INTERNAL PROJECT REPORT ON INVENTORY OF URBAN GREEN SPACE DEMAND FOR THE TWO SCALE LEVELS, ULLS AND EUROPEAN URBAN ATLAS CITIES

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1 INTRODUCTION

This milestone presents the results of the identification and quantification of the demand for urban green space at two scales, the Urban Learning Labs (ULLs) and Europe as a whole. For the European scale, the "Urban Atlas data set cities" are used.

Urban residents' mental and physical health and well-being can benefit from the ecosystem services provided by green spaces. The demand for urban green space can therefore be roughly approximated by the number of urban population. The application of per capita urban green space values and accessibility threshold values can provide a broad overview-kind of assessment of green space provision for a whole city without looking into the inner differentiation of the city itself (Larondelle & Haase, 2013). Green spaces can be broadly defined as any vegetated areas found in the urban environment, including parks, forests, open spaces, lawns, residential gardens, or street trees. For the purpose of this analysis, a narrower definition is used (see section 2, Methods).

The benefits of green space are broad and diverse (for an overview see a review by Kabisch, Qureshi, & Haase, 2015): Urban green spaces help to preserve and enhance biodiversity within urban ecosystems (Tzoulas et al., 2007). Green spaces provide fresh air, reduce noise and counteract high air temperatures through their cooling capabilities (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Spronken-Smith & Oke, 1998). Social benefits include positive influence on psychological and mental health (Ulrich et al., 1991; Völker & Kistemann, 2013) via stress reduction (Chiesura, 2004; Kaplan, 1985) and relaxation (Kuo, Bacaicoa, & Sullivan, 1998). Within a broader social view, urban green spaces act as meeting places in neighbourhoods (Martin, Warren, & Kinzig, 2004) and play an important role in the interactions of residents of different population groups with others in their community by providing space (Kabisch & Haase, 2014). Finally, urban green spaces often provide the primary contact with local flora and fauna and the natural environment for urban residents and thus increase environmental learning (Krasny, Lundholm, Shava, Lee, & Kobori, 2013).

Because of the above listed benefits green spaces provide, their availability and accessibility to residents in cities have been the focus of planning and research for quite a while. Van Herzele and Wiedemann (2003) applied a spatial GIS (Geographical Information System)-based indicator system to cities in Belgium to plan accessible and attractive green spaces. Germann-Chiari and Seeland (2004) used GIS and regression analyses to assess the distribution and access of urban green space by social target groups in three cities in Switzerland. Comber et al. (2008) used a GIS approach for Leicester, UK to assess urban green space accessibility for different ethnic and religious groups. Balram & Dragićević (2005) used multiple methods involving semi-structured interviews and a collaborative GIS workshop for accessibility assessment. In the US, the focus of research and planning has been on the distribution of tree canopy rather than green space. Heynen (2003) for example, found that minorities and residents with low socio-economic status had a lower canopy cover in their neighbourhood. Danford, Strohbach, Ryan, Nicolson, & Warren (2014) studied the difficulties in reaching an equitable tree canopy distribution in Boston, MA, USA.

Some European cities provide per capita threshold values for urban green space or for minimum accessibility for a defined area. For instance, the city of Berlin, Germany, aims at providing at least 6 m^2 urban green per person (Senatsverwaltung für Stadtentwicklung und Umwelt, 2013), while Leipzig, also Germany, aims at 10 m^2 per capita (City of Leipzig, 2003). In the UK, it is recommended that – as a national target – city residents should have access to a natural green space of minimum 2 ha within a distance of 300 m from home (Handley et al., 2003). Berlin's Department of Urban Development and the Environment recommends that every resident should have access to urban green of minimum 0.5 ha within a 500 m distance from home. Similarly, Hutter, Westphal, Siedentop, Janssen, & Müller (2004) recommend green space of 1.0 – 10 ha for every resident within 500 m.

2 METHODS

European scale

To assess the demand for urban green space, both land use data (land cover data) and demographic data are used for calculation of statistical and GIS models.

Land cover data stem from the European Urban Atlas land cover dataset obtained from the European Environmental Agency (EEA, http://www.eea.europa.eu/data-and-maps/data/urban-atlas). The data in the Urban Atlas data refer to 301 larger urban zones which refer to commuting zones around cities. Urban Atlas data are based on Earth observation satellite images with a 2.5 m spatial resolution and, thus provides comparable land use data for all of the European core cities and respective larger urban zones with more than 100,000 inhabitants.

The analyses in this Milestone focus on the core cities, exclusively. Therefore, core cities were delineated using the core city layer from the Urban Audit (European Commission, 2004), which refers to current administrative city boundaries.

In the Urban Atlas, 21 thematic classes, including diverse urban fabric, transportation, industrial and environmental classes, are distinguished (European Commission, 2011). This classification of urban land cover and land use is, thus, finer than commonly used datasets of land-cover/land use. In particular, the Urban Atlas includes groups of different urban fabric classes according to density and a ''land without current use'' class, which represents brown fields. For green assessments the classes "green urban areas" and "forest areas" are used. Unfortunately, the class "agricultural areas, semi-natural areas and wetlands" combines land that can potentially serves as green space (i.e. grasslands, semi-natural land) with land of low recreational value (i.e. cropland). We therefore excluded it from our analysis. We also decided not to include Urban Atlas class 142 "sports and leisure facilities" in our definition of urban green spaces because "sports and leisure facilities" includes race courses and areas of sport compounds (e.g., football stadiums, tennis courts, golf courses), which can be sealed to a high degree. In addition, nearly all of them are not publicly available and thus not accessible to all urban residents. Both restrictions might lead to an underestimation of both per capita green space values and its accessibility. The Urban Atlas land use data refer to the year 2006, but a follow-up version that should be based on 2012 imagery is in preparation and expected to be published in 2015.

Population data is provided by the Urban Audit Data Explorer and by national statistical agencies and are used to calculate per capita values. The data refer to the selection period 2012/2013 and are provided for core cities and are, thus, comparable to the Urban Atlas spatial delineation (see Kabisch & Haase, 2013 for a methodological comparison). In total, 290 cities in 26 countries are part of this analysis. We had to exclude some of the Urban Atlas cities were no or insufficient population data was available.

Using both, Urban Atlas data and population data, we calculated the total amount of the land use classes per city and the per capita values of green spaces on city level.

Finally, a 1 km^2 grid dataset of population data for the EU from 2011 was used for calculating the access to green space (≥ 2 ha) within a 500 m distance. The grid dataset was produced by the ESSnet project GEOSTAT which was launched in co-operation with the European Forum for GeoStatistics (EFGS, http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_grids). For accessibility calculations, a 500 m buffer around green and forest areas within administrative boundaries of cities was calculated within GIS (ArC Map 10.0, Figure 1). All grid cells which had their centroids within the city area were selected and respective population numbers were aggregated per cities. Then the grid cells were combined with the buffer of the green space (using the Arc Map toolbox function "intersect"). If a grid cell was only partly within the buffer zone, percentage share of area within buffer was calculated and used for calculating the respective population numbers within this part of the grid cell.

All data used for calculation at European scale is presented in Table 1.

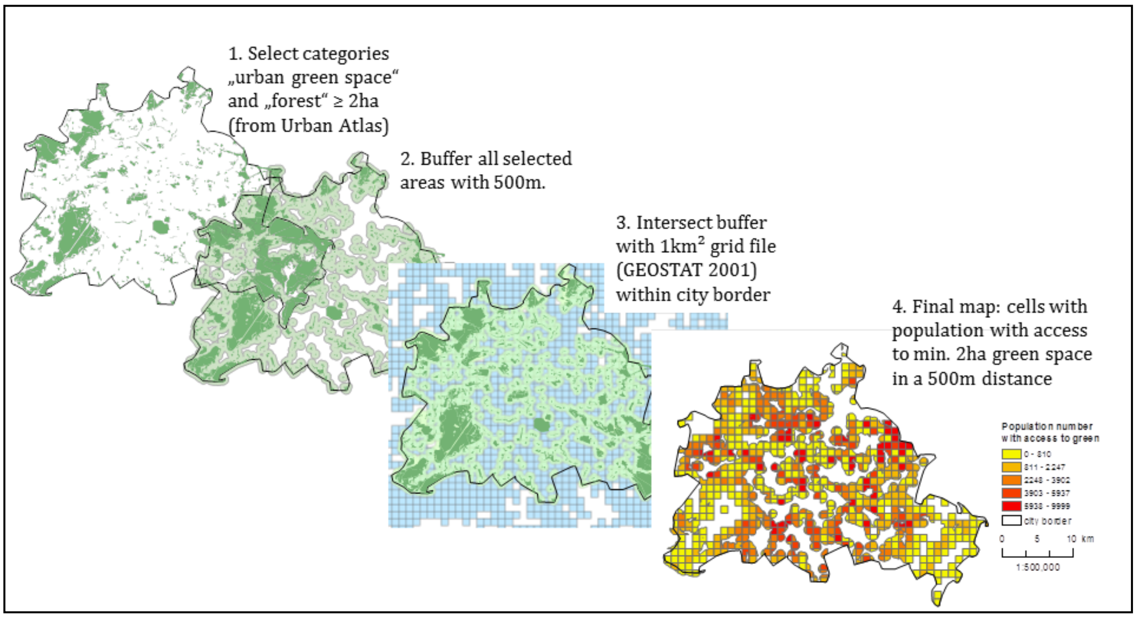

Figure 1. Method for accessibility calculation in ARC GIS.

Table 1. Data used for calculation of demand for urban green space at European scale.

Data	Temporal scale	source
Administrative city boundaries	2004	GISCO Urban Audit
Demography GEO STAT Grid	2011	GISCO 2014
Urban green space (class 141 and class forest areas class 30)	2006	Urban Atlas 2006 (EEA)
Urban residential area (classes 111-1124)	2006	Urban Atlas 2006 (EEA

Urban learning lab scale

Data for calculating the demand of the case study cities reflect land use/cover data and demographic data (Table 2). Land use data are based on the Urban Atlas data base for comparability reasons. Data for demographic calculations stem from local administrative agencies. They include population number for specific years. District data is available for the ULLs of Berlin (Germany) and Ljubljana (Slovenia). Although not being a case study city, we also included the Polish city of Łódź into the case study analysis to discuss a case from Eastern Europe.

Table 2. Data used for calculation of demand for urban green space at ULL scale.

Data	Temporal scale	source
Administrative city boundaries	2004	GISCO Urban Audit
District borders Berlin, Edinburgh, Ljubljana	2012	Local communal statistical agencies
Demographic data (population number)	2013	Local communal statistical agencies
Land cover/use data (class 141 and class forest areas class 30)	2006	Urban Atlas 2006 (EEA)

3 RESULTS

European Scale

Table 3 shows mean values for total area, residential area, forest areas, and green urban areas for Northern, Southern, Eastern and Western European cities. The sample was grouped according to macro-geographical regions (United Nations Institute of Social Affairs, 2010). In Western and Northern Europe, the share of residential area is comparatively higher which gives a first hint on the long and ongoing sprawl process after WW II there. Not surprisingly, forest areas are most frequent in Northern European cities. Cities in Eastern and Southern Europe show lowest values for green areas within their city boundaries. This reflects the ideal of the dense southern European city where in a number of cities narrow roads have been most important to provide shadow during hot summers. This is also represented in comparatively low values for per capita green space. From social science analyses we know that residents in Southern European cities expect their recreational space more outside their cities (http://www.re-urban.com/outcomes.htm)

Table 3. Land use/land cover area and per capita values for European urban regions.

Indicator	Western Europe	Southern Europe	Eastern Europe	Northern Europe
Total area (ha)	29625.04	25595.24	18958.96	48816.15
Total residential area	4936.69	2489.48	2665.92	5661.93
Forest	4168.85	2487.7	3035.86	16700.32
Green urban areas	853.24	399.2	462.06	1288.32
Water bodies	842.72	639.52	518.87	3096.19
Per capita green space (m^2 per inh.)	27.25	10.97	13.71	32.95
Per capita green +forest (m^2 per inh.)	233.97	137.39	157.52	1277.95
per capita water area (m^2 per inh.)	32.52	28.01	27.05	229.18

The spatial differentiation of total urban green and forest areas in the different European regions is also reflected in accessibility values. Figure 2 shows a European map in which the share of population which has access to green and forest areas of a minimum size of 2 ha within a 500 m distance. More than two third of the population living in Scandinavian countries or in countries in Western Europe such as Austria or North-Western Germany has access to green space in their vicinity. In addition, a number of cities in the Eastern European countries of Poland, Slovakia and the Czech Republic show high values. Notably cities in Southern-Eastern or Southern European countries show comparatively low values. In a number of cities in Hungary, Bulgaria or Romania only on third or less have access to urban green space ≥ 2 ha within a 500 m distance from their home. This is also the case for Southern European cities notably in Greek and some cities in Italy and Spain. Those cities in Eastern and South-Eastern European countries with lower accessibility values may lack a sound green space management after their entry into the market economy and new construction dominates the land use change. For Southern Europe, the traditional narrowness of the cities comes together with higher efforts to maintain green spaces under conditions of considerable summer dryness there. Moreover, Southern European cities' area contains considerable rock surface.

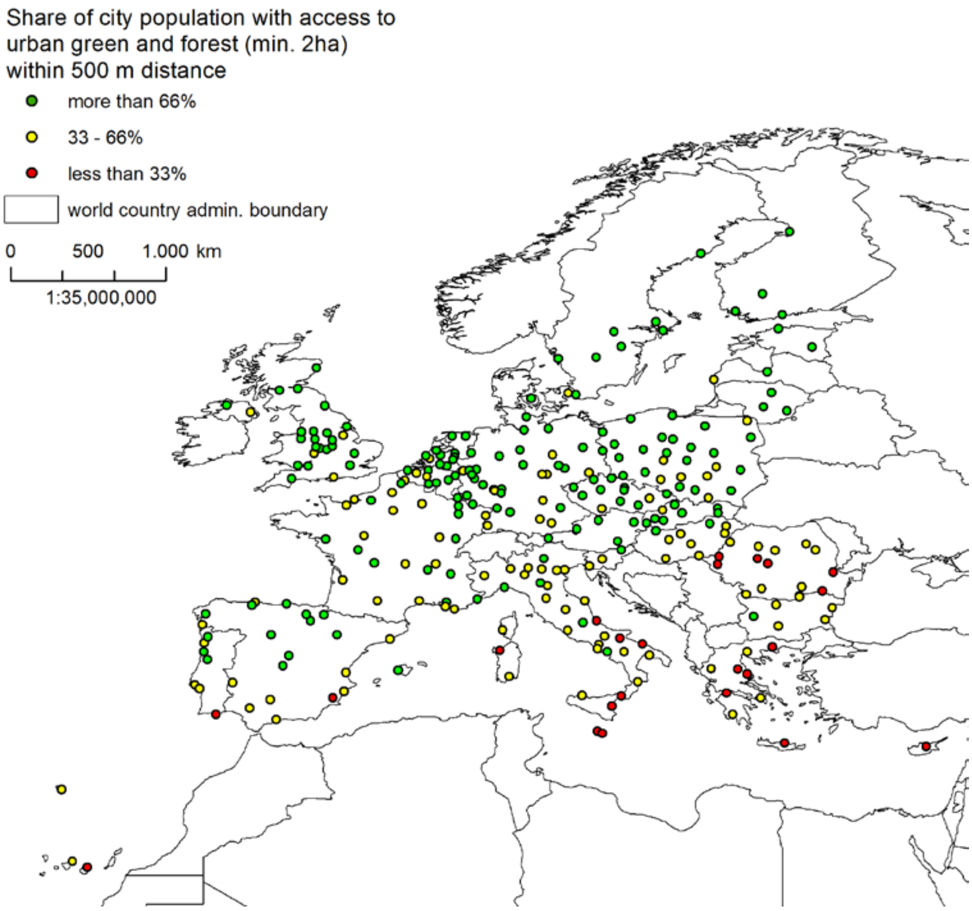

Figure 2. Share of population with access to urban green space (≥2 ha) within 500 m in administrative city boundaries. Note: Calculation based on GEOSTAT 1 km² grid and Urban Atlas land cover data.

ULL scale

The ULL cities in GREEN SURGE are Berlin, Malmö, Ljubljana, Edinburgh, and Bari. In this Milestone, we additionally studied Łódź.

Berlin is the largest city with more than 89,000 ha (Table 4). Residential area in Berlin comprises nearly 30 % of the city area while open spaces including forest areas, green spaces and water bodies do also represent nearly 30 %. Among all case study cities, Berlin has the highest population number with more than 3.5 million inhabitants. Per capita green space (including forest and urban green) is high with more than 60 m^2 per inhabitant.

Malmö in Sweden is one of the smaller case study cities. The city had around 313,000 inhabitants by 2013. Share of urban green space is comparatively high which results in a value of 36 m^2 per capita green space (including forest areas).

Ljubljana is the capital of Slovenia. The city has only 248 ha of urban green space but a very high forest area of more than 11,000 ha which is based on its topographical situation. Ljubljana's population was 280,600 in 2013. Per capita green space is comparatively low with around 9 m^2 per inhabitant while it is very high when also forest areas are considered (422.30 m^2/inh.)

Bari, situated in Italy is the smallest case study city with around 11,000 ha. Forest area is small with only 7 ha while urban green spaces comprise 182 ha. With around 313,000 inhabitants per capita green space is calculated with around 6 m^2 and is the lowest value among the cities. Bari also only comprises 5 ha of water bodies within administrative city boundaries.

The Scottish city of Edinburgh is situated in northern UK. The city had nearly half a million inhabitants in 2013. More than one fifth of the city area is residential area. Around 3,000 ha of land are urban green space and forest areas. Per capita urban green space is relatively high with 31 m^2 per inhabitants and even higher is the value when forest areas are considered as well.

Finally, the city of Łódź in Poland is the second largest city of the case studies with around 719,000 inhabitants. Per capita values for urban green space and forest areas are similar to those of Berlin with 12.5 and 60.0 m^2 per inhabitant respectively.

Figure 3 shows the land use values as share of the total city area for the Urban Learning Lab cities.

Table 4. Area of land cover/land use in the ULL case study cities.

City	Berlin	Malmö	Ljubljana	Edin-burgh	Bari	Łódź
Total area Urban Atlas (ha)	89,042	15,309	27,563	26,218	11,374	29,428
Residential area (ha)	28,791	3,060	3,122	5,424	1,992	6,720
Green space (ha)	5,727	1,029	248	1,515	182	898
Forest (ha)	15,578	107	11,602	1,379	7	3,417
Water area (ha)	5,077	184	273	260	5	59
Population nr. 2013 (in 1000)	3,502	313	281	483	313	719
per capita green (m^2/inh)	16.35	32.86	8.85	31.39	5.81	12.50
per capita green + forest (m^2/inh)	60.84	36.28	422.30	59.97	6.04	60.03
per capita water area (m^2/inh)	14.50	5.87	9.72	5.38	0.15	0.82
Share of pop who has access to green space (2 ha within 500m)	67.66	84.08	56.79	88.32	21.44	75.79

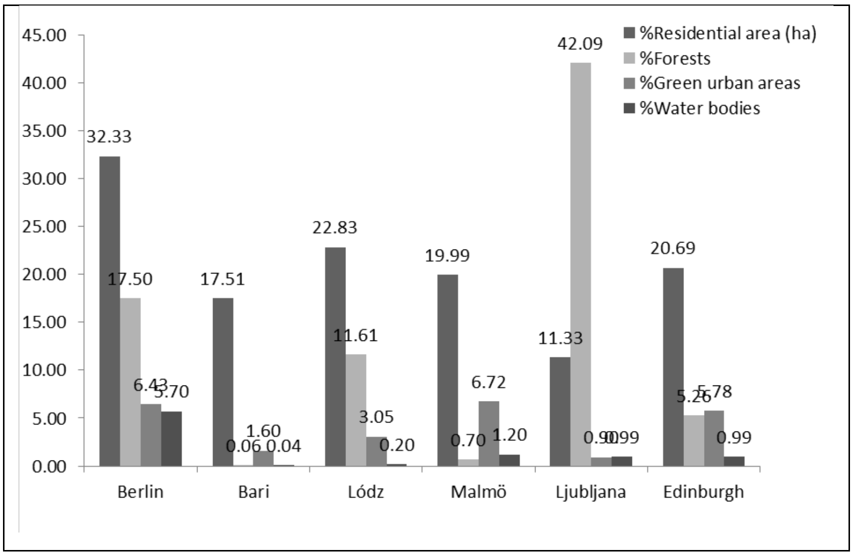

Figure 3. Land use/cover as share of total area based on Urban Atlas 20006 (EEA).

Figure 4 shows the results of the accessibility calculations for the case study cities. Again, they reflect the results from the total and per capita values. Berlin as the largest city of the sample has a high share of urban green spaces. Over the whole city area, high numbers of residents have access to green space in their vicinity. Similar results were found for Ljubljana, Edinburgh and Malmö. In Łódź, notably people living near the city border have access to forest areas and those living in the inner parts of the city to green urban areas. Bari shows only some areas in which people have access to urban green of a minimum size of 2 ha.

For any conclusions in terms of green infrastructure provision within the ULL cities, it needs to be mentioned again that in the calculation of all cases only the Urban Atlas classes "forest" and "green urban areas" were included because of the mentioned shortcomings in the data base. Therefore, cemeteries, allotment gardens, green sports areas and brownfield sites could not be included. These land uses are summarized in other classes such as "industrial, commercial, public, military and private units" where no further distinction is made. In addition, the raster-based type of analysis does not include the road and path network of the cities and show always the "bird's eye view".

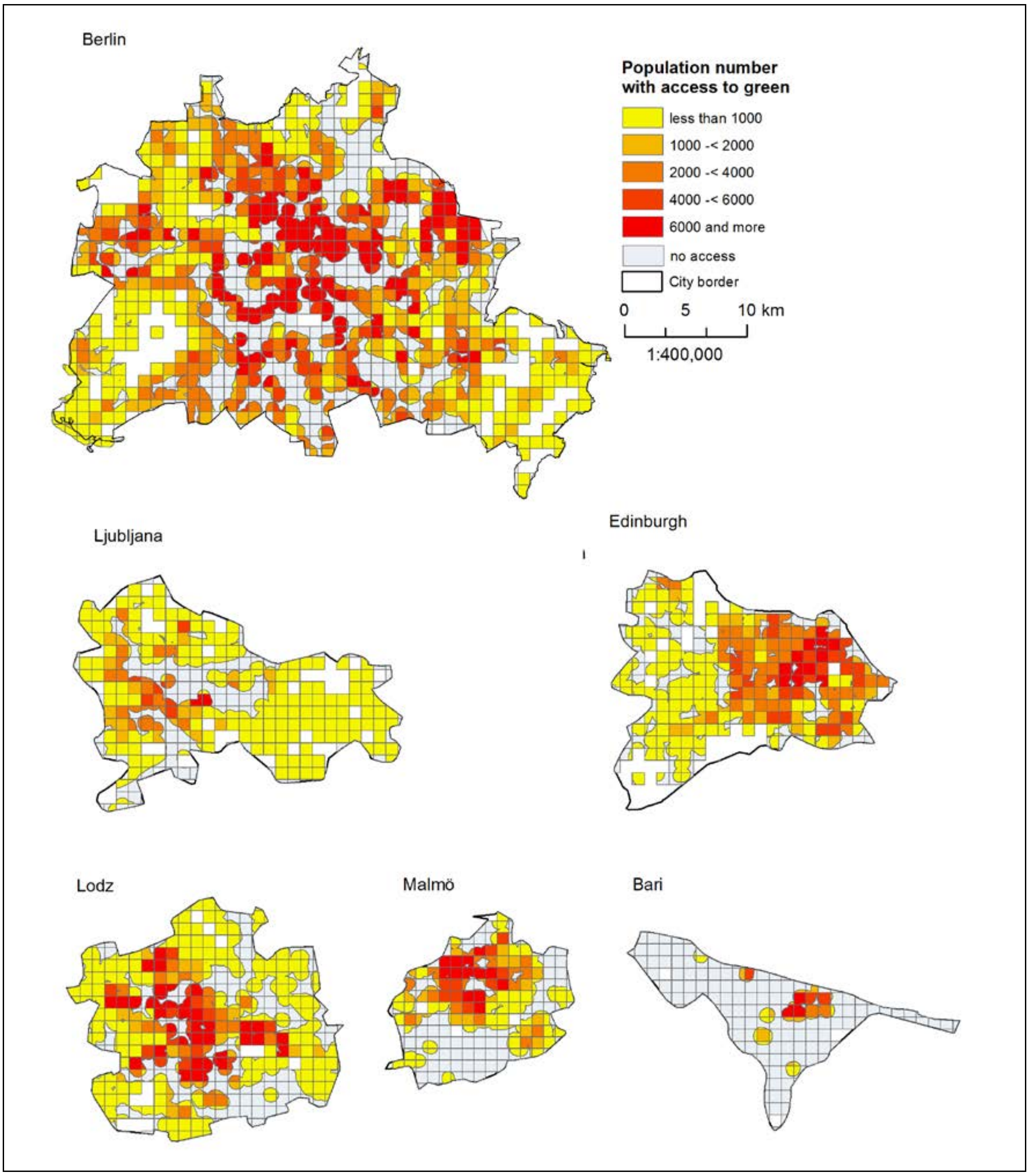

Figure 4. Accessibility calculation of population which has access to urban green and forest areas of a minimum size of 2 ha within 500 m distance. Note: Calculation is based on GEOSTAT 1km² grid and Urban Atlas land cover data. No street or public transport net was included in the analysis.

At district level (Figure 5), urban green space distribution (including forest areas) is different. Figure 5 shows per capita green space and population density values for the districts of Berlin, Germany and Ljubljana, Slovenia. In Berlin, districts situated near the city border have higher shares of urban green and notably forest areas as in the southwest of the city. Accordingly, per capita values are high in these districts. By comparison, the map of the population density shows that density is highest in inner city areas. This is also the case for Ljubljana although population density values is overall lower than in Berlin. Per capita values for urban green and forest areas are highest in the north and the east of the city with values of more than 500 m^2 per inhabitant. These per capita values represent the land use distribution in the city. Share of forest area is high in those districts near the city border and population numbers are low. Per capita values, thus, result to be exceptionally high in these areas.

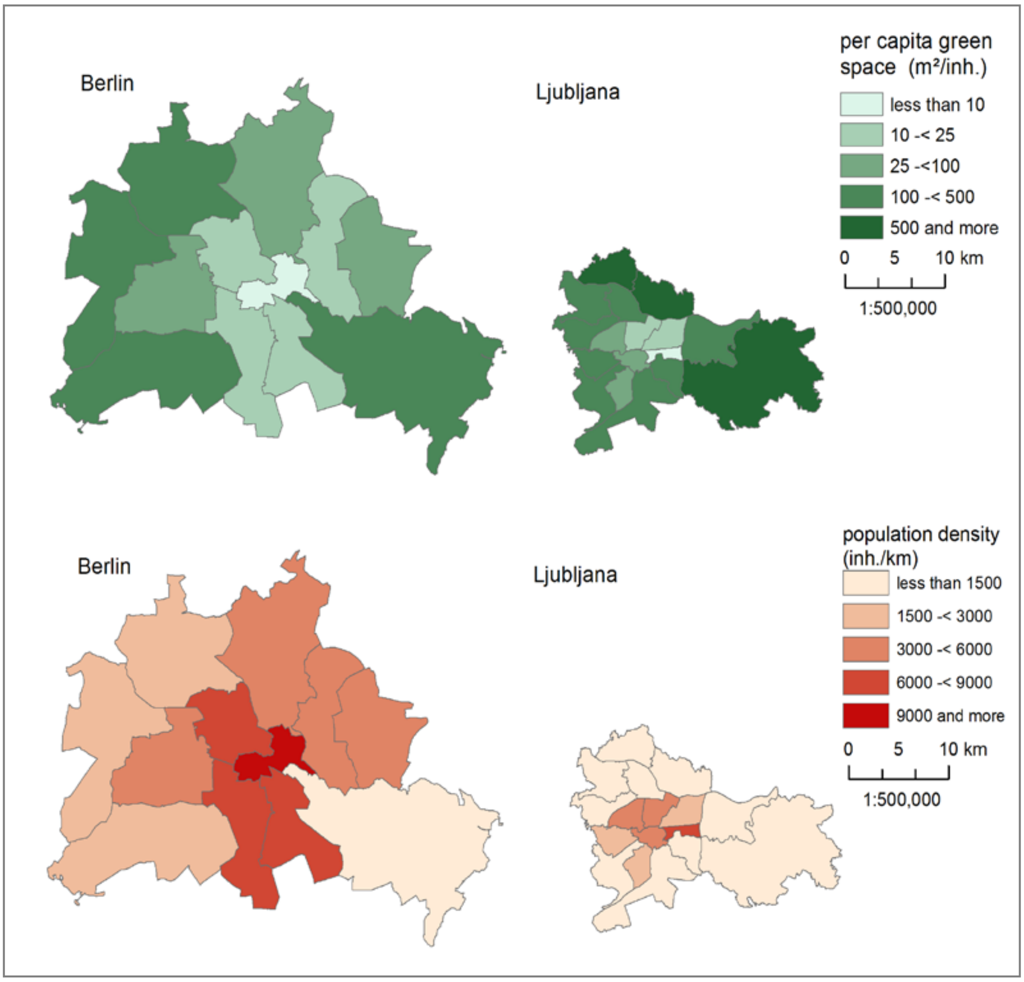

Figure 5. Per capita green space (m^2/inh.) and population density at district level for the ULL cities Berlin and Ljubljana.

4 DISCUSSION AND CONCLUSIONS

The results of the calculation for the demand of urban green space show a heterogeneous picture across the EU. The ULL cities, which act as case studies in the GREEN SURGE project stand as an representative example for the general trend of values in Western, Southern, Eastern and Northern urban Europe.

Accordingly, the low forest and tree cover in Southern Europe explains the below-average per capita urban green and accessibility values in Southern European cities such as in Bari. Additionally, cities along the Mediterranean coastline have a high degree of soil sealing and rock surface, which further explains lower values for green land use (Kasanko et al., 2006).

The above-average values for green, forest and water areas in Northern European cities results from the biophysical conditions and the forest richness of the respective countries in general. Malmö as the Swedish case study city in Northern Europe is situated at the Baltic see. It has the highest share of water area and respectively high per capita water area.

Western European cities present a divers picture. Whereas in many cities, urban sprawl reduces green space of any type outside the core cities, in their inner parts, green spaces have been started to be better preserved and enhanced. Some cities do have a very high share of urban green spaces such as Berlin. This is mainly due to an increased awareness of planning, protecting and investing in nature is developing in the last years. Further, an increase in ecological ''green'' lifestyles such as urban gardening activities are appearing in cities such as Berlin and may lead to the diverse picture of green space provision and access.

Łódź is an example of an Eastern European city. Per capita values are below average but still represent a certain provision of urban green and forest areas for city residents. The accessibility map however shows that a number of inhabitants benefit from access to green. Notably those people living live near the city border benefit from access to urban forest areas. Larondelle et al. (2014) concluded that for the case of Eastern European cities, the ecosystem services provision based on green land use is very dynamic and hard to predict. Authors noted that biophysical pre-conditions are different according to location in Europe making comparisons between, for example, the more Mediterranean Bulgarian cities and semi-continental cities in Poland and the Czech Republic difficult.

Data issues

Due to the broad focus of this Milestone, green space was defined rather narrowly based on Urban Atlas classification. Only those areas were included in the analyses which are represented in the two Urban Atlas classes “forest” and “green urban areas”. Due to the classification in Urban Atlas, which summarizes different land uses in one class, important green spaces such as cemeteries, allotment gardens or green brownfield sites could not be included. Future research within GREEN SURGE will look at how different green infrastructure (including cemeteries or allotment gardens) can supply the demand for ecosystem services by residents. For a detailed analysis, land use maps with higher resolution will be used at ULL scale.

Finally, accessibility threshold values are differently used in literature. Thus, a comparative analysis using different threshold values such as a 300 m distance for 2 ha or a 1500 m distance for 50 ha as well as the inclusions of a street network is planned for future work.

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