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Analysis of Urban Ecosystem Condition Indicators for the Large Urban Zones and City Cores in EU

Threshold Assessment and Exploration of the Relation to Ecosystem Services through the Application of G.I.S.

Christina Kourdounouli

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Department of
Physical Geography and Ecosystem Science
Centre for Geographical Information Systems
Lund University
Sölvegatan 12
S-223 62 Lund
Sweden

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Christina Kourdounouli
Master thesis, 30 credits, in Geographical Information Science
Lund University, Sweden

Supervisor:

Anna Maria Jönsson
Professor at Department of Physical Geography and Ecosystems Science
Lund University, Sweden

Exam committee:

Harry Lankreijer
Senior lecturer at Dept of Physical Geography and Ecosystem Science
Lund University, Sweden

Andreas Persson
Senior lecturer at Dept of Physical Geography and Ecosystem Science
Lund University, Sweden

Abstract

As almost three out of four EU citizens live in urban areas and this number is expected to further grow, studies on urban ecosystems and their services are crucial to understand a city's environmental structure and capabilities. The European Commission has published a relative report which suggests an urban ecosystem condition indicator framework, yet without suggesting respective thresholds that might indicate a "desired" environmental condition of the city. The European Commission's report also points up that the relation between the ecosystem condition and the ecosystem services still needs scientific underpinning. The current study estimates 8 (eight) of the suggested by the European Commission, urban ecosystem condition indicators, for 305 EU cities, suggests relative thresholds in Urban and Metropolitan spatial scales and explores their relation to ES and the Urban Heat Island effect. Furthermore, the intermediate zone is studied to assess its contribution to the overall GI and by extension the ecosystem services provided. The estimation of the indicators was mainly based on the processing of land use spatial data of 305 EU cities with population more than 100.000 inhabitants through the application of G.I.S. The assessment of the relative thresholds is based on the method of simple averaging of each estimated indicator values for territories in EU, defined on a case-by-case basis in relation to precipitation and temperature patterns through a cluster analysis. The estimated ecosystem condition indicators and respective thresholds have been visually and numerically juxtaposed to two (2) ecosystem service indicators and the Urban Heat Island effect to examine their relation. The study found a relation between the majority of the studied ecosystem condition indicators and the examined ecosystem services and the Urban Heat Island effect either at the one or at both the examined spatial levels. The study also found a significant differentiation between the examined indicators at urban and metropolitan scale while the intermediate zone that lies in between the two spatial levels presents a considerable contribution to the overall GI and by extension the provided ES, fact that is to be considered when implementing climate adaptation strategies. Another outcome of the study is the revealing of a significant differentiation of the indicator values between the northern and the southern EU countries and the provision of evidence about the imprint that the national urban planning policies may have an on the urban ecosystem condition indicators. The results of the current study are expected to work as an aiding tool of policies and planning purposes that seek to ensure urban resilience and climate adaptation.

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List of Abbreviations

EEA – European Environmental Agency

EC – Ecosystem Condition

ECI – Ecosystem Condition Indicator

EC-OECD – European Commission/ Europe Aid Co-operation Office

ES – Ecosystem Service

ESI – Ecosystem Service Indicator

EU – European Union

GI – Green Infrastructure

G.I.S. – Geographical Information Systems

GRUMP – Global Rural-Urban Mapping Project

LST – Land Surface Temperature

LUZ – Larger Urban Zone

MAES – Mapping and Assessment of Ecosystems and their Services

MODIS – Moderate Resolution Imaging Spectroradiometer

NO_2 – Nitrogen Dioxide

PEER – Partnership for European Environmental Research

ROS – Recreation Opportunities Spectrum

SEDAC – Socioeconomic Data and Applications Center

UHI – Urban Heat Island

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

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1. Introduction

According to the United Nations (2014), humanity is increasingly urbanizing and it is expected that by 2050, more than 60% of the world population will live in cities. This urbanization trend in combination with the scarcity of land within cities, creates pressure for an uncontrolled expansion outside the city cores, driven by price rather than environmental considerations (European Commission, 2011a). An expansion like that would inevitably transform the land use types of the cities' surrounding areas which might lead to a change in the structure and function of the Ecosystem Services (ES) provided (Zhang et al., 2015). These facts highlight the need for further investigation of the living conditions within the city cores and their surroundings which heavily depend on the condition of the respective urban ecosystems and their services. The interrelation of an urban ecosystem and the quality of the living conditions has been pointed out by Bolund et. al (1999), according to whom "the natural urban ecosystems may contribute to public health and increase the quality of-life of urban citizens".

Bai and Schandl (2010), define an urban ecosystem as "a hybrid of natural and man-made elements, whose interactions are affected not only by the natural environment, but also by human culture, personal behavior, politics, economics and social organization". In the case of the urban ecosystems the "natural" and "man-made" elements correspond to the urban Green Infrastructure (GI) and the Built Infrastructure respectively. According to the European Commission (2013a), GI can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of Ecosystem Services and protect biodiversity in both rural and urban settings. On the other hand, the Built Infrastructure is composed of mainly artificial elements such as buildings, roads and pavements, bridges as well as brown fields or dumping and construction sites.

The quality of the living conditions within an urban area depends on the quality of an urban ecosystem and its services i.e. the benefits to the human populations that derive from the ecosystem itself (Bolund et al.,1999). The ES according to "The Economics of ES and Biodiversity initiative" (TEEB, 2010) can be grouped in four major categories: provisioning, regulating, habitat, and cultural and amenity services. Each category consists of several benefits that are provided to the urban ecosystem: food, fresh water and wood are considered as provisioning services; climate regulation, water purification, pollination and erosion control are considered as regulating services; tourism, recreation, appreciation and spirituality are considered as cultural and amenity services; habitat for species and maintenance of the genetic diversity are considered as supporting and habitat services.

A significant factor that is related to urban Ecosystems' Condition (EC) and their services is climate change. Climate change is increasing the frequency and intensity of environmental extremes, and cities and their surroundings experience different degrees of warming (Maes et al., 2016). Projections of climate change show an increasing frequency of extreme weather and climate events (IPCC,2014) which coupled with the Urban Heat Island (UHI) are likely to amplify the challenges of an urban growth (Gunawardena et al., 2017). In the case of the urban environments, it is important to focus on the creative use of the GI as it is one of the most promising opportunities for climate adaptation and this fact needs to be recognized in the planning process (Gill et al., 2007).

The European Commission has acknowledged the need for mapping and assessment the urban ecosystems' condition and their services as matter of significance as it is estimated that almost three out of four EU citizens live in urban areas and this number will further grow (Maes et al., 2016). That is why the 4th Mapping and Assessment of Urban Ecosystems (MAES) report (Maes et al., 2016) of the European Commission, exclusively deals with the urban ecosystems and provides some guidelines for their mapping and assessment. These guidelines are more specified through a suggested indicator framework that is expected to be implemented at a local, metropolitan and regional level as a support of policies and planning purposes (Maes et al., 2016). The 4th MAES report suggests three types of indicators: pressure indicators, Ecosystem Condition Indicators (ECI) and indicators for measuring urban biodiversity. Concerning the ECI, the 4th MAES report proposes that "urban ecosystem condition could be assessed along the gradient from built infrastructure to green infrastructure". However, as mentioned in the same report, reference conditions, baselines or target situations are not defined for the suggested ECI. The report suggests that there are three approaches on defining a reference condition of an urban ecosystem: taking into account existing policy targets, taking into account new policy targets and ambitions or scientifically analyze indicators and their associated data to define empirically derived thresholds and reference levels. The latter approach is the one that the current study adopts as its basis. Furthermore, the 4th MAES report states that the relation between ES and EC needs more scientific underpinning.

The **objective** of the current study is the estimation of eight (8) ECI for 305 European cities, the assessment of relative thresholds for each ECI and the exploration of their relation to ES Indicators (ESI) and the UHI effect through the analysis of spatial data in two spatial levels: Larger Urban Zone (LUZ) and city core. Furthermore, the intermediate zone in between the LUZ and the city core is studied to detect the differences between these two areas concerning the ECI.

The main **aim** of the current study is to extort information relative to the current condition of the urban ecosystems in EU that might be used as an aiding tool of policies and planning purposes which seek to ensure urban resilience and climate adaptation.

The main **research questions** that the study will attempt to answer, could be deconstructed as follows: "What are the thresholds that might indicate a desired balance between the green and build infrastructure of a city, according to certain ECI that have been suggested by the 4th MAES report and to what extent are they related to ESI?", "What is the contribution of the city core and its surroundings to the overall GI?" and " Do the indicators' values present any spatial patterns towards the EU cities and where they may be attributed to?"

The ECI that will be studied are the following:

1. Proportion of urban green space (%)
2. Proportion of impervious surface (%)

3. Proportion of natural area (%)
4. Proportion of protected area (%)
5. Proportion of agricultural area (%)
6. Proportion of abandoned area (%)
7. Number of inhabitants per area (number/ ha)
8. Artificial area per inhabitant (m^2/person)

The ESI whose relation to the afore mentioned ECI will be studied are the following:

1. Removal of NO_2 by urban vegetation (Tons/ha*year)
2. Recreation Opportunity Spectrum (ROS) (ROS classes)
3. UHI (ºC)

The study will be developed in the context of the assessment of urban ecosystems as "it is important that the ES in urban areas and the ecosystems that provide them are understood and valued by city planners and political decision makers" (Bolund et al.,1999).

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2. Background

The eight (8) ECI that will be analyzed by the current study were suggested by the 4th MAES report (Maes et al., 2016) which involved an indicator framework for the EC that contains 26 indicators in total. The selection of the indicators by the 4th MAES report was based on the results of the survey and a literature survey reported in a report of the Joint Research Centre[1] (Rocha et al., 2015). The two basic procedures of this survey may be briefly described as follows:

- *Online survey*: it has been addressed to researchers and stakeholders and involved policy and mapping related questions. More specifically, the mapping questions were related to the condition of the natural state of urban ecosystems, to the specific features of urban GI, as well as to the ES that are delivered by the urban ecosystems (Rocha et al. 2015)
- *Literature review*: the desired information has been collected by published, strictly scientific articles that focus on urban ecosystems and their services. The data that finally derived from the literature review were relative to the urban GI (type of urban GI, indicators, units of measure), to the EC (urban ecosystem typology, indicators, output types) and to the ES (type of the ES, indicators, output types, units of measure, primary source) (Rocha et al. 2015).

The final selection of the indicators, as reported by the 4th MAES report (Maes et al., 2016), was based on the results of the above-mentioned surveys, on ten case studies of cities that documented what policies related to urban ecosystems and urban GI are in place and how maps of biodiversity, EC and ES are used as well as on an expert workshop where three key issues were discussed: policies related to urban GI; concepts and indicators related to the condition of urban ecosystem and their services. A similar procedure that led to the suggestion of 40 ESI was followed by the 4th MAES report (Maes et al., 2016).

Concerning the ES, the need to protect and enhance the benefits they provide to urban ecosystems has been flagged by Target 2 of the EU Biodiversity Strategy to 2020 (European Commission, 2015). Furthermore, the Millennium Ecosystem Assessment reports have provided scientific evidence about the degradation of several ES. More specifically, it has been noted that at the global scale, 15 out of 24 examined ES were being degraded and/or used unsustainably including fresh water, capture fisheries, air and water purification, and regulation of regional and local climate (Millennium Ecosystem Assessment, 2005). The inter-relation between the ES and the EC has been appointed by the Millennium Ecosystem Assessment program (2005), which has defined EC as "the capacity to provide ES" i.e. it is assumed that there is a positive relation between EC and ES. However, it should be noted that the 4th MAES report points out that the afore-mentioned positive relation between ES and EC still needs more scientific underpinning.

Concerning the UHI effect that the current study will discuss through a juxtaposition with the ECI thresholds, its relation to the urban land uses (and by extension to the urban EC) has

[1] The Joint Research Centre (JRC) is the European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy.

been a subject of several studies (e.g. Stone and Norman, 2007; Alobaydi et al., 2016). According to Stone and Norman (2007), "it is important that landuse planners have a more complete understanding of the role of land use policies in heat island formation".

The decision about the type of the correlation (positive or negative) that the ECI share with the ES is based on scientific literature that the current study consulted. Concerning the ECI which are relative to GI (e.g. proportion of urban green space), the correlation with the examined E is considered as positive, based on the results of the PEER report (Maes et al. 2012) which indicate that policy measures related to the enrichment of GI in urban areas are expected to enhance the provision of ES relative to climate regulation (e.g. UHI reduction), air purification (e.g. NO_2 removal by urban vegetation), recreation (e.g. ROS) and other. On the basis of the same report the "Proportion of abandoned area" and the "Proportion of protected area" ECI are regarded as positively correlated to the under-study ES as the first one may represent a potential of a city to obtain more GI and the second one is regarded as the core of European GI (European Union, 2013b). Conversely, the "Proportion of impervious surface" ECI's correlation with the ES is regarded as negative, especially when it comes to climate regulation, as impervious surfaces consisted of brick, concrete, asphalt stone and similar surfaces met in urban areas may intensify the UHI effect (Solecki et al.,2005). On the other hand, but for the same reasons, the "Artificial area per inhabitant" ECI is considered to share a positive correlation to the ES as it expresses the land use intensity and a high land use intensity refers to a small amount of artificial surface per inhabitant, being mainly the result of very compact settlement structures and high population density (Prokop et al., 2011).

Concerning the "Number of inhabitants per area" ECI, its correlation to the under-study ES is considered as negative as the according to Lamsal et al. (2013), the highest levels of NO_2 are found in heavily populated areas and concerning the UHI, a significantly positive correlation between the population and warming rate of average air temperature has been found by Huang and Lu (2015). As regards the ROS and the "Number of inhabitants per area" ECI, their correlation is considered as negative because the capability of the resource base to continue to provide for recreational use is generally viewed through the concept of "carrying capacity"(Papageorgiou and Brotherton, 1999) which is in the maximum number of people that can be sustainably supported by the recreation resource. Conclusively, when the population of a city grows, the quality of the offered recreational opportunities may present decrease if appropriate measures are not taken. Furthermore, a higher population density, in general, indicates a higher land development intensity (Liu et al.,2012) fact that may lead to a degradation of the GI that could be utilized for recreational purposes.

3. Input Data for Europe

The potentiality for the estimation of the ECI and their relative thresholds is provided by the existence of spatial datasets that involve data relative to land uses, population, environmentally protected areas, ES as well as climate data. In the current chapter are presented the data sources that are used to perform the analysis that will lead to the estimation of the ECI for each of the 305 EU cities with population larger than 100,000 inhabitants, to the assessment of relative thresholds and to the exploration of their relation to ES as well as the background of these data (*Table 1*).

Table 1: *Summary table, general characteristics of the datasets that have been utilized by the current study. The data exclusively derive from internet sources and are spatial data in raster or polygon form. The factors that have been taken into account in the data selection procedure, have been the temporal and spatial scale of the data as well as the reliability and credibility of the data providers.*

Content	Type	Format	units	Scale or Resolution	Publication date	Internet Source (last date accessed 15/09/2017)
Land use data for LUZ	Polygon	shapefile	m^2	1: 10,000	2014	http://www.eea.europa.eu/data-and-maps/data/urban-atlas
FUA, Kernels, cores boundaries	Polygon	shapefile	m^2	1: 100,000	2010	http://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/urban-audit
“Natura 2000”	Polygon	shapefile	m^2	1: 100,000	2015	http://www.eea.europa.eu/data-and-maps/data/natura-7#tab-gis-data
Population Density	Raster	grid.GeoTiff	habitants/km^2	100m. x 100m.	2009	https://www.eea.europa.eu/data-and-maps/data/population-density-disaggregated-with-corine-land-cover-2000-2
NO2 Removal	Raster	grid.GeoTiff	Tons/ha*year	100m. x 100m.	2010	http://esp-mapping.net/Home/
Recreation Opportunity Spectrum (ROS)	Raster	grid.GeoTiff	ROS classes (1-9)	100m. x 100m.	2010	http://esp-mapping.net/Home/
Global Urban Heat Island (UHI)	Polygon	shapefile	°C	-	2016	http://sedac.ciesin.columbia.edu/data/set/sdei-global-uhi-2013/data-download
Daily Precipitation sum (1995-2016)	Raster	grid	mm.	0.25 x 0.25 deg.	2017	http://www.ecad.eu/download/ensembles/downloadchunks.php
Daily mean Temperature (1995-2016)	Raster	grid	°C	0.25 x 0.25 deg.	2017	http://www.ecad.eu/download/ensembles/downloadchunks.php

3.1. Urban Audit

The dataset involves the boundaries of city cores, city Kernels and Functional Urban Areas (FUA) as defined by the EC-OECD (*Figure 1*). In general terms, the EC-OECD city definition is based on the presence of an "urban center" which is a spatial concept based on high-density population grid cells. The city Kernel is a concept introduced to improve comparability between large cities and the FUA consists of the city and its commuting zone. A commuting zone contains the surrounding travel-to-work areas of a city where at least 15 % of their employed residents are working within. Finally, the Urban Audit definition concerning the LUZ is based on commuter flows, thus approximating the FUA. Geometry was derived from Eurogeographics EuroBoundaryMap[2] (EBM) versions 6 and 6.2. The coverage is the EU-28 plus Iceland, Norway and Switzerland.

The "Urban Audit" dataset was used by the current study to identify city boundaries at the level of city cores and city kernels in order to estimate the ECI and ESI in the urban scale. Furthermore, the area of the cores and kernels was used for the estimation of the "Number of inhabitants per area" ECI.

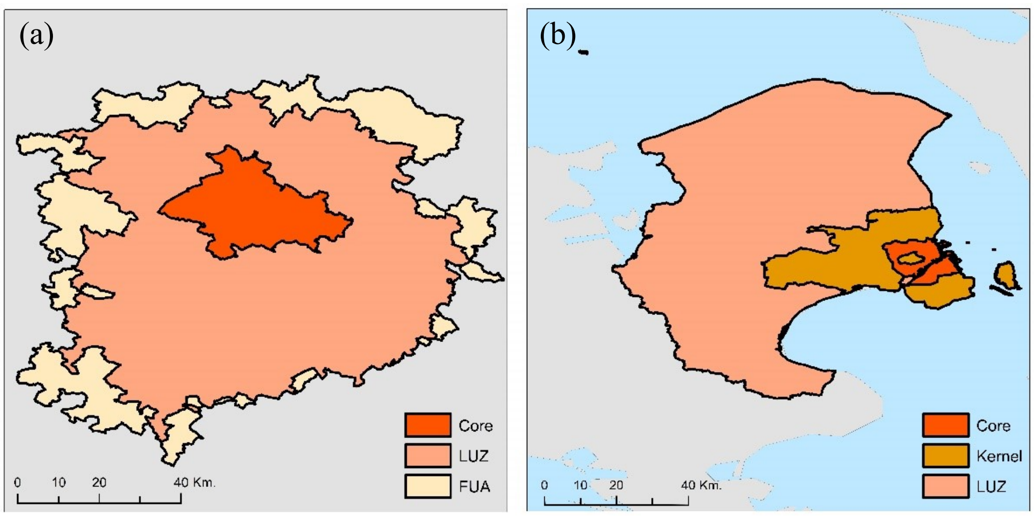

Figure 1 (a): *The Functional Urban Area (FUA) which corresponds to the city and its commuting zone, Larger Urban Zone (LUZ) which corresponds to administrative boundaries that approximate the functional urban region and core borders which correspond to the core area of the FUA for the city of Toulouse (France), overlaid by each other.* ***(b)*** *The LUZ, Kernel (an approximation of the built-up area around the core city) and core borders of the city of Copenhagen (Denmark) overlaid by each other. In the case of Copenhagen, the FUA and LUZ borders coincide.*

3.2. Urban Atlas

The primary data that the current study uses to estimate the ECI derive from the "Urban Atlas" data source of the Environmental Agency (EEA) and concern the land uses for LUZ with more than 100.000 inhabitants (305 cities) as defined by the Urban Audit (*Figure 2*).

[2] http://www.eurogeographics.org/products-and-services/euroboundarymap

According to the “Urban Atlas” Mapping Guide (European Comission,2011b) the product contains information that has mainly derived from data backed by other reference data, such as Commercial-off-the-Shelf (COTS) navigation data and topographic maps. As the current study utilizes the different Urban Atlas land use classes to estimate the ECI, it has been considered as purposeful to present them in detail (*Table 2*). The ECI which will directly derive from the “Urban Atlas” dataset are the following: Proportion of urban green space, Proportion of natural area, Proportion of impervious surface, Proportion of agricultural area.

The “Urban Atlas” dataset is a significant source of urban land use data. The dataset has been developed to fill a gap in the knowledge about the land uses of the European cities and to facilitate a policy-making that would be more evidence-based by enhancing the comparison of landuse patterns amongst major European cities. The “Urban Atlas” service offers high-resolution pan-European comparable land use and land cover data adapted to European needs.

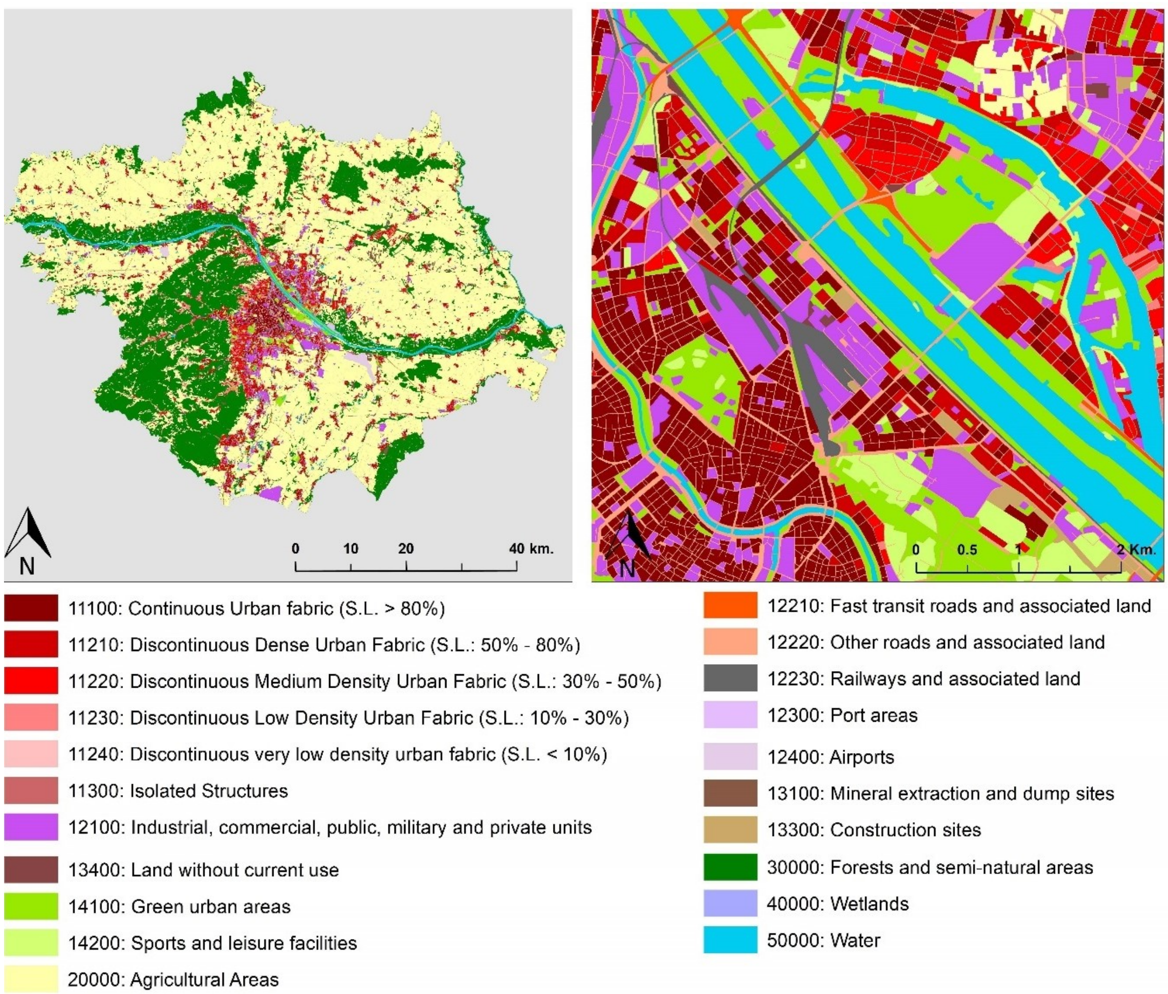

Figure 2: *The city of Wien (Austria) composed of the “Urban Atlas” dataset land uses within the outline of the Larger Urban Zone (LUZ) which corresponds to the administrative boundaries that approximate the functional urban region. The right picture presents a zoomed (20x) section of the city center.*

Table 2: *The codes and corresponding nomenclature that are used by the Urban Atlas dataset of the EEA and represent the different land use classes recorded within Larger Urban Zones (administrative boundaries that approximate the functional urban region). The land use areas will be the basis for the estimation of the ECI. (in bold: classes without any further subdivision)*

Urban Atlas No.	Vector Data Code	Nomenclature
1		Artificial surfaces
1.1		Urban Fabric
1.1.1	**11100**	**Continuous Urban Fabric (S.L. > 80%)**
1.1.2	11200	Discontinuous Urban Fabric (S.L. 10% - 80%)
1.1.2.1	**11210**	**Discontinuous Dense Urban Fabric (S.L. 50% - 80%)**
1.1.2.2	**11220**	**Discontinuous Medium Density Urban Fabric (S.L. 30% - 50%)**
1.1.2.3	**11230**	**Discontinuous Low Density Urban Fabric (S.L. 10% - 30%)**
1.1.2.4	**11240**	**Discontinuous Very Low Density Urban Fabric (S.L. < 10%)**
1.1.3	11300	Isolated structures
1.2		Industrial, commercial, public, military, private and transport units
1.2.1	**12100**	**Industrial, commercial, public, military and private units**
1.2.2	12200	Road and rail network and associated land
1.2.2.1	**12210**	**Fast transit roads and associated land**
1.2.2.2	**12220**	**Other roads and associated land**
1.2.2.3	**12230**	**Railways and associated land**
1.2.3	**12300**	**Port areas**
1.2.4	**12400**	**Airports**
1.3		Mine, dump and construction sites
1.3.1	**13100**	**Mineral extraction and dump sites**
1.3.3	**13300**	**Construction sites**
1.3.4	**13400**	**Land without current use**
1.4		Artificial non-agricultural vegetated areas
1.4.1	**14100**	**Green urban areas**
1.4.2	**14200**	**Sports and leisure facilities**
2	**20000**	**Agricultural areas, semi-natural areas and wetlands**
3	**30000**	**Forests**
5	**50000**	**Water**

3.3. Natura 2000

The utilization of the “Natura 2000” dataset by the current study, serves the purpose of the estimation of the “Proportion of protected areas” ECI. This ECI is related to several ES as protected areas such as Natura 2000 sites and ecosystems inside and around cities may lead to several tangible benefits such as air quality improvement, noise reduction, mitigation of extreme summer temperatures as well as to non-material benefits such as recreation, education, cultural and aesthetic values and maintenance of social relations (Maes et al., 2016).

Natura 2000 is composed of sites designated under the Birds Directive (Special Protection Areas, SPAs) and the Habitats Directive (Sites of Community Importance, SCIs, and Special Areas of Conservation, SACs). More specifically, the ecological network is based on the 1979 Birds Directive and the 1992 Habitats Directive. Altogether, the sites cover a substantial area – equivalent in size to Germany, Poland and the Czech Republic combined

(European Commission, 2012). The version that was used by the current study covers the reporting in 2015. The data that compose the ecological network derive from national authorities and are filtered by a quality control process that has been developed by the European Topic Centre for Biological Diversity (ETC/BD) which identifies potential inconsistencies in the national reports.

3.4. Population density disaggregated with Corine land cover 2000

The dasymetric[3] population density grid of the EU at a 100m. resolution was used by the current study to estimate the population within the borders of LUZ and city cores in order to estimate the values of two ECI: “Artificial area per inhabitant” and “Number of inhabitants per area”. The dataset is provided by the EEA and is a result of the application of a disaggregation method which is a modified version of the “limiting variable method” (Eicher and Brewer, 2001). The main ancillary information source was “CORINE[4] Land Cover 2000” inventory. It should be mentioned that compared with the traditional choropleth maps that represent a homogeneous density in each commune, the accuracy improvement of the disaggregated maps ranged between 46% and 67% (F.J. Gallego et al., 2011).

3.5. Removal of NO_2 by urban vegetation

The “Removal of NO2 by urban vegetation” regulating ESI dataset was used by this study to discuss the suggested ECI thresholds at the LUZ and city core spatial levels. The grid that represents the ES of the NO_2 removal by urban vegetation is based on the calculation of three different indicators: average concentrations of NO_2, deposition velocity, and removal capacity (Maes et al., 2015). These indicators have been evaluated at European scale by using simple GIS map algebra operations. According to Maes et al. (2015), concentrations of NO_2 were calculated using Land Use Regression (LUR) models. LUR models are used to evaluate the relationship between observed air pollution concentrations and predictor variables (e.g. traffic, land use). The parameters that have been inserted to the LUR models were calculated and evaluated at 100m. resolution. The air pollution deposition velocity indicator has been calculated according to an approach proposed by Pistocchi (2010) where deposition velocity depends on the wind speed at 10m and the land cover type, either forest or bare soil or water. Annual removal capacity was estimated as the total pollution removal flux[5] in the areas covered by vegetation. From the results that have been obtained by the described processes, total pollution removal flux was calculated for NO_2.

The estimation of the “Removal of NO_2 by urban vegetation” ESI was facilitated by a

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[3]A dasymetric map depicts quantitative areal data using boundaries that divide the mapped area into zones of relative homogeneity with the purpose of best portraying the underlying statistical surface (Eicher and Brewer, 2001) .

[4] In 1985 the Corine (Coordination of Information on the Environment) programme was initiated in the European Union. Corine means 'coordination of information on the environment' and it was a prototype project working on many different environmental issues. The CORINE land cover inventory is composed of 44 classes, and presented as a cartographic product, at a scale of 1:100 000.

[5] Removal flux = (deposition velocity) x (pollutant concertation)

model called ESTIMAP (Ecosystem Mapping Tool) that was developed by the Joint Research Centre to estimate trends in regulating and maintenance ES. ESTIMAP is a collection of spatially explicit models to support the mapping and modelling of ES at European scale whose main objective is to support EU policies with spatial information on where ES are provided (Maes et al., 2015).

3.6. Recreation Opportunities Spectrum (ROS)

The ROS cultural ESI data are utilized by the current study for the discussion of the suggested ECI thresholds. The recreation opportunity Spectrum is a method to map different degrees of recreation services available according to their proximity to the people (Zulian et al.,2013). In order to assess how the benefit of recreation can be delivered to people, the EU has been classified into zones of remoteness versus proximity to areas of recreational interest. The inputs to this classification have been the distances from roads and residential areas whose data have derived from the TeleAtlas[6] Database and CORINE land cover classes respectively.

Another parameter that was studied is the RPI (Recreation Potential Index). Recreation potential is mapped through components that have a specific link with people's behavior and have divided in three components: the first relates to the degree of naturalness identified as a proxy for people's preference for more natural areas; the second concerns protected areas as public recreation areas and the third, water attractiveness (Paracchini et al.,2014).

Finally, according to the above-mentioned report, in order to tune the remoteness and proximity concepts to the experience of the EU citizens, a panel of ten European experts of different nationalities have been asked to define thresholds for distances from roads and urban, and assign each combination a label among the following five: neighborhood, proximity, far, remote, very remote.

The final ROS has been computed by a cross tabulation between the RPI and the zoning for the EU in terms of remoteness and accessibility (*Table 3*).

[6] Tele Atlas is a Netherlands-based company founded in 1984 which delivers digital maps and other dynamic content for navigation and location-based services

1	Low provision- easily accesible
2	Low provision- accesible
3	Low provision- not easily accessible
4	Medium provision- easily accesible
5	Medium provision- accesible
6	Medium provision- not easily accesible
7	High provision- easily accessible
8	High provision- accesible
9	High provision- not easily accesible

			Remotenes/Accessibility				
			1	2	3	4	5
			Neighborhood	Proximity	Far	Remote	Very Remote
Recreation Potential	1	<0.19	1	1	2	3	3
	2	0.19-0.25	4	4	5	6	6
	3	>0.25	7	7	8	9	9

Table 3:*The Recreation Opportunity Spectrum (ROS) classes, that have been used to map different degrees of recreation services available according to their proximity to the people. (legend on the left)*

Source: (Paracchini et al.,2014 modified after Kourdounouli, 2017)

3.7. Global Urban Heat Island (UHI) Data Set

The UHI dataset was utilized by this study to discuss the suggested ECI thresholds. Although, it is not considered as an ES itself, it is closely related to "climate regulation" ES as a low UHI might indicate high values of the said service.

The primal purpose of the dataset is to provide summer daytime and nighttime minimum and maximum surface temperatures (LST) for urban extents and their surroundings as well as the LST difference between them which represents the UHI effect. According to the documentation for the UHI Data Set (CIESIN ,2013), the basic approach was to use LP DAAC's MODIS data on land surface temperature in conjunction with the SEDAC's (Socioeconomic Data &Applications Center) Global Rural-Urban Mapping Project (GRUMP) urban extents data (CIESIN et al., 2011) to estimate the average daytime maximum and average nighttime minimum land surface temperatures within the urban extents during the highest temperature period of the northern and southern hemisphere summers. The same average was calculated for a 10 indexkm. buffer surrounding the urban extents. Nighttime was included in addition to daytime because the health impacts of the urban heat island effect are often most pronounced at night.

The dataset refers to the "urban extents" grid that distinguishes urban and rural areas based on a combination of population counts, settlement points, and the presence of Nighttime Lights.

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3.8. E-OBS gridded dataset

The "E-OBS gridded dataset" is a daily gridded observational dataset for precipitation, temperature and sea level pressure in Europe. The sub-datasets of precipitation and temperature of the "E-OBS gridded dataset" are used by the current study to perform a cluster analysis which will define the territories for which, different ECI thresholds will be suggested.

The “E-OBS gridded dataset” which derives from the ENSEMBLES project, supported by the European Commission's 6th Framework Programme. According to the ENSEMBLES official website (ENSEMBLESFP6_index, 2018), one of the main aims of the project is to develop an ensemble prediction system for climate change based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe, validated against quality controlled, high resolution gridded datasets for Europe.

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4. Methodology

The general concept of the methodology that was followed is imprinted at the flowchart of *Figure 3.* For ease of reference, the Methodology will be destructured and described in five parts: definition of the Study Area, Data Collection and Preprocessing, Estimation of the ECI, Quality Control of the Resulted ECI Values, Selection and Application of the Threshold Assessing Method and Exploration of the relation of the Suggested ECI Thresholds to ES. Appropriate software has been used to conduct the analysis and illustrate the results (*Table 4*).

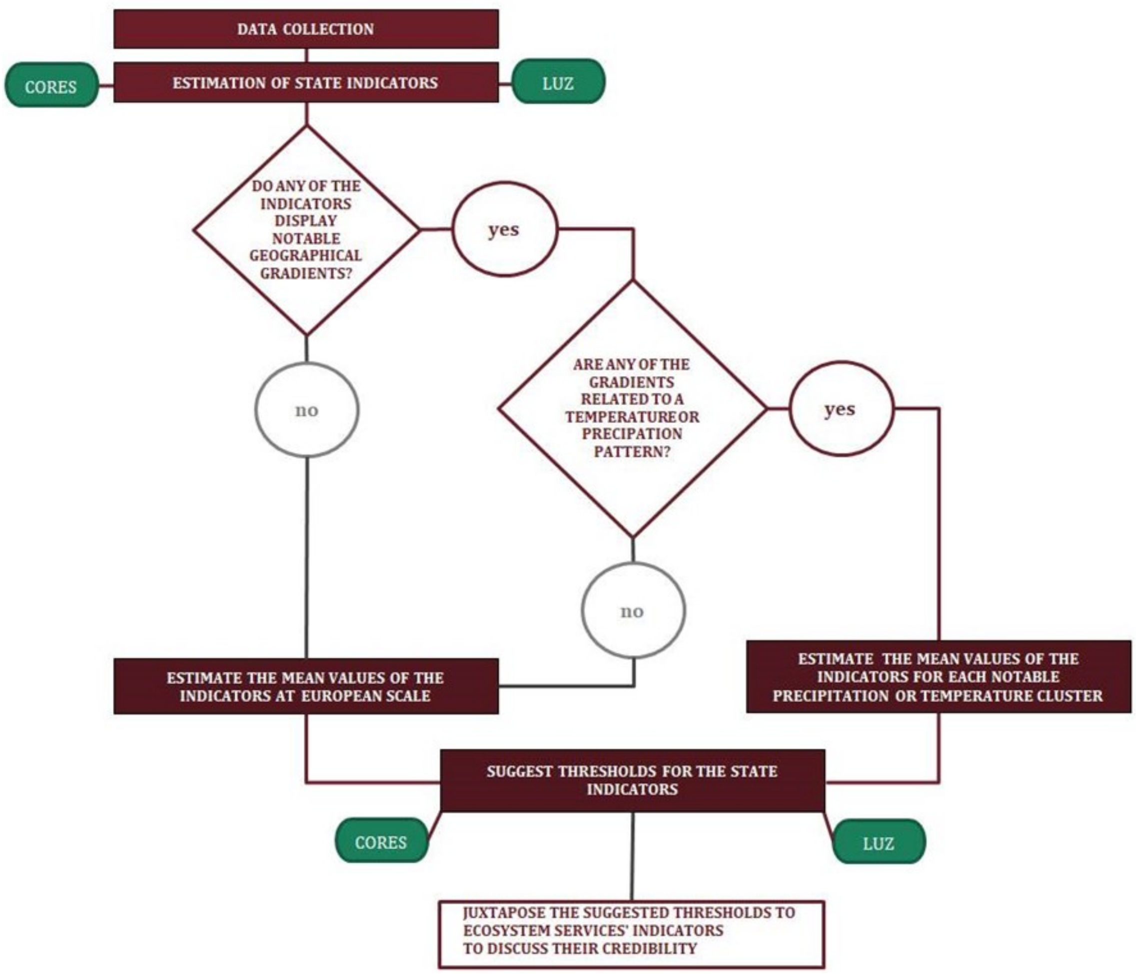


Figure 3: *Flowchart of the basic lines of the methodology that has been followed. The investigation of the existence of notable indicator geographical gradients and their potential relation to a temperature or precipitation pattern defines the territories for which different indicator thresholds will be suggested.*

Table 4: *The software that has been utilized by the current study to perform the analysis of the ESI and ECI and to illustrate the results.*

Software	***Version***	***Manufacturer***	***City Head Quarters***	***Country***
ArcMap	10.3.1	ESRI	Redlands, California	United States
Excel	2016	Microsoft	Redmond, Washington	United States
Paint.Net	4.0.21	dotPDN, LLC	-	-

4.1. The Study Area

The broader study area geographically corresponds to the territories of 27 countries that are members of the European Union (EU) -Croatia excluded. The 4th MAES report suggests that the ECI are estimated in three spatial scales: Urban, Metropolitan and Regional. The current study will attempt to estimate the ECI and suggest the respective thresholds in Urban and Metropolitan scale.

Concerning the Metropolitan scale, although the said report suggests that it corresponds to the Functional Urban Areas (FUA), the current study accepts that it will refer to the Larger Urban Zones (LUZ) as defined by the Urban Audit. This is because the relative urban land use data were not yet generalized for the areas within the FUA borders for all the European cities during the prepatation of the current study. However, it should be noted that FUA and LUZ borders do not deviate much in terms of magnitude as "the Urban Audit works with administrative boundaries that approximate the functional urban region" (Bretagnolle et al., 2011).

Concerning the urban scale, the 4th MAES report suggests that it "focuses on the core area of the Functional Urban Area (FUA), the city" and the current study will adapt to this direction. The boundaries of the core cities delineate the corresponding political boundaries, fact that ensures that data will be straightforwardly usable by the policy makers. However, for capitals that are very under-bounded (e.g. Paris, Lisbon), an additional spatial level has been introduced: the "kernel". The kernel is an approximation of the built-up area around the core city (Eurostat, 2009). The kernels provide a more uniform perception of the large cities in terms of area as the corresponding core city makes up less than 20 % of the area of the LUZ. As regards the logic behind the kernel delineation, an exception has been made for London, where the kernel was defined to match the core city of Paris in terms of population, in order to facilitate the comparison between the two largest European cities. It should be mentioned that London and Paris are considered as the largest European cities by the UN (2014), based on the concept of urban agglomeration which takes into account along with the core city, all the suburbs that are linked to the city by continuous urban areas.

The current study will also analyze the intermediate zone that is located at the area in between the LUZ and the city core (or Kernel outlines). The total number of the LUZ and corresponding city cores that will be processed is 305.

4.2. Data Collection, Preprocessing and Grouping

Data collection through reliable internet sources (*Table 1,p.5*) was the first process to be transacted. The downloaded data were of several formats and coordinate systems and in many cases, they had to be re-projected to be simultaneously processed by the same software (ArcMap 10.3.1). The main Geographic Coordinate System (GCS) that was used during the data analysis was ETRS 1989, and the projection was Lambert Azimuthal Equal Area. In many cases, the data had to be decompressed or converted in a form that is readable by the used software. For example, some datasets were compressed and packed in ZIP or TAR (Tape ARchive) file formats and some in NetCDF (Network Common Data Form) file format. Finally, the data have been grouped into folders according to the procedure they participate in *(Figure 4)*.

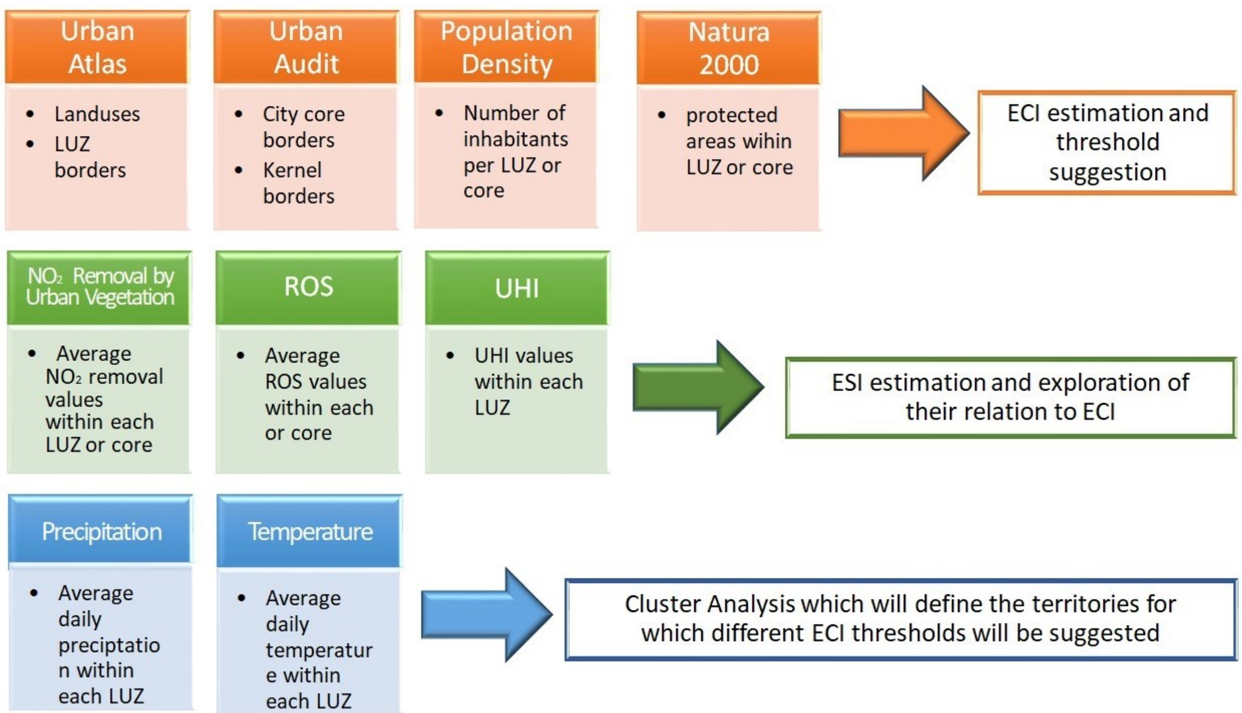


Figure 4: *The elements of the available datasets that have been used by the current study to generalize the data for each individual procedure of the analysis.*

4.3. Estimation of the ECI

The ECI for the two spatial levels, LUZ and city core were estimated using the same methodology. Initially, the six ECI that derive from the "Urban Atlas" dataset were estimated. The first step to the estimation was to decide which of the "Urban Atlas" land uses will participate to the estimation of which ECI (*Table 5*). It should be mentioned that all the LUZ and cores have been studied one by one individually.

The classification (*Table 6),* was transformed into simple SQL[7] expressions that were queried to acquire results in area units for each LUZ and core. In ArcMap terms, the *Select by Attributes* tool was applied to each LUZ and city core's *attribute table* by using SQL expressions (*Table 4*) and a simple Vb script[8].

Concerning the "Proportion of impervious surface" ECI, it was considered as purposeful to multiply the respective areas of each of its Urban Fabric related components with factors that correspond to the mid-range[9] of the percentages of soil sealing that characterizes them. For example, the Urban Atlas class "Discontinuous Medium Density Urban Fabric (S.L. 30% - 50%)" has a degree of soil sealing between 30% and 50% and its corresponding area was multiplied by 0.40 which is calculated as follows: (0.50+0.30)/2. The multiplication factors of each component of the "Proportion of impervious surface" ECI can be found in the following Vb script which was applied after the SQL queries of *Table 6*:

```
dim x
if ([CODE] = "11100") then
x = ([area] * 0.90)
elseif ([CODE] = "11210") then
x = ([area] * 0.65)
elseif ([CODE] = "11220") then
x = ([area] * 0.40)
elseif ([CODE] = "11230") then
x = ([area] * 0.20)
elseif ([CODE] = "11240") then
x = ([area] * 0.05)
else
x= ([area] * 1)
End If
```

After the SQL queries and Vb script were applied, the sum of the corresponding polygon areas of each ECI were copied into the respective LUZ or core and indicator cell in a spreadsheet. The process was repeated for all the ECI that are found in *Table 5* and the results were two tables (one for LUZ and one for city cores) of 305 lines which correspond to each LUZ or core and six columns which correspond to the area that each ECI "occupies".

The next step was to estimate the population for each LUZ and city core based on the acquired population grid (*Table 1*). The population is essential to estimate two ECI: "Number of inhabitants per area" and "Artificial area per inhabitant". The first step after inserting the population grid in ArcMap was to apply the *zonal statistics by table* tool in order to estimate the total population within each LUZ and core. The results have been inserted into the same spreadsheet mentioned in the previous paragraph.

The estimation of the "Proportion of protected area" ECI was based on the Natura 2000 dataset (*Table 1*). Initially, the Natura polygons were *clipped* to the boundaries of the LUZ and the cores and then the *intersect* tool was performed between the clipped boundaries and

[7] Structured Query Language (SQL) is a standard computer language for accessing and managing databases

[8] VBScript ("Microsoft Visual Basic Scripting Edition") is an Active Scripting language developed by Microsoft that is modeled on Visual Basic

[9] the mid-range is the arithmetic mean of the maximum and minimum values

the LUZ and cores outlines respectively. Finally, the *summary statistics* tool was applied to the outcome of the intersection and the total area of protected areas for each LUZ and core was inserted to the same spreadsheet mentioned in the previous paragraphs.

The next process was the final estimation of the iECI through calculations that were performed in a spreadsheet. Considering that areas that correspond to each indicator are now estimated, the final step to their estimation was to perform the appropriate mathematical operations to reach the desired results (*Table 7*). Finally, the eight estimated indicators for each LUZ and corresponding city core (or kernel) were converted to shapefiles in order to be further processed in the G.I.S. software.

Table 5: *The land uses that participate to the estimations of the six ECI that derive from the "Urban Atlas" dataset and the corresponding vector data codes as defined by the same dataset.*

indicator	***vector data codes***	***nomenclature***
Proportion of urban green space (%)	14100,14200	Green Urban Areas, Sports and leisure facilities
Proportion of impervious surface (%)	All codes except from 14100,14200,20000,30000,50000,13400	All nomenclatures except from Green Urban Areas, Sports and leisure facilities, Agricultural areas & semi-natural areas & wetlands Forests, Water, land without current use
Proportion of natural area (%)	30000, 50000	Forests, Water
Proportion of agricultural area (%)	20000	Agricultural areas & semi-natural areas & wetlands
Proportion of abandoned area (%)	13400	Land without current use
Artificial area per inhabitant (m^2/ person)	All codes except from 20000,30000,50000	All nomenclatures except from agricultural areas & semi natural areas & wetlands, forests and water

Table 6: *The SQL queries that have been performed by the "Select by Attributes" tool of the ArcMap 10.3.1 software to estimate the corresponding areas of the ECI that derive from the Urban Atlas Dataset.*

ECI	***SQL query /SELECT*FROM***
Proportion of urban green space (%)	"CODE" = '14100' OR "CODE" = '14200'
Proportion of impervious surface (%)	"CODE" IN (‘11100' ,'11210' ,'11220', '11230', '11240', '11300', '12100', '12210', '12220', '12230', '12300', '12400', '13100', '13300', '13400', '14100', '14200')
Proportion of natural area (%)	"CODE" = '30000' OR "CODE" = '50000'
Proportion of agricultural area (%)	"CODE" = '20000'
Proportion of abandoned area (%)	"CODE" = '13400'
Artificial area per inhabitant (m^2/ person)	"CODE" IN (‘11100' ,'11210' ,'11220', '11230', '11240', '11300', '12100', '12210', '12220', '12230', '12300', '12400', '13100', '13300', '13400', '14100', '14200')

Table 7: *The calculations that have been performed in MS excel to estimate the final values of the ECI. (the respective calculations have also been performed for the city cores)*

ECI	*calculation*
Proportion of urban green space (%)	URBAN GREEN SPACE AREA WITHIN LUZ/LUZ AREA*100
Proportion of impervious surface (%)	IMPERVIOUS SURFACE AREA/ LUZ AREA *100
Proportion of natural area (%)	NATURAL AREA WITHIN LUZ/ LUZ AREA*100
Proportion of protected area (%)	PROTECTED AREA WITHIN LUZ/ LUZ AREA*100
Proportion of agricultural area (%)	AGRICULTURAL AREA WITHIN LUZ/ LUZ AREA*100
Proportion of abandoned area (%)	ABANDONED AREA WITHIN LUZ/ LUZ AREA *100
Number of inhabitants per area (number/ ha)	NUMBER OF INHABITANTS WHITHIN LUZ/ LUZ AREA
Artificial area per inhabitant (m2/person)	ARTIFICIAL AREA WITHIN LUZ / NUMBER OF IHABITANTS WITHIN LUZ

4.4. Cross-checking of the Resulted ECI Values

To ensure the validity of the results several checks were performed. The results were examined for duplicate and negative values as well as for formula related errors. The proportional ECI were also examined for values that overcome the 100%.

Another check that was performed, concerns the summary of the 5 ECI whose values strictly derive from the “Urban Atlas” dataset (proportion of urban green space, proportion of natural area, proportion of agricultural area, proportion of impervious surface, proportion of abandoned area) for each LUZ or city core. Since these five ECI cover all of the “Urban Atlas” nomenclatures and none of them is repeated for the estimation of more than one ECI it was expected that their sum should approach the 100%. The check was expected to approach the 100% and not to result to exactly 100%, as the impervious areas which participated to the estimation of “Proportion of impervious surface” ECI have been multiplied by certain factors as previously mentioned. The values that the checks have dug up, were re-checked and finally, corrected when needed. The majority of the errors were due to repetitions of values that occurred during the data transfer from the G.I.S. software to the spreadsheet.

4.5. Selection and Application of the ECI Threshold Assessing Method

According to Mitchell et al. (1995), threshold values may identify problematic, critical and irreversible or uncontrollable levels of an indicator and should be identified and explained especially for indicators of sustainability as “they set limits, so that the indicators relate to development, and not simply growth”. The threshold assessing method that will be utilized is the estimation of the average values of the ECI in a European-wide scale or in a scale that will be defined by a cluster analysis of the estimated ECI as well as of temperature and precipitation data (*Table 1*). The main concept behind the selection of the threshold assessing method is the following: *if* the ECI present visible geographical gradients that are related to a respective precipitation or temperature pattern *then* the precipitation or temperature pattern will define the territories for which, different thresholds will be suggested *else* the average European-wide ECI values will be suggested as thresholds.

The *zonal statistics* tool was utilized to estimate the mean precipitation and temperature values for each LUZ. The process is presented only for the LUZ and not for the city cores (or kernels) as the gridded observed climate data would not allow for a discrimination between the temperature and precipitation in the LUZ and city cores.

To verify the existence or not of significant geographical gradients that the estimated ECI may present towards the under study European cities, apart from the visual examination of the data, the spatial autocorrelation of each ECI was studied. That is because a high spatial autocorrelation might indicate the presence of the clusters that form the possible geographical gradients. According to Griffith (2009), "spatial autocorrelation means a dependency exists between values of a variable in neighboring or proximal locations, or a systematic pattern in values of a variable across the locations on a map due to underlying common factors". In this case, the common factors whose relationship with the ECI is under examination, are precipitation and temperature. The ArcMap tool that was utilized to estimate the autocorrelation of the estimated ECI as well as the autocorrelation of precipitation and temperature is the *Spatial Autocorrelation (Global Moran's I)* tool (ESRI, n.d.). According to the official ESRI website[10], this tool measures spatial autocorrelation (feature similarity) based on both feature locations and feature values simultaneously. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random. The tool calculates the Moran's I Index value and both a Z score and p-value evaluating the significance of that index. In general, a Moran's Index value near +1.0 indicates clustering while an index value near -1.0 indicates dispersion. The results of the *Spatial Autocorrelation (Global Moran's I)* tool will indicate which ECI correspond to the most notable spatial autocorrelations.

The relationship between the ECI that are qualified as most spatially autocorrelated and the precipitation and temperature will be visually explored through a cluster analysis. The core concept of cluster analysis may be stated as follows: "given a set of data points, partition them into a set of groups which are as similar as possible" (Aggarwal, 2014). The logic behind the *Cluster and Outlier Analysis tool does* not deviate much from the *Spatial Autocorrelation (Global Moran's I)* tool that has already been performed, but it also facilitates a visual juxtaposition of the gradients as it produces illustrated results.

4.6. Exploration of the relation of the Suggested ECI Thresholds to ES

The reliability of the suggested ECI thresholds is discussed through a juxtaposition of the with the respective ESI for each LUZ and city core. As the current study accepts that the ES and the ecosystem condition are related to each other, the results of the examination of their relation may give credence to the suggested thresholds. More specifically, the ECI will be compared to one regulating (NO_2 removal) ES, one cultural (ROS) ES and to the UHI effect which is linked to climate regulating ES.

[10] http://resources.esri.com

The main question that is to be answered here could be formulated as follows: *Do the majority of the LUZ or city cores whose ECI values surpass the suggested thresholds (in a positive way) also surpass the average values of the respective ESI?* A positive answer is considered to give credence o the suggested ECI threshold. It should be clarified that an ECI surpasses the suggested threshold in a positive way when it presents a positive correlation to the ES provided i.e. it acts supportively to them and that it has been accepted that that "majority" of the LUZ or cores corresponds to percentages greater than the 50%. The reason why the exploration of the relation between the EC and the ES has been decided to be based on the threshold values and formed classes and not, for example, on the estimation of the correlation across the entire range of values, has to do with the aim of the study which looks forward to enhancing decision making towards planning procedures. A categorization like that may facilitate an urban planner to immediately form an opinion about whether or not the LUZ or core is amongst the ones with the "best" or "worst" EC and ES performances and to be acknowledged with the extent of the credibility of the threshold concerned to obtain a broader perception of the city's planning needs.

The UHI effect was estimated through the application of the ArcMap's *Identity* tool within each LUZ. The features of the UHI effect dataset have been used as identity coverage to obtain only their attributes that overlap the LUZ. The NO_2 removal and ROS ESI were estimated through the utilization of the *Zonal Statistics tool* by calculating the mean values within each LUZ and core. The *Select by Attributes* tool was applied to select the LUZ and city cores which surpass the suggested threshold values. The same tool was applied to the ESI to select the LUZ and city cores whose values are above the average (and below the average for the UHI effect). The results of the *Select by Attributes* tool have been exported into shapefiles. Finally, the *Select by Location* tool was applied to select the LUZ and city cores that present values which surpass both the suggested ECI thresholds (in a positive way) and the average ESI values.

Finally, it should be mentioned that although the "proportion of agricultural area" ECI corresponds to three suggested thresholds in accordance with the temperature cluster that the respective LUZ or core belongs to, it has been decided that this categorization is of minor importance for the current evaluation and that is why the European-wide mean values of the ECI have been used.

The results of the analysis are presented in two spatial levels: the LUZ and the City Core (or Kernel) which will be juxtaposed to each other. However, the ECI are also estimated for an extra spatial level that is the area in between the LUZ and cores outlines. The reason why it has been decided to perform the analysis of the intermediate zone is to highlight each ECI's differences between the core and its surroundings and furthermore to offer the possibility of a further analysis of the data that might concern the extent to which the environmental conditions of the surroundings may affect the cores and vice versa. Additionally, an analysis like that might reveal the value of the intermediate zone concerning the ES provided.

The results are presented in the form of maps, graphs and tables. Concerning the maps, the method that was used for the classification of the ECI and ESI values is the "natural break method", modified to incorporate the mean EU wide value of each indicator as the lower limit of the class that corresponds to "medium" values". This modification was carried out to clearly visualize which LUZ or cores surpass the thresholds i.e. the LUZ or cores that appear in the maps to correspond to "medium", "high" and "very high" classes surpass the suggested thresholds. According the ArcMap 10.3.1 user guide, "Natural breaks classes are based on natural groupings inherent in the data. Class breaks are identified that best group similar values and that maximize the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big differences in the data values." It should be mentioned that in most cases the mean values of the indicators did not deviate much by the lower limit of the classes that corresponded to "medium values" with the natural break method.

All the individual indicator values can be found at the Appendices A, B and C at the end of the paper that correspond to the LUZ, city core (or Kernel) and area in between the core and the LUZ outlines spatial scales respectively. It should be noted that for the latter spatial scale the number of the relative areas is 282 and not 305 because there are cases where the LUZ and the city core coincide.

5. Results

5.1. Estimated ECI

The **"Proportion of urban green space"** ECI significantly deviates for the LUZ and cores in terms of magnitude (*Figure 5*). More specifically, the highest and lowest values for the cores are almost double than the ones for the LUZ (*Table 6*). However, the spatial distribution of the classes appears to be quite similar for the two spatial levels: the majority of the LUZ and cores which present the highest indicator values are met within the borders of four countries: United Kingdom, Germany, Netherlands and Belgium. As regards the core spatial level (*Figure 5b*), Poland also presents medium to high values. Aggregates of very low percentages for both spatial levels are observed within the borders of Sweden, Hungary, Greece, Serbia, and Spain while the Baltic countries present relatively low percentages at LUZ level and relatively high at core level. The LUZ of Liverpool (United Kingdom) presents the highest percentage (13.19%) and the LUZ of Potenza (Italy) presents the lowest one (0.09%) while at core level the highest percentage corresponds to Karlovy Vary of the Czech Republic (25.94%) and the lowest one to Kalamata (Greece) and is 0.25% (*Table 10*).

Table 8: *The cities and the respective countries that correspond to the highest and lowest values of the "Proportion of urban green space" ECI for the LUZ and city core (or Kernel) spatial levels*

Proportion of urban green space					
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Liverpool	United Kingdom	13.19
		2	Manchester	United Kingdom	10.47
		3	s' Gravenhage	Netherlands	10.25
		4	Portsmouth	United Kingdom	9.61
		5	Waterford	Ireland	7.97
	CORE	**1**	Karlovy Vary	Czech Republic	25.94
		2	Hannover	Germany	20.65
		3	London	United Kingdom	16.66
		4	Kaunas	Lithuania	16.04
		5	s' Gravenhage	Netherlands	15.75
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Potenza	Italy	0.09
		2	Campobasso	Italy	0.13
		3	Toledo	Spain	0.13
		4	l'Aquila	Italy	0.13
		5	Umeå	Sweden	0.13
	CORE	**1**	Kalamata	Greece	0.25
		2	Badajoz	Spain	0.26
		3	l'Aquila	Italy	0.28
		4	Sassari	Italy	0.29
		5	Foggia	Italy	0.29

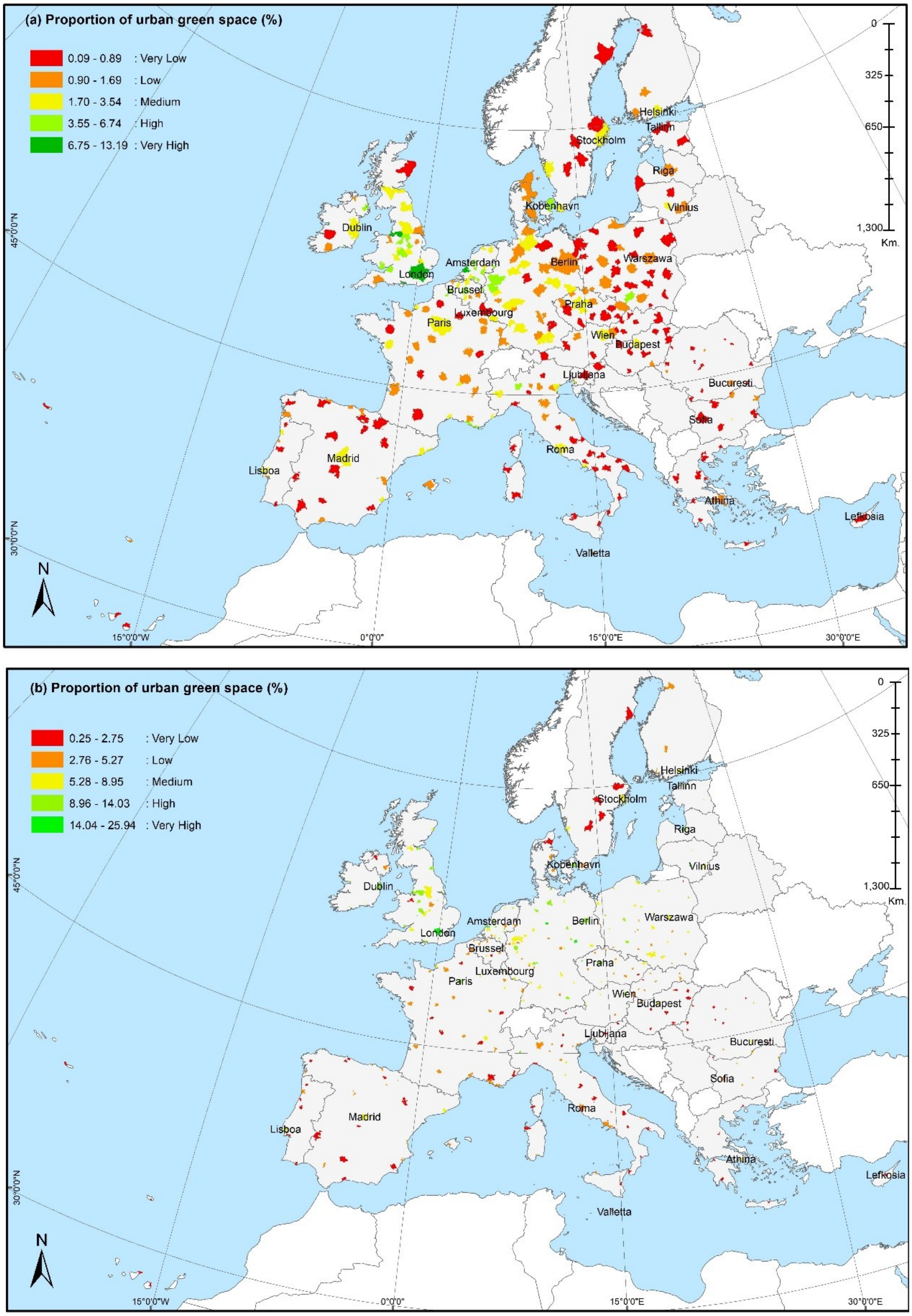


***Figure 5 (a)** LUZ spatial level **(b)** city core spatial level**:** the "Proportion of urban green space" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **"Proportion of natural area"** ECI (*Figure 6*), presents from medium to very high values at north-east Europe and especially at Sweden and Finland which present almost exclusively very high values at both the spatial levels of LUZ and core. The spatial distribution of the different classes along Europe looks similar for the two spatial levels at first glance, however for certain countries there is a significant differentiation concerning the classes their LUZ and cores belong to. Examples are Poland and the Baltic Countries. Significant aggregates of exclusively low to very low indicator values are observed for the LUZ and cores of the United Kingdom and Ireland. Italy, Spain and Greece mostly present from medium to very low values for both spatial levels.

As regards the magnitude of the indicator for the two levels, there is a slight precedence of the LUZ. The city of Umeå (Sweden) presents the highest indicator values for both spatial levels (

Table 9), while Lefkosia (Cyprus) and Bari (Italy) present the lowest percentages for the LUZ (0.46%) and core (0.11%) spatial level respectively. It is noticeable that the highest indicator values are observed at Sweden and Finland while the lowest ones at countries of the southern Europe.

Table 9: *The cities and the respective countries that correspond to the highest and lowest values of the "Proportion of natural area" ECI for the LUZ and city core spatial levels.*

			Proportion of natural area		
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Umeå	Sweden	85.65
		2	Jönköping	Sweden	76.67
		3	Tampere	Finland	74.79
		4	Uppsala	Sweden	71.39
		5	Oulu	Finland	68.90
	CORE	**1**	Umeå	Sweden	81.29
		2	Tampere	Finland	75.67
		3	Jönköping	Sweden	74.98
		4	Oulu	Finland	65.62
		5	Uppsala	Sweden	64.20
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Lefkosia	Cyprus	0.46
		2	Valletta	Malta	0.56
		3	Gozo	Malta	0.90
		4	Iraklion	Greece	0.98
		5	Bari	Italy	1.07
	CORE	**1**	Bari	Italy	0.11
		2	Iraklion	Greece	0.13
		3	Valletta	Malta	0.31
		4	Alicante/Alacant	Spain	0.42
		5	Foggia	Italy	0.51

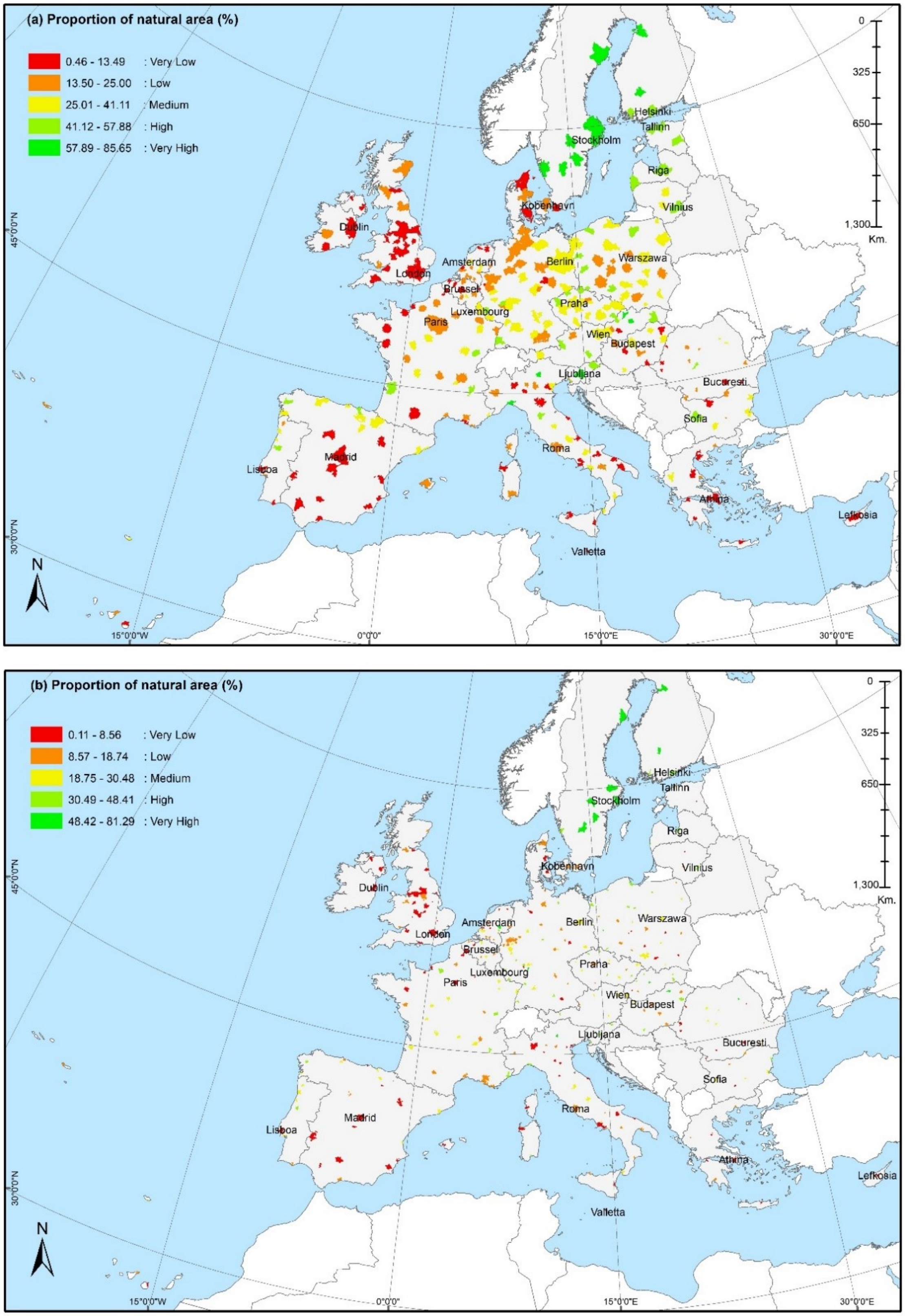


Figure 6 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Proportion of natural area" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

In broad terms, the **"proportion of impervious surface"** ECI presents relatively low values along Europe for the LUZ (*Figure 7a*) while for the cores the presence of medium to high values is frequent (*Figure 7b*). Aggregates of LUZ that present high to very high values are only observed within the borders of Belgium and Netherlands. As regards the city cores, the majority of them that correspond to the highest indicator values are concentrated in Central Europe and especially at Netherlands, Belgium, Germany and Poland. The Scandinavian countries show very low values for both spatial levels and the Baltic countries just for the LUZ. The city cores of the European capitals, as a rule, correspond from high to very indicator values as for example London, Paris, Rome, Athens or Berlin with certain exceptions (e.g. Helsinki, Stockholm). The core indicator values are of significantly larger magnitude than the LUZ. In fact, we may notice that the values that correspond to core classes are approximately double than the respective values for the LUZ (*Figure 7*).

The highest percentages for the LUZ and city core spatial level correspond to s' Gravenhage (Netherlands) with a percentage of 45.09% and Thessaloniki (Greece) with a percentage of 82.70 % respectively (*Table 10*). The lowest percentages correspond to Umeå (Sweden) for both spatial levels with a percentage of 1.73 % for the LUZ level and 2.82% for the core level. It is notable that the country that prevails when it comes to the LUZ and cores with the lowest percentages is Sweden.

Table 10: *The cities and the respective countries that correspond to the highest and lowest values of the "Proportion of impervious" ECI for the LUZ and city core spatial levels.*

	Proportion of impervious surface				
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	s' Gravenhage	Netherlands	45.09
		2	Napoli	Italy	39.34
		3	Liverpool	United Kingdom	37.89
		4	Portsmouth	United Kingdom	37.82
		5	Nancy	France	36.57
	CORE	**1**	Thessaloniki	Greece	82.70
		2	Paris	France	66.48
		3	Bucuresti	Romania	62.57
		4	Kingston-upon-Hull	United Kingdom	62.03
		5	Valletta	Malta	60.20
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Umeå	Sweden	1.73
		2	Liepaja	Latvia	2.47
		3	Uppsala	Sweden	2.92
		4	Pamplona/Iruna	Spain	3.09
		5	Oulu	Finland	3.19
	CORE	**1**	Umeå	Sweden	2.82
		2	Jönköping	Sweden	3.68
		3	Uppsala	Sweden	3.92
		4	Padova	Italy	4.20
		5	Örebro	Sweden	4.37

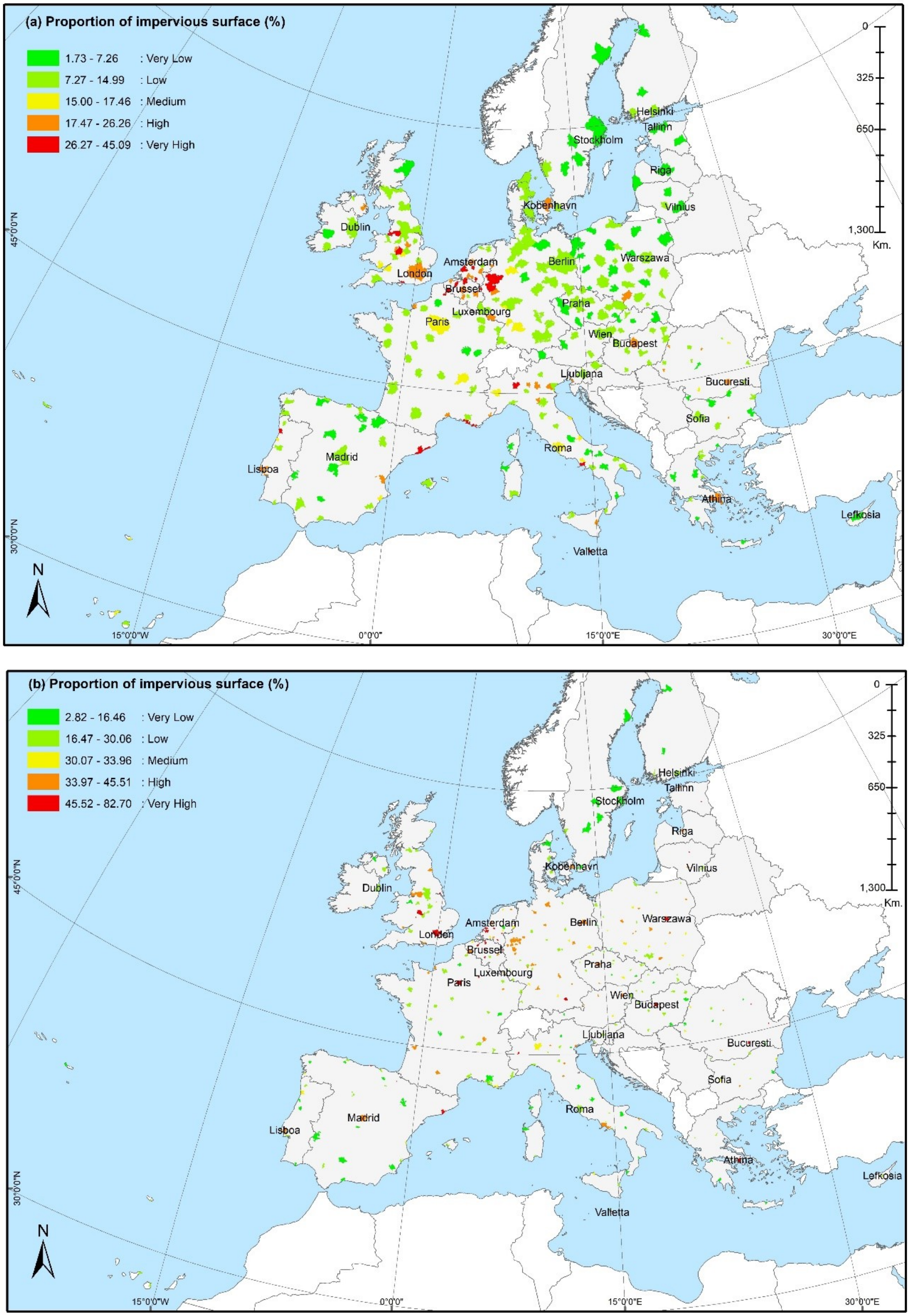


Figure 7 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Proportion of impervious surface" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **"Proportion of agricultural area"** ECI shows large aggregates of low values at north-east Europe while central Europe presents relatively moderate values and south Europe presents high values for both the LUZ and core spatial levels (*Figure 8*). The majority of the LUZ and corresponding cores that are located within the borders of the United Kingdom, Ireland and Denmark present high to very high indicators values. The LUZ within the borders of Sweden and Finland show very low indicator values for the LUZ and low to very low for the core level. We may also observe that most of the LUZ and corresponding city cores that are found within the borders of the southern European countries present from high to very high indicator values capitals included (e.g. Spain, Italy, Cyprus, Greece). Concerning the magnitude of the indicator values, it is significantly larger for the LUZ spatial level.

The cities with the highest indicators percentages are the Badajoz of Spain with a percentage of 92.12 % (*Table 13*). It should be noted that the percentage is exactly the same for both scales because Badajoz is one of the few cases where the LUZ and core coincide. The lowest indicator percentages for the LUZ and core levels correspond to Umeå (Sweden) and Thessaloniki (Greece) respectively and these are 11.70 % and 0.75% respectively. A general note on *Table 9,* is that all the cities that present the highest percentages are located at southern Europe.

Table 11: *The cities and the respective countries that correspond to the highest and lowest values of the "Proportion agricultural area" ECI for the LUZ and city core spatial levels.*

Proportion of agricultural area					
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Badajoz	Spain	92.12
		2	Lefkosia	Cyprus	90.71
		3	Toledo	Spain	90.44
		4	Cordoba	Spain	89.80
		5	Foggia	Italy	89.62
	CORE	**1**	Badajoz	Spain	92.12
		2	Cordoba	Spain	89.80
		3	Foggia	Italy	89.73
		4	Sassari	Italy	85.81
		5	Ajaccio	France	83.44
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Umeå	Sweden	11.70
		2	Tampere	Finland	14.56
		3	Jönköping	Sweden	17.89
		4	Stockholm	Sweden	18.60
		5	Wuppertal	Germany	20.22
	CORE	**1**	Thessaloniki	Greece	0.75
		2	Bruxelles/Brussel	Belgium	2.73
		3	Zielona Gora	Poland	3.29
		4	Paris	France	3.54
		5	Padova	Italy	3.67

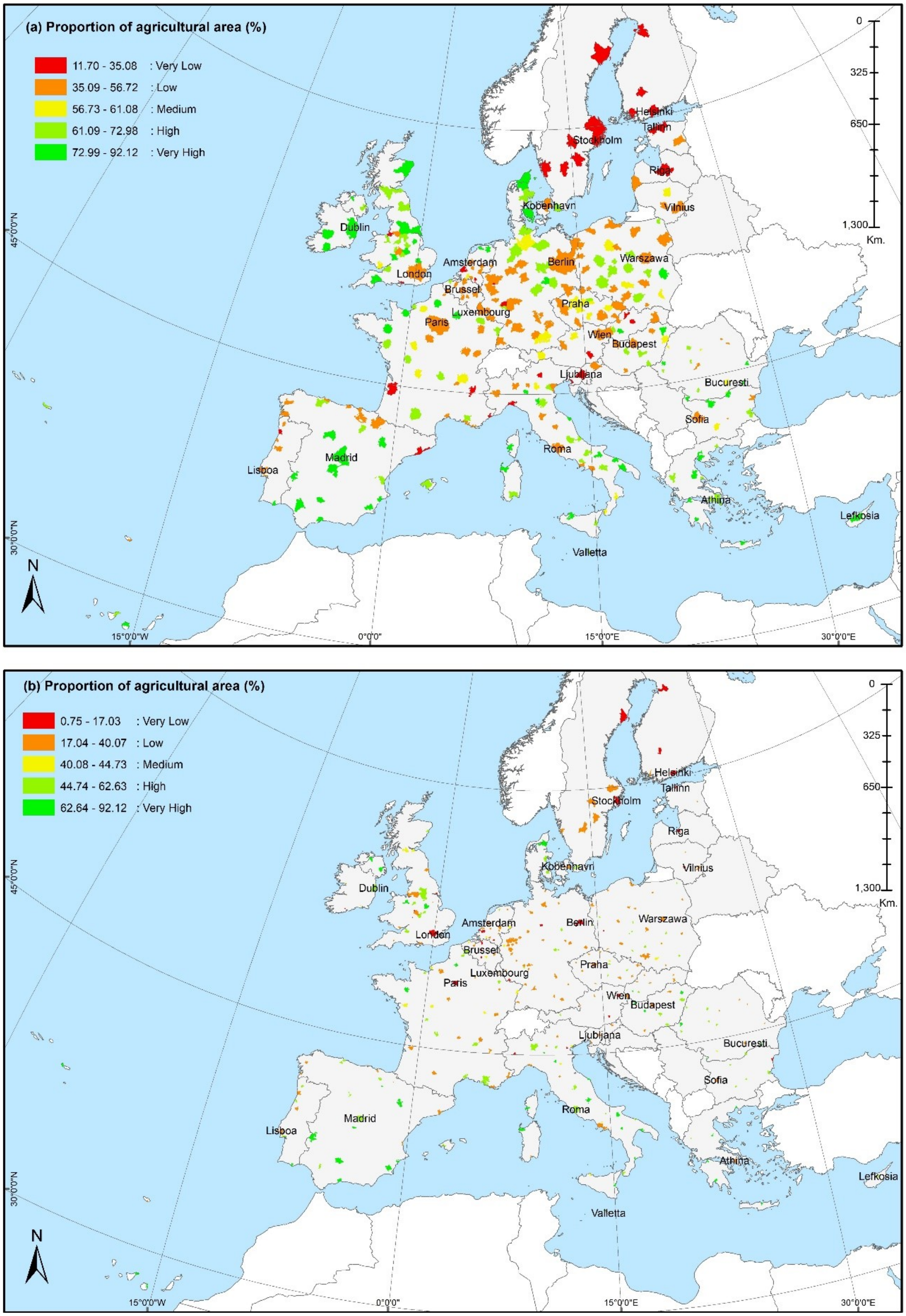


Figure 8 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Proportion of agricultural area" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **"Proportion of protected area"** ECI mainly presents very low values across Europe for both the LUZ and the core spatial levels (*Figure 9).* Furthermore, there are some LUZ and several cores which do not have any protected areas within their territories (28 out of 305). LUZ and cores that present from medium to very high percentages are mainly located within the borders of Spain and Greece. Concerning the capitals, we may see that Madrid and Wien present relatively high indicator values for both spatial levels. Significant differentiations between the two spatial levels are observed at Slovakia and Poland. As regards the magnitude of the indicator values, the LUZ level seems to generally involve higher percentages.

The city of Aveiro (Portugal) presents the highest percentage (87.02%) for the LUZ level while the city of Cagliari (Italy) presents the highest percentage (98.97%) for the core level (*Table 10*). It is notable that, especially concerning the core level, the territories of the cities that correspond to the highest percentages are almost completely characterized as protected areas. The cities with the lowest indicator values are Modena (Italy) for the LUZ level and Wuppertal (Germany) for the core level with 1.03% and 1.10% respectively (*Table 12*).

Table 12: *The cities and the respective countries that correspond to the highest and lowest values of the "Proportion of protected area" ECI for the LUZ and city core spatial levels. Values below 1% have been excluded from the ranking and can be found at Appendices A and B.*

			Proportion of protected area		
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Aveiro	Portugal	87.02
		2	Santa Cruz de Tenerife	Spain	79.81
		3	Trieste	Italy	79.65
		4	Venezia	Italy	74.90
		5	l'Aquila	Italy	73.51
	CORE	**1**	Cagliari	Italy	98.97
		2	Ioannina	Greece	97.35
		3	Aveiro	Portugal	97.28
		4	Santa Cruz de Tenerife	Spain	94.95
		5	Valencia	Spain	84.65
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Modena	Italy	1.03
		2	Rennes	France	1.07
		3	Wuppertal	Germany	1.10
		4	Milano	Italy	1.15
		5	Edinburgh	United Kingdom	1.22
	CORE	**1**	Wuppertal	Germany	1.10
		2	London	United Kingdom	1.10
		3	Glasgow	United Kingdom	1.11
		4	Rzeszow	Poland	1.12
		5	Radom	Poland	1.13

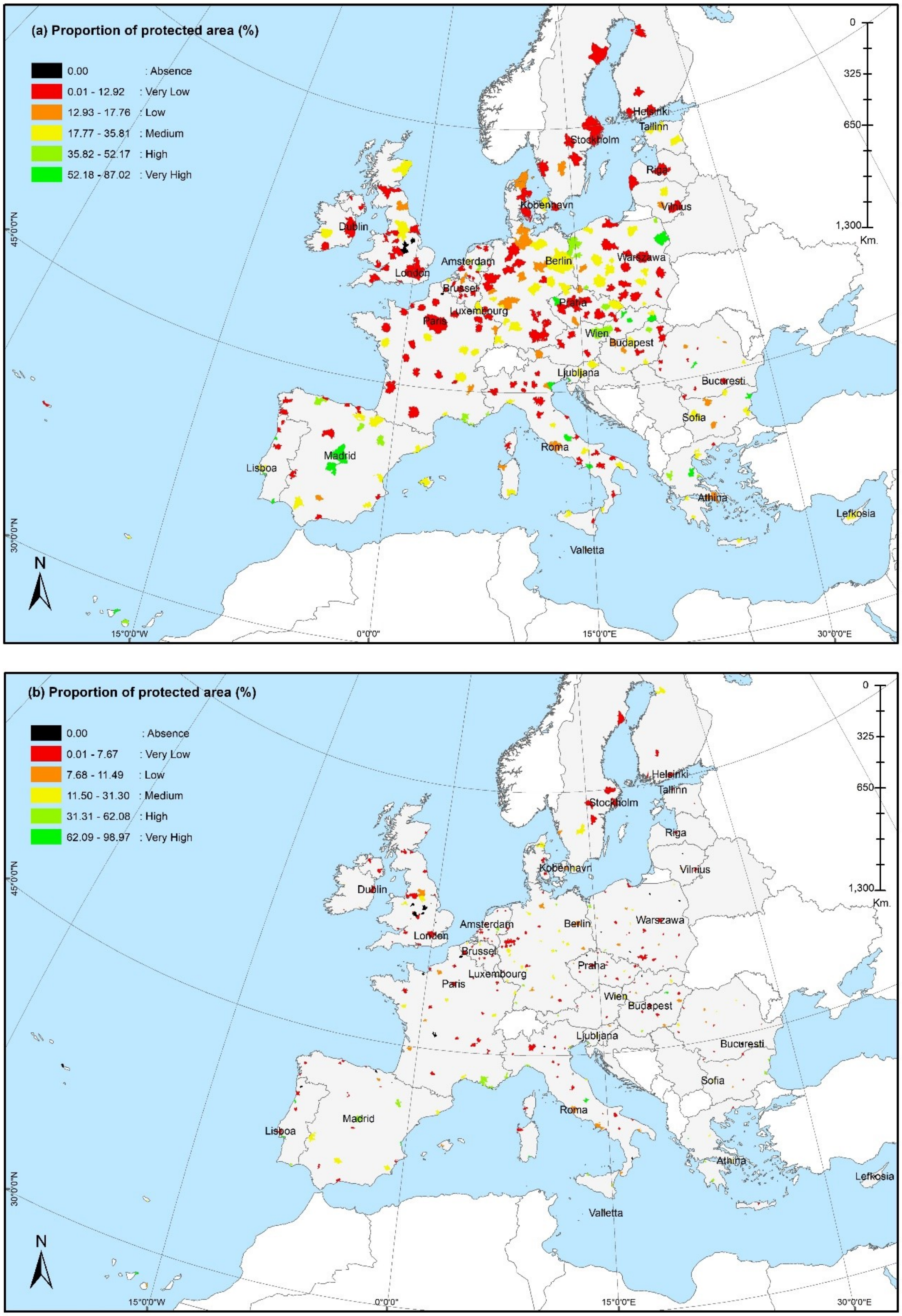


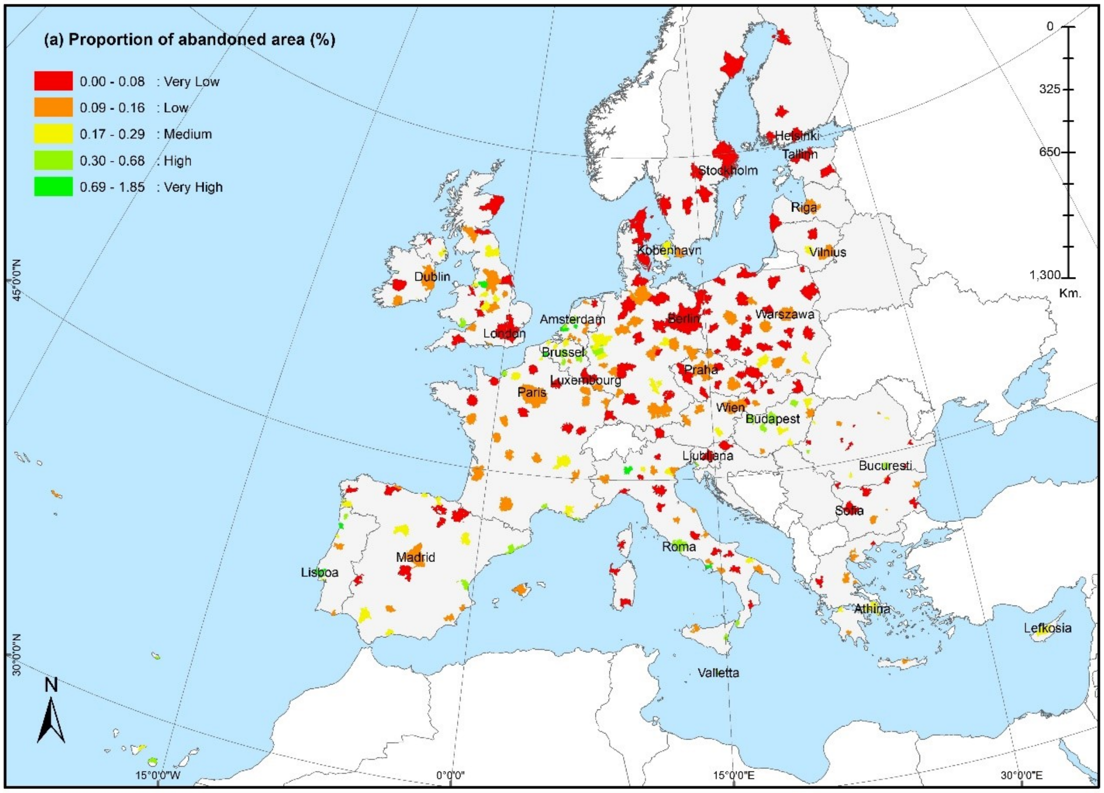
Figure 9 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Proportion of protected area" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **“Proportion of abandoned area”** ECI generally presents very low values towards Europe for both the examined spatial levels (*Figure 10*). Very few LUZ present high and very high indicator values and they are mainly met within the borders of Hungary, Netherlands and Belgium (*Figure 10a*). Concerning the core level, several cores of Germany present medium percentages while a few that correspond from medium to high percentages are located at Netherlands, Belgium and the Baltic countries (*Figure 10b*). In general, the indicator values of the LUZ present significantly larger values than the ones of the cores.

The city that presents the highest percentages for both spatial levels is Rotterdam (Netherlands) with percentages of 3.05 % and 1.85% for the core and LUZ respectively while the city of Örebro (Sweden) presents zero percentages (*Table 13*). It is notable that Sweden is the country that prevails amongst the ones that present the lowest percentages for the core level.

Table 13: *The cities and the respective countries that correspond to the highest and lowest values of the “Proportion agricultural area” ECI for the LUZ and city core spatial levels.*

			Proportion of abandoned area		
	Level	**Rank**	**City**	**Country**	**Value (%)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Rotterdam	Netherlands	1.85
		2	Milano	Italy	1.17
		3	Napoli	Italy	1.06
		4	Oporto	Portugal	0.90
		5	Lille	France	0.87
	CORE	**1**	Rotterdam	Netherlands	3.05
		2	Santander	Spain	2.44
		3	Liepaja	Latvia	2.43
		4	Utrecht	Netherlands	2.41
		5	Lefkosia	Cyprus	2.30
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Örebro	Sweden	0.00
		2	Olsztyn	Poland	0.00
		3	Umeå	Sweden	0.01
		4	Linköping	Sweden	0.01
		5	Oviedo	Spain	0.01
	CORE	**1**	Örebro	Sweden	0.00
		2	Linköping	Sweden	0.01
		3	Umeå	Sweden	0.01
		4	Uppsala	Sweden	0.02
		5	Derry	United Kingdom	0.02



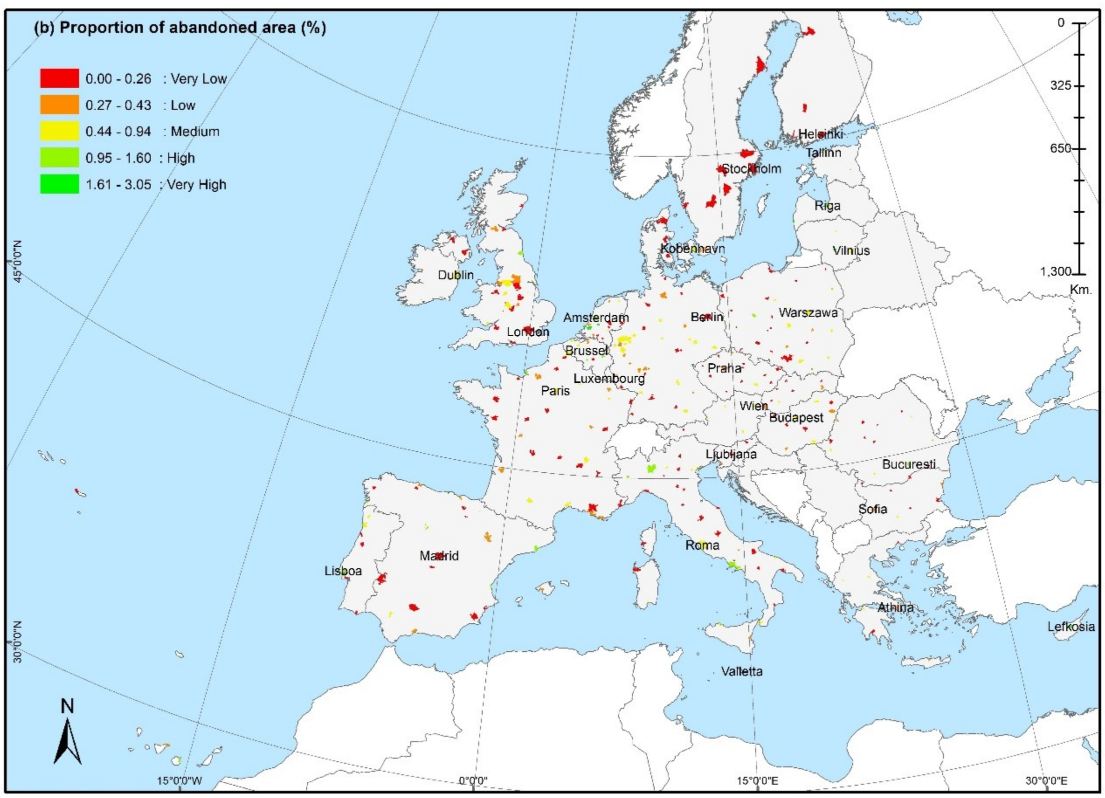


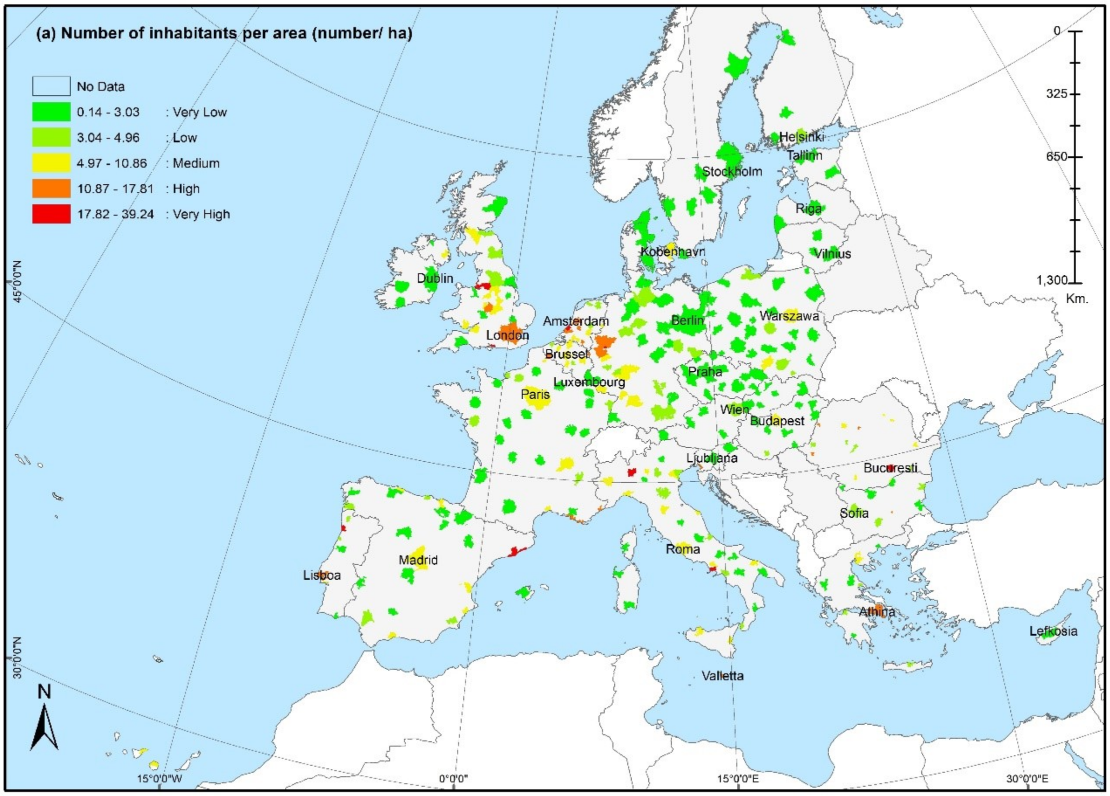
***Figure 10 (a)** LUZ spatial level **(b)** city core spatial level: the "Proportion of abandoned area" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **"Number of inhabitants per area"** ECI mainly presents from medium to very low values for both the examined spatial levels (*Figure 11*). The capital cities that are distinguished because of their high values for both levels are London and Athens. A large majority of the city cores that present medium indicator values are observed within the borders of Poland and Germany (*Figure 11b*). Concerning the magnitude of the indicator values, the city cores present significantly larger values according to the distribution of the classes of (*Figure 11).*

The LUZ that presents the highest indicator value is Napoli (Italy) with approximately 39 inhabitants/ ha and the one with the lowest value is Umeå (Sweden) with 0.14 inhabitants / ha . The city core with highest indicator value is clearly Thessaloniki (Greece) with an estimated value of approximately 223 inhabitants/ ha while the lowest indicator value corresponds to Umeå (Sweden) with 0.43 inhabitants/ ha (*Table 12*). It is also notable that the cities which correspond to the lowest values for both the examined spatial levels belong to Sweden.

Table 14: *The cities and the respective countries that correspond to the highest and lowest values of the "Number of Inhabitants per area" ECI for the LUZ and city core spatial levels.*

			Number of inhabitants per area		
	Level	**Rank**	**City**	**Country**	**Value (number/ ha)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Napoli	Italy	39.24
		2	Portsmouth	United Kingdom	24.54
		3	s' Gravenhage	Netherlands	22.72
		4	Barcelona	Spain	22.14
		5	Milano	Italy	22.10
	CORE	**1**	Thessaloniki	Greece	223.32
		2	Paris	France	80.81
		3	Athina	Greece	80.71
		4	Bucuresti	Romania	79.68
		5	Pamplona/Iruna	Spain	72.41
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Umeå	Sweden	0.14
		2	Uppsala	Sweden	0.35
		3	Liepaja	Latvia	0.37
		4	Jönköping	Sweden	0.42
		5	Linköping	Sweden	0.43
	CORE	**1**	Umeå	Sweden	0.43
		2	Jönköping	Sweden	0.60
		3	Uppsala	Sweden	0.76
		4	Örebro	Sweden	0.76
		5	Linköping	Sweden	0.85



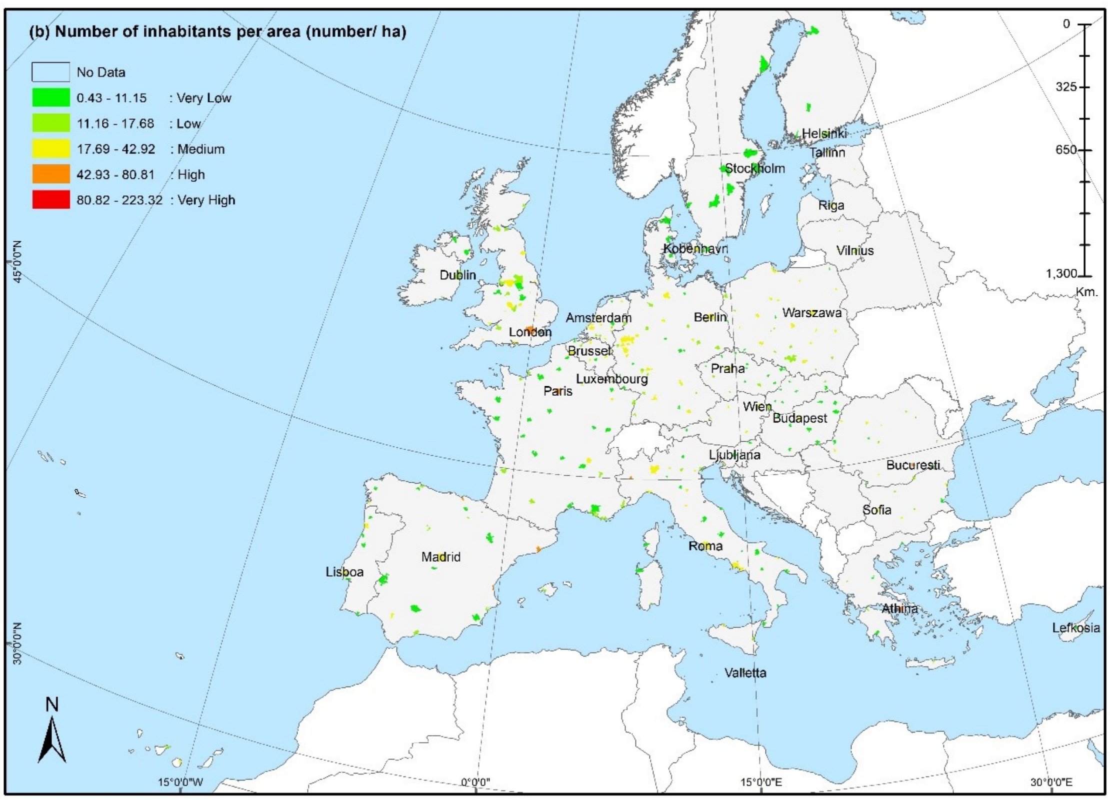


Figure 11 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Number of inhabitants per area" indicator, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

The **"Artificial area per inhabitant"** indicator generally presents from medium to very low values for both the LUZ and core spatial level with the distinguished exceptions of (*Figure 12*) of the Scandinavian countries which exclusively present high to very high values. The majority of the LUZ that are located within the Baltic countries present high values (*Figure 12a*), while the respective cores present medium values (*Figure 12b*). Most of the European capitals present very low values at both spatial levels as for example London, Madrid, Paris, Rome and Athens.

The city with the largest indicator value for both spatial levels is Umeå (Sweden) with 1903.91 m^2/inhab. at LUZ level and 1137.76 m^2/inhab. at core level (*Table 13*). The lowest indicator value for the LUZ is observed at Napoli (Italy) and for the cores at Thessaloniki (Greece) with values 140.25 m^2/inhab. and 43.27 m^2/inhab. respectively (*Table 15).*

Table 15: *The cities and the respective countries that correspond to the highest and lowest values of the "Artificial area per inhabitant" ECI for the LUZ and city core spatial levels.*

			Artificial area per inhabitant		
	Level	**Rank**	**City**	**Country**	**Value (m2/inhab)**
Cities that correspond to the highest indicator values from highest (1) to lowest (5)	**LUZ**	**1**	Umeå	Sweden	1903.91
		2	Aalborg	Denmark	1370.83
		3	Uppsala	Sweden	1368.94
		4	Limerick	Ireland	1341.51
		5	Linköping	Sweden	1314.71
	CORE	**1**	Umeå	Sweden	1137.76
		2	Jönköping	Sweden	1028.91
		3	Örebro	Sweden	1000.34
		4	Linköping	Sweden	942.48
		5	Aalborg	Denmark	894.62
Cities that correspond to the lowest indicator values from lowest (1) to highest (5)	**LUZ**	**1**	Napoli	Italy	140.25
		2	Bucuresti	Romania	149.19
		3	Barcelona	Spain	159.22
		4	Braila	Romania	161.23
		5	Stara Zagora	Bulgaria	167.59
	CORE	**1**	Thessaloniki	Greece	43.47
		2	Valencia	Spain	77.41
		3	Bilbao	Spain	86.54
		4	Athina	Greece	89.00
		5	Bucuresti	Romania	92.80

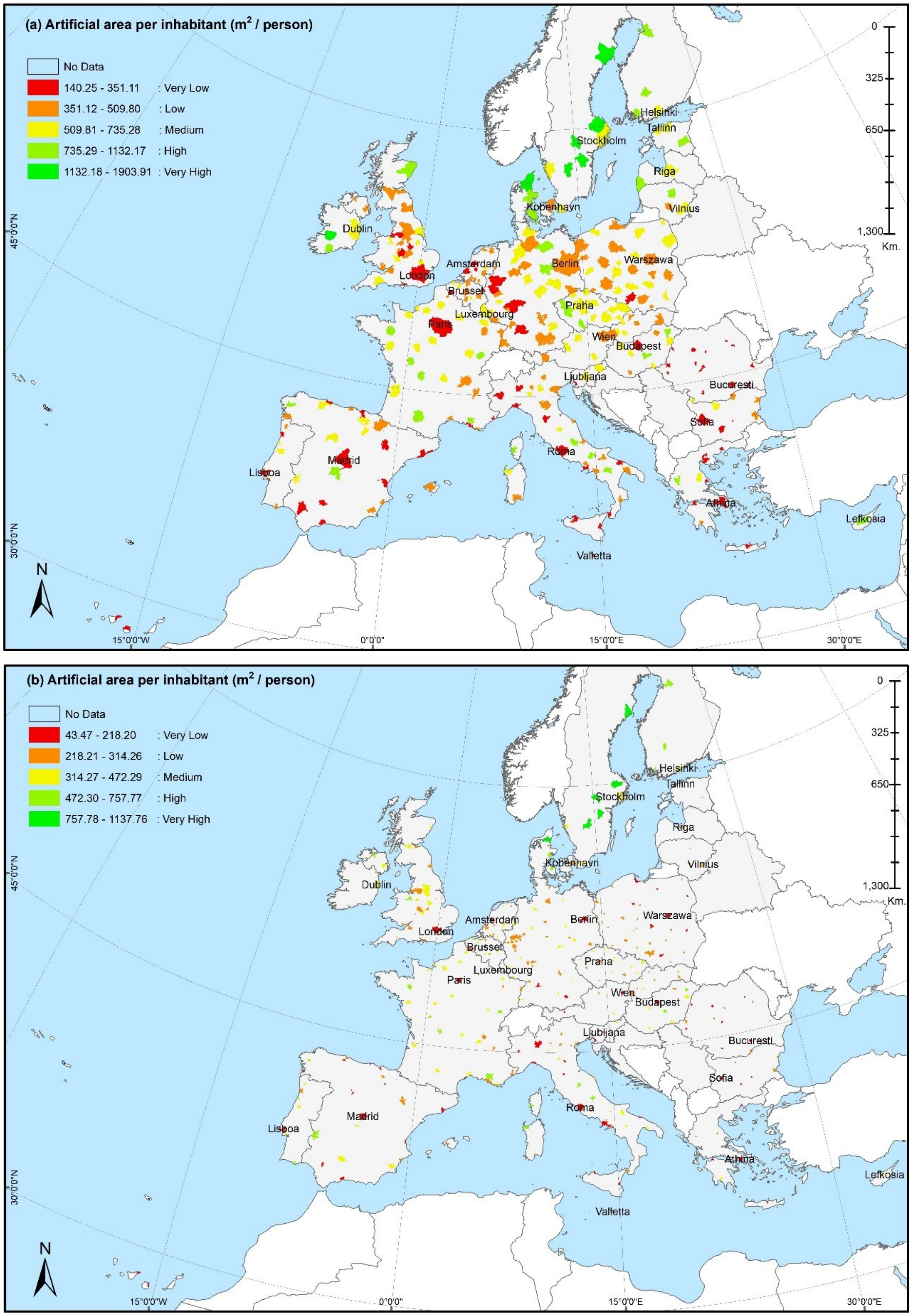


Figure 12 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "Artificial area per inhabitant" ECI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

5.2. ECI Values Differential between the City Core and its Surroundings

In *Figure 13* are presented the average percentages of the contribution of each ECI to the cumulative indicator value of the city core and the intermediate zone that lies among the LUZ and core outlines. The detailed results of this analysis i.e. each ECI's value for the city core and each surroundings are presented at Appendices B and C respectively.

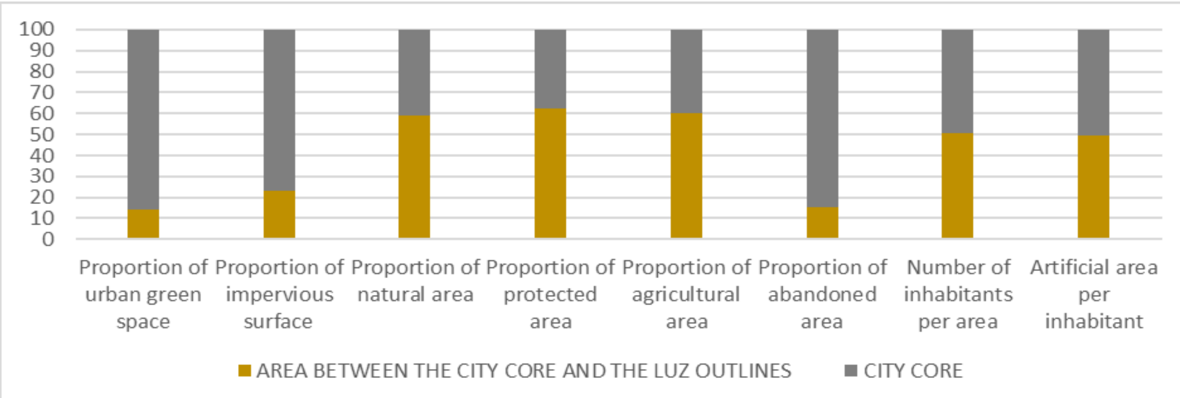


Figure 13: *The contribution of each ECI at "City core" and "Area in between the city core and LUZ outline" spatial levels to their cumulative value. The percentages correspond to the average ECI values of the under-study cities whose LUZ does not coincide with their core (282 cities).*

The "Proportion of urban green space" ECI appears to be much higher for the city core in accordance with the surrounding area (*Figure 13*). The same is also valid for the "Proportion of impervious surface" and "Proportion of abandoned area" ECI which appear to be clearly higher for the city cores. The ECI which appear to be significantly higher for the surroundings than for the city cores are the "Proportion of natural area", Proportion of protected area and "Proportion of agricultural area."

Finally, the ECI that involve the population of the city core or surrounding area seem to equally contribute to their cumulative value and these are the "Artificial area per inhabitant" and the "Number of inhabitants per area".

5.3. Identification of the Territories that will correspond to the ECI Thresholds

The results that concern the spatial autocorrelation of the ECI as well as of precipitation and temperature, indicate that the most notable spatial autocorrelations correspond to the variables whose Moran's I index is greater than 0.09 and whose z-scores are greater than 10. Subsequently, the Proportion of urban green space, Proportion of natural area, Proportion of agricultural area and Number of inhabitants per area ECI as well as to the mean temperature (*Table 16*) are subjected to a cluster analysis which defines the territories to which different indicator thresholds will be applied (*Figure 14*).

Table 16: *Moran's I index, z-scores and p-values for each ECI per LUZ, as well as for precipitation and temperature. The values in bold correspond to Moran's Index and z-score greater than 0.09 and 10 respectively and are considered as the most spatially autocorrelated.*

indicator	*Moran's Index*	*z-score*	*p-value*
Proportion of urban green space (%)	**0.313255**	**41.453855**	<0.001
Proportion of impervious surface (%)	0.053507	7.948471	<0.001
Proportion of natural area (%)	**0.15524**	**20.49507**	<0.001
Proportion of protected area (%)	0.082460	9.361405	<0.001
Proportion of agricultural area (%)	**0.099363**	**13.256068**	<0.001
Proportion of abandoned area (%)	0.041045	6.158351	<0.001
Number of inhabitants per area (number/ ha)	**0.111579**	**15.024278**	<0.001
Artificial area per inhabitant (m2/person)	0.075255	10.220107	<0.001
Mean Daily Precipitation sum (mm)	0.050041	7.050154	<0.001
Mean Temperature (^{O}C)	**0.22122**	**29.082607**	<0.001

By examining *Figure 14*, the following can be noted for each indicator:

- *Proportion of urban green space*: we can observe that the majority of the LUZ at south-east Europe (within Italy, Greece and Bulgaria) belong to a low-low cluster while the corresponding mean temperature to a high-high cluster. However, this fact may be considered as incidental as this ECI is mainly related to the urban planning policy that is followed within each LUZ
- *Proportion of natural area*: This ECI presents a high-high cluster of a large magnitude at north-east Europe and another significant low-low cluster at north-west Europe. An insignificant low-low cluster is presented towards the south coastline of Europe. However, these clusters do not seem to be related in their largest parts with the corresponding temperature clusters expect from the opposed trends that are observed at north-east Europe.
- *Proportion of agricultural area:* This ECI presents low-low clusters at north-east and north central Europe and a smaller high-high cluster at south Europe. We might say that this ECI could be correlated to temperature as it follows the pattern of temperature clusters.
- *Number of inhabitants per area:* This ECI presents a low-low cluster at north-east Europe and a smaller one at north-central Europe. However, these clusters do not seem to be related in their largest parts with the corresponding temperature cluster.

Concerning the clusters that are formed by the mean temperature towards the LUZ, the mean temperature within the LUZ presents low-low clusters at north Europe, insignificant clusters at middle Europe and high-high clusters at south Europe.

On the basis of the above, it has been decided that the thresholds that will be proposed will correspond to their European-wide mean values expect from the Proportion of agricultural area ECI for which three thresholds will be proposed according the temperature cluster to which the LUZ belongs to.

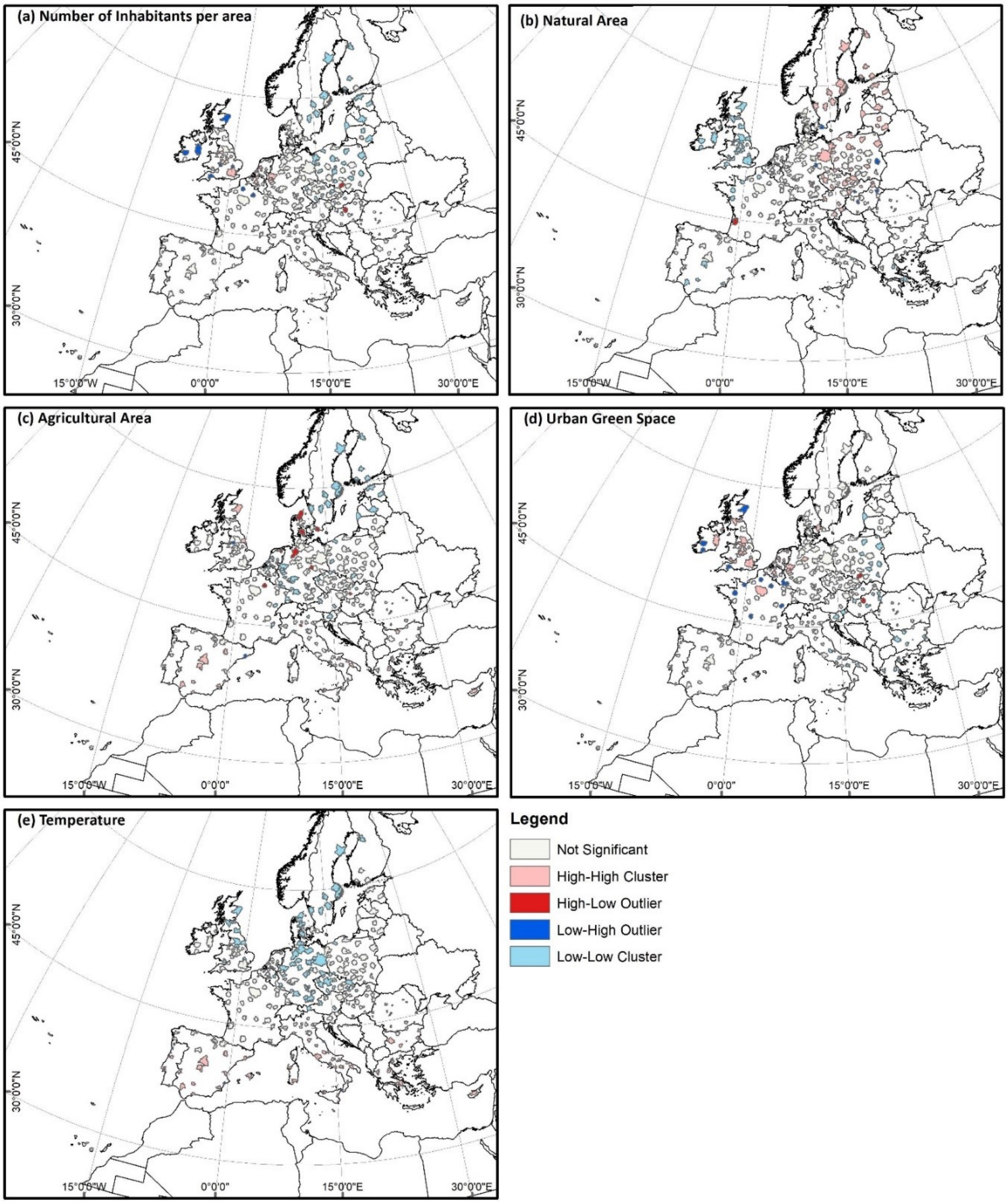


Figure 14 (a) to (e): *The formed clusters of each of the indicators that present significant spatial autocorrelation and the temperature cluster, as defined by the application of the Cluster and Outlier Analysis method.*

5.4. Suggested ECI Thresholds

The suggested thresholds are addressed to the entire territory of Europe except from the one that corresponds to the "Proportion of agricultural area" ECI (*Table 17*) which is assigned three thresholds in accordance with the temperature cluster that the LUZ or core belong to (*Figure 14*). It is noticeable that the suggested thresholds for the said ECI decrease while moving from South to North Europe for both spatial levels.

A general perception of the results indicates that the land uses that prevail over the other for the LUZ as well as for the core spatial levels are the agricultural land uses but though for the LUZ the natural areas come second, for the cores the impervious surfaces follow. We may notice that the greater deviation between the thresholds of the different spatial levels is observed for the "Number of inhabitants per area" ECI (71.95%) while the smallest difference is observed for the "Proportion of natural area" ECI.

The suggested thresholds for the city cores appear to be larger than the corresponding for the LUZ in the cases of the "Proportion of urban green space", "Proportion of impervious surface", "Proportion of abandoned area" and "Number of inhabitants per area" ECI.

Table 17: *The suggested thresholds for each ECI for the LUZ and city cores spatial levels and their corresponding territories. The South, Central and North Europe territories correspond the respective HH, not significant and LL temperature clusters that are presented in Figure 14. The deviation column expresses the proportional difference of the city core thresholds in accordance to the LUZ thresholds.*

No	ECI	Units	Territory	Spatial Level		Deviation (%)
				LUZ	City Core	
1	*Proportion of urban green space*	%	Europe	1.69	5.27	67.93
2	*Proportion of impervious surface*	%	Europe	14.99	30.06	50.13
3	*Proportion of natural area*	%	Europe	25.00	18.74	-33.40
4	*Proportion of protected area*	%	Europe	17.76	11.49	-54.57
			South Europe	67.88	56.18	-20.83
5	*Proportion of agricultural area*	%	Central Europe	56.21	38.07	-47.65
			North Europe	50.02	32.52	-53.81
6	*Proportion of abandoned area*	%	Europe	0.16	0.43	62.79
7	*Number of inhabitants per area*	(num./ ha)	Europe	4.96	17.68	71.95
8	*Artificial area per inhabitant*	(m2/inh.)	Europe	509.80	314.26	-62.22

5.5. Juxtaposition of the Suggested ECI Thresholds to ES

The outcome of the juxtaposition of the suggested thresholds to ES, which will be a measure for the suggested thresholds (*Table 17*) credibility, is heavily dependent on the type of the correlation that the ECI with the ES which is based on scientific literature (*Table 18*). We may notice the differentiation of the UHI effect correlations in relation to the ROS the NO_2 removal by urban vegetation ESI which is attributed to the fact that the UHI effect is not an ES itself, but it is linked to climate regulation ES in an inversely proportionate way.

Table 18: *The correlation between ECI and ESI based on scientific literature.*

ECI	Type of correlation to ES		
	NO_2 removal by urban vegetation	ROS	UHI effect
Proportion of urban green space	+	+	-
Proportion of impervious surface	-	-	+
Proportion of natural area	+	+	-
Proportion of protected area	+	+	-
Proportion of agricultural area	+	+	-
Proportion of abandoned area	+	+	-
Number of inhabitants per area	-	-	+
Artificial area per inhabitant	+	+	-

Concerning the **"NO_2 removal by urban vegetation"** ESI values' spatial distribution, both the examined spatial levels present a similar pattern (*Figure 15*). A general perception of *Figure 15* indicates that the majority of the European LUZ correspond to relatively low or medium values. However, the majority of the LUZ and cores that are located within the borders of Finland and Sweden as well as Portugal present high to very high percentages. Furthermore, according to the same figure, Stockholm is the only European capital with high values at both spatial levels. In general, the magnitude of the LUZ values does deviate much from the respective magnitude of the cores.

As regards the "NO_2 removal by urban vegetation" ESI and its relation to the suggested thresholds, the threshold which is given credence for both the spatial levels of LUZ and city cores corresponds to the "Proportion of natural area" ECI (*Table 17*). That is because the percentages that represent the number of LUZ and cores that positively surpass both the threshold and the average ESI value, to the total number of the said LUZ and cores are 68.42% and 70.87% respectively. Furthermore, there are two ECI whose respective proportions also surpass the 50% and these are the "Proportion of impervious surface" and "Proportion of protected area" ECI.

The majority of the proportions presented at *Table 19* exceed the 40% for both the examined spatial levels, except from the ones that correspond to the "Proportion of agricultural area" ECI. Finally, the total number of LUZ and cores which surpass the average "NO_2 removal by urban vegetation" ECI values are 133 and 131 respectively.

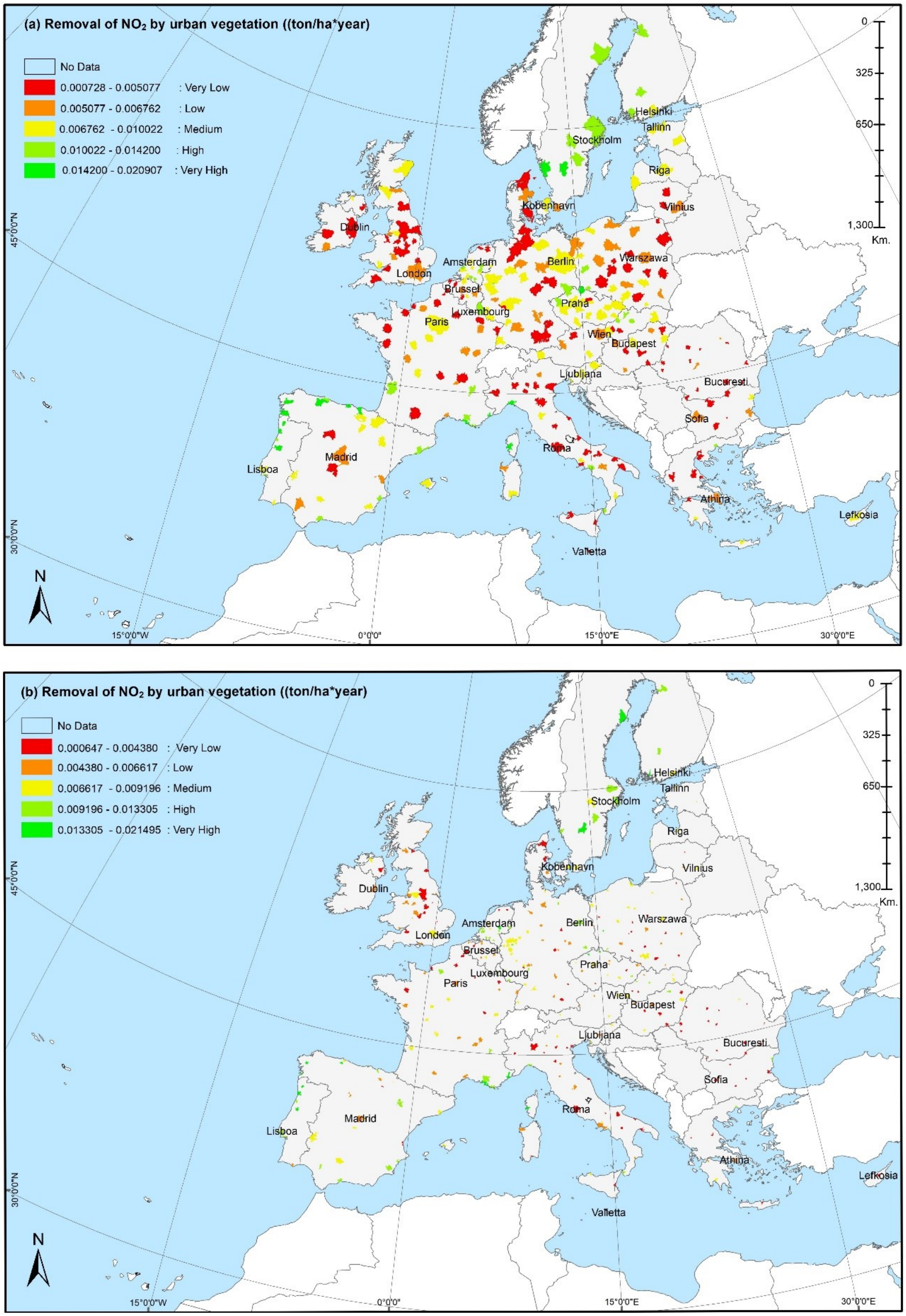


Figure 15 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the " NO_2 removal by urban vegetation " ESI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

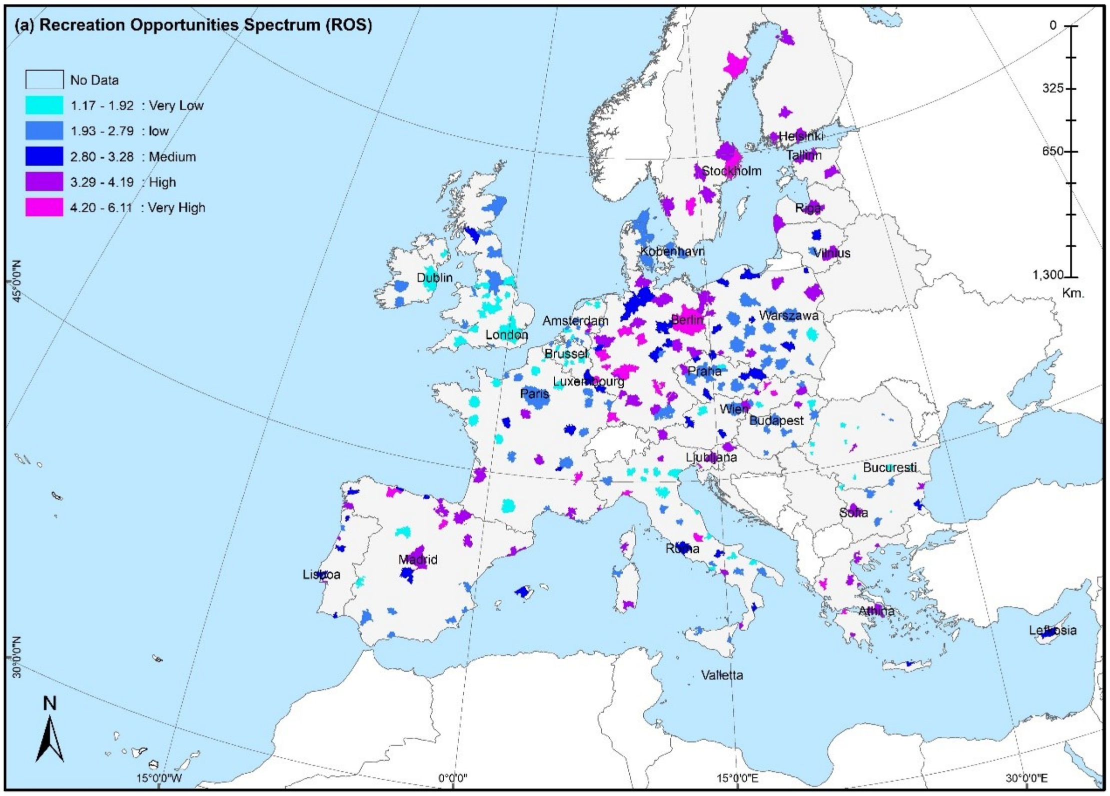
Table 19: *The number of LUZ and cores which positively surpass the suggested ECI threshold as well as the number and proportion of them which also surpass the average "NO_2 removal by urban vegetation" ESI values. An ECI value positively surpasses the threshold when it is greater than the threshold for the indicators that share a positive correlation with the ES and less than the threshold for the indicators that share a negative correlation with the ES. Proportions equal or greater to 50% are considered to give credence to the respective suggested ECI threshold and are in bold.*

ECI	**(A) Number of LUZ or cores which positively surpass the suggested ECI threshold**		**(B) Number of the LUZ or cores of column (A) which ALSO surpass the average "NO_2 removal by urban vegetation" ECI value**		**(C) Proportion (%) of the LUZ or cores of column (B) to the LUZ or cores of column (A)**	
	LUZ	**CORE**	**LUZ**	**CORE**	**LUZ**	**CORE**
Proportion of urban green space	94	121	44	51	46.81	42.15
Proportion of impervious surface	196	90	90	47	45.92	**52.22**
Proportion of natural area	133	127	91	90	**68.42**	**70.87**
Proportion of protected area	112	90	56	43	**50.00**	47.78
Proportion of agricultural area	154	139	34	33	22.08	23.74
Proportion of abandoned area	90	108	37	38	41.11	35.19
Number of inhabitants per area	208	192	90	86	43.27	44.79
Artificial area per inhabitant	127	117	61	54	48.03	46.15

Concerning the **"ROS"** ESI values' spatial distribution, aggregates of LUZ and cores that correspond from high to very high indicator values are mainly found within the borders of Germany, Sweden, Finland, the Baltic countries and Greece (*Figure 16*). LUZ and cores that are lagging behind concerning this ES are mainly observed at southern United Kingdom and northern France. In general, the magnitude of the ESI values that refer to the LUZ does deviate much from the respective magnitude of the cores.

Concerning the "ROS" ESI relation to the suggested ECI thresholds, three thresholds are given credence for both spatial levels and these correspond to the following ECI: "Proportion of natural area", "Proportion of protected area" and "Proportion of impervious surface" (*Table 20*). In fact, the "Proportion of natural area" ECI corresponds to very high percentages for both the LUZ and city core spatial levels which are 70.68 and 70.08 respectively. Furthermore the "Number of inhabitants per area" and "Artificial area per inhabitant" per area ECI correspond to percentages higher than 50% only for the LUZ spatial level (*Table 20*). The lowest proportions for both spatial levels correspond to the "Proportion of agricultural area" ECI.

Finally, it should be mentioned that the total number of LUZ and cores which surpass the average "ROS" values are 136 and 12 respectively.



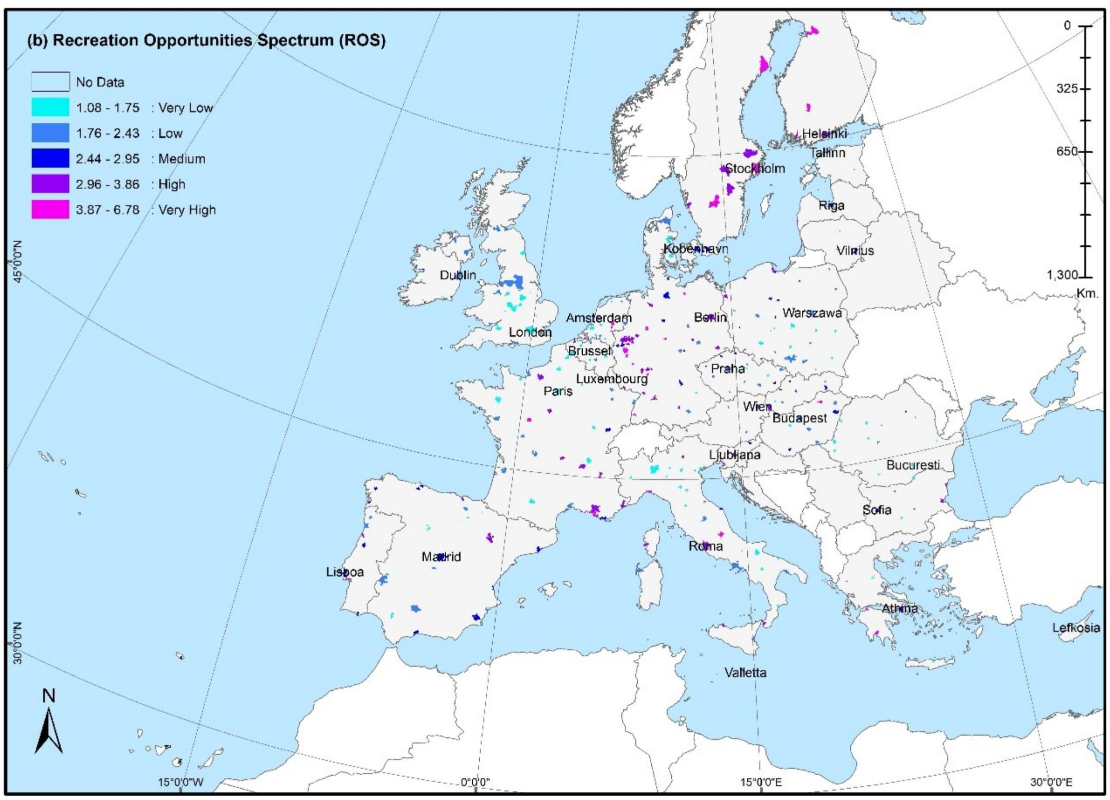


Figure 16 (a) *LUZ spatial level* ***(b)*** *city core spatial level: the "ROS " ESI, classified in five classes by the natural break method, modified to incorporate the mean value of the indicator as the lower limit of the "medium" class.*

Table 20: *The number of LUZ and cores which positively surpass the suggested ECI threshold as well as the number and proportion of them which also surpass the average "ROS" ESI values. An ECI value positively surpasses the threshold when it is greater than the threshold for the ECI that share a positive correlation with the ES and less than the threshold for the ECI that share a negative correlation with the ES. Proportions equal or greater to 50% are considered to give credence to the respective suggested threshold and are in bold.*

ECI	**(A) Number of LUZ or cores which positively surpass the suggested ECI threshold**		**(B) Number of the LUZ or cores of column (A) which ALSO surpass the average "ROS" ECI value**		**(C) Proportion (%) of the LUZ or cores of column (B) to the LUZ or cores of column (A)**	
	LUZ	**CORE**	**LUZ**	**CORE**	**LUZ**	**CORE**
Proportion of urban green space	94	121	31	44	32.98	36.36
Proportion of impervious surface	196	90	105	49	**53.57**	**54.44**
Proportion of natural area	133	127	94	89	**70.68**	**70.08**
Proportion of protected area	112	90	73	61	**65.18**	**67.78**
Proportion of agricultural area	154	139	42	36	27.27	25.90
Proportion of abandoned area	90	108	29	32	32.22	29.63
Number of inhabitants per area	208	192	109	87	**52.40**	45.31
Artificial area per inhabitant	127	117	72	50	**56.69**	42.74

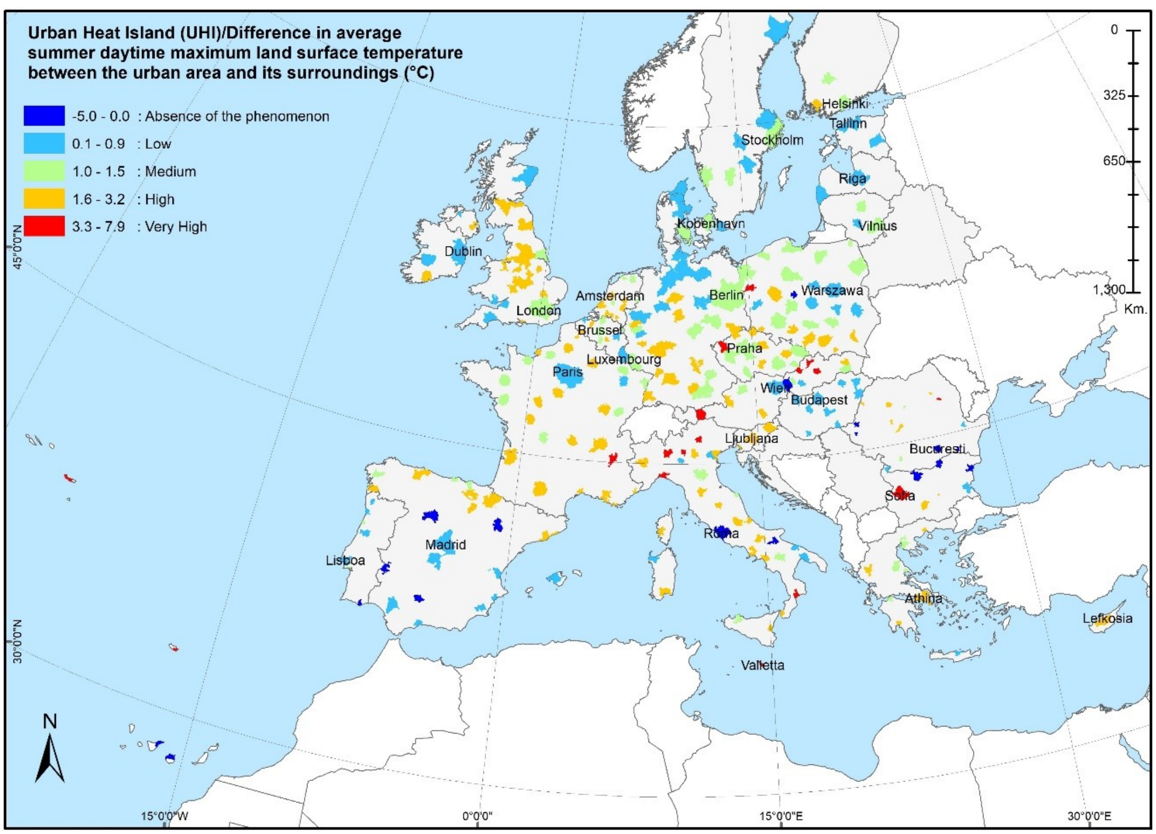


Figure 17 : *LUZ spatial level, the UHI effect, classified in five classes by the natural break method, modified to incorporate the mean value as the lower limit of the "medium" class. The UHI effect values concern the LUZ as well as the core spatial levels.*

Concerning the **UHI effect's** values spatial distribution, an aggregate of very high values is observed at northern Italy (*Figure 17*) while aggregates of high values are mainly observed at central United Kingdom, northern Spain, southern France, west Germany, central Italy, southern Poland and northern Romania. As regards the European capitals, the majority of them correspond from medium to low values with the Exception of Sofia (Bulgaria) which corresponds to very low UHI values. There also cases of some LUZ where there is an absence of the phenomenon and these are mainly found within the borders of Spain and Bulgaria.

As regards the relation between the UHI effect and the suggested ECI thresholds, the thresholds that are considered that are being given credence by the current juxtaposition for both the examined spatial levels, correspond to the "Proportion of impervious surface" and "Artificial area per inhabitant" ECI *(Table 21)*. The lowest percentage corresponds to the "Artificial area per inhabitant" ECI for the LUZ spatial level and is 31.50% meaning that the 30% approximately of the LUZ that have high indicator values also have high UHI values. Furthermore, percentages less than 50% also correspond to the "Proportion of protected area", "Proportion of agricultural area", "Proportion of abandoned area and "Number of inhabitants per area" ECI for the LUZ spatial level and to the "Proportion of urban green space" and "Proportion of natural area" for the city core spatial level.

Table 21: *The number of LUZ and cores which positively surpass the suggested ECI threshold as well as the number and proportion of them which also surpass the average UHI effect values. In the case of the UHI effect, an ECI value positively surpasses the threshold when it is greater than the threshold for the ECI that share a negative correlation with the UHI effect and less than the threshold for the ECI that share a positive correlation with the UHI effect. Proportions equal or less than 50% are considered to give credence to the respective suggested threshold and are in bold.*

ECI	**(A) Number of LUZ or cores which positively surpass the suggested ECI threshold**		**(B) Number of the LUZ or cores of column (A) which ALSO surpass the average "UHI" effect value**		**(C) Proportion (%) of the LUZ or cores of column (B) to the LUZ or cores of column (A)**	
	LUZ	**CORE**	**LUZ**	**CORE**	**LUZ**	**CORE**
Proportion of urban green space	94	121	54	36	57.45	**29.45**
Proportion of impervious surface	196	90	77	33	**39.29**	**36.67**
Proportion of natural area	133	127	72	60	54.14	**47.24**
Proportion of protected area	112	90	53	54	**47.32**	60.00
Proportion of agricultural area	154	139	59	91	**38.31**	65.47
Proportion of abandoned area	90	108	42	60	**46.67**	55.56
Number of inhabitants per area	208	192	85	102	**40.87**	53.13
Artificial area per inhabitant	127	117	40	56	**31.50**	**47.86**

6. Discussion

The current study is very much dependent on the available spatial data that were used as input for its analysis. The primary source of these data, which were freely available and easily accessible, was the EEA. For the data to be relevant and usable, they need to be comparable based on agreed standards and concerning the EEA ‘s spatial data, there are EU initiatives aimed at addressing spatial data standardization, interoperability and availability issues (Jensen, 2014). In any case, special care was given by the current study to incorporate data of comparable scales that would facilitate the analysis for all the examined spatial levels (LUZ, city core, intermediate zone). An exception were the data that concerned the temperature and precipitation which did not allow for a discrimination between the LUZ and the city core spatial levels.

The study provided a comparative perspective for the EC of the EU cities with population larger than 100.000 inhabitants. What makes these different cities across Europe environmentally comparable is the fact that the respective countries are all members of the EU and should conform to the EU’s environmental regulation and directives to reach an objective of common interest. The comparability amongst the under-study cities is enhanced by the fact that the same specification for the “city-area” is used for all of them either for the LUZ or for the core spatial level. However, it should be noted that the city cores which correspond to political and administrative boundaries are not always strictly comparable between countries because economic activity, health services, air pollution etc. cross a city' s administrative boundaries (Feldmann, 2008). On the other hand, the LUZ may capture this extended spatial level as it is based on commuter flows and includes the core city and its commuter belt. Yet, it is important to mention that data at a city level are sometimes less comparable between countries than regional or national statistics despite the efforts to harmonize concepts definitions and the response behavior may differ. (Feldmann, 2008).

Concerning the methodology that has been followed to identify the territories for which different ECI thresholds are suggested and was based on the spatial correlation that climate factors may share with the under study ECI, it should be noted that the results of the cluster analysis may, in some measure, be biased by for example national legislations or towards cities with large amounts of natural areas. However, the main concept behind the selection of this method is that in regions prone to high temperatures and heavy precipitation, the need of ES to handle these events is larger than other regions and that is why the ECI thresholds should differentiate. In fact, Fang et al. (2018) proved that the value of certain ES is significantly affected by meteorological factors, especially precipitation. The climate conditions that have been presented by the current study, showed a notable spatial correlation between the “Proportion of agricultural area” ECI and the temperature for the examined LUZ. However, these climatic conditions are dynamic and continuously changing as climate change is already happening and according to UNFCCC (1992), it is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Increased anthropogenic activities that are relative to the cities and their surroundings such as industrialization, urbanization, deforestation, agriculture, change in land use pattern etc. may lead to emission of greenhouse gases due to which the rate of climate change is much faster (Mahato, 2014). It could be said that the estimation of the ECI and respective thresholds that the current study suggests quantifies these anthropogenic activities, mainly in terms of urban landuses, and could function as an alarm for the authorities to proceed to the incorporation of climate adaptation strategies when needed.

Climate adaptation strategies may involve a wide variety of practices that mainly promote the boost of the urban GI. The climate adaptation benefits of GI are generally related to its ability to moderate the expected increases in extreme precipitation or temperature (Foster et al., 2011). Some wide known contemporary practices that are implemented to enhance urban GI include green, blue, and white roofs; hard and soft permeable surfaces; green alleys and streets; urban forestry; green open spaces such as parks and wetlands; and adapting buildings to better cope with floods and coastal storm surges (Foster et al., 2011) (*Figure 18*). Taking into consideration the ECI and their thresholds, the policy makers could form an opinion about the condition of the respective urban ecosystem while acknowledging that the "good condition" of a city, reflects a "good" or "desired" balance between green and built infrastructure (Maes et al., 2016).

Figure 18 : *Possible actions that the cities could take to enhance the urban GI according to Foster et al. (2011)*

The fact that the study estimated relative and not fixed impact ECI thresholds subserves the thresholds to have relevance in all parts of the EU, fact that may allow the results of relative studies from different parts of the EU to fit together seamlessly (Zhang et al., 2011). Concerning the acceptance that has been made by the current study that the "suggested ECI thresholds are given credence if the majority of the LUZ or city cores whose ECI values surpass the threshold values also surpass the average values of the respective ESI", we might say that it involves the risk of generalization although it is used in the context of the comparative perspective that the study attempts to provide.

Amongst all the examined ECI and respective thresholds, the one that seems to share the strongest relation with the studied ES and the UHI effect is the **"Proportion of natural**

area" for both the examined spatial levels (*Tables 19 to 21*). On the other hand, the results indicate that the **"Proportion of urban green space"** may only play a critical role in the counterbalancing of the UHI effect at city core level (*Table 21*). This dominance of the natural areas against the urban green spaces, in relation to the ES, is largely connected to the "Urban Atlas" land use classification as well as to the selection of the "Urban Atlas" landuses for the estimation of the ECI by the current study. However, if combined, the land uses that these two ECI involve, compose the urban GI of each LUZ or core which "influences the capacity to provide services across a range of scales" (Maes et al., 2014). Actually, *Figure 5* and *Figure 6,* if juxtaposed show that the two ECI may compensate one another in several cases. As regards the relation between the GI and UHI effect which is underpinned by the current study (*Table 21*), it confirms the statement of Gill et al. (2007) that greenspace is an 'environmental capital' that can be utilized to mitigate the adverse effects of the UHI, extreme heat events, and climate change. Concerning the **"Proportion of Agricultural area"** ECI, the results show that is related to the UHI effect for the LUZ spatial level (*Table 21*). In fact, according to Dubbeling and de Zeeuw (2011), Urban and Peri-Urban Agriculture (UPA) may provide services of reducing the UHI effect by providing shade and enhanced evapotranspiration. As regards the **"Proportion of impervious surface"** ECI, it seems to be related to both the two examined ES and more strongly to the UHI effect, fact that confirms the findings of Xu (2010) which have revealed a strong positive exponential relationship between impervious surface and LST which suggests that an increase in built-up land percentage would exponentially accelerate LST rise and UHI development.

The results show that **"Proportion of protected areas"** ECI is related to the ROS ES at both the examined spatial scales as well as to the "NO_2 removal by urban vegetation" ES and the UHI effect in LUZ spatial level. These results support the claiming that although the primary purpose of Natura 2000 network is the conservation of biodiversity and the sustainable development of activities, the network also provides a range of ES and co-benefits related to health and social well-being (Brink et al.,2016). It is worth to mention here that "Urban areas are surprisingly rich in biodiversity, hosting a great variety of species and habitats, some of which are rare and threatened on a European scale" (Sundseth and Raeymaekers, 2006). Furthermore, the Natura 2000 network, which appears to cover large areas of several LUZ and cores (*Figure 9*), could act as a protective shield to the existent GI of the European cities as the cities that involve Natura 2000 sites are obliged to conform to the relative legal provisions which should be considered within a wider urban policy context. For example, Article 6 of the Habitats Directive and Article 4 of the Birds Directive require Member States to ensure that, within Natura 2000 sites damaging activities are avoided that could significantly disturb the species or deteriorate the habitats for which the site designated and that positive conservation measures are taken, where necessary, to maintain and restore these habitats and species to a 'favorable conservation status' in their natural range (Sundseth and Raeymaekers, 2006).

An ECI that, according to the results, has no obvious connection to the ES services and is weakly related to the UHI effect (*Table 21*), is the **"Proportion of abandoned area"**. However, the abandoned areas of a city could contribute to a future enhancement of the urban GI as they could be regarded as a further potential that the cities have to obtain more urban GI. In other words, the indicator could express the proportion of the areas that are "waiting to be used" or re-used as parks, sports or leisure facilities etc. An example of a city that is planning to take advantage of its vacant land to obtain more GI is Bari (Italy). An amount of vacant residual places in Bari which are selected by the respective initiative, are to be turned into properly managed green spaces that are integrated into new neighborhoods (DeBellis and Lubisco, 2016).

The **"Number of inhabitants per area"** ECI is related to the ROS ES and UHI effect for the LUZ spatial level (*Table 20, Table 21*). Concerning the relation to UHI, it has been supported by a case study (Mallick and Rahman, 2012), which showed that population density is one of the main contributing factors for the high surface temperature, UHI intensity and also micro-climate. Finally, the **"Artificial area per inhabitant"** ECI which is related to landuse intensity i.e. it is a combination of the population density with the proportion of impervious surfaces is, according to the findings of the current study, related to the UHI effect in both the examined spatial levels (*Table 21*).

Overall, the results that concern the exploration of relation between the ECI thresholds and the ES, imply that there is a positive relation between the EC and the examined ES which according the 4th MAES report requires more scientific underpinning (Maes et al., 2016).

Another outcome of the study is that, according to the results, the national legislations regarding the urban planning policies, play a determinant role to the cities' EC. More specifically, the results show that in most cases there is a homogeneity of the ECI's classes within the national borders. On the other hand, a general heterogenicity is observed between the northern and southern countries regarding their EC: the northern countries generally present higher ECI values that are positively correlated to ES and lower ECI values for the ones that are negatively correlates to ES. In fact, it has been noted by the NALAS Urban Planning Task Force (2011), that many of the countries in South-East Europe are challenged by an insufficient legal framework and insufficient implementation of plans which amongst other produce dysfunctions in terms of green spaces. In any case, urbanization in Europe should be accompanied with additional growth of GI which provides services that are as important as other urban infrastructure (Maes et al., 2014).

Updating the "Urban Atlas" dataset at regular intervals and re-estimating the under-study ECI might create the conditions of a successful monitoring of the ECI and maybe to reveal potential trends in their values. Furthermore, the monitoring of the under-study ECI, in long term, might enhance the answering of questions like the following:

- Are each ECI values increased or decreased?
- What is the spatial distribution of the LUZ or city cores that present the most noteworthy changes in their values?
- What are the factors that these changes may be attributed to? Did the corresponding LUZ or cores implemented climate adaptation strategies?
- Do the respective ESI and the UHI effect present proportionate changes of their values?
- Do the European-wide averages of the ECI present an increase or a decrease?

The answers to the above questions could be the basis to form managerial decisions that may concern either the EU as a whole or each city as a unit. These decisions should of course pay respect to the national and international legislation and should look ahead to the future of the EU as a whole and its cities individually in terms of environmental sustainability.

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7. Conclusions

The study has attempted to define empirically derived relative thresholds in two spatial levels (LUZ, city core) for eight urban ECI that the 4th MAES report proposes and to juxtapose the results to two ESI and the UHI effect to examine their relation. According to the 4th MAES report, the assessment of the thresholds in different spatial levels, serves the purpose of providing a structured framework that can be implemented at a local, metropolitan and regional level as a support of policies and planning purposes. Apart from this objective, the study has pointed out contradictions that the ECI present between the examined spatial levels. A significant outcome of the study is the quantification of the large deviations of the ECI between the urban (city core) and metropolitan (LUZ) scale, which points out that there are fundamental differences relative to the land use types and respective areas between them and by extension to their EC and deriving ES. This differentiation has been further explored by estimating the ECI for the area in between the city core and its surroundings which revealed an added value that this intermediate zone has to the ES provided, fact that needs to be considered when implementing climate adaptation strategies.

Since growing cities heavily depend on the supply of the ES which are necessary to sustain healthy urban living conditions and vibrant commerce (Ervin et al. 2012), the assessment of the urban EC through an indicator framework could be a useful aiding tool for the policy-makers to safeguard the ES provided. The study concluded that the relative national policies may have an imprint on the ECI at the LUZ and city core spatial levels and that most commonly countries of southern Europe are lagging behind concerning their urban EC in accordance with the northern ones. A significant differentiation between the southern and northern EU countries concerns their climate and especially their temperature which showed a notable spatial correlation to the examined ECI which is based on agricultural land uses.

The majority of the suggested ECI thresholds, are related to the examined ES and UHI effect either in LUZ or city core spatial levels or in both. Amongst the examined ES and the UHI effect, the latter is the one that seems to be more affected by the under-study ECI.

The current study looks forward to work as an aiding tool for policy makers to form a general overview of the EC of the LUZ or core, yet it should be noted that the incorporation of existing or new policy targets and ambitions would lead to a more legitimate and justifiable decision-making.

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References

Aggarwal, C. and Reddy, C. (2014). *Data clustering*. Boca Raton: CRC Press/Taylor & Francis Group, pp.2-2. ISBN: 13: 978-1-4665-5821-2

Alobaydi, D., Bakarman, M. and Obeidat, B. (2016). The Impact of Urban Form Configuration on the Urban Heat Island: The Case Study of Baghdad, Iraq. *Procedia Engineering*, 145, pp.820-827.

Bai, X. and Schandl, H. (2010). *Urban ecology and industrial ecology from* The Routledge Handbook of Urban Ecology. Abingdon: Routledge Publications, Routledge Handbooks Online, pp. 26-37.

Bolund, P. and Hunhammar, S. (1999). *Ecosystem services in urban areas*. Ecological Economics, 29(2), pp.293-301.

Bretagnolle, A., Delisle, F. and Mathian, H. (2011). *Larger Urban Zones (Urban Audit) specifications*. EPSON Database 2013, p.8-8.

Center for International Earth Science Information Network (CIESIN) of the Columbia University, International Food Policy Research Institute (IFPRI) , The World Bank and Centro Internacional de Agricultura Tropical (CIAT) (2013). *Global Rural-Urban Mapping Project, Version 1 (GRUMPv1): Urban Extents Grid*. Palisades NY: NASA Socioeconomic Data and Applications Center (SEDAC).

Center for International Earth Science Information Network (CIESIN) of the Columbia University (2013). *Documentation for the Global Urban Heat Island (UHI) Data Set, 2013*. Palisades NY: NASA Socioeconomic Data and Applications Center (SEDAC).

DeBellis, Y., Lubisco, G. (2016). Bari: Revitalizing residual urban areas as green spaces. *Green Surge: Joining forces for greener European cities*, pp: 4-4. Available at: http://greensurge.eu/skabelon/GreenSurge_Newsletter_2_FINAL-www.pdf [Accessed 2 Sep. 2017].

Dubbeling, M. and de Zeeuw, H. (2011). Urban Agriculture and Climate Change Adaptation: Ensuring Food Security Through Adaptation. In: *Resilient Cities*. Dordrecht: Springrer, pp.441-449. ISBN: 978-94-007-0785-6, doi: 10.1007/978-94-007-0785-6_44.

Eicher, C. and Brewer, C. (2001). Dasymetric Mapping and Areal Interpolation: Implementation and Evaluation. *Cartography and Geographic Information Science*, 28(2), pp.125-138.

Environmental Systems Research Institute (ESRI) (2014). ArcGIS for Desktop Help. Spatial Autocorrelation (Global Moran's I).Retrieved March 07, 2018, from http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/spatial-autocorrelation.htm

Ervin, D., Brown, D., Chang, H., Dujon, V., Granek, E., Shandas, V. and Yeakley, A. (2012). Growing Cities Depend on Ecosystem Services. Solutions, 2(6), pp.74-86.

ENSEMBLESFP6_index (2018). Ensembles-eu.metoffice.com. Retrieved 3 April 2018, from http://ensembles-eu.metoffice.com/

European Commission (2011a). *Cities of tomorrow: Challenges, visions, ways forward*. Luxembourg: Office for Official Publications of the European Union, pp.27-27. ISBN: 978-92-79-21307-6, doi:10.2776/41803.

European Commission (2011b). Mapping guide for a European Urban Atlas. [online] pp.1-10. Available at: https://www.eea.europa.eu/data-and-maps/data/urban-atlas/mapping-guide [Accessed 25 Sep. 2017].

European Commission (2013). *Building a Green Infrastructure for Europe*. Luxembourg: Publications Office of the European Union, pp.10-10. ISBN: 978-92-79-33428-3, doi: 10.2779/54125

European Commission (2013a). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Green Infrastructure (GI) — Enhancing Europe's Natural Capital*. pp. 3-3. COM/2017/0247 final.

European Commission (2015). *Report from the Commission to the European Parliament and the Council the mid-term review of the EU biodiversity Strategy to 2020*. COM/2015/0478 final.

Eurostat (2009). *Eurostat regional yearbook 2009.* Luxembourg: Office for Official Publications of the European Union.pp.32-32. ISBN 978-92-79-11696-4, doi: 10.2785/17776.

Fang, J., Song, H., Zhang, Y., Li, Y., Liu, J. (2018) *Climate-dependence of ecosystem services in a nature reserve in northern China*. PLoS ONE 13 (2): e0192727. Available at: https://doi.org/10.1371/journal.pone.0192727

FELDMANN, B. (2008). *The Urban Audit — Measuring the Quality of life in European Cities*. Eurostat-Statistics In Focus, 82/2008, 7. Retrieved from http://ec.europa.eu/eurostat/web/products-statistics-in-focus/-/KS-SF-08-082

Foster J., Lowe A., Winkelman S. (2011). *The Value of Green Infrastructure for Urban Climate Adaptation*, *Working Paper*, Washington, DC: Center for Clean Air Policy (CCAP) [online] pp.3-3. Available at: http://ccap.org/resource/the-value-of-green-infrastructure-for-urban-climate-adaptation [Accessed 2 Sep. 2017].

Gallego, F., Batista, F., Rocha, C. and Mubareka, S. (2011). Disaggregating population density of the European Union with CORINE land cover. *International Journal of Geographical Information Science*, 25(12), pp.2051-2069.

Gill, S., Handley, J., Ennos, A. and Pauleit, S. (2007). Adapting Cities for Climate Change: The Role of the Green Infrastructure. *Built Environment*, 33(1), pp.115-133.

Griffith, D. A. (2009). Methods: Spatial Autocorrelation. *International Encyclopedia of Human Geography,* Edited by R. Kitchin and N. Thrift, New York: Elsevier, pp. 396–402.

Gunawardena, K.R. , Wells, M.J. and Kershaw, T. (2017). Utilizing green and blue space to mitigate urban heat island intensity. New York: Elsevier. *Science of the Total Environment*, 584–585 (2017) 1040–1055.

Huang, Q. and Lu, Y. (2015). The Effect of Urban Heat Island on Climate Warming in the Yangtze River Delta Urban Agglomeration in China. *International Journal of Environmental Research and Public Health*, 12(8), pp.8773-8789.

IPCC (2014). *Summary for policymakers* in *Climate Change 2014: Impacts, Adaptation, and Vulnerability,* Cambridge: Cambridge University Press, pp. 1-32. ISBN: 978-0-2038-392-63, doi: 10.4324/ 9780203839263

Jensen S. (2014). Personal interview. *Environmental spatial data: what is happening where?* Retrieved from https://www.eea.europa.eu/articles/environmental-spatial-data-what-is

Joshi, R., Raval, H., Pathak, M., Prajapati, S., Patel, A., Singh, V. and Kalubarme, M. (2015). Urban Heat Island Characterization and Isotherm Mapping Using Geo-Informatics Technology in Ahmedabad City, Gujarat State, India. *International Journal of Geosciences*, 06(03), pp.274-285.

Lamsal, L., Martin, R., Parrish, D. and Krotkov, N. (2013). Scaling Relationship for NO2Pollution and Urban Population Size: A Satellite Perspective. *Environmental Science & Technology*, 47(14), pp.7855-7861.

Liu, M., Luo, X., & Li, Q. (2012). *An Integrated Method Used to Value Recreation Land–a Case Study of Sweden*. Energy Procedia, 16, 244-251. http://dx.doi.org/10.1016/j.egypro.2012.01.041

Maes, J., Barbosa, A., Baranzelli, C., Zulian, G., Batista e Silva, F., Vandecasteele, I., Hiederer, R., Liquete, C., Paracchini, M., Mubareka, S., Jacobs-Crisioni, C., Castillo, C. and Lavalle, C. (2014). More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe. *Landscape Ecology*, 30(3), pp.517-534.

Maes, J., Barbosa, A., Baranzelli, C., Zulian, G., Batista e Silva, F., Vandecasteele, I., Hiederer, R., Liquete, C., Paracchini, M., Mubareka, S., Jacobs-Crisioni, C., Castillo, C. and Lavalle, C. (2014). More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe. *Landscape Ecology*, 30(3), pp.517-534.

Maes, J., Fabrega, N., Zulian, G., Barbosa, A., Vizcaino, P., Ivits, E., Polce, C., Vandecasteele, I., Rivero, I., Guerra, C., Perpiña Castillo, C., Vallecillo, S., Baranzelli, C., Barranco, R., Batista e Silva, F., Jacobs-Crisoni, C., Trombetti, M. and Lavalle, C. (2015). *Mapping and assessment of ecosystems and their services: Trends in ecosystems and ecosystem services in the European Union between 2000 and 2010*. Luxembourg: Office for Official Publications of the European Union. ISBN 978-92-79-46206-1, doi:10.2788/341839.

Maes, J., Hauck, J., Termansen, M., Paracchini, M., Ratamäki, O., Perez-Soba, M., Kopperoinen, L., Rankinen, K., Schägner, J., Henrys, P., Cisowska, I., Zandersen, M., Jax, K., La Notte, A., Leikola, N., Pouta, E., Smart, S., Hasler, B., Lankia, T., Estrup Andersen, H., Lavalle, C., Vermaas, T., Hussen Alemu, M., Scholefield, P., Batista, F., Pywell, R., Hutchins, M., Blemmer, M., Fonnesbech-Wulff, A., Vanbergen, A., Münier, B., Baranzelli, C., Roy, D., Thieu, V., Zulian, G., Kuussaari, M., Thodsen, H., Alanen, E., Egoh, B., Borgen Sørensen, P., Braat, L. and Bidoglio, G. (2014). *A spatial assessment of ecosystem services in Europe*. Ispra: Partnership for European Environmental Research (PEER), pp.29-30. ISBN: 978-92-79-25879-4, doi: 10.2788/41831.

Maes, J., Zulian, G., Thijssen, M., Castell, C., Baró, F., Ferreira, A., Melo, J., Garrett, C., David, N., Alzetta, C., Geneletti, D., Cortinovis, C., Zwierzchowska, I., Louro Alves, F., Souto Cruz, C., Blasi, C., Alós Ortí, M., Attorre, F., Azzella, M., Capotorti, G., Copiz, R., Fusaro, L., Manes, F., Marando, F., Marchetti, M., Mollo, B., Salvatori, E., Zavattero, L., Zingari, P., Giarratano, M., Bianchi, E., Duprè, E., Barton, D., Stange, E., Perez-Soba, M., Eupen, M., Verweij, P., Vries, A., Kruse, H., Polce, C., Cugny-Seguin, M., Erhard, M., Nicolau, R., Fonseca, A., Fritz, M. and Teller, A. (2016). *Mapping and assessment of ecosystems and their services*, *Urban ecosystems- 4th Report- Final*. Luxembourg: Office for Official Publications of the European Union. ISBN 978-92-79-58515-9, doi: 10.2779/625242.

Mahato, A. (2014). Climate change and its impact on agriculture. *International Journal of Scientific and Research Publications (IJSRP)*, 4(4), pp.221-226.

Mallick, J. and Rahman, A. (2012). Impact of population density on the surface temperature and micro-climate of Delhi. *Current science*, 102(12), pp.1708-1713.

Millennium Ecosystem Assessment (2005). *Ecosystems and human well-being.* Washington, D.C.: Island Press, pp.1-2. ISBN: 1-59726-040-1

Mitchell, G., May, A. & McDonald, A. (1995). PICABUE: A Methodological Framework for the Development of Indicators of Sustainable Development. *International Journal of Sustainable Development and World Ecology*, 2, pp. 104-123.

Network of Associations of Local Authorities in South-East Europe (NALAS) (2011). *Challenges of regularization of informal settlements in South East Europe-Overview of the relevant urban planning and legalization laws and practice.* pp.2-2, ISBN: 978-608-65394-6-7.

Papageorgiou, K. and Brotherton, I. (1999). A management planning framework based on ecological, perceptual and economic carrying capacity: The case study of Vikos-Aoos National Park, Greece. *Journal of Environmental Management*, 56(4), pp.271-284.

Paracchini, M., Zulian, G., Kopperoinen, L., Maes, J., Schägner, J., Termansen, M., Zandersen, M., Perez-Soba, M., Scholefield, P. and Bidoglio, G. (2014). Mapping cultural ecosystem services: A framework to assess the potential for outdoor recreation across the EU. *Ecological Indicators*, 45, pp.371-385.

Pistocchi, A., Zulian, G., Vizcaino, P. and Marinov, D. (2010). *Multimedia Assessment of Pollutant Pathways in the Environment, European scale model*. Luxembourg: Publications Office of the European Union, pp.9-12. ISBN 978-92-79-15026-5, doi: 10.2788/63765.

Prokop, G., Jobstmann, H. and Schönbauer, A. (2011). *Overview of best practices for limiting soil sealing or mitigating its effects in EU-27*. Luxembourg: Office for Official Publications of the European Union, pp. 26-26. ISBN : 978-92-79-20669-6, doi : 10.2779/15146.

Rocha, S., Zulian, G., Maes, J. and Thijssen, M. (2015). *JRC Technical Reports: Mapping and assessment of urban ecosystems and their services*. Luxembourg: Publications Office of the European Union, pp.5-24. ISBN 978-92-79-54589-4, doi:10.2788/638737.

Solecki, W., Rosenzweig, C., Parshall, L., Pope, G., Clark, M., Cox, J. and Wiencke, M. (2005). Mitigation of the heat island effect in urban New Jersey. *Environmental Hazards*, 6(1), pp.39-49.

Stone, B. and Norman, J. (2006). Land use planning and surface heat island formation: A parcel-based radiation flux approach. *Atmospheric Environment*, 40(19), pp.3561-3573.

Sundseth, K. (2012). *The habitats directive*. Luxembourg: Office for Official Publications of the European Union. ISBN 978-92-79-23658-7, doi:10.2779/15019.

Sundseth, K. and Raeymaekers, G. (2006). *Biodiversity and NATURA 2000 in urban areas Nature in cities across Europe: a review of key issues and experiences.* Brussels: Ecosystems Ltd, pp.4-5, 21-22.
TEEB (2010). *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*. Edited by Pushpam Kumar. Earthscan, London and Washington.

Ten Brink, P., Mutafoglu, K., Schweitzer, J., Kettunen, M., Twigger-Ross, C., Baker, J., Kuipers, Y., Emonts, M., Tyrväinen, L., Hujala, T. and Ojala, A. (2016). *The health and social benefits of nature and biodiversity protection*. Luxembourg: Office for Official Publications of the European Union, pp.11-12. ISBN: 978-92-79-58421-3, doi: 10.2779/294232.

United Nations Framework Convention on Climate Change (UNFCCC) (1992). *United Nations Framework Convention on Climate Change (UNFCCC)*. New York: United Nations, General

Assembly, pp.3-3. Available at: https://unfccc.int/resource/docs/convkp/conveng.pdf [Accessed 2 Jul. 2017].

United Nations, Department of Economic and Social Affairs (2014). *World Urbanization Prospects: The 2014 Revision, Highlights*. New York: United Nations, pp.1-2. ISBN: 978-92-1-151517-6

Xu, H. (2010). Analysis of impervious surface and its impact on urban heat environment using the normalized difference impervious surface index (NDISI). *Photogrammetric Engineering and Remote Sensing, 76*(5), 557–565.

Zhang, X., Alexander, L., Hegerl, G., Jones, P., Tank, A., & Peterson, T. et al. (2011). *Indices for monitoring changes in extremes based on daily temperature and precipitation data*. Wiley Interdisciplinary Reviews: Climate Change, 2(6), 851-870. http://dx.doi.org/10.1002/wcc.147

Zhang, Y., Zhao, L., Liu, J., Liu, Y. and Li, C. (2015). The Impact of Land Cover Change on Ecosystem Service Values in Urban Agglomerations along the Coast of the Bohai Rim, China. *Sustainability*, 7(8), pp.10365-10387.

Zulian, G., Paracchini, M., Maes, J. and Liquete, C. (2013). *ESTIMAP*: *Ecosystem services mapping at European scale.* Luxembourg: Publications Office of the European Union, pp.30-31. ISBN 978-92-79-35274-4, doi: 10.2788/64369.

APPENDICES

A : ESTIMATED INDICATORS /LUZ SPATIAL LEVEL

Order No	Country	Cities/LUZ	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
1	Austria	Graz	1230.60	0.70	54.42	28.78	0.17	10.39	0.05	578.60	2.90
2	Austria	Innsbruck	2093.52	0.28	34.52	60.30	0.05	3.47	17.38	403.64	1.28
3	Austria	Linz	1744.69	1.27	22.94	59.95	0.15	11.53	4.11	569.29	3.01
4	Austria	Salzburg	1743.88	0.84	49.97	39.72	0.11	6.72	5.34	541.44	1.90
5	Austria	Wien	4618.18	2.06	26.93	56.68	0.11	10.66	45.01	356.89	4.59
6	Belgium	Antwerpen	944.40	3.40	17.95	36.08	0.23	27.86	17.46	479.83	9.58
7	Belgium	Brugge	412.28	1.48	10.23	64.89	0.24	18.16	24.57	619.55	4.02
8	Belgium	Bruxelles/Brussel	1623.95	3.78	12.82	48.37	0.34	20.89	9.07	357.36	10.86
9	Belgium	Charleroi	619.21	1.71	15.07	54.70	0.33	19.32	1.69	485.33	6.23
10	Belgium	Gent	539.89	2.55	7.77	47.79	0.23	29.87	1.75	607.39	7.32
11	Belgium	Liège	1055.98	1.56	20.24	50.34	0.39	18.30	4.74	497.94	5.91
12	Belgium	Namur	397.41	1.69	25.03	51.25	0.12	11.93	4.25	685.75	3.46
13	Bulgaria	Burgas	1396.09	0.18	29.44	62.86	0.03	6.53	28.87	459.52	1.68
14	Bulgaria	Pleven	1791.97	0.72	11.76	81.88	0.07	4.36	16.50	595.24	1.07
15	Bulgaria	Plovdiv	1226.72	0.37	31.32	57.35	0.13	9.21	16.74	311.38	3.64
16	Bulgaria	Ruse	892.61	1.35	15.55	76.19	0.08	5.89	29.40	377.31	2.19
17	Bulgaria	Sofia	3419.66	0.72	41.79	46.06	0.07	9.08	33.02	322.92	3.76
18	Bulgaria	Stara Zagora	85.48	3.33	23.95	47.03	0.13	23.63	0.02	167.59	17.32
19	Bulgaria	Varna	880.72	0.91	30.69	54.07	0.10	11.69	55.69	395.64	3.85
20	Bulgaria	Vidin	517.50	0.48	16.38	75.00	0.05	6.63	11.66	543.00	1.59
21	Cyprus	Lefkosia	2712.36	0.29	0.46	90.71	0.24	6.77	30.09	875.13	1.01
22	Czech Republic	Brno	3300.64	0.66	37.76	50.72	0.12	8.04	3.76	515.98	2.23
23	Czech Republic	Ceske Budejovice	1624.54	0.72	37.90	53.57	0.01	6.33	13.25	777.30	1.10
24	Czech Republic	Hradec Kralove	876.00	0.95	18.64	69.78	0.04	8.61	4.63	632.11	1.83
25	Czech Republic	Jihlava	1178.70	0.53	32.95	60.54	0.01	4.67	0.74	707.12	0.92
26	Czech Republic	Karlovy Vary	1621.36	1.41	47.96	45.11	0.02	4.33	59.56	921.51	0.75
27	Czech Republic	Liberec	1328.97	1.03	52.46	35.80	0.08	7.73	13.13	630.83	1.86
28	Czech Republic	Olomouc	1617.25	0.52	33.94	57.10	0.03	7.45	37.52	631.73	1.42
29	Czech Republic	Ostrava	3885.90	1.44	34.87	49.48	0.07	11.62	30.13	522.17	3.00
30	Czech Republic	Pardubice	890.91	1.21	27.82	59.54	0.03	9.11	3.72	699.76	1.81

Order No	Country	Cities/LUZ	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
31	Czech Republic	Plzen	3103.01	0.66	39.67	51.72	0.02	6.47	1.92	758.15	1.14
32	Czech Republic	Praha	6974.53	1.72	25.04	60.71	0.10	10.26	5.66	511.74	2.78
33	Czech Republic	Usti nad Labem	874.66	1.30	43.29	40.38	0.08	12.75	27.93	585.67	2.79
34	Czech Republic	Zlin	1032.07	0.68	47.78	42.38	0.03	6.91	8.40	519.60	1.89
35	Denmark	Aalborg	6165.73	1.19	12.86	76.14	0.05	7.65	14.55	1370.83	0.80
36	Denmark	Aarhus	4538.88	1.23	18.30	68.55	0.03	8.91	7.51	932.14	1.41
37	Denmark	Kobenhavn	3002.11	4.14	21.91	48.37	0.21	25.37	22.35	494.38	6.01
38	Denmark	Odense	3491.38	1.20	10.92	75.22	0.03	9.77	10.96	1025.85	1.35
39	Estonia	Tallinn	4340.43	0.61	57.33	35.08	0.05	5.32	19.10	627.19	1.21
40	Estonia	Tartu	3000.56	0.19	46.38	48.53	0.01	4.20	18.59	1020.35	0.50
41	Finland	Helsinki	3111.44	2.44	54.30	25.97	0.05	11.09	5.98	512.12	3.85
42	Finland	Oulu	3768.37	0.70	68.90	25.43	0.01	3.19	6.64	1132.17	0.50
43	Finland	Tampere	2378.05	1.36	74.79	14.56	0.04	6.24	1.00	854.40	1.25
44	Finland	Turku	1756.29	1.36	50.09	34.91	0.07	9.14	2.54	910.44	1.65
45	France	Aix-en-Provence	1293.21	0.91	18.29	62.23	0.19	13.39	42.37	757.77	2.57
46	France	Ajaccio	1015.02	0.25	14.81	78.78	0.03	4.42	3.99	851.73	0.75
47	France	Amiens	1769.08	0.84	13.82	76.62	0.05	5.96	2.33	624.68	1.53
48	France	Besancon	1668.63	0.45	46.52	43.27	0.07	7.21	18.43	766.55	1.33
49	France	Bordeaux	3890.84	1.02	56.98	25.79	0.10	12.33	5.20	724.41	2.38
50	France	Caen	1625.42	1.00	7.14	77.16	0.05	11.35	0.87	688.31	2.28
51	France	Clermont-Ferrand	1818.94	1.08	23.34	62.06	0.09	10.09	9.32	648.62	2.25
52	France	Dijon	2279.98	0.95	37.80	53.36	0.07	6.11	23.84	617.09	1.43
53	France	Grenoble	1601.27	1.04	52.99	33.31	0.10	9.02	13.73	425.95	3.21
54	France	Le Havre	641.09	2.02	7.14	67.22	0.68	18.61	10.56	553.99	4.63
55	France	Lens - Liévin	239.79	4.86	7.39	51.27	0.24	28.09	0.00	395.33	10.46
56	France	Lille	612.78	4.18	2.44	47.73	0.87	34.54	0.00	279.88	17.81
57	France	Limoges	1836.16	0.60	28.57	58.01	0.08	8.25	1.36	993.98	1.35
58	France	Lyon	3318.53	1.67	20.03	57.39	0.27	16.38	21.45	455.11	4.96
59	France	Marseille	605.93	4.30	11.97	49.16	0.28	27.91	38.84	240.24	16.18
60	France	Metz	1839.02	1.19	23.04	64.31	0.10	9.22	6.40	541.70	2.34
61	France	Montpellier	591.14	3.25	20.08	48.81	0.45	21.91	33.88	445.29	6.99
62	France	Nancy	1835.85	1.12	32.98	55.93	0.09	7.93	2.10	496.01	2.24
63	France	Nantes	2307.43	1.77	9.04	70.54	0.09	13.61	21.59	662.59	3.08
64	France	Nice	329.19	2.06	35.20	26.89	0.15	24.15	38.38	254.76	14.88
65	France	Orleans	2070.53	1.17	36.69	50.97	0.04	9.27	33.04	718.23	1.72
66	France	Paris	12068.57	3.15	24.14	52.08	0.12	15.63	10.75	262.08	9.07
67	France	Poitiers	1760.75	0.92	18.78	69.28	0.11	8.30	9.70	1004.43	1.19

Order No	Country	Cities/LUZ	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
68	France	Reims	1793.55	0.70	14.60	75.76	0.04	7.70	1.80	592.58	1.63
69	France	Rennes	2558.43	0.67	10.96	73.32	0.04	12.64	1.07	772.13	2.04
70	France	Rouen	1585.25	1.22	20.92	59.71	0.16	11.98	3.69	592.53	3.27
71	France	Saint-Etienne	570.99	2.44	27.16	47.51	0.22	17.46	6.07	376.22	6.73
72	France	Strasbourg	1368.96	1.61	20.41	61.68	0.09	13.22	14.16	400.71	4.47
73	France	Toulon	335.01	4.36	16.33	39.48	0.36	31.07	42.33	364.75	12.12
74	France	Toulouse	4040.42	0.79	11.49	70.07	0.13	13.14	1.95	772.04	2.39
75	France	Tours	1812.70	1.19	26.03	59.24	0.08	10.69	8.55	710.01	2.07
76	Germany	Augsburg	1994.43	1.10	30.70	55.11	0.09	10.30	3.21	460.52	3.08
77	Germany	Berlin	17464.26	1.52	40.67	45.88	0.03	9.34	27.97	475.82	2.83
78	Germany	Bielefeld	2924.44	1.89	21.51	56.33	0.14	16.07	11.09	503.48	4.40
79	Germany	Bonn	1294.47	2.20	33.57	41.03	0.19	18.05	15.78	373.99	6.79
80	Germany	Bremen	5897.32	1.20	15.57	70.97	0.07	9.86	11.66	643.69	2.09
81	Germany	Darmstadt	782.74	1.60	38.97	42.34	0.05	14.52	16.87	344.02	5.43
82	Germany	Dresden	2618.39	2.03	31.70	51.44	0.15	11.85	24.25	489.61	3.44
83	Germany	Dusseldorf	1201.18	4.42	16.75	44.76	0.19	29.27	3.00	304.08	12.66
84	Germany	Erfurt	2857.18	1.35	26.39	62.42	0.08	8.02	26.61	579.82	1.93
85	Germany	Essen	4438.53	5.13	21.32	39.26	0.29	27.90	6.86	326.43	12.07
86	Germany	Frankfurt (Oder)	148.32	4.05	31.68	47.69	0.46	13.67	15.36	424.52	4.86
87	Germany	Frankfurt am Main	4300.38	2.24	38.87	41.99	0.08	13.99	16.21	330.08	5.80
88	Germany	Freiburg im Breisgau	2211.18	1.19	48.76	40.29	0.06	9.70	33.89	405.37	2.70
89	Germany	Gottingen	2387.57	0.87	38.14	52.72	0.07	6.48	15.94	523.84	1.74
90	Germany	Halle an der Saale	1574.26	2.20	8.98	73.81	0.21	12.52	8.31	582.07	2.96
91	Germany	Hamburg	7211.75	2.27	20.01	61.06	0.09	13.35	13.56	442.22	4.27
92	Germany	Hannover	2973.59	2.80	24.17	56.42	0.12	13.20	9.39	449.26	4.32
93	Germany	Karlsruhe	1258.54	2.00	36.47	42.83	0.14	15.20	34.11	373.12	5.55
94	Germany	Kiel	3381.64	1.29	17.63	70.41	0.04	8.31	13.88	636.71	1.88
95	Germany	Koblenz	922.62	0.99	34.32	47.92	0.10	13.91	28.04	514.02	3.45
96	Germany	Köln	1626.38	4.82	21.63	40.53	0.32	27.79	6.36	331.78	11.40
97	Germany	Leipzig	2802.04	2.77	15.59	63.92	0.13	14.77	22.04	629.47	3.26
98	Germany	Magdeburg	4327.02	1.25	22.35	66.20	0.04	8.85	14.55	818.45	1.40
99	Germany	Mainz	703.18	1.81	15.32	65.20	0.10	15.16	23.39	363.40	5.36
100	Germany	Mönchengladbach	170.69	4.08	11.60	41.44	0.55	35.66	1.34	304.70	15.41
101	Germany	Munchen	5195.20	2.09	23.87	58.39	0.11	12.55	6.27	377.02	4.71
102	Germany	Nurnberg	2676.20	1.58	37.41	44.46	0.17	12.57	10.92	385.09	4.71
103	Germany	Regensburg	2364.90	0.65	32.71	56.35	0.08	7.80	7.54	629.29	1.74
104	Germany	Saarbrucken	1538.26	2.02	36.97	37.04	0.16	19.05	12.80	461.83	5.63

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			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
105	Germany	Schwerin	4892.08	0.66	31.23	61.63	0.02	5.21	32.33	1021.79	0.70
106	Germany	Stuttgart	3653.65	3.05	33.04	44.87	0.07	15.52	24.58	308.85	7.15
107	Germany	Trier	1211.15	0.69	47.19	40.60	0.05	9.25	11.31	623.96	1.96
108	Germany	Weimar	889.49	1.35	17.68	71.93	0.07	7.38	27.77	600.53	1.73
109	Germany	Wiesbaden	1017.73	2.06	53.28	31.03	0.12	10.81	15.64	351.11	4.47
110	Germany	Wuppertal	168.36	4.81	29.45	20.22	0.52	34.66	1.10	231.09	21.78
111	Greece	Athina	3040.45	1.54	10.06	63.07	0.22	19.12	14.84	211.85	12.68
112	Greece	Ioannina	1326.32	0.18	31.16	61.78	0.04	5.74	42.95	751.54	0.94
113	Greece	Iraklion	604.78	0.25	0.98	88.80	0.09	7.13	19.02	321.41	3.18
114	Greece	Kalamata	441.96	0.16	12.43	81.32	0.08	4.54	21.50	396.00	1.58
115	Greece	Kavala	351.48	0.25	22.74	70.13	0.04	5.81	0.00	339.71	2.10
116	Greece	Larisa	1555.69	0.15	4.09	88.42	0.09	6.50	61.33	643.58	1.16
117	Greece	Patrai	512.97	0.64	10.21	79.05	0.20	7.50	34.87	256.97	4.18
118	Greece	Thessaloniki	1425.86	0.52	12.04	73.72	0.11	11.90	31.16	213.10	6.68
119	Greece	Volos	304.29	0.39	13.93	72.21	0.15	10.89	45.60	311.64	4.45
120	Hungary	Budapest	2522.50	2.62	25.19	41.53	0.35	24.27	22.09	342.63	9.71
121	Hungary	Debrecen	1676.71	0.34	29.18	59.88	0.10	8.52	11.88	595.87	1.84
122	Hungary	Gyõr	1439.17	0.65	18.78	51.04	0.33	7.97	15.22	681.96	1.47
123	Hungary	Kecskemet	1483.05	0.43	23.28	65.78	0.21	8.68	10.78	969.17	1.13
124	Hungary	Miskolc	1006.32	0.64	34.61	53.28	0.36	8.85	44.81	432.12	2.80
125	Hungary	Nyiregyhaza	1437.65	0.28	9.36	74.30	0.20	9.15	10.38	804.81	1.54
126	Hungary	Pecs	570.66	0.66	29.56	54.92	0.13	10.62	28.30	472.84	3.28
127	Hungary	Szeged	752.92	1.08	12.75	72.90	0.25	10.34	21.64	525.57	2.73
128	Hungary	Szekesfehervar	1144.17	0.86	7.99	67.20	0.35	7.56	13.41	715.46	1.43
129	Ireland	Cork	2120.03	1.10	10.39	76.35	0.10	9.52	2.51	906.31	1.46
130	Ireland	Dublin	7016.65	2.60	9.50	75.86	0.14	9.10	11.26	687.07	2.13
131	Ireland	Galway	50.35	7.93	5.22	42.62	0.34	35.14	12.71	413.44	12.62
132	Ireland	Limerick	3523.53	0.47	15.97	75.84	0.06	6.09	18.63	1341.51	0.61
133	Ireland	Waterford	41.66	7.97	8.33	43.63	0.28	31.09	8.64	457.24	10.51
134	Italy	Ancona	408.44	1.09	3.65	75.91	0.08	15.93	5.64	408.82	5.00
135	Italy	Bari	895.61	0.66	1.07	82.60	0.18	13.81	5.56	242.17	6.74
136	Italy	Bologna	2048.31	1.04	13.19	71.39	0.05	11.50	9.47	436.81	3.53
137	Italy	Brescia	539.95	1.20	19.29	50.18	0.25	24.58	0.01	403.97	7.56
138	Italy	Cagliari	1687.54	0.47	19.74	69.10	0.06	8.71	32.88	446.90	2.50
139	Italy	Campobasso	1308.68	0.13	28.36	64.29	0.02	5.71	25.98	829.39	0.89
140	Italy	Caserta	670.80	0.46	12.74	65.44	0.11	17.17	10.81	369.83	5.90
141	Italy	Catania	587.03	0.75	3.80	66.94	0.34	21.11	8.46	301.80	9.70

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142	Italy	Catanzaro	761.40	0.19	31.94	59.71	0.04	6.25	10.08	434.86	1.92
143	Italy	Cremona	661.33	0.67	3.12	84.59	0.02	9.99	6.70	627.74	1.96
144	Italy	Firenze	1262.67	1.03	41.82	42.20	0.04	11.95	7.45	298.12	5.36
145	Italy	Foggia	1048.12	0.19	3.58	89.62	0.07	6.09	5.78	362.11	1.88
146	Italy	Genova	924.53	0.62	63.48	21.39	0.06	9.59	31.03	193.83	7.81
147	Italy	l'Aquila	1587.79	0.13	29.90	64.66	0.04	4.02	73.51	890.35	0.61
148	Italy	Milano	1345.10	4.91	2.96	50.60	1.17	32.38	1.15	210.20	22.10
149	Italy	Modena	641.95	1.32	3.28	73.87	0.07	17.90	1.03	480.97	4.75
150	Italy	Napoli	566.95	2.90	5.77	39.19	1.06	39.34	9.60	140.25	39.24
151	Italy	Padova	975.86	1.04	6.77	64.67	0.25	19.41	14.78	486.98	5.87
152	Italy	Palermo	1177.45	0.54	6.94	77.73	0.13	9.87	32.31	209.65	7.31
153	Italy	Perugia	806.02	0.73	30.14	55.45	0.10	10.29	21.31	595.44	2.42
154	Italy	Pescara	676.11	0.65	8.65	71.52	0.11	15.68	5.90	404.78	4.90
155	Italy	Potenza	1498.48	0.09	22.51	69.83	0.02	6.18	3.40	788.70	0.97
156	Italy	Reggio di Calabria	490.10	0.34	28.59	58.54	0.32	9.58	35.37	275.52	4.67
157	Italy	Roma	3595.23	2.17	16.29	56.46	0.34	16.88	14.86	297.86	9.15
158	Italy	Salerno	949.54	0.49	39.52	42.57	0.15	14.31	61.09	444.76	4.03
159	Italy	Sassari	1226.48	0.38	1.87	88.08	0.04	7.26	13.49	639.82	1.57
160	Italy	Taranto	1444.27	0.43	11.05	74.14	0.09	11.33	35.81	488.96	3.03
161	Italy	Torino	1879.30	1.83	23.81	51.92	0.14	16.53	8.17	270.73	8.96
162	Italy	Trento	779.16	0.34	66.85	22.68	0.04	7.94	2.34	463.19	2.26
163	Italy	Trieste	212.08	1.77	38.16	33.56	0.35	18.98	79.65	248.66	11.37
164	Italy	Venezia	1215.40	1.73	31.22	48.89	0.15	12.93	74.90	410.28	4.85
165	Italy	Verona	1207.95	1.11	15.24	60.70	0.12	18.86	6.02	537.80	4.47
166	Latvia	Liepaja	3657.31	0.21	49.08	47.87	0.06	2.47	7.81	817.31	0.37
167	Latvia	Riga	5391.65	1.14	57.88	32.26	0.12	6.63	11.34	517.05	1.91
168	Lithuania	Kaunas	1622.08	2.08	33.64	52.98	0.24	8.96	13.73	471.41	2.84
169	Lithuania	Panevezys	2228.22	0.34	33.94	60.24	0.03	4.95	23.07	798.51	0.73
170	Lithuania	Vilnius	4246.76	0.97	45.80	45.13	0.08	6.51	4.14	544.64	1.66
171	Luxembourg	Luxembourg	2595.87	0.72	36.99	51.60	0.07	8.65	32.15	674.26	1.69
172	Malta	Gozo	69.11	0.94	0.90	77.08	0.10	14.23	17.97	493.46	4.46
173	Malta	Valletta	246.70	1.30	0.56	63.72	0.40	28.81	15.30	243.02	14.70
174	Netherlands	Amsterdam	1172.48	5.17	30.60	36.64	0.56	23.51	28.20	275.33	11.90
175	Netherlands	Apeldoorn	625.04	2.66	39.76	41.32	0.10	12.98	44.26	561.63	3.37
176	Netherlands	Arnhem	488.22	4.09	25.68	45.96	0.15	20.37	39.49	407.08	6.97
177	Netherlands	Breda	498.12	2.71	15.68	57.20	0.14	20.02	13.93	450.82	6.02
178	Netherlands	Eindhoven	327.05	6.00	20.18	33.54	0.14	33.19	3.77	381.47	12.13

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179	Netherlands	Enschede	352.28	4.09	15.06	50.93	0.05	24.84	3.58	392.20	8.67
180	Netherlands	Groningen	938.09	2.25	7.96	74.71	0.07	12.60	5.75	485.11	3.57
181	Netherlands	Heerlen	211.57	4.65	12.21	46.39	0.32	30.02	4.40	328.01	12.62
182	Netherlands	Leeuwarden	452.06	2.06	4.88	77.71	0.11	13.24	5.13	505.99	3.44
183	Netherlands	Nijmegen	317.57	5.00	18.30	48.78	0.16	22.50	10.47	386.35	8.52
184	Netherlands	Rotterdam	708.66	7.10	20.51	29.17	1.85	35.96	6.83	304.29	16.54
185	Netherlands	s' Gravenhage	419.88	10.25	7.59	30.13	0.36	45.09	7.77	274.19	22.72
186	Netherlands	Tilburg	388.73	4.48	20.91	49.02	0.09	21.56	9.21	413.36	7.27
187	Netherlands	Utrecht	389.74	6.52	15.71	42.08	0.76	27.67	6.51	303.73	13.90
188	Poland	Bialystok	5114.54	0.31	37.93	55.64	0.05	5.29	63.59	627.30	1.03
189	Poland	Bydgoszcz	3404.09	0.65	34.57	57.86	0.04	6.05	9.72	441.82	1.71
190	Poland	Czestochowa	2569.54	0.43	32.18	56.85	0.05	8.11	2.74	599.45	1.83
191	Poland	Gdansk	3339.02	1.14	31.05	56.46	0.06	9.79	9.44	379.53	3.29
192	Poland	Gorzow Wielkopolski	1305.39	0.82	47.30	45.38	0.03	5.41	46.86	506.19	1.45
193	Poland	Jelenia Gora	585.65	0.95	46.32	42.98	0.04	6.86	52.17	487.21	2.20
194	Poland	Kalisz	3103.56	0.32	24.09	67.56	0.02	6.95	20.49	633.59	1.32
195	Poland	Katowice	2636.50	3.70	30.74	39.29	0.20	22.26	0.82	287.84	10.41
196	Poland	Kielce	2355.93	0.45	38.02	52.35	0.01	7.05	19.26	556.72	1.73
197	Poland	Konin	758.43	0.58	22.80	66.21	0.03	9.38	32.51	583.75	1.88
198	Poland	Koszalin	1751.06	0.58	48.30	46.42	0.02	4.05	19.55	539.69	0.98
199	Poland	Kraków	3006.27	1.26	18.12	63.18	0.14	13.30	5.66	447.17	4.18
200	Poland	Lodz	2858.23	1.07	21.43	63.55	0.10	11.36	1.51	364.42	4.12
201	Poland	Lublin	2882.37	0.73	14.07	74.63	0.04	8.38	0.50	499.55	2.26
202	Poland	Nowy Sacz	448.35	0.45	38.85	44.12	0.10	12.63	21.32	488.13	3.49
203	Poland	Olsztyn	2930.03	0.45	46.73	48.15	0.00	4.17	23.01	528.36	0.97
204	Poland	Opole	1693.23	0.49	47.59	44.11	0.06	6.36	7.18	527.60	1.57
205	Poland	Plock	1885.46	0.33	22.88	69.00	0.06	6.90	8.28	654.95	1.24
206	Poland	Poznan	3717.58	1.62	23.33	64.23	0.15	9.10	21.03	457.50	2.72
207	Poland	Radom	1630.67	0.38	25.64	64.18	0.03	8.17	28.86	446.02	2.28
208	Poland	Rzeszow	1273.58	0.66	27.51	57.08	0.16	10.64	11.76	595.21	2.59
209	Poland	Suwalki	618.33	0.34	27.62	65.58	0.02	6.05	51.91	510.99	1.33
210	Poland	Szczecin	6045.73	0.73	37.51	56.25	0.02	4.79	50.05	484.46	1.29
211	Poland	Torun	1347.17	0.94	35.32	55.01	0.08	8.12	11.93	443.22	2.18
212	Poland	Warszawa	5201.72	1.39	29.70	51.69	0.14	14.82	11.86	367.71	5.06
213	Poland	Wroclaw	4584.81	1.10	22.46	67.16	0.04	8.02	18.28	461.72	2.25
214	Poland	Zielona Gora	1627.00	0.73	55.68	37.42	0.02	5.15	15.04	544.36	1.27
215	Portugal	Aveiro	273.35	1.19	26.83	49.93	0.27	16.92	87.02	574.90	4.04

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216	Portugal	Braga	493.81	0.83	22.75	54.45	0.32	14.72	3.22	491.26	4.64
217	Portugal	Coimbra	1252.95	0.41	52.02	35.47	0.09	8.15	5.20	648.59	1.93
218	Portugal	Faro	482.17	0.28	13.02	75.75	0.14	9.20	56.94	497.67	2.26
219	Portugal	Funchal	260.95	1.35	38.85	37.26	0.41	16.72	22.48	NoData	NoData
220	Portugal	Lisboa	1437.11	3.10	10.30	53.47	0.85	26.26	29.08	220.47	16.43
221	Portugal	Oporto	563.17	3.33	26.13	26.42	0.90	34.39	2.62	245.46	19.33
222	Portugal	Ponta Delgada	537.14	0.39	16.42	72.68	0.09	7.97	2.39	NoData	NoData
223	Portugal	Setubal	172.83	1.28	18.95	56.44	0.23	19.21	68.28	374.24	6.58
224	Romania	Alba Iulia	258.81	0.46	19.34	68.86	0.05	9.48	5.52	293.18	4.02
225	Romania	Arad	519.78	0.47	5.68	81.58	0.04	10.20	6.16	321.22	3.97
226	Romania	Bacau	220.78	0.77	32.43	48.39	0.23	15.87	14.79	186.63	10.28
227	Romania	Braila	436.03	0.41	17.76	73.43	0.04	7.51	31.50	161.23	5.46
228	Romania	Bucuresti	1074.35	1.66	12.80	57.59	0.48	25.37	6.45	149.19	19.84
229	Romania	Calarasi	245.78	0.24	8.63	82.62	0.03	7.81	14.35	243.95	3.58
230	Romania	Cluj Napoca	591.68	0.37	18.01	70.23	0.08	9.77	15.09	199.25	5.90
231	Romania	Craiova	341.31	0.89	13.88	68.04	0.16	15.06	12.92	187.84	9.62
232	Romania	Giurgiu	111.00	0.38	16.43	67.79	0.08	14.44	27.30	234.47	6.73
233	Romania	Oradea	201.11	0.83	12.54	61.08	0.23	22.42	6.38	227.06	11.62
234	Romania	Piatra Neamt	146.71	0.31	36.28	46.26	0.10	14.11	29.54	184.87	9.44
235	Romania	Sibiu	588.13	0.36	52.71	39.31	0.04	6.86	70.02	235.67	3.39
236	Romania	Targu Mures	141.35	1.09	18.03	59.15	0.06	19.48	4.48	171.73	13.28
237	Romania	Timisoara	236.84	1.59	5.48	64.21	0.39	24.34	7.48	217.14	13.96
238	Slovakia	Banska Bystrica	808.87	0.55	68.75	25.19	0.04	4.80	58.87	435.77	1.39
239	Slovakia	Bratislava	2046.23	0.95	41.11	46.06	0.09	9.67	46.40	425.28	3.01
240	Slovakia	Kosice	1776.13	0.80	44.32	46.35	0.05	6.98	61.02	476.77	1.96
241	Slovakia	Nitra	870.21	0.81	11.61	77.45	0.10	7.86	7.98	582.56	1.88
242	Slovakia	Presov	934.56	0.53	45.33	46.10	0.03	6.29	20.38	494.47	1.73
243	Slovakia	Trencin	674.03	0.44	50.45	40.63	0.06	7.13	6.07	527.72	1.69
244	Slovakia	Trnava	740.92	0.79	18.80	70.84	0.02	7.87	39.61	607.50	1.71
245	Slovakia	Zilina	813.91	0.58	61.15	29.25	0.04	7.61	58.42	497.58	1.93
246	Slovenia	Ljubljana	2555.42	0.34	61.83	27.51	0.06	7.57	31.11	557.91	1.91
247	Slovenia	Maribor	2170.60	0.26	43.74	45.73	0.05	7.56	35.26	735.28	1.43
248	Spain	Alicante/Alacant	674.98	1.93	4.38	73.67	0.11	16.62	10.96	380.23	5.77
249	Spain	Badajoz	1470.34	0.26	2.02	92.12	0.05	4.57	12.57	645.75	0.91
250	Spain	Barcelona	1800.69	2.73	31.45	33.30	0.52	32.00	27.27	159.22	22.14
251	Spain	Bilbao	983.16	1.39	47.58	36.51	0.16	11.03	10.26	167.74	9.48
252	Spain	Cordoba	1255.22	0.36	2.45	89.80	0.14	5.17	15.79	316.13	2.45

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253	Spain	Gijón	526.01	1.04	28.93	52.16	0.13	12.15	2.68	342.34	5.52
254	Spain	Las Palmas	876.81	0.55	8.24	76.75	0.32	11.19	48.44	223.02	6.73
255	Spain	Logrono	1437.03	0.44	29.81	63.65	0.02	5.27	39.00	587.83	1.11
256	Spain	Madrid	8022.04	1.93	8.22	75.76	0.10	11.43	62.88	236.99	6.76
257	Spain	Malaga	944.30	1.06	7.68	75.57	0.19	12.50	0.39	241.07	6.95
258	Spain	Murcia	1324.59	0.55	9.70	75.79	0.10	10.65	25.95	431.79	3.36
259	Spain	Oviedo	2343.82	0.30	29.28	63.08	0.01	4.97	44.97	573.38	1.33
260	Spain	Palma di Mallorca	2172.92	0.96	15.76	72.13	0.09	8.25	23.94	495.97	2.44
261	Spain	Pamplona/Iruna	4382.23	0.32	40.78	55.44	0.02	3.09	24.96	495.14	0.76
262	Spain	Santa Cruz de Tenerife	609.29	0.58	18.21	61.60	0.21	15.37	79.81	286.90	7.04
263	Spain	Santander	594.09	1.60	26.74	56.45	0.23	11.91	2.05	356.55	4.71
264	Spain	Sant. de Compostela	1351.65	0.36	48.63	38.65	0.04	7.42	0.60	953.62	1.33
265	Spain	Sevilla	3076.17	0.77	4.60	83.06	0.18	9.95	18.55	317.39	3.89
266	Spain	Toledo	3616.35	0.13	5.30	90.44	0.03	3.57	56.03	976.50	0.44
267	Spain	Valencia	1447.66	1.28	5.85	69.86	0.36	17.95	32.49	240.71	10.09
268	Spain	Valladolid	3036.73	0.47	13.49	79.23	0.24	5.66	7.25	528.11	1.38
269	Spain	Vigo	1430.62	1.04	34.29	47.60	0.20	10.85	2.51	489.88	3.70
270	Spain	Vitoria/Gasteiz	2314.43	0.34	39.29	54.84	0.02	4.93	32.55	557.42	1.05
271	Spain	Zaragoza	2288.99	0.55	3.71	86.64	0.24	7.91	51.41	336.28	2.87
272	Sweden	Goteborg	4221.38	1.89	63.54	22.02	0.04	7.60	4.87	715.35	2.02
273	Sweden	Jönköping	3473.32	0.59	76.67	17.89	0.02	3.39	17.53	1295.87	0.42
274	Sweden	Linköping	4231.93	0.65	66.13	28.28	0.01	3.66	2.32	1314.71	0.43
275	Sweden	Malmö	1857.91	3.34	10.83	70.73	0.14	10.03	5.71	638.36	2.89
276	Sweden	Örebro	3687.77	0.58	67.80	25.97	0.00	3.73	1.30	1301.91	0.48
277	Sweden	Stockholm	7162.39	2.50	65.59	18.60	0.05	6.49	2.65	621.56	2.54
278	Sweden	Umeå	9812.10	0.13	85.65	11.70	0.01	1.73	7.62	1903.91	0.14
279	Sweden	Uppsala	6879.40	0.43	71.39	23.77	0.01	2.92	4.47	1368.94	0.35
280	United Kingdom	Aberdeen	6527.72	0.71	15.54	78.70	0.01	4.26	21.38	855.34	0.67
281	United Kingdom	Belfast	960.47	3.86	4.94	67.00	0.19	19.25	0.88	417.00	6.73
282	United Kingdom	Birmingham	1598.11	6.74	4.79	49.03	0.27	28.48	0.02	315.98	14.61
283	United Kingdom	Bristol	1335.71	4.44	7.26	64.45	0.14	17.00	1.59	383.80	7.37
284	United Kingdom	Cambridge	942.73	2.70	3.17	81.72	0.02	8.53	0.07	596.07	2.53
285	United Kingdom	Cardiff	1181.38	4.84	15.61	57.71	0.32	16.41	0.52	381.51	6.99
286	United Kingdom	Coventry	814.64	4.70	4.21	67.27	0.08	17.21	0.00	366.72	7.78
287	United Kingdom	Derry	387.51	1.60	6.61	79.77	0.02	10.06	0.94	502.18	2.71
288	United Kingdom	Edinburgh	1742.29	3.54	10.00	72.12	0.04	11.14	1.22	400.04	4.47
289	United Kingdom	Exeter	2452.60	1.17	12.94	75.08	0.03	8.31	2.46	688.37	1.74

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			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
290	United Kingdom	Glasgow	3376.50	3.51	15.52	64.94	0.14	12.31	3.68	377.16	5.18
291	United Kingdom	Kingston-upon-Hull	2495.69	1.60	3.31	84.73	0.05	8.02	2.66	535.19	2.23
292	United Kingdom	Leeds	5123.07	2.78	5.91	76.02	0.12	11.64	18.85	392.13	4.61
293	United Kingdom	Leicester	1397.45	3.36	3.87	75.15	0.11	12.63	0.00	387.69	5.41
294	United Kingdom	Lincoln	723.78	1.54	5.09	80.99	0.08	9.03	0.00	612.82	2.27
295	United Kingdom	Liverpool	646.01	13.19	3.48	34.56	0.29	37.89	5.29	293.93	21.08
296	United Kingdom	London	9094.34	7.85	12.45	49.15	0.05	20.45	3.54	300.46	12.78
297	United Kingdom	Manchester	1276.90	10.47	4.67	37.98	0.74	34.60	6.34	294.98	19.44
298	United Kingdom	Newcastle upon Tyne	3391.38	1.83	19.07	69.18	0.21	7.79	15.74	381.41	3.08
299	United Kingdom	Nottingham	903.69	4.86	7.08	62.01	0.20	18.79	0.00	343.37	9.00
300	United Kingdom	Portsmouth	198.76	9.61	7.23	28.02	0.13	37.82	5.12	263.85	24.54
301	United Kingdom	Sheffield	1866.80	3.84	9.21	65.97	0.08	14.19	35.25	366.30	6.78
302	United Kingdom	Stoke-on-trent	880.87	4.18	7.63	70.35	0.22	12.96	6.21	424.44	5.19
303	United Kingdom	Wolverhampton	477.13	3.06	8.94	64.13	0.08	17.95	0.09	375.34	7.18
304	United Kingdom	Worcester	1274.87	1.77	7.57	78.29	0.02	9.07	0.28	646.67	2.19
305	United Kingdom	Wrexham	943.48	1.63	9.51	72.98	0.07	12.40	12.87	596.29	2.94

B : ESTIMATED INDICATORS /CORE (OR KERNEL) SPATIAL LEVEL

Order ID	Country	Cities/LUZ	Core or Kernel	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
				Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
1	Austria	Graz	core	127.43	3.61	26.63	16.56	0.85	33.49	0.15	321.23	17.68
2	Austria	Innsbruck	core	104.83	1.91	31.25	45.99	0.19	15.75	47.55	211.56	10.76
3	Austria	Linz	core	96.05	8.16	22.54	21.10	0.56	39.01	7.12	291.98	19.30
4	Austria	Salzburg	core	65.61	7.53	17.32	24.89	0.80	36.37	0.11	266.58	21.68
5	Austria	Wien	core	414.85	11.45	21.82	17.03	0.51	38.23	13.44	163.87	37.32
6	Belgium	Antwerpen	core	203.92	5.13	20.54	12.19	0.38	55.80	12.21	306.51	21.95
7	Belgium	Brugge	core	139.19	2.84	16.09	41.37	0.65	32.11	19.77	505.99	8.41
8	Belgium	Bruxelles/Brussel	core	162.47	12.44	12.08	2.73	0.45	56.44	14.32	142.43	59.81
9	Belgium	Charleroi	core	102.97	5.85	11.42	14.25	1.30	49.89	0.00	381.95	19.46
10	Belgium	Gent	core	157.85	3.46	8.56	26.58	0.53	48.37	0.41	454.46	14.27
11	Belgium	Liège	core	178.52	5.11	16.45	19.89	1.05	42.97	2.38	317.02	20.08
12	Belgium	Namur	core	176.13	2.43	25.53	40.49	0.19	17.52	3.84	568.67	5.98
13	Bulgaria	Burgas	core	255.37	0.83	24.32	58.34	0.03	15.31	43.59	222.72	7.78
14	Bulgaria	Pleven	core	85.11	10.44	16.08	51.18	0.14	20.54	8.67	231.28	14.16
15	Bulgaria	Plovdiv	core	101.89	3.72	3.00	49.67	0.94	39.63	8.54	139.77	33.86
16	Bulgaria	Ruse	core	129.65	7.35	18.71	51.86	0.23	20.27	4.93	229.35	12.83
17	Bulgaria	Sofia	core	450.02	4.13	23.54	34.77	0.31	32.31	13.04	165.59	25.18
18	Bulgaria	Stara Zagora	core	85.15	3.33	23.95	47.03	0.13	23.63	0.01	167.59	17.31
19	Bulgaria	Varna	core	154.00	4.21	39.18	15.97	0.35	32.73	38.13	239.41	18.73
20	Bulgaria	Vidin	core	63.35	2.18	7.70	67.53	0.15	19.82	7.38	259.00	9.57
21	Cyprus	Lefkosia	core	205.86	2.53	0.57	57.32	2.30	29.93	0.00	432.08	9.75
22	Czech Republic	Brno	core	230.21	3.89	29.93	28.02	0.45	30.10	5.40	257.39	16.34
23	Czech Republic	Ceske Budejovice	core	55.61	6.15	13.70	39.67	0.05	36.40	19.27	267.09	17.46
24	Czech Republic	Hradec Kralove	core	105.70	4.10	25.13	42.39	0.20	24.36	4.66	352.32	9.22
25	Czech Republic	Jihlava	core	87.87	2.96	32.08	47.16	0.05	15.19	2.71	360.55	5.76
26	Czech Republic	Karlovy Vary	core	59.10	25.94	29.90	20.55	0.09	19.60	7.87	550.51	9.00
27	Czech Republic	Liberec	core	106.06	5.23	44.83	20.05	0.38	23.12	0.01	375.40	9.36
28	Czech Republic	Olomouc	core	103.34	3.45	13.75	54.31	0.16	26.17	13.80	321.93	9.92
29	Czech Republic	Ostrava	core	303.78	5.44	20.34	32.41	0.09	25.21	5.98	440.79	10.72
30	Czech Republic	Pardubice	core	82.66	6.08	14.69	47.09	0.10	28.06	0.82	347.71	10.99
31	Czech Republic	Plzen	core	137.65	4.90	24.48	39.09	0.09	28.07	0.17	301.96	12.07
32	Czech Republic	Praha	core	533.30	11.49	12.83	32.65	0.35	38.33	1.86	234.79	23.22
33	Czech Republic	Usti nad Labem	core	93.97	4.17	40.96	26.91	0.26	23.26	0.00	316.00	10.17
34	Czech Republic	Zlin	core	118.89	2.35	45.39	32.50	0.09	15.13	0.00	325.41	6.80
35	Denmark	Aalborg	core	1141.30	1.45	10.29	74.76	0.07	10.15	18.11	894.62	1.67

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36	Denmark	Aarhus	core	472.45	4.13	8.22	60.73	0.10	20.03	2.21	510.62	6.08
37	Denmark	Kobenhavn	kernel	527.54	9.35	9.77	24.92	0.60	44.29	11.02	298.45	21.88
38	Denmark	Odense	core	305.12	5.24	7.63	57.86	0.06	22.62	1.31	573.34	6.02
39	Estonia	Tallinn	core	159.47	9.26	27.06	8.39	0.66	44.14	7.10	257.11	25.10
40	Estonia	Tartu	core	38.89	6.79	7.85	24.48	0.28	51.59	2.54	260.21	26.01
41	Finland	Helsinki	kernel	783.89	6.02	42.78	15.09	0.14	22.64	4.40	346.75	12.15
42	Finland	Oulu	core	1445.58	4.19	65.62	14.92	0.02	9.08	17.29	676.08	2.88
43	Finland	Tampere	core	689.54	2.81	75.67	9.39	0.06	8.53	0.16	526.50	2.84
44	Finland	Turku	core	248.44	5.03	37.06	28.67	0.12	20.44	5.16	494.57	6.93
45	France	Aix-en-Provence	core	1293.29	0.91	18.29	62.23	0.19	13.39	42.37	757.77	2.57
46	France	Ajaccio	core	270.45	0.46	3.76	83.44	0.07	10.05	6.96	549.12	2.33
47	France	Amiens	core	313.21	2.69	14.16	63.82	0.15	14.82	3.99	392.42	5.61
48	France	Besancon	core	434.01	1.31	45.20	34.52	0.17	14.23	15.22	515.75	3.93
49	France	Bordeaux	core	550.43	4.94	27.56	19.67	0.36	38.94	11.10	440.03	11.99
50	France	Caen	core	185.59	4.30	2.66	50.92	0.18	36.17	0.00	395.79	11.73
51	France	Clermont-Ferrand	core	302.75	4.21	23.99	39.43	0.26	26.37	5.87	402.12	9.10
52	France	Dijon	core	219.94	5.24	18.09	42.23	0.39	28.50	5.54	358.56	11.07
53	France	Grenoble	core	311.79	3.21	44.48	21.94	0.23	23.51	0.22	268.45	12.51
54	France	Le Havre	core	199.69	5.46	8.00	44.16	1.27	35.08	2.49	374.34	12.78
55	France	Lens - Liévin	core	239.69	4.86	7.39	51.27	0.24	28.09	0.00	395.58	10.46
56	France	Lille	core	612.47	4.18	2.44	47.73	0.87	34.54	0.00	279.88	17.81
57	France	Limoges	core	475.19	1.71	22.34	52.55	0.17	15.46	0.00	636.46	3.94
58	France	Lyon	core	519.99	6.16	13.51	25.20	0.84	44.18	3.74	266.43	23.00
59	France	Marseille	core	605.05	4.30	11.97	49.16	0.28	27.91	38.76	240.30	16.18
60	France	Metz	core	277.18	4.80	20.72	49.29	0.26	20.28	2.17	375.38	7.99
61	France	Montpellier	core	438.62	3.19	15.72	51.04	0.50	23.62	21.71	396.84	8.37
62	France	Nancy	core	143.11	7.46	23.86	24.68	0.78	36.57	1.79	285.36	18.03
63	France	Nantes	core	535.01	5.03	11.42	44.62	0.25	28.87	25.93	424.01	10.37
64	France	Nice	core	459.13	2.06	35.20	26.89	0.15	24.15	38.46	254.76	14.91
65	France	Orleans	core	336.10	3.44	26.91	36.61	0.16	27.22	11.89	460.23	7.93
66	France	Paris	kernel	762.64	13.08	6.40	3.54	0.48	66.48	1.52	111.44	80.81
67	France	Poitiers	core	253.02	2.50	21.08	49.35	0.27	26.80	8.78	596.86	4.95
68	France	Reims	core	87.98	7.59	2.23	35.94	0.48	48.97	0.61	253.92	24.35
69	France	Rennes	core	613.66	2.05	4.77	66.69	0.09	22.64	0.11	480.10	5.94
70	France	Rouen	core	663.49	2.80	33.04	35.01	0.30	21.35	10.15	362.21	8.82
71	France	Saint-Etienne	core	570.68	2.44	27.16	47.51	0.22	17.46	6.07	376.22	6.73
72	France	Strasbourg	core	315.86	5.02	19.86	40.47	0.21	29.51	19.39	276.91	14.33

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73	France	Toulon	core	371.51	4.36	16.33	39.48	0.36	31.07	42.20	378.00	12.12
74	France	Toulouse	core	461.18	3.71	8.94	36.12	0.55	40.35	2.83	412.11	13.33
75	France	Tours	core	340.03	4.20	21.91	42.71	0.22	24.43	7.67	445.83	7.94
76	Germany	Augsburg	core	146.46	4.11	34.23	25.16	0.15	33.68	9.03	409.62	9.91
77	Germany	Berlin	core	1079.20	11.78	25.43	11.76	0.15	38.57	10.72	192.57	32.62
78	Germany	Bielefeld	core	259.10	5.35	20.67	36.94	0.16	28.75	3.66	341.61	12.41
79	Germany	Bonn	core	176.12	6.16	29.01	17.94	0.30	37.56	31.30	261.39	20.29
80	Germany	Bremen	core	325.40	9.95	8.19	35.16	0.26	39.91	30.86	345.97	16.37
81	Germany	Darmstadt	core	123.35	4.15	49.31	18.66	0.10	24.75	25.68	284.48	11.26
82	Germany	Dresden	core	328.01	6.85	24.06	31.03	0.52	31.73	10.69	307.79	14.59
83	Germany	Dusseldorf	core	316.44	8.25	16.51	28.46	0.28	40.26	3.56	242.32	22.71
84	Germany	Erfurt	core	271.04	4.62	9.95	61.87	0.24	20.48	23.34	380.57	7.41
85	Germany	Essen	core	1889.26	8.69	16.45	25.87	0.45	39.81	2.54	288.19	20.01
86	Germany	Frankfurt (Oder)	core	147.82	4.05	31.68	47.69	0.46	13.67	15.29	424.52	4.86
87	Germany	Frankfurt am Main	core	370.77	10.30	25.37	20.40	0.30	39.32	5.72	236.33	22.95
88	Germany	Freiburg im Breisgau	core	154.32	5.31	43.71	25.84	0.15	21.98	40.61	404.87	13.25
89	Germany	Gottingen	core	116.75	4.94	32.17	37.40	0.44	22.07	19.48	286.23	10.63
90	Germany	Halle an der Saale	core	135.77	10.65	13.91	34.94	0.73	33.41	20.02	280.26	18.25
91	Germany	Hamburg	core	753.16	10.49	12.22	25.87	0.26	43.67	11.45	266.09	23.26
92	Germany	Hannover	core	204.09	20.65	10.47	16.62	0.81	45.48	4.34	288.33	25.29
93	Germany	Karlsruhe	core	174.08	7.13	32.30	21.98	0.46	32.18	41.66	285.37	16.02
94	Germany	Kiel	core	112.26	12.33	11.50	27.31	0.18	39.97	1.23	293.20	20.87
95	Germany	Koblenz	core	106.02	4.34	36.86	25.98	0.38	27.11	21.23	363.49	10.22
96	Germany	Köln	core	568.83	10.41	20.50	21.67	0.51	39.94	11.51	267.02	21.66
97	Germany	Leipzig	core	298.75	14.53	6.36	37.26	0.57	35.16	18.00	342.04	16.48
98	Germany	Magdeburg	core	200.59	10.67	9.69	46.78	0.32	28.14	12.21	375.35	11.60
99	Germany	Mainz	core	97.66	4.98	6.38	46.33	0.33	37.13	13.14	253.49	18.66
100	Germany	Mönchengladbach	core	170.94	4.08	11.60	41.44	0.55	35.66	1.28	304.79	15.41
101	Germany	Munchen	core	311.28	12.67	5.56	18.12	0.65	51.78	4.48	196.44	38.86
102	Germany	Nurnberg	core	325.39	7.15	17.71	27.39	0.56	38.93	11.84	252.49	21.74
103	Germany	Regensburg	core	79.68	5.79	9.66	35.16	0.32	41.41	3.12	350.41	15.75
104	Germany	Saarbrucken	core	168.88	5.56	48.41	14.15	0.22	26.22	17.85	344.01	10.88
105	Germany	Schwerin	core	129.93	6.27	46.47	25.12	0.09	19.53	32.81	361.23	7.87
106	Germany	Stuttgart	core	350.44	8.92	26.63	22.66	0.11	35.46	8.46	216.01	23.48
107	Germany	Trier	core	116.13	2.73	46.02	24.54	0.33	21.62	5.18	344.54	8.54
108	Germany	Weimar	core	84.42	8.03	19.47	49.97	0.24	18.44	40.52	413.10	7.40
109	Germany	Wiesbaden	core	203.82	6.30	31.35	31.42	0.38	25.66	22.03	280.48	13.28

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110	Germany	Wuppertal	core	168.48	4.81	29.45	20.22	0.52	34.66	1.10	231.51	21.78
111	Greece	Athina	kernel	370.01	7.50	4.29	23.88	0.39	51.58	21.07	89.00	80.71
112	Greece	Ioannina	core	48.40	1.80	14.19	52.79	0.47	25.95	97.35	218.20	15.13
113	Greece	Iraklion	core	108.81	0.54	0.13	76.60	0.27	16.46	1.31	179.51	12.96
114	Greece	Kalamata	core	254.56	0.25	16.04	76.25	0.13	5.48	37.85	317.33	2.43
115	Greece	Kavala	core	111.98	0.55	8.94	79.55	0.05	9.95	0.01	198.68	5.79
116	Greece	Larisa	core	122.62	1.14	1.86	71.38	0.72	23.03	14.84	244.41	10.95
117	Greece	Patrai	core	126.35	1.37	4.57	74.85	0.51	15.38	36.09	152.27	13.51
118	Greece	Thessaloniki	core	18.32	8.10	2.18	0.75	0.89	82.70	0.00	43.47	223.32
119	Greece	Volos	core	26.81	1.83	1.07	48.44	0.65	48.02	0.00	155.49	32.47
120	Hungary	Budapest	core	525.27	6.84	12.60	18.02	0.67	51.71	6.31	205.32	33.79
121	Hungary	Debrecen	core	461.67	1.02	31.86	49.50	0.32	14.26	8.16	407.72	4.57
122	Hungary	Gyõr	core	174.60	3.69	24.20	65.79	0.06	23.25	17.47	407.26	7.41
123	Hungary	Kecskemet	core	321.45	1.38	18.14	58.32	0.07	17.88	2.82	703.19	3.35
124	Hungary	Miskolc	core	236.60	1.47	51.12	27.14	0.79	16.75	73.88	279.48	7.78
125	Hungary	Nyiregyhaza	core	274.57	0.80	13.28	65.77	0.04	18.91	2.51	574.53	4.33
126	Hungary	Pecs	core	162.72	1.30	37.12	29.47	0.43	23.60	36.50	335.16	9.97
127	Hungary	Szeged	core	281.02	2.60	16.09	62.00	0.55	14.93	10.32	365.91	5.99
128	Hungary	Szekesfehervar	core	170.89	2.45	11.49	78.30	0.08	19.69	3.45	398.78	6.22
129	Ireland	Cork	core	39.62	10.68	5.00	8.27	1.60	56.98	0.62	282.57	30.69
130	Ireland	Dublin	kernel	925.58	10.32	4.02	50.02	0.67	26.67	6.60	386.26	11.90
131	Ireland	Galway	core	50.72	7.93	5.22	42.62	0.34	35.14	12.71	413.55	12.62
132	Ireland	Limerick	core	19.48	7.53	4.26	17.69	2.17	53.45	8.61	289.03	27.00
133	Ireland	Waterford	core	41.66	7.97	8.33	43.63	0.28	31.09	8.64	457.80	10.51
134	Italy	Ancona	core	124.61	1.84	8.11	67.41	0.08	18.23	18.39	304.14	8.05
135	Italy	Bari	core	116.20	2.95	0.11	47.97	0.75	41.04	0.00	190.92	27.20
136	Italy	Bologna	core	140.85	5.94	6.62	41.49	0.11	36.93	4.95	197.08	26.33
137	Italy	Brescia	core	90.39	2.83	17.50	28.08	0.60	43.46	0.00	262.27	20.75
138	Italy	Cagliari	core	83.76	3.94	42.88	22.00	0.44	26.75	98.97	249.82	14.06
139	Italy	Campobasso	core	55.85	1.02	11.16	55.11	0.35	22.33	3.66	371.56	9.08
140	Italy	Caserta	core	53.73	2.61	20.82	44.43	0.16	24.51	8.06	248.99	13.95
141	Italy	Catania	core	181.67	1.01	0.74	64.63	0.28	28.80	21.19	201.45	17.19
142	Italy	Catanzaro	core	111.69	0.53	10.02	69.40	0.11	15.12	0.00	240.93	8.54
143	Italy	Cremona	core	70.54	3.32	2.34	64.24	0.12	25.95	1.22	333.33	10.02
144	Italy	Firenze	core	102.32	6.86	6.60	34.01	0.08	41.09	0.18	170.66	34.80
145	Italy	Foggia	core	505.90	0.29	0.51	89.73	0.13	9.34	2.17	317.66	3.07
146	Italy	Genova	core	239.90	1.41	36.47	31.27	0.13	22.72	32.70	127.30	25.34

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147	Italy	l'Aquila	core	476.86	0.28	23.12	68.03	0.10	6.59	72.35	611.94	1.45
148	Italy	Milano	kernel	1346.47	4.91	2.96	50.60	1.17	32.38	1.15	210.20	22.09
149	Italy	Modena	core	183.24	2.79	1.98	64.85	0.09	25.11	0.40	346.20	9.58
150	Italy	Napoli	kernel	1071.27	2.90	5.77	39.19	1.06	39.34	9.60	140.25	39.24
151	Italy	Padova	core	93.00	3.80	1.68	3.67	0.54	4.20	0.08	273.78	21.85
152	Italy	Palermo	core	160.12	3.35	8.95	41.92	0.45	32.60	39.58	114.48	42.92
153	Italy	Perugia	core	449.02	0.91	22.61	60.42	0.12	11.68	4.54	514.25	3.30
154	Italy	Pescara	core	34.03	4.27	2.71	30.30	0.75	51.15	0.00	195.41	34.28
155	Italy	Potenza	core	174.16	0.32	9.75	73.70	0.09	12.32	0.85	417.87	3.96
156	Italy	Reggio di Calabria	core	236.99	0.58	19.80	62.63	0.60	13.18	8.26	231.99	7.58
157	Italy	Roma	core	1285.97	4.51	10.15	51.15	0.62	26.05	8.51	205.33	18.84
158	Italy	Salerno	core	59.50	1.87	22.53	38.29	0.56	29.71	0.04	170.77	22.95
159	Italy	Sassari	core	547.07	0.29	1.26	85.81	0.06	8.53	3.13	655.22	1.97
160	Italy	Taranto	core	253.00	1.44	8.85	66.25	0.19	20.80	8.31	344.22	7.23
161	Italy	Torino	core	130.08	10.80	10.51	9.71	1.05	57.06	2.94	120.49	66.21
162	Italy	Trento	core	157.90	0.78	52.87	26.59	0.15	16.00	6.34	308.78	6.65
163	Italy	Trieste	core	84.81	3.31	33.90	22.56	0.35	29.45	52.56	174.56	24.94
164	Italy	Venezia	core	159.38	4.91	5.94	44.73	0.47	36.09	17.59	306.84	16.08
165	Italy	Verona	core	198.96	2.19	12.01	50.53	0.23	29.49	4.69	295.05	12.70
166	Latvia	Liepaja	core	61.01	6.17	35.03	22.17	2.43	30.94	22.74	291.11	14.70
167	Latvia	Riga	core	304.16	11.55	31.42	12.16	1.26	36.08	6.13	223.99	25.19
168	Lithuania	Kaunas	core	156.98	16.04	16.69	16.07	2.00	42.17	10.75	279.19	24.08
169	Lithuania	Panevezys	core	50.18	5.70	4.22	38.12	0.48	48.36	0.00	243.29	23.70
170	Lithuania	Vilnius	core	400.58	7.33	35.65	23.68	0.57	27.57	2.22	294.59	13.81
171	Luxembourg	Luxembourg	core	51.74	4.76	28.53	21.80	1.12	37.19	14.33	334.25	14.86
172	Malta	Gozo	core	69.11	0.94	0.90	77.08	0.10	14.23	17.97	493.78	4.46
173	Malta	Valletta	core	50.23	3.74	0.31	26.68	1.18	60.20	1.96	177.62	41.11
174	Netherlands	Amsterdam	kernel	322.10	9.49	15.42	28.14	1.18	39.31	3.69	191.65	29.45
175	Netherlands	Apeldoorn	core	341.15	3.27	50.42	28.85	0.13	14.22	57.24	460.19	4.50
176	Netherlands	Arnhem	core	101.54	11.30	32.24	20.47	0.23	31.98	40.12	344.98	13.71
177	Netherlands	Breda	core	129.16	4.33	12.64	42.43	0.32	32.85	0.87	357.81	12.56
178	Netherlands	Eindhoven	core	88.86	10.12	11.56	15.16	0.17	56.11	0.04	319.92	22.91
179	Netherlands	Enschede	core	204.50	5.07	15.48	43.60	0.09	30.11	0.81	362.47	11.29
180	Netherlands	Groningen	core	83.72	10.69	8.31	36.20	0.62	39.97	0.00	266.56	20.82
181	Netherlands	Heerlen	core	45.48	8.95	13.64	22.83	0.67	46.20	8.32	302.87	20.97
182	Netherlands	Leeuwarden	core	84.05	6.80	6.58	53.26	0.31	30.48	3.64	377.59	10.64
183	Netherlands	Nijmegen	core	57.74	11.34	10.27	18.50	0.46	49.72	6.63	267.61	26.62

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184	Netherlands	Rotterdam	kernel	397.50	8.66	21.22	11.63	3.05	49.23	0.88	278.84	24.08
185	Netherlands	s' Gravenhage	core	181.97	15.75	6.76	20.64	0.36	47.74	3.77	180.97	40.12
186	Netherlands	Tilburg	core	119.19	7.35	14.20	35.29	0.22	37.05	4.86	307.37	16.43
187	Netherlands	Utrecht	core	99.30	10.60	6.43	25.79	2.41	47.83	0.00	262.52	25.82
188	Poland	Bialystok	core	102.12	9.70	19.89	22.86	1.11	43.27	0.00	199.73	28.66
189	Poland	Bydgoszcz	core	175.98	5.58	38.65	22.02	0.03	30.92	9.00	185.09	21.25
190	Poland	Czestochowa	core	159.72	4.05	6.13	49.08	0.31	32.52	0.43	284.88	15.72
191	Poland	Gdansk	core	396.83	6.51	33.61	27.52	0.20	29.17	2.89	214.65	18.11
192	Poland	Gorzow Wielkopolski	core	85.72	9.50	9.26	51.00	0.16	26.20	8.27	270.42	14.69
193	Poland	Jelenia Gora	core	109.23	4.03	38.94	37.32	0.07	15.42	47.69	290.13	8.18
194	Poland	Kalisz	core	111.32	4.09	7.39	47.84	0.23	35.44	0.04	269.70	16.60
195	Poland	Katowice	kernel	1217.97	6.51	30.18	29.74	0.25	29.16	1.45	238.17	16.83
196	Poland	Kielce	core	109.65	5.32	23.13	33.14	0.04	32.23	9.32	225.67	19.38
197	Poland	Konin	core	82.20	3.98	22.30	47.13	0.18	24.03	21.24	304.32	10.04
198	Poland	Koszalin	core	98.35	6.03	39.05	34.58	0.13	18.27	7.56	236.50	11.15
199	Poland	Kraków	core	326.80	7.34	8.39	41.35	0.84	36.54	1.18	216.53	23.21
200	Poland	Lodz	core	368.59	6.10	13.02	37.78	0.47	35.86	0.00	197.40	24.93
201	Poland	Lublin	core	147.45	8.29	14.52	38.89	0.47	33.78	0.05	192.40	24.21
202	Poland	Nowy Sacz	core	57.57	2.87	19.07	37.01	0.37	33.51	2.19	299.41	14.67
203	Poland	Olsztyn	core	88.33	7.96	38.31	21.82	0.03	29.14	0.00	203.41	19.60
204	Poland	Opole	core	96.55	4.89	14.34	48.86	0.23	28.03	0.00	273.94	13.43
205	Poland	Plock	core	88.05	5.89	19.83	40.70	0.60	29.94	11.45	271.31	14.55
206	Poland	Poznan	core	261.85	12.30	17.94	27.19	1.07	35.95	1.36	248.50	22.08
207	Poland	Radom	core	111.80	4.00	8.28	45.95	0.35	37.40	1.13	223.39	20.49
208	Poland	Rzeszow	core	116.35	4.79	5.77	48.22	0.89	32.09	1.12	300.86	15.29
209	Poland	Suwalki	core	65.50	2.48	15.95	57.18	0.18	22.69	11.65	255.43	10.52
210	Poland	Szczecin	core	348.61	7.58	39.07	26.81	0.14	23.73	39.44	244.86	13.93
211	Poland	Torun	core	115.71	8.52	33.91	20.33	0.72	34.77	13.44	251.06	18.23
212	Poland	Warszawa	core	517.23	8.95	20.28	19.00	0.61	46.44	5.46	186.03	32.64
213	Poland	Wroclaw	core	292.82	10.84	11.93	39.65	0.10	33.60	8.85	221.44	21.87
214	Poland	Zielona Gora	core	58.34	7.88	51.39	3.29	0.08	33.33	0.00	223.45	20.28
215	Portugal	Aveiro	core	197.57	0.96	26.34	53.16	0.20	14.79	97.28	552.14	3.71
216	Portugal	Braga	core	183.40	1.70	19.78	47.60	0.59	22.62	0.00	363.90	8.96
217	Portugal	Coimbra	core	319.39	1.18	40.56	39.06	0.10	13.61	1.62	437.76	4.66
218	Portugal	Faro	core	201.84	0.31	14.16	71.61	0.19	12.02	62.08	492.90	2.89
219	Portugal	Funchal	core	72.91	2.71	29.95	34.26	0.97	25.99	25.97	NoData	NoData
220	Portugal	Lisboa	kernel	640.79	5.63	5.55	39.16	1.46	39.92	6.32	196.82	28.09

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221	Portugal	Oporto	kernel	479.27	3.63	26.87	25.60	0.90	33.96	3.08	235.32	20.20
222	Portugal	Ponta Delgada	core	233.08	0.47	13.37	73.33	0.14	9.54	0.00	NoData	NoData
223	Portugal	Setubal	core	170.24	1.28	18.95	56.44	0.23	19.21	66.34	374.24	6.57
224	Romania	Alba Iulia	core	102.55	0.70	24.51	58.65	0.11	13.63	10.75	234.48	7.18
225	Romania	Arad	core	252.53	0.86	6.04	74.06	0.05	16.40	13.13	264.51	7.52
226	Romania	Bacau	core	43.17	2.80	7.68	31.90	0.89	52.96	5.13	123.40	48.96
227	Romania	Braila	core	45.04	3.57	11.50	27.11	0.40	52.64	3.55	116.90	52.51
228	Romania	Bucuresti	core	239.58	6.22	6.80	19.26	1.45	62.57	0.00	92.80	79.68
229	Romania	Calarasi	core	132.83	0.40	13.47	73.65	0.05	11.71	24.92	225.13	5.72
230	Romania	Cluj Napoca	core	179.29	1.16	19.01	55.16	0.20	21.72	10.99	145.02	17.81
231	Romania	Craiova	core	81.29	3.58	3.85	41.83	0.60	45.51	3.18	138.04	39.35
232	Romania	Giurgiu	core	52.99	0.79	20.19	50.03	0.17	27.43	1.68	214.76	13.87
233	Romania	Oradea	core	112.70	1.23	3.53	57.55	0.34	33.67	1.85	193.37	20.13
234	Romania	Piatra Neamt	core	76.92	0.58	51.28	29.00	0.10	16.19	29.78	120.85	16.32
235	Romania	Sibiu	core	118.68	1.30	21.08	54.29	0.13	21.49	0.92	174.61	14.11
236	Romania	Targu Mures	core	49.28	3.02	25.18	32.11	0.13	36.53	11.58	129.18	33.06
237	Romania	Timisoara	core	129.24	2.75	5.65	52.81	0.61	33.44	2.82	165.54	25.10
238	Slovakia	Banska Bystrica	core	103.30	3.09	55.04	23.81	0.22	16.13	5.25	260.69	8.11
239	Slovakia	Bratislava	core	367.51	3.33	30.48	37.37	0.35	24.69	29.10	261.36	12.30
240	Slovakia	Kosice	core	243.79	4.36	33.99	37.05	0.32	22.28	21.09	291.81	9.93
241	Slovakia	Nitra	core	100.44	4.53	14.38	57.05	0.45	19.83	7.94	338.25	8.45
242	Slovakia	Presov	core	70.44	5.23	35.80	31.86	0.19	23.63	0.00	243.28	13.29
243	Slovakia	Trencin	core	82.01	2.05	43.38	34.77	0.18	17.53	0.35	304.27	7.18
244	Slovakia	Trnava	core	71.54	2.92	0.60	72.70	0.13	21.93	2.91	274.35	9.73
245	Slovakia	Zilina	core	80.04	3.54	35.98	33.61	0.16	24.18	0.00	281.64	10.80
246	Slovenia	Ljubljana	core	275.05	1.73	43.01	27.89	0.22	22.06	26.12	301.03	9.67
247	Slovenia	Maribor	core	147.49	1.60	41.67	33.05	0.16	17.62	11.43	336.88	7.51
248	Spain	Alicante/Alacant	core	200.87	4.00	0.42	65.93	0.21	24.98	5.39	238.45	14.11
249	Spain	Badajoz	core	1470.24	0.26	2.02	92.12	0.05	4.57	12.56	645.83	0.91
250	Spain	Barcelona	kernel	452.06	5.46	18.88	20.40	1.02	54.25	17.84	94.00	64.60
251	Spain	Bilbao	kernel	167.14	5.26	20.20	39.17	0.40	29.76	0.00	86.54	46.96
252	Spain	Cordoba	core	1255.22	0.36	2.45	89.80	0.14	5.17	15.79	316.15	2.45
253	Spain	Gijón	core	181.63	2.49	17.12	48.52	0.36	22.08	0.60	234.85	14.63
254	Spain	Las Palmas	core	202.96	1.79	0.66	65.49	1.30	26.19	9.66	156.08	21.69
255	Spain	Logrono	core	79.56	5.01	4.87	64.80	0.13	22.25	1.55	181.49	16.71
256	Spain	Madrid	core	1246.51	8.61	2.55	47.35	0.24	41.25	44.95	136.90	36.60
257	Spain	Malaga	core	415.10	1.73	11.71	67.57	0.29	16.21	0.13	151.42	13.69

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258	Spain	Murcia	core	886.04	0.77	7.75	76.32	0.11	10.98	25.08	380.51	4.19
259	Spain	Oviedo	core	186.63	1.66	23.89	52.78	0.05	15.49	1.33	216.61	10.77
260	Spain	Palma di Mallorca	core	208.49	4.00	5.33	57.39	0.43	26.07	9.44	233.22	15.98
261	Spain	Pamplona/Iruna	core	25.24	15.52	2.67	24.88	1.12	50.74	0.00	100.05	72.41
262	Spain	Santa Cruz de Tenerife	core	252.64	0.90	10.70	65.23	0.40	19.51	94.95	194.12	12.40
263	Spain	Santander	core	34.71	7.13	1.23	35.43	2.44	48.13	0.00	122.04	51.90
264	Spain	Sant. de Compostela	core	219.99	1.52	43.68	35.53	0.14	12.84	0.42	506.42	4.10
265	Spain	Sevilla	core	301.84	4.79	2.22	58.68	0.50	29.97	1.93	149.98	26.07
266	Spain	Toledo	core	231.91	0.89	2.65	83.43	0.22	11.13	0.04	472.29	2.95
267	Spain	Valencia	core	134.65	4.41	21.12	36.41	1.22	33.14	84.65	77.41	54.86
268	Spain	Valladolid	core	197.62	3.06	11.40	60.57	1.45	20.69	0.45	174.94	16.02
269	Spain	Vigo	core	108.96	4.11	25.64	23.32	1.20	30.95	4.21	198.67	25.69
270	Spain	Vitoria/Gasteiz	core	276.80	1.72	22.76	59.24	0.10	14.96	9.22	229.78	7.83
271	Spain	Zaragoza	core	973.64	1.07	2.60	81.54	0.41	12.93	36.98	259.20	6.12
272	Sweden	Goteborg	core	455.99	8.51	38.67	20.01	0.12	21.16	9.47	392.34	10.53
273	Sweden	Jönköping	core	1937.39	0.73	74.98	18.83	0.02	3.68	22.61	1028.91	0.60
274	Sweden	Linköping	core	1578.17	0.97	54.76	37.26	0.01	4.89	4.13	942.48	0.85
275	Sweden	Malmö	core	601.27	4.88	17.63	56.54	0.37	14.21	11.95	432.34	5.97
276	Sweden	Örebro	core	1631.16	0.97	62.24	30.11	0.00	4.37	1.61	1000.34	0.76
277	Sweden	Stockholm	kernel	1391.26	6.85	53.78	10.93	0.07	13.94	4.78	354.85	9.95
278	Sweden	Umeå	core	2396.28	0.38	81.29	13.77	0.01	2.82	4.76	1137.76	0.43
279	Sweden	Uppsala	core	2248.18	0.81	64.20	29.06	0.02	3.92	2.21	892.66	0.76
280	United Kingdom	Aberdeen	core	187.01	8.11	9.96	46.84	0.10	26.68	0.61	380.64	11.35
281	United Kingdom	Belfast	core	561.35	3.74	3.99	68.57	0.19	19.51	1.28	399.13	6.88
282	United Kingdom	Birmingham	kernel	734.21	11.01	2.40	21.68	0.51	46.32	0.00	276.11	27.50
283	United Kingdom	Bristol	core	461.99	6.32	6.92	56.79	0.20	21.36	1.64	304.98	11.90
284	United Kingdom	Cambridge	core	40.70	14.03	1.47	21.81	0.16	41.55	0.00	286.45	26.78
285	United Kingdom	Cardiff	core	140.98	13.54	8.88	26.09	0.68	37.64	1.41	300.10	21.67
286	United Kingdom	Coventry	core	460.78	6.37	4.45	57.14	0.11	22.63	0.01	323.84	11.86
287	United Kingdom	Derry	core	387.43	1.60	6.61	79.77	0.02	10.06	0.94	502.18	2.71
288	United Kingdom	Edinburgh	core	263.55	11.16	6.24	44.36	0.14	28.88	0.13	290.17	17.03
289	United Kingdom	Exeter	core	47.21	7.53	8.53	26.26	0.50	43.81	1.68	277.30	23.52
290	United Kingdom	Glasgow	core	647.68	8.15	13.78	42.56	0.37	27.48	1.11	314.68	13.87
291	United Kingdom	Kingston-upon-Hull	core	71.76	10.87	2.12	9.11	1.05	62.03	0.32	261.48	33.95
292	United Kingdom	Leeds	core	1666.66	6.10	6.51	56.12	0.30	23.30	11.45	330.01	11.32
293	United Kingdom	Leicester	kernel	227.43	8.83	1.45	46.52	0.42	29.89	0.00	277.72	18.73
294	United Kingdom	Lincoln	core	35.65	10.23	6.36	22.69	0.72	41.68	0.00	295.91	23.98

Order ID	Country	Cities/LUZ	Core or Kernel	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
				Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
295	United Kingdom	Liverpool	kernel	488.34	13.19	3.48	34.56	0.29	37.89	4.17	293.93	16.25
296	United Kingdom	London	kernel	1575.73	16.66	3.76	12.05	0.14	47.77	1.10	185.03	45.51
297	United Kingdom	Manchester	kernel	1276.92	10.47	4.67	37.98	0.74	34.60	6.34	295.01	19.44
298	United Kingdom	Newcastle upon Tyne	kernel	405.48	9.22	6.90	36.67	1.21	36.45	0.15	287.64	19.62
299	United Kingdom	Nottingham	kernel	684.39	4.59	6.24	64.47	0.15	17.71	0.00	338.37	8.66
300	United Kingdom	Portsmouth	kernel	196.41	9.61	7.23	28.02	0.13	37.82	4.50	263.98	24.54
301	United Kingdom	Sheffield	core	1050.42	5.44	10.00	55.77	0.14	19.24	20.80	333.21	10.27
302	United Kingdom	Stoke-on-trent	core	304.53	9.27	7.14	50.75	0.57	23.87	0.00	353.38	11.92
303	United Kingdom	Wolverhampton	kernel	69.52	11.15	1.41	5.25	0.41	60.19	0.30	273.52	34.13
304	United Kingdom	Worcester	core	33.31	15.13	2.81	15.16	0.08	46.80	0.03	292.74	28.02
305	United Kingdom	Wrexham	core	504.02	1.41	8.92	76.68	0.08	10.10	17.27	564.38	2.55

C : ESTIMATED INDICATORS /AREA IN BETWEEN THE CORE AND THE LUZ OUTLINE

Order ID	Country	Cities/LUZ	LUZ Area	Proportion of urban green space	Proportion of natural area	Proportion of agricultural area	Proportion of abandoned area	Proportion of impervious surface	Proportion of protected area	Artificial area per inhabitant	Number of inhabitants per area
			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
1	Austria	Graz	1103.17	0.36	57.63	30.19	0.09	7.73	0.04	1017.91	1.20
2	Austria	Innsbruck	1988.68	0.20	34.70	61.06	0.04	2.82	15.79	542.98	0.78
3	Austria	Linz	1648.63	0.87	22.96	62.21	0.13	9.93	3.94	720.99	2.06
4	Austria	Salzburg	1678.28	0.57	51.25	40.30	0.09	5.56	5.55	747.35	1.13
5	Austria	Wien	4201.27	1.14	27.43	60.59	0.07	7.94	48.12	877.78	1.36
6	Belgium	Antwerpen	740.70	2.92	17.24	42.65	0.19	20.18	18.91	649.16	6.18
7	Belgium	Brugge	273.37	0.79	7.24	76.85	0.03	11.08	27.01	891.42	1.78
8	Belgium	Bruxelles/Brussel	1461.48	2.81	12.91	53.44	0.33	16.94	8.49	621.11	5.42
9	Belgium	Charleroi	516.24	0.88	15.80	62.77	0.13	13.23	2.03	597.11	3.59
10	Belgium	Gent	382.04	2.17	7.44	56.55	0.11	22.22	2.30	810.38	4.44
11	Belgium	Liège	877.46	0.83	21.01	56.53	0.25	13.28	5.22	742.17	3.03
12	Belgium	Namur	221.29	1.10	24.63	59.83	0.07	7.48	4.58	1068.59	1.45
13	Bulgaria	Burgas	1140.80	0.04	30.58	63.87	0.03	4.57	25.57	1791.95	0.31
14	Bulgaria	Pleven	1706.85	0.24	11.55	83.41	0.06	3.55	16.89	1212.70	0.42
15	Bulgaria	Plovdiv	1124.83	0.07	33.89	58.05	0.06	6.46	17.48	896.69	0.90
16	Bulgaria	Ruse	762.96	0.33	15.01	80.32	0.05	3.45	33.56	1222.64	0.38
17	Bulgaria	Sofia	2969.75	0.20	44.55	47.78	0.03	5.56	36.05	1482.52	0.52
18	Bulgaria	Varna	726.94	0.21	28.90	62.13	0.04	7.24	59.40	1275.85	0.70
19	Bulgaria	Vidin	454.25	0.25	17.58	76.04	0.04	4.80	12.26	1335.33	0.48
20	Cyprus	Lefkosia	2506.50	0.10	0.46	93.45	0.07	4.87	32.56	2093.78	0.29
21	Czech Republic	Brno	3070.43	0.42	38.35	52.42	0.10	6.38	3.64	785.72	1.17
22	Czech Republic	Ceske Budejovice	1568.93	0.53	38.76	54.07	0.01	5.27	13.04	1388.10	0.52
23	Czech Republic	Hradec Kralove	770.58	0.52	17.75	73.52	0.02	6.45	4.63	1061.01	0.82
24	Czech Republic	Jihlava	1091.07	0.34	33.02	61.62	0.01	3.83	0.58	1008.90	0.53
25	Czech Republic	Karlovy Vary	1562.35	0.48	48.64	46.04	0.01	3.75	61.51	1207.47	0.44
26	Czech Republic	Liberec	1222.91	0.66	53.13	37.17	0.06	6.40	14.27	802.19	1.21
27	Czech Republic	Olomouc	1513.91	0.32	35.32	57.29	0.02	6.17	39.14	882.22	0.84
28	Czech Republic	Ostrava	3582.12	0.94	36.70	51.63	0.06	9.91	33.17	576.41	2.02
29	Czech Republic	Pardubice	807.99	0.71	29.16	60.82	0.02	7.17	4.02	1155.82	0.87
30	Czech Republic	Plzen	2965.36	0.46	40.38	52.31	0.01	5.47	2.00	1165.03	0.63
31	Czech Republic	Praha	6441.22	0.92	26.05	63.04	0.08	7.94	5.97	999.43	1.09
32	Czech Republic	Usti nad Labem	780.90	0.96	43.57	42.00	0.06	11.49	31.29	758.79	1.90
33	Czech Republic	Zlin	913.18	0.47	48.09	43.67	0.03	5.84	9.49	656.48	1.26
34	Denmark	Aalborg	5028.65	1.13	13.44	76.45	0.04	7.09	13.75	1667.98	0.61
35	Denmark	Aarhus	4069.36	0.90	19.47	69.45	0.03	7.63	8.12	1271.25	0.87

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			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
36	Denmark	Kobenhavn	2479.25	3.04	24.47	53.31	0.13	21.38	24.74	833.66	2.66
37	Denmark	Odense	3186.48	0.81	11.24	76.88	0.03	8.54	11.89	1314.06	0.90
38	Estonia	Tallinn	4181.45	0.28	58.48	36.09	0.03	3.85	19.55	1794.70	0.30
39	Estonia	Tartu	2961.67	0.10	46.89	48.84	0.01	3.58	18.80	2605.54	0.16
40	Finland	Helsinki	2327.90	1.23	58.18	29.63	0.02	7.20	6.51	1149.57	1.06
41	Finland	Oulu	3336.33	0.26	69.32	26.77	0.01	2.43	5.28	1983.40	0.20
42	Finland	Tampere	1688.51	0.77	74.43	16.66	0.03	5.30	1.34	1489.76	0.60
43	Finland	Turku	1508.01	0.75	52.24	35.93	0.06	7.28	2.11	1520.35	0.78
44	France	Ajaccio	744.70	0.18	18.82	77.09	0.02	2.38	2.91	2277.82	0.18
45	France	Amiens	1455.87	0.44	13.74	79.37	0.03	4.06	1.97	1053.67	0.65
46	France	Besancon	1234.63	0.14	46.98	46.34	0.03	4.75	19.56	1593.37	0.42
47	France	Bordeaux	3340.41	0.38	61.82	26.80	0.06	7.95	4.22	1431.83	0.79
48	France	Caen	1439.83	0.57	7.72	80.54	0.04	8.15	0.99	1104.22	1.06
49	France	Clermont-Ferrand	1516.19	0.46	23.21	66.58	0.06	6.84	10.01	1154.88	0.88
50	France	Dijon	2060.04	0.49	39.90	54.54	0.03	3.72	25.80	1370.36	0.41
51	France	Grenoble	1289.53	0.52	55.05	36.06	0.07	5.52	16.99	917.98	0.97
52	France	Le Havre	441.47	0.47	6.75	77.64	0.42	11.16	14.21	1655.19	0.94
53	France	Limoges	1361.05	0.22	30.74	59.92	0.06	5.73	1.84	2101.62	0.44
54	France	Lyon	2798.31	0.83	21.24	63.37	0.16	11.21	24.75	956.25	1.61
55	France	Metz	1561.84	0.55	23.45	66.98	0.07	7.26	7.15	718.64	1.33
56	France	Montpellier	152.97	3.45	32.55	42.43	0.32	17.01	68.74	831.49	3.01
57	France	Nancy	1692.74	0.59	33.76	58.57	0.04	5.51	2.12	852.86	0.90
58	France	Nantes	1772.44	0.78	8.32	78.36	0.04	9.01	20.28	1507.52	0.88
59	France	Orleans	1734.43	0.73	38.58	53.75	0.01	5.80	37.13	1487.19	0.52
60	France	Paris	11305.93	2.48	25.34	55.35	0.10	12.20	11.38	455.99	4.23
61	France	Poitiers	1507.72	0.65	18.39	72.63	0.09	5.20	9.86	1613.44	0.56
62	France	Reims	1705.57	0.34	15.24	77.82	0.02	5.57	1.86	1530.04	0.45
63	France	Rennes	1944.77	0.24	12.91	75.40	0.02	9.48	1.38	1453.38	0.80
64	France	Rouen	1035.13	0.37	14.48	72.83	0.09	7.00	0.25	3986.02	0.32
65	France	Strasbourg	1053.10	0.59	20.57	68.04	0.05	8.33	12.59	751.79	1.52
66	France	Toulouse	3579.24	0.42	11.82	74.45	0.07	9.63	1.84	1404.01	0.98
67	France	Tours	1472.67	0.49	26.98	63.06	0.05	7.52	8.75	1381.46	0.72
68	Germany	Augsburg	1847.97	0.67	30.18	59.50	0.08	6.88	2.36	495.97	2.08
69	Germany	Berlin	16384.43	0.84	41.68	48.13	0.03	7.41	29.11	1180.81	0.86
70	Germany	Bielefeld	2665.35	1.56	21.60	58.22	0.13	14.84	11.81	557.39	3.62
71	Germany	Bonn	1118.14	1.58	34.29	44.66	0.17	14.98	13.33	451.12	4.67

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			Km2	(%)	(%)	(%)	(%)	(%)	(%)	(m2/person)	(number/ ha)
72	Germany	Bremen	5572.24	0.69	16.01	73.06	0.06	8.10	10.54	869.96	1.26
73	Germany	Darmstadt	659.49	1.13	37.04	46.77	0.03	12.61	15.22	372.88	4.34
74	Germany	Dresden	2291.80	1.35	32.79	54.35	0.10	9.02	26.19	693.51	1.85
75	Germany	Dusseldorf	882.41	3.06	16.83	50.59	0.16	25.34	2.80	359.40	9.06
76	Germany	Erfurt	2586.42	1.01	28.11	62.48	0.06	6.72	26.95	693.72	1.36
77	Germany	Essen	2551.37	2.50	24.93	49.16	0.17	19.10	10.05	417.63	6.20
78	Germany	Frankfurt am Main	3929.31	1.48	40.14	44.02	0.05	11.60	17.19	378.58	4.18
79	Germany	Freiburg im Breisgau	2056.86	0.88	49.14	41.38	0.05	8.78	33.39	405.63	1.91
80	Germany	Gottingen	2270.83	0.66	38.45	53.51	0.05	5.68	15.76	624.77	1.29
81	Germany	Halle an der Saale	1438.49	1.40	8.52	77.48	0.16	10.55	7.21	926.03	1.51
82	Germany	Hamburg	6475.08	1.34	20.90	65.06	0.07	9.91	13.79	663.58	2.11
83	Germany	Hannover	2769.49	1.48	25.18	59.35	0.07	10.82	9.76	557.39	2.77
84	Germany	Karlsruhe	1084.74	1.18	37.14	46.17	0.09	12.48	32.90	431.33	3.87
85	Germany	Kiel	3269.73	0.91	17.84	71.89	0.03	7.23	14.31	836.43	1.23
86	Germany	Koblenz	816.93	0.56	33.99	50.76	0.06	12.20	28.92	591.24	2.58
87	Germany	Köln	1058.24	1.82	22.24	50.66	0.21	21.27	3.60	459.38	5.90
88	Germany	Leipzig	2503.30	1.37	16.69	67.10	0.08	12.34	22.52	966.62	1.68
89	Germany	Magdeburg	4126.43	0.79	22.96	67.14	0.03	7.91	14.66	1094.82	0.90
90	Germany	Mainz	605.41	1.30	16.76	68.25	0.07	11.61	25.04	466.19	3.22
91	Germany	Munchen	4884.33	1.42	25.03	60.95	0.08	10.06	6.38	553.29	2.53
92	Germany	Nurnberg	2354.94	0.82	40.09	46.78	0.12	8.97	10.80	549.93	2.39
93	Germany	Regensburg	2285.23	0.47	33.51	57.09	0.07	6.63	7.69	751.74	1.25
94	Germany	Saarbrucken	1369.39	1.59	35.57	39.86	0.15	18.17	12.17	493.45	4.98
95	Germany	Schwerin	4763.05	0.51	30.82	62.62	0.01	4.82	32.31	1300.73	0.50
96	Germany	Stuttgart	3303.21	2.43	33.72	47.23	0.07	13.40	26.29	351.51	5.42
97	Germany	Trier	1095.02	0.48	47.31	42.30	0.02	7.94	11.96	825.15	1.26
98	Germany	Weimar	804.79	0.64	17.49	74.24	0.05	6.21	26.43	728.62	1.14
99	Germany	Wiesbaden	814.35	1.00	58.76	30.94	0.06	7.10	14.04	454.38	2.27
100	Greece	Athina	2670.44	0.71	10.86	68.50	0.19	14.62	13.98	633.56	3.26
101	Greece	Ioannina	1277.92	0.11	31.82	62.13	0.03	4.95	40.83	1564.32	0.39
102	Greece	Iraklion	495.97	0.19	1.17	91.49	0.05	5.07	22.93	718.71	1.02
103	Greece	Kalamata	187.40	0.05	7.68	87.99	0.02	3.30	0.00	941.63	0.46
104	Greece	Kavala	239.50	0.12	28.97	65.88	0.04	3.94	0.00	1196.30	0.43
105	Greece	Larisa	1433.07	0.06	4.28	89.86	0.03	5.10	65.26	1740.13	0.34
106	Greece	Patrai	386.63	0.39	12.06	80.43	0.10	4.91	34.47	674.57	1.11
107	Greece	Thessaloniki	1407.54	0.42	12.16	74.61	0.10	11.03	31.54	328.05	4.03

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108	Greece	Volos	277.48	0.26	15.13	74.42	0.10	7.44	49.85	568.47	1.84
109	Hungary	Budapest	1997.23	1.51	28.51	47.71	0.27	17.06	26.23	703.63	3.38
110	Hungary	Debrecen	1215.05	0.09	28.16	63.82	0.02	6.34	13.30	1005.58	0.80
111	Hungary	Gyõr	1264.58	0.24	24.95	67.83	0.02	5.86	14.91	1115.81	0.65
112	Hungary	Kecskemet	1161.60	0.17	24.70	67.85	0.03	6.13	12.98	1447.10	0.52
113	Hungary	Miskolc	769.77	0.39	29.54	61.31	0.22	6.42	35.87	718.82	1.27
114	Hungary	Nyiregyhaza	1163.08	0.15	14.21	76.31	0.00	6.85	12.24	1070.34	0.89
115	Hungary	Pecs	407.95	0.41	26.55	65.07	0.01	5.44	25.02	1360.91	0.62
116	Hungary	Szeged	471.90	0.18	10.77	79.39	0.07	7.61	28.38	1247.81	0.79
117	Hungary	Szekesfehervar	973.29	0.59	12.10	80.25	0.03	5.43	15.16	1305.61	0.59
118	Ireland	Cork	2080.41	0.91	10.49	77.65	0.07	8.62	2.55	1308.66	0.91
119	Ireland	Dublin	6091.40	1.43	10.33	79.78	0.06	6.43	11.96	1526.94	0.65
120	Ireland	Limerick	3504.05	0.43	16.03	76.16	0.05	5.82	18.69	1682.08	0.46
121	Italy	Ancona	283.93	0.76	1.69	79.63	0.09	14.92	0.05	509.66	3.66
122	Italy	Bari	779.61	0.32	1.22	87.75	0.09	9.76	6.39	298.26	3.70
123	Italy	Bologna	1907.45	0.68	13.68	73.60	0.04	9.62	9.81	689.35	1.85
124	Italy	Brescia	449.56	0.88	19.65	54.63	0.18	20.79	0.01	524.54	4.90
125	Italy	Cagliari	1604.49	0.29	18.55	71.54	0.05	7.78	29.46	522.53	1.90
126	Italy	Campobasso	1252.83	0.09	29.12	64.70	0.01	4.97	26.98	1185.01	0.52
127	Italy	Caserta	617.24	0.28	12.03	67.26	0.11	16.53	11.05	397.93	5.20
128	Italy	Catania	405.61	0.64	5.17	67.97	0.37	17.67	2.77	423.41	6.34
129	Italy	Catanzaro	649.76	0.14	35.71	58.05	0.02	4.72	11.81	798.64	0.78
130	Italy	Cremona	590.79	0.35	3.21	87.01	0.01	8.08	7.36	981.64	1.00
131	Italy	Firenze	1160.35	0.52	44.92	42.92	0.03	9.38	8.09	439.54	2.77
132	Italy	Foggia	542.53	0.10	6.45	89.52	0.01	3.06	9.14	528.84	0.76
133	Italy	Genova	684.82	0.34	72.94	17.93	0.03	4.99	30.45	547.51	1.67
134	Italy	l'Aquila	1111.38	0.07	32.80	63.21	0.02	2.91	74.01	1569.81	0.25
135	Italy	Modena	458.83	0.74	3.80	77.47	0.06	15.02	1.29	663.56	2.82
136	Italy	Padova	882.86	0.75	7.30	67.43	0.22	16.82	16.33	604.33	4.18
137	Italy	Palermo	1017.64	0.09	6.62	83.40	0.07	6.27	31.16	595.02	1.68
138	Italy	Perugia	357.28	0.52	39.60	49.21	0.07	8.55	42.36	851.18	1.32
139	Italy	Pescara	642.10	0.45	8.96	73.71	0.08	13.80	6.21	518.51	3.34
140	Italy	Potenza	1324.32	0.06	24.19	69.33	0.01	5.37	3.74	1123.35	0.58
141	Italy	Reggio di Calabria	253.24	0.11	36.82	54.71	0.05	6.21	60.73	433.36	1.95
142	Italy	Roma	2311.55	0.88	19.70	59.41	0.19	11.79	18.38	555.16	3.76
143	Italy	Salerno	890.09	0.39	40.65	42.86	0.12	13.29	65.16	596.55	2.76

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144	Italy	Sassari	679.55	0.45	2.36	89.91	0.02	6.24	21.83	620.18	1.25
145	Italy	Taranto	1192.29	0.22	11.52	75.80	0.07	9.33	41.63	592.30	2.14
146	Italy	Torino	1749.22	1.16	24.80	55.06	0.07	13.52	8.56	427.89	4.71
147	Italy	Trento	621.47	0.23	70.39	21.68	0.02	5.89	1.33	690.41	1.15
148	Italy	Trieste	127.44	0.75	40.99	40.87	0.35	12.03	97.63	768.88	2.36
149	Italy	Venezia	1056.08	1.25	35.04	49.52	0.10	9.44	83.54	489.87	3.15
150	Italy	Verona	1009.04	0.90	15.88	62.70	0.10	16.77	6.29	750.85	2.85
151	Latvia	Liepaja	3596.57	0.11	49.32	48.31	0.02	1.98	7.56	1818.42	0.13
152	Latvia	Riga	5088.18	0.52	59.46	33.46	0.05	4.87	11.65	1366.29	0.52
153	Lithuania	Kaunas	1465.12	0.58	35.45	56.93	0.06	5.41	14.05	1352.15	0.56
154	Lithuania	Panevezys	2178.04	0.21	34.62	60.75	0.02	3.95	23.61	2310.19	0.20
155	Lithuania	Vilnius	3846.19	0.31	46.86	47.37	0.03	4.32	4.34	1443.18	0.40
156	Luxembourg	Luxembourg	2544.13	0.64	37.16	52.20	0.04	8.07	32.51	746.33	1.43
157	Malta	Valletta	196.71	0.68	0.62	73.13	0.21	20.83	18.70	328.53	7.99
158	Netherlands	Amsterdam	850.37	3.54	36.35	39.86	0.32	17.53	37.48	453.20	5.25
159	Netherlands	Apeldoorn	283.89	1.93	26.94	56.29	0.06	11.49	28.66	834.97	2.01
160	Netherlands	Arnhem	386.68	2.20	23.96	52.66	0.14	17.32	39.32	450.11	5.20
161	Netherlands	Breda	368.97	2.14	16.74	62.36	0.07	15.53	18.51	560.51	3.73
162	Netherlands	Eindhoven	238.19	4.46	23.40	40.39	0.13	24.64	5.16	446.30	8.11
163	Netherlands	Enschede	147.78	2.73	14.47	61.09	0.00	17.54	7.41	484.23	5.05
164	Netherlands	Groningen	854.38	1.43	7.93	78.49	0.02	9.92	6.32	722.00	1.88
165	Netherlands	Heerlen	166.10	3.47	11.82	52.84	0.23	25.59	3.33	341.98	10.33
166	Netherlands	Leeuwarden	368.01	0.98	4.49	83.29	0.06	9.30	5.47	679.49	1.80
167	Netherlands	Nijmegen	259.83	3.59	20.09	55.50	0.09	16.46	11.33	542.40	4.50
168	Netherlands	Rotterdam	311.16	5.11	19.60	51.57	0.33	19.00	14.44	417.71	6.90
169	Netherlands	s' Gravenhage	238.03	6.06	8.22	37.38	0.36	9.81	10.82	577.97	9.41
170	Netherlands	Tilburg	269.54	3.21	23.88	55.09	0.03	14.71	11.13	652.29	3.22
171	Netherlands	Utrecht	290.44	5.12	18.89	47.64	0.20	20.78	8.74	340.77	9.82
172	Poland	Bialystok	5012.42	0.12	38.29	56.31	0.02	4.52	64.88	1167.56	0.46
173	Poland	Bydgoszcz	3228.20	0.38	34.35	59.81	0.04	4.69	9.75	899.78	0.65
174	Poland	Czestochowa	2409.82	0.19	33.91	57.37	0.03	6.49	2.89	960.33	0.91
175	Poland	Gdansk	2944.30	0.42	30.71	60.34	0.04	7.19	10.32	687.07	1.30
176	Poland	Gorzow Wielkopolski	1219.66	0.21	49.98	44.98	0.02	3.95	49.57	979.11	0.51
177	Poland	Jelenia Gora	476.47	0.25	48.01	44.28	0.03	4.90	53.20	936.17	0.82
178	Poland	Kalisz	2992.24	0.18	24.71	68.29	0.01	5.89	21.25	933.25	0.75
179	Poland	Katowice	1419.22	1.29	31.22	47.48	0.15	16.35	0.29	433.80	4.91

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180	Poland	Kielce	2246.28	0.21	38.75	53.29	0.01	5.82	19.75	918.02	0.87
181	Poland	Konin	676.23	0.16	22.86	68.53	0.02	7.59	33.89	966.81	0.89
182	Poland	Koszalin	1652.71	0.25	48.85	47.12	0.01	3.21	20.27	1078.16	0.37
183	Poland	Kraków	2679.47	0.52	19.30	65.84	0.05	10.46	6.20	797.87	1.86
184	Poland	Lodz	2489.64	0.33	22.67	67.37	0.04	7.73	1.73	956.57	1.04
185	Poland	Lublin	2734.92	0.33	14.05	76.56	0.02	7.01	0.52	871.72	1.08
186	Poland	Nowy Sacz	390.79	0.10	41.76	45.17	0.05	9.56	24.14	709.45	1.84
187	Poland	Olsztyn	2841.70	0.22	47.00	48.97	0.00	3.39	23.72	1037.93	0.39
188	Poland	Opole	1596.68	0.22	49.60	43.82	0.05	5.05	7.61	768.25	0.86
189	Poland	Plock	1797.41	0.06	23.03	70.39	0.03	5.77	8.12	1121.12	0.59
190	Poland	Poznan	3455.73	0.81	23.74	67.03	0.08	7.07	22.52	736.68	1.25
191	Poland	Radom	1518.88	0.12	26.92	65.52	0.01	6.01	30.90	802.38	0.94
192	Poland	Rzeszow	1157.22	0.25	29.70	57.98	0.09	8.48	12.83	940.59	1.31
193	Poland	Suwalki	552.82	0.08	29.00	66.57	0.00	4.08	56.68	1814.73	0.24
194	Poland	Szczecin	5697.13	0.32	37.42	58.06	0.01	3.63	50.70	883.12	0.51
195	Poland	Torun	1231.38	0.22	35.45	58.27	0.02	5.61	11.79	931.44	0.67
196	Poland	Warszawa	4684.49	0.56	30.74	55.30	0.08	11.32	12.57	692.68	2.01
197	Poland	Wroclaw	4291.99	0.43	23.18	69.04	0.04	6.28	18.93	856.30	0.91
198	Poland	Zielona Gora	1568.66	0.47	55.84	38.69	0.02	4.10	15.60	976.56	0.56
199	Portugal	Aveiro	76.02	1.77	28.12	41.57	0.45	22.44	60.39	619.77	4.89
200	Portugal	Braga	310.74	0.32	24.50	58.49	0.16	10.06	5.12	812.54	2.09
201	Portugal	Coimbra	933.64	0.15	55.94	34.24	0.09	6.29	6.42	985.14	1.00
202	Portugal	Faro	281.15	0.26	12.21	78.71	0.11	7.18	53.27	503.13	1.81
203	Portugal	Funchal	188.57	0.81	42.33	38.43	0.18	13.10	21.12	-9999.00	-9999.00
204	Portugal	Lisboa	797.34	1.07	14.11	64.96	0.37	15.30	47.35	295.82	7.08
205	Portugal	Oporto	84.49	1.62	21.95	31.05	0.91	36.80	0.01	325.86	14.42
206	Portugal	Ponta Delgada	304.28	0.33	18.75	72.17	0.05	6.76	4.22	-9999.00	-9999.00
207	Romania	Alba Iulia	158.76	0.31	16.09	75.29	0.02	6.87	2.22	423.80	2.03
208	Romania	Arad	275.86	0.12	5.36	88.22	0.02	4.72	0.00	778.97	0.82
209	Romania	Bacau	178.46	0.29	38.30	52.30	0.07	7.08	17.09	851.80	1.10
210	Romania	Braila	391.86	0.05	18.47	78.65	0.00	2.43	34.66	1826.71	0.16
211	Romania	Bucuresti	834.78	0.35	14.53	68.59	0.20	14.70	8.29	631.51	2.67
212	Romania	Calarasi	114.59	0.05	3.09	92.90	0.02	3.34	2.25	352.27	1.14
213	Romania	Cluj Napoca	412.84	0.03	17.58	76.76	0.03	4.59	16.87	762.62	0.74
214	Romania	Craiova	262.30	0.08	16.90	75.94	0.03	5.88	15.86	1067.71	0.67
215	Romania	Giurgiu	59.08	0.01	13.12	83.39	0.00	3.02	49.81	752.83	0.46

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216	Romania	Oradea	91.37	0.34	23.36	65.31	0.10	8.91	11.82	808.07	1.40
217	Romania	Piatra Neamt	70.68	0.02	20.14	64.83	0.10	11.88	29.28	733.15	2.05
218	Romania	Sibiu	470.38	0.12	60.63	35.56	0.01	3.20	87.31	543.11	0.70
219	Romania	Targu Mures	92.32	0.06	14.24	73.51	0.02	10.42	0.71	440.39	2.78
220	Romania	Timisoara	110.62	0.26	5.29	77.23	0.14	13.97	12.79	1405.01	1.24
221	Slovakia	Banska Bystrica	705.63	0.18	70.75	25.39	0.01	3.14	66.72	945.33	0.41
222	Slovakia	Bratislava	1682.72	0.44	43.41	47.94	0.04	6.43	50.14	857.67	1.01
223	Slovakia	Kosice	1532.34	0.23	45.96	47.83	0.01	4.55	67.38	900.58	0.69
224	Slovakia	Nitra	769.77	0.33	11.25	80.11	0.06	6.30	7.99	846.27	1.02
225	Slovakia	Presov	864.12	0.15	46.11	47.26	0.01	4.87	22.04	838.30	0.79
226	Slovakia	Trencin	592.02	0.22	51.43	41.45	0.05	5.69	6.86	767.29	0.93
227	Slovakia	Trnava	669.38	0.57	20.74	70.64	0.01	6.37	43.53	1016.11	0.85
228	Slovakia	Zilina	734.00	0.26	63.89	28.77	0.03	5.80	64.78	760.78	0.96
229	Slovenia	Ljubljana	2280.37	0.17	64.10	27.47	0.04	5.82	31.72	864.96	0.98
230	Slovenia	Maribor	2023.15	0.16	43.89	46.66	0.04	6.82	37.00	955.62	0.99
231	Spain	Alicante/Alacant	474.11	1.06	6.05	76.95	0.06	13.08	13.32	758.60	2.24
232	Spain	Barcelona	1348.63	1.82	35.67	37.62	0.35	24.54	30.44	337.88	7.91
233	Spain	Bilbao	816.03	0.59	53.19	35.97	0.11	7.20	12.36	599.25	1.81
234	Spain	Gijón	344.39	0.28	35.16	54.07	0.02	6.91	3.77	1491.35	0.72
235	Spain	Las Palmas	673.88	0.18	10.52	80.14	0.02	6.68	60.12	419.20	2.23
236	Spain	Logrono	1357.48	0.17	31.27	63.58	0.01	4.27	41.20	2590.12	0.20
237	Spain	Madrid	6775.34	0.70	9.27	80.98	0.08	5.94	66.18	767.25	1.27
238	Spain	Malaga	529.20	0.53	4.52	81.85	0.11	9.59	0.59	821.55	1.66
239	Spain	Murcia	438.55	0.12	13.64	74.71	0.09	9.97	27.72	687.73	1.69
240	Spain	Oviedo	2157.19	0.18	29.74	63.97	0.00	4.06	48.74	1217.32	0.52
241	Spain	Palma di Mallorca	1964.44	0.63	16.87	73.70	0.06	6.36	25.48	940.64	1.00
242	Spain	Pamplona/Iruna	4356.99	0.23	41.00	55.62	0.01	2.81	25.10	970.12	0.35
243	Spain	Santa Cruz de Tenerife	356.65	0.36	23.54	59.02	0.07	12.44	69.08	538.68	3.24
244	Spain	Santander	559.38	1.26	28.33	57.75	0.09	9.66	2.18	779.26	1.79
245	Spain	Santiago de Compostela	1131.66	0.14	49.59	39.25	0.02	6.37	0.63	1401.83	0.80
246	Spain	Sevilla	2774.34	0.33	4.85	85.71	0.14	7.77	20.36	638.59	1.48
247	Spain	Toledo	3384.64	0.08	5.48	90.92	0.02	3.05	59.86	1362.01	0.26
248	Spain	Valencia	1313.00	0.96	4.28	73.29	0.27	16.40	27.14	407.70	5.50
249	Spain	Valladolid	2839.12	0.29	13.64	80.53	0.16	4.62	7.73	1625.23	0.36
250	Spain	Vigo	1321.66	0.78	35.01	49.60	0.11	9.19	2.37	817.47	1.88
251	Spain	Vitoria/Gasteiz	2037.62	0.16	41.53	54.25	0.01	3.57	35.72	3200.83	0.13

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252	Spain	Zaragoza	1315.35	0.17	4.54	90.42	0.11	4.19	62.09	1091.14	0.46
253	Sweden	Goteborg	3778.72	1.12	66.46	22.25	0.03	6.01	4.33	1105.84	1.02
254	Sweden	Jönköping	1536.05	0.42	78.80	16.72	0.01	3.01	11.12	2364.36	0.19
255	Sweden	Linköping	2653.76	0.45	72.88	22.93	0.01	2.92	1.25	2379.56	0.18
256	Sweden	Malmö	1257.93	2.60	7.59	77.49	0.03	8.04	2.73	1052.73	1.42
257	Sweden	Örebro	2056.61	0.28	72.22	22.68	0.01	3.22	1.05	2030.15	0.25
258	Sweden	Stockholm	5785.01	1.47	68.40	20.42	0.05	4.71	2.14	1429.40	0.78
259	Sweden	Umeå	7424.18	0.06	87.06	11.04	0.00	1.39	8.54	4351.98	0.04
260	Sweden	Uppsala	4631.22	0.25	74.88	21.20	0.01	2.44	5.57	2468.09	0.16
261	United Kingdom	Aberdeen	6340.95	0.49	15.71	79.64	0.01	3.60	21.99	1297.93	0.36
262	United Kingdom	Belfast	399.12	4.05	6.29	64.78	0.19	18.88	0.31	443.50	6.52
263	United Kingdom	Birmingham	863.98	3.11	6.82	72.26	0.08	13.34	0.04	569.31	3.67
264	United Kingdom	Bristol	874.01	3.45	7.44	68.50	0.11	14.69	1.56	483.52	4.97
265	United Kingdom	Cambridge	902.03	2.19	3.25	84.42	0.01	7.04	0.07	855.77	1.44
266	United Kingdom	Cardiff	1040.45	3.66	16.52	61.99	0.27	13.53	0.40	429.26	5.00
267	United Kingdom	Coventry	354.23	2.53	3.90	80.43	0.04	10.17	0.00	633.68	2.47
268	United Kingdom	Edinburgh	1478.78	2.19	10.68	77.07	0.02	7.98	1.42	549.45	2.23
269	United Kingdom	Exeter	2405.40	1.05	13.02	76.04	0.02	7.61	2.47	832.74	1.31
270	United Kingdom	Glasgow	2729.10	2.41	15.94	70.24	0.09	8.71	4.29	443.11	3.12
271	United Kingdom	Kingston-upon-Hull	2423.96	1.32	3.35	86.97	0.02	6.42	2.73	747.34	1.30
272	United Kingdom	Leeds	3456.41	1.18	5.62	85.61	0.03	6.02	22.42	639.49	1.37
273	United Kingdom	Leicester	1169.92	2.30	4.34	80.72	0.05	9.27	0.00	529.69	2.82
274	United Kingdom	Lincoln	688.12	1.09	5.03	84.01	0.05	7.34	0.00	956.05	1.15
275	United Kingdom	London	7518.61	6.00	14.27	56.92	0.03	14.72	4.05	486.31	5.92
276	United Kingdom	Newcastle upon Tyne	2986.20	0.82	20.72	73.59	0.08	3.90	17.85	679.39	0.84
277	United Kingdom	Nottingham	219.78	5.70	9.67	54.36	0.33	22.17	0.00	356.74	10.08
278	United Kingdom	Sheffield	816.63	1.80	8.20	79.07	0.01	7.70	53.81	557.54	2.28
279	United Kingdom	Stoke-on-trent	576.70	1.49	7.89	80.69	0.03	7.21	9.49	697.09	1.64
280	United Kingdom	Wolverhampton	407.49	1.68	10.22	74.15	0.02	10.76	0.05	604.00	2.59
281	United Kingdom	Worcester	1241.57	1.41	7.70	79.99	0.01	8.05	0.29	824.83	1.49
282	United Kingdom	Wrexham	440.09	1.88	10.20	68.75	0.06	15.04	7.83	623.89	3.37

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Department of Physical Geography and Ecosystem Science

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