGER, J., BERTILLER, R., KIENAST, F. (2010). Urban Sprawl in Switzerland - unstoppable? Quantitative Analysis 1935 to 2002 and Implications for Regional Planning. Bristol Publication Series, vol. 26.

WHITE, R., ENGELEN, G., & ULJEE, I. (2015). Modeling cities and regions as complex systems: From theory to planning applications. MIT Press.

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