TECHNISCHE UNIVERSITÄT WIEN

MASTERARBEIT

ANALYSING THE POTENTIAL OF NETWORK KERNEL DENSITY ESTIMATION FOR THE STUDY OF TOURISM BASED ON GEOSOCIAL MEDIA DATA

Ausgeführt am Department für
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der Technischen Universität Wien

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10.09.2019

Unterschrift (Student)

MASTER'S THESIS

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Conducted at the Department of
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ACKNOWLEDGMENTS

If someone told me two years ago that I will sit now in a computer room of the Cartography Research Group at TU Wien, writing Acknowledgments of my finished master's thesis, I would say "I don't believe you!" This whole experience is something that I will always carry with me. Different cities, universities, people, cultures, learning and becoming proficient in a completely new field; these two years were a rollercoaster.

First and foremost, I would like to thank my supervisor Francisco Porras Bernárdez, muchas gracias por tu paciencia, motivación y apoyo, por compartir tu conocimiento conmigo. Esta tesis fue posibile gracias a ti.

My deepest thanks to Professor Georg Gartner; it was a pleasure having you as a professor. Thank you for your support, kindness and positive energy.

Special thanks to Silvia Klettner for moral support during the writing of the thesis.

I would like to express my deepest gratitude and appreciation to Juliane Cron. Thank you so much for everything, for an enormous support that you give us and for all the help during studies.

Special thanks go to amazing people I met at this programme, 23 of them. Thank you for being true friends.

And last but not least, I would like to thank my mother for her unconditional support and love. Thank you for believing in me and pushing me further so I can become a "man of the world".

ABSTRACT

Social media today has an important role in promoting tourist destinations. It is considered as a useful and reliable source of tourist information. The analysis of its big data can give an important insight into tourists' behaviour and preferences. By using geotagged photos from social media sites, e.g. Flickr, destination management organisations can predict tourist behaviour and patterns at a destination. A major challenge today is how to track these behavioural patterns. Some of the possible methods are Kernel Density Estimation and Network Kernel Density Estimation. In this research, both analyses were used to identify areas and streets of interest of Brussels by using Flickr dataset. The assumption is that using NKDE in tourism could lead to the identification of the most popular tourist places in a city. NKDE is a density analysis on a network and it was used to identify the most popular tourist street segments in a city, while KDE was used to determine tourist areas of interest. To define tourist places, it was necessary to acquire tourist information about landmarks from various sources and compare them with the results of analyses. Areas and street segments of interest were also determined for visitors from different countries of origin. All countries of origin were included in the research and they were categorized in groups. The final product is maps presenting integration of results from both density analyses and maps with tourist attractions, per each group. Both KDE and NKDE were compared and evaluated, main differences between results of the analyses were established, and advantages and disadvantages of both methods were defined.

Keywords: Kernel Density Estimation, Network Kernel Density Estimation, Flickr, Geosocial Media, Tourism, Map visualization, Areas of Interest, Street Segment of Interest

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ABBREVIATIONS

AOI – Area of Interest

DMO – Destination Management Organisation

GIS – Geographic Information System

GSM – Geosocial Media

KDE – Kernel Density Estimation

NKDE – Network Kernel Density Estimation

SSOI – Street Segment of Interest

1. INTRODUCTION

In the past years, a lot of different survey methods of evaluations of natural and cultural heritage (such as Hilary du Cros method, AHP method, Qualitative-quantitative method, Tourist valorisation, etc.) were developed in tourism industry. These methods can be used to get an insight of a tourist destination potential, to determine its strengths, possibilities and weaknesses in order to improve the existing or develop a new tourist product. However, most of these methods are based on subjective feelings of the respondents. Developments in technology and availability of more datasets, especially from social media, could create new and objective survey methods that tourism managers could use to acquire better results. Social media platforms have become an integral part of everyday life, and their data are a sought-after tool in modern marketing research.

Today, social media is playing an important role in promoting tourist destinations, and its use has proven to be a successful strategy (Kiráľová & Pavlíčeka, 2015). Even though social media is considered as a useful and reliable source of tourist information, the analysis of its big data is still underexplored in tourist destination management. Big data is rarely collected by tourism authorities, although it can give an important insight into tourists' behaviour and preferences, which are relevant to tourist destination management. By using geotagged photos uploaded by tourists to the photo-sharing social media sites, e.g. Flickr, destination management organisations can easily predict tourist behaviour and patterns at a destination. Currently, a major challenge in tourist destination management is how to track these behavioural patterns of tourists (Miah, Vu, Gammack, & McGrath, 2017). One of the possible methods to determine tourists' patterns is density analysis.

To generate tourist hotspots from the point distribution, a method called Kernel Density Estimation (KDE) was chosen for this study. The KDE is a nonparametric way of estimating an unknown probability distribution based on a set of data samples which are independently drawn from the unknown distribution (Memon et al., 2015). KDE can also be used to derive the perceived boundaries of a city centre for holiday makers and to calculate the density of touristic features in a city (Huang, Gartner, & Turdean, 2013). KDE mostly defines tourist areas of interest. To define streets of interest is advisable to use an additional density analysis.

Network Kernel Density Estimation is a method for adapting KDE to characterize the intensity of point patterns generated in a network space (J. Downs & W Horner, 2007). NKDE is identical to Euclidean-based KDE, except that the distance-weighting kernel measures distances as a function of a network. Firstly, each grid point where the intensity is to be evaluated is connected to the nearest node in the network. Secondly, distances from each grid point to each event point are calculated as shortest paths along the network. And finally, a bandwidth is specified, and a distance-weighting kernel is applied to compute density estimates at each grid point. The result is a continuous surface of the relative intensity of the point pattern (J. A. Downs & Horner, 2007).

Figure 1. Collage of Brussels. Adapted from Floral carpet on the Grand Place in Brussels, Belgium (Hagens, 2008); A panorama of the the Northern Quarter business district in Brussels (Cridland, Solberg, 2009); Vista panorámica de noche del centro de Bruselas (García, 2007); Cinquantenaire in Brussels (Redvers, 2007); Manneken Pis van Brussel (gildermax, 2005); Cathedral of St. Michael and St. Gudula in Brussels, Belgium. (style gothic) (Viatour, 2008); The Royal Palace in Brussels, Belgium (Zepper, 2009); The Congress Column in Brussels (Murphy, 2007).

In this master's thesis, both KDE and NKDE were used as methods of the analysis of GSM data from Flickr. These methods were used for various analyses, including:

1. to identify areas and streets of interest of Brussels, the capital city of Belgium.
2. to discover if the outputs of the analyses are similar with the offered information of the most visited landmarks in Brussels, collected from the official website of the Brussels tourist agency and popular tourism magazines.
3. to create new and more personalized tourist products based on tourists' countries of origin such as tourist maps, promotional material, etc.

1.1. MOTIVATION

The main motivation behind this report is to combine two great disciplines tourism and cartography together and to encourage tourism and travel experts to use geoinformation in marketing strategies. Furthermore, it can help them to discover and track tourists' behaviour and patterns and make strategic decisions to improve the tourist experience in a tourist destination. Development of technology and constant evolving of cartography techniques is improving handling and visualization of data and with advance training and education could be of great importance in tourism industry. Tourism managers are not aware of the true potential of cartography and geoinformation in tourism. In this research paper, NKDE will be presented as one of the methods that could be of great use in tourism strategies, along with KDE.

1.2. RESEARCH QUESTIONS

The master's thesis is focused on the possibility of using NKDE in tourism industry, mainly in marketing, and its prospect of using it to identify the most popular tourist places in a city. As NKDE is a density analysis on a network, in this case it was used to identify the most popular tourist street segments in a city. Besides defining street segments, determining tourist areas were also of importance, by using KDE. In order to explain the purpose of the thesis more precisely, the following research questions had been specified:

1. Can the NKDE analysis of Flickr datasets be a suitable technique to identify touristic streets in a city?
2. Which are the main differences in the results of an analysis based on KDE vs. NKDE?
3. Which are the pros and cons of both approaches for this type of analysis?
4. Is there a possibility to integrate both: KDE for areas of interest (AOIs) and NKDE for street segments of interest (SSOIs)? How would such integration look?

To accomplish defined research questions, specifying a set of objectives is essential. Objectives are also used as a "guide" through research. The objectives of this master's thesis research are:

1. Identify areas of interest (AOIs) and streets segments of interest (SSOIs) of Brussels based on the use of KDE and NKDE.
2. Collect touristic information from different sources of Brussels and compare them with the results of the KDE and NKDE analysis.

3. Determine areas of interests (AOIs) and street segments of interest (SSOIs) for visitors from different countries of origin.
4. Generate city maps with tourist routes and areas of interest according to the results of previous analyses.

1.3. BRUSSELS

Brussels (in Flemish Brussel, in French Bruxelles) is the capital of Belgium and it is located in the valley of the Senne River in the middle of Belgium. It is the largest urban agglomeration in Belgium and it is made of 19 municipalities, the largest is named Brussels and includes the historic core of the city and the “European Quarter,” where the institutions of the European Union are located. Along with the regions of Flanders and Wallonia, the Brussels-Capital Region constitutes one of the country’s three main political divisions. Brussels is the administrative, commercial, and financial centre of Belgium, a major European tourist and cultural attraction, regional metropolis and an international centre. As the seat of the EU, Brussels is known as the "capital of Europe". The city is bilingual, and in all spheres of public life Flemish and French are used side by side (Verniers, Papadopoulos, & Hermans, 2019).

As one of the capitals of Europe, Brussels attracts tourist from all over the world thanks to its rich culture and history, Art Nouveau and Art Deco architectures, world-class museums and galleries, parks and café culture. In the research, Flickr data of Brussels was used.

2. SCIENTIFIC BACKGROUND AND LITERATURE REVIEW

To better understand the topic, it was necessary to investigate existing work in the domain. Furthermore, KDE and NKDE need to be explained, including the definitions of areas of interest and streets segments of interest. Most of the related works that include social media data analysis will be mentioned below, such as analyses of Flickr or Instagram datasets and geotagged photos to develop strategies in tourism management of a tourist destination and give insight into what attract tourists in a destination.

2.1. KERNEL DENSITY ESTIMATION

Thanks to the huge development in high-performance computing and deep learning, many computer vision algorithms along with spatial analysis methods are used today which gives an excellent opportunity to discover human activity patterns out of geotagged social media images (Koylu, Zhao, & Shao, 2019). One of these useful statistical methods is Kernel Density Estimation.

Kernel Density Estimation (KDE) is a class of statistical method with purpose to estimate the probability density function of a random variable. Its bivariate implementation is frequently used in geospatial and geographic information analysis to estimate the density distribution of the geographic process underlying a set of observations (O'Sullivan & Unwin, 2010) (Grothe & Schaab, 2009). KDE can be effective to visualize the "shape" of some data, as a kind of continuous replacement for the discrete histogram, and it can be helpful to generate points from a certain dataset (Conlen, n.d.). It enables to create better analysis of the studied probability distribution than when using a traditional histogram. Unlike the histogram, the kernel technique produces smooth estimate of the probability density function, uses all sample points' locations and more convincingly suggest multimodality (Węglarczyk, 2018). To understand KDE, firstly histograms need to be understood. It is important to consider following: the width of the bins in a histogram, equal sub-intervals in which the whole data interval is divided, and the end points of the bins where each of the bins start. As it is established before, histograms are not smooth, and KDE is used to alleviate this problem. To remove the dependence on the end points of the bins, KDE centres a kernel function at each data point. And if a smooth kernel function is used for building block, then a smooth density estimate will be created. This way two of the problems associated with histograms are eliminated (Liebenberg, Demhardt, & Vervust, 2016).

The function of the KDE is:

$$f(\mathbf{x}) = \sum_{i=1}^{N} \alpha_i k_h(\mathbf{x} - \mathbf{x}_i)$$

The x presents estimated density and α_i are the kernel weights with $\sum_{i=1}^{N} \alpha_i = 1$, kernels are mostly equally weighted $\alpha_i = \frac{1}{N}$. The $k_h(\cdot)$ needs to satisfy $\int k_h(\mathbf{x})d\mathbf{x} = 1$ and $k_h(\mathbf{x}) \geq 0 \forall \mathbf{x} \in \mathrm{R}^2$. The most commonly used $k_h(\cdot)$ is the Gaussian kernel. The h is bandwidth and a smoothing parameter, which controls the kernel's width and height (Grothe & Schaab, 2009). The quality of a kernel estimate depends less on the shape of the kernel, but on the value of its bandwidth h. It is important to choose the most appropriate bandwidth; small values of bandwidth can lead to spiky estimates and not enough smoothing, while larger bandwidth values can lead to over smoothing (Okabe, Satoh, & Sugihara, 2009).

Kernel Density Estimation is a class of nonparametric density estimations. Nonparametric density estimation means that the estimator does not have a fixed functional form or structure and depends upon all the data points in order to reach an estimate. On the other hand, parametric estimation has a structure and the parameters of this function are the only information that needs to be stored (Claborn, 2014).

2.2. NETWORK KERNEL DENSITY ESTIMATION

As it was mentioned, KDE produces homogeneous density surfaces of linear or point events over a 2-D planar space based on Euclidean distances. However, the distribution of many events is sometimes constrained by street networks. To avoid this obstacle, efforts have been made to develop Network Kernel Density Estimation (NKDE) algorithms to be used to analyse point events over street networks (Delso, Martín, & Ortega, 2018).

There are numerous events that can be analyzed in terms of the density of points on a network, such as car crashes on streets, urban crime sites on sidewalks, tree spacing along a roadside, seabirds located along a coastline, breaks in a wiring network, signal power of Wi-Fi along streets and disconnections on the Internet, etc. In addition, events that occur alongside and not directly on a network can be represented by the density of points on a network. In recent years, statistical methods are being developing to analyze these events. Technical difficulties have been resolved considerably by easily accessible detailed spatial data through the Internet and GIS that manage network data (Okabe et al., 2009). One NKDE approach was developed by Xie and Yan (2008) to estimate the density of traffic collisions over a street network and investigate different factors influencing the density outputs. Results were later compared with KDE. Okabe et al. (2009) analysed the bias of three NKDE functions and proposed computational implementations for two of them which are proved to be unbiased. NKDE has been widely used to identify hotspots, especially in the field of road accident analyses (Okabe et al., 2009; Xie & Yan, 2013) and to evaluate pedestrian mobility (Delso et al., 2018).

Equation for calculating NKDE is:

$$NKDE(x)_i = \sum_{i=1}^{n} K_{yi}(x)$$

The $K_{yi}(x)$ is the different network kernel function for each point event and $NKDE(x)_i$ is the value of the NKDE at a point x (Delso et al., 2018).

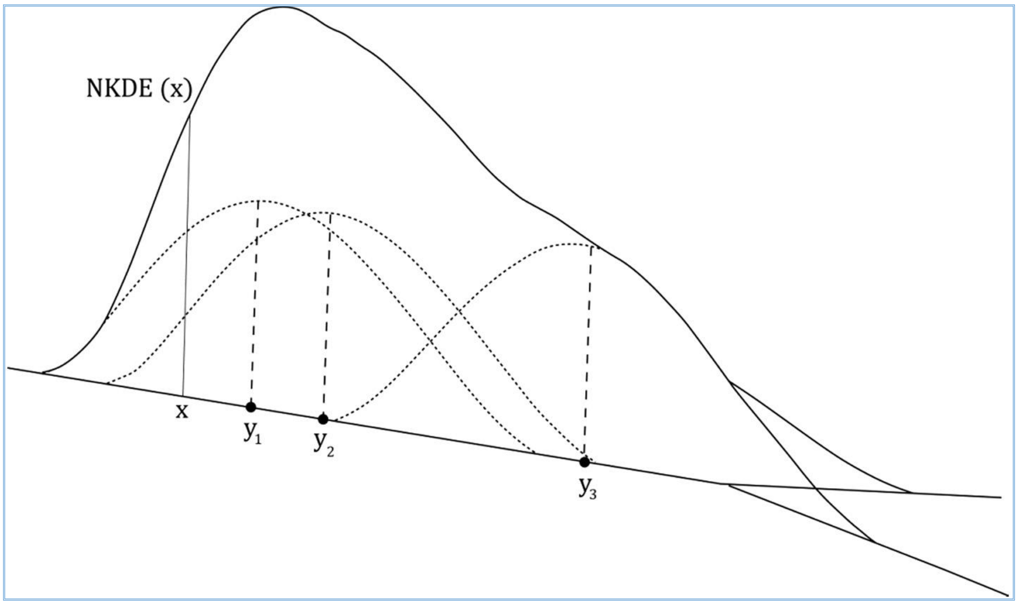

Figure 2. NKDE example performed with the continuous equal-split kernel function for three point events ($\boldsymbol{y_i}$), dashed lines present the individually calculated three kernel estimations (Delso et al., 2018).

The inputs required for the NKDE are a street network and the overlapped point events. For the various groups of obstacles the analysis is done separately. The final value of the NKDE in a point of the network presents the sum of different densities of individual kernels for each point event. The densities of overlapped points will be summed up, as well as densities from close obstacles. The density distance decay effect of the obstacles impacts is controlled by the bandwidth and the selected kernel function. If the distance from a point event to the nearest node is less than the selected bandwidth, the kernel function for that point event is the same as the base kernel function (Okabe et al., 2009).

NKDE is focused on examining point pattern distributions on a network, without taking into consideration the usual hypotheses of homogeneity and isotropy of space, but considering network spaces as frameworks for the distribution of point patterns. Many human related point phenomena are distributed over a space which is mostly not homogenous, as their location in space also depends on network. The main idea is to consider the kernel function as a density function based on network distances rather than Euclidean ones. One of the advantages of NKDE is that it can identify "linear" clusters along networks and a more precise surface pattern of network related phenomena (Borruso, 2005).

2.3. AREAS OF INTEREST

Areas of interest or AOIs are the areas in a usually urban environment that attract attention. Those areas are city landmarks, commercial centres, recreational zones, or areas with a scenic view of the city. AOIs should be understood as the areas, social spaces that are formed by people's interests and behaviours, popular on social networks such as Twitter, Facebook, Flickr, etc. AOIs may also include the areas that provide scenic views and do not have popular landmarks (Hu et al., 2015; Hudson-Smith, 2008).

AOIs feature the interesting zones in urban environment and they are included in trip planning for tourists. For city planners, AOIs are regions in a city which receive high exposure among the general public, and these regions have higher priorities for urban planning projects, such as city beautification (Espuche, Guardia, Monclus, & Oyón, 1991; Gandy, 2018). In transportation analysis these regions can be examined to understand traffic flows and human mobility patterns (Batty, 2005; Yuan & Raubal, 2012).

The boundaries of AOIs are vague because they are subjective. People in a city are interested in different areas according to age, culture, education backgrounds, personal interests, etc. and they have different understanding of the boundary. They do not agree on spatial extents and delineations of a certain AOI. This lead to the conclusion that AOIs are related to the concept of a vague place (Cohn & Gotts, 1996; Jones, Purves, Clough, & Joho, 2008; Liu, Yuan, Xiao, Zhang, & Hu, 2010; Montello, Goodchild, Gottsegen, & Fohl, 2003).

In terms of geometric representations, AOIs are not present as points, but rather as polygons. Polygon representation of AOIs has several advantages:

1. It enables new functionalities that require spatial relations (Jones et al., 2008).
2. It is generally more efficient to perform operations on a polygon than on a set of points (Akdag, Eick, & Chen, 2014).
3. Polygons can provide simple and accessible representations for areas compared with clustered points (Hu et al., 2015).

2.4. STREET SEGMENTS OF INTEREST

Besides defining AOIs, social media data can also be used to discover which streets are of great interest for tourists. Density analysis could be used to indicate segments of a street network with the highest density. These segments will be of great importance for this research and they will be emphasized as Street Segments of Interest or SSOIs. SSOIs present attractive parts of streets that intrigue locals and tourists, sections where you can find the most popular attractions of a city. SSOI can be defined as a street segment with a large density of relevant points of interest around them. To provide information regarding points of interest, a valuable source with relevant images can be used, such as Flickr and Panoramio.

Skoutas, Sacharidis and Stamatoukos (2016) addressed the problem of finding and exploring Streets of Interest (in this master's thesis Streets of Interest will be reformulated into SSOIs) based on points of interest and images characterized by geolocation and keywords. According to a set of keywords, authors ranked streets with relevant nearby POIs. Interest score for a street was defined accordingly. For their research, authors proposed an algorithm inspired from top-k query processing to retrieve a ranked list of SSOIs. After ranking streets, authors select for each discovered street a small, diversified set of photos. They formulate this as a diversification problem for spatiotextual objects. To perform a search using a spatiotextual grid, authors presented an efficient algorithm to speed up the selection of candidates. Final results showed that the proposed algorithms drastically reduce the computation time and allow online discovery and exploration of interesting parts of a street network (Skoutas, Sacharidis, & Stamatoukos, 2016).

Previous paragraph shows that scientist are involved in defining SSOIs and discovering which parts of cities are of great interest to people using images and keywords. This research is a contribution in the ongoing search to specify and present SSOIs, in this case by using NKDE.

2.5. RELATED WORKS

Authors in the research (Miah et al., 2017) suggested a method to extract, rank, locate and identify tourist information, mostly by analysing geotagged photos, from big data sets that are not structured, which will help Destination Management Organisations to make more effective strategic decisions. The possibility of using Flickr photos to analyse spatiotemporal patterns of tourist accommodations was examined in a research (Sun, Fan, Helbich, & Zipf, 2013), by making spatial clusters for each season.

This study would help to get a deeper insight in tourist accommodations with the help of Flickr photos.

Flickr photos can also be used to extract information regarding the most visited tourist sites. Authors of the study (Popescu & Grefenstette, 2009) used geotagged photos to answer questions like "how long does it takes to visit a tourist attraction?" or "what can I visit in one day in a city?" Duration times of visits were taken from geotagged and time-stamped images and were calculated. To perform a market study of tourism consumption in the city of Zaragoza in Spain, Flickr and Instagram images were analysed, using hashtags and geoposition indicators. The study (Martínez, Berrozpe, & Lasarte, 2015) showed that social media can provide quantitative and qualitative information about tourists by using mobile applications.

In the following paper (Chareyron, Da-Rugna, & Branchet, 2014), authors explained a new methodology to automatically rebuild main paths from Flickr's traces, thanks to the images metadata which contain timeline of photographers. Main paths were computed from the density of images and reconstructed between consecutive images. In the similar research (Li et al., 2011), authors described a photography-based approach to analyse tourists' spatiotemporal behaviour in China, out of 1308 images. They estimated tourists' temporal variation, length of stay, daily average number of tourists, individual movement traces and tourist hotspots.

Authors in the research (Kurata, 2012) constructed an example of potential-of-interest maps by using Flickr's image data. To accomplish this, they used five possible approaches to obtain and compare data about locations where tourists were the most impressed. Finally, authors developed a mobile tourist information tool, which features potential-of-interest maps. A new method of defining locations for travelling and recommendations was recommended by the authors (Memon et al., 2015), based on their past time in a city, according to the tourists' time and preference. They collected and examined Flickr images data. Results showed that the method is capable of giving better recommendations based on the tourists' location.

Flickr images data proved to be effective in estimating visitation rates at 836 recreational sites around the world (Wood, Guerry, Silver, & Lacayo, 2013). To accomplish this, authors used information from the profiles of the photographers to acquire travellers' origins. These estimates were compared to empirical data at each site. Conclusion was that the crowd-sourced information can serve as a reliable proxy for empirical visitation rates. This approach gives opportunities to understand which elements of nature attract people to locations and whether ecosystem changes can alter visitation rates.

3. METHODOLOGY

Behaviour and movement of tourists in a geographic space is valuable information. Social media contains a lot of information about tourists' preferences, and it can be retrieved through APIs of social media platforms. Even though social media data has been criticized for the representative issue, millions of people from all over the world still generate them (Chou, Hunt, Beckjord, Moser, & Hesse, 2009). Thankfully, these data can be analysed in researches and be used to improve marketing strategies, services and lifestyle. This is one of these researches. In the following chapter, methodology of this research will be explained.

The most important part in completing the research is to perform KDE and NKDE analysis with the use of the software ArcGIS 10.2. To perform NKDE analysis, the SANET toolbox was installed in ArcGIS. SANET is an ArcGIS-based tool that analyzes events that occur on or alongside a network. For a given set of points on a network, SANET estimates the density function of the points over a network ("What can SANET," 2009). In this research, NKDE was applied on geolocated pictures represented as points distributed along the street network. KDE analysis was performed using Kernel Density Spatial Analyst Tool included in ArcGIS software. PostgreSQL 10 was used to manage Flickr dataset. Some calculations were done in Excel.

In order to compare results of AOIs and SSOIs from KDE and NKDE analysis with the today's tourist offer, tourist information of the most popular tourist attractions in Brussels was collected.

3.1. WORKFLOW

To complete research, several steps were taken. First step was to get familiar with the dataset and SANET toolbox, second to perform NKDE and KDE, and third to find the best visualization technique to present results of both analyses. One of the challenges of completing the research was not enough expertise in required software. Through performing analysis and handling data, this challenge was successfully overcome. Another problem was that dataset could not be complete. Luckily, Brussels' Flickr dataset was complete and with well defined countries of origin.

In order to explain it more understandable, workflow was divided in four parts:

1. Data preparation
    a. getting familiar with Flickr dataset,
    b. opening and sorting of dataset in PostreSQL,
    c. creating a shapefile with points,
    d. searching for a Brussels' street network (shapefile),

e. defining groups of countries of origin,
f. calculating number of users and images per country and group in Excel,
g. getting familiar with the SANET toolbox.

2. Analysis
   a. performing KDE analysis in ArcGIS, first for all Flickr points, then for each group,
   b. performing NKDE analysis in ArcGIS with SANET toolbox, first for all Flickr points, then for each group.

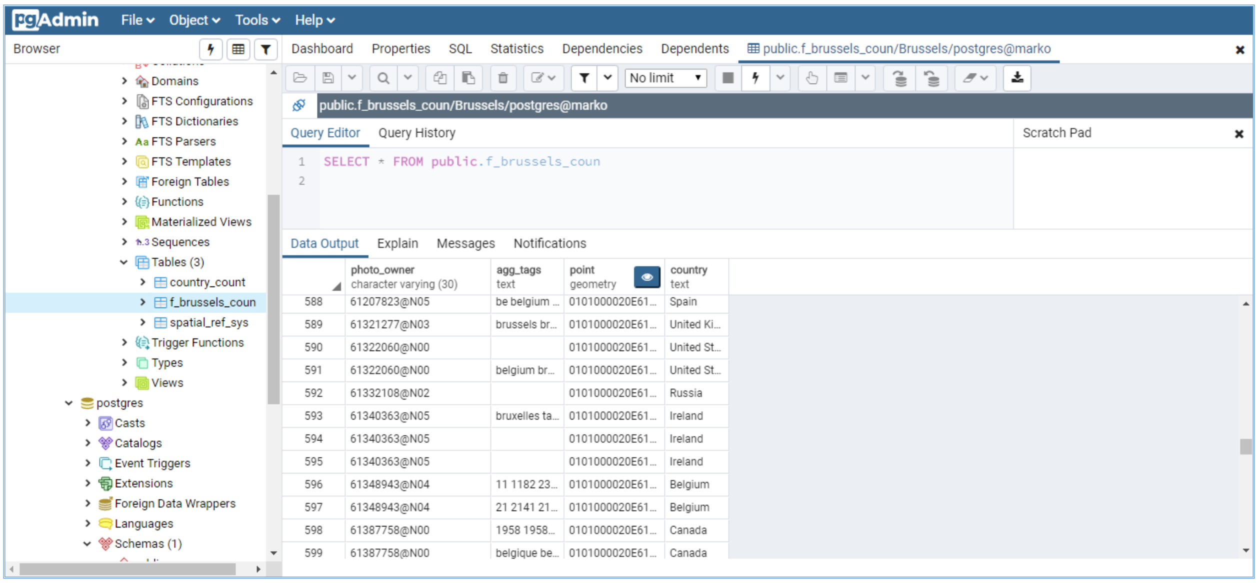

Figure 3. Flickr database in pgAdmin (PostgreSQL) (Screenshot by author)

3. Visualization
   a. finding the best visualization approach and colour scheme to present both analyses outcomes,
   b. integrate both KDE and NKDE results and present the integration with appropriate visualization technique,
   c. present KDE and NKDE results for all Flickr points and for each group of countries of origin.
4. Results interpretation
   a. according to the visualized outcomes of both analyses, extract the most attractive locations of Brussels for each group,
   b. make maps with tourist attractions for each group.

3.2. DATABASE

Data was collected from Flickr's API. Retrieved metadata of each uploaded picture contains photo owner, geolocation, description text and photo owner's country of origin. Dataset has 150,002 pictures from 12,261 users. Pictures inside the area of Brussels-Capital Region were used. Out of the total number of users, only 9,987 had a country of origin, other users did not mention country of origin, or it was stated "not found". Only pictures from users with countries of origin were included in the research (138,999).

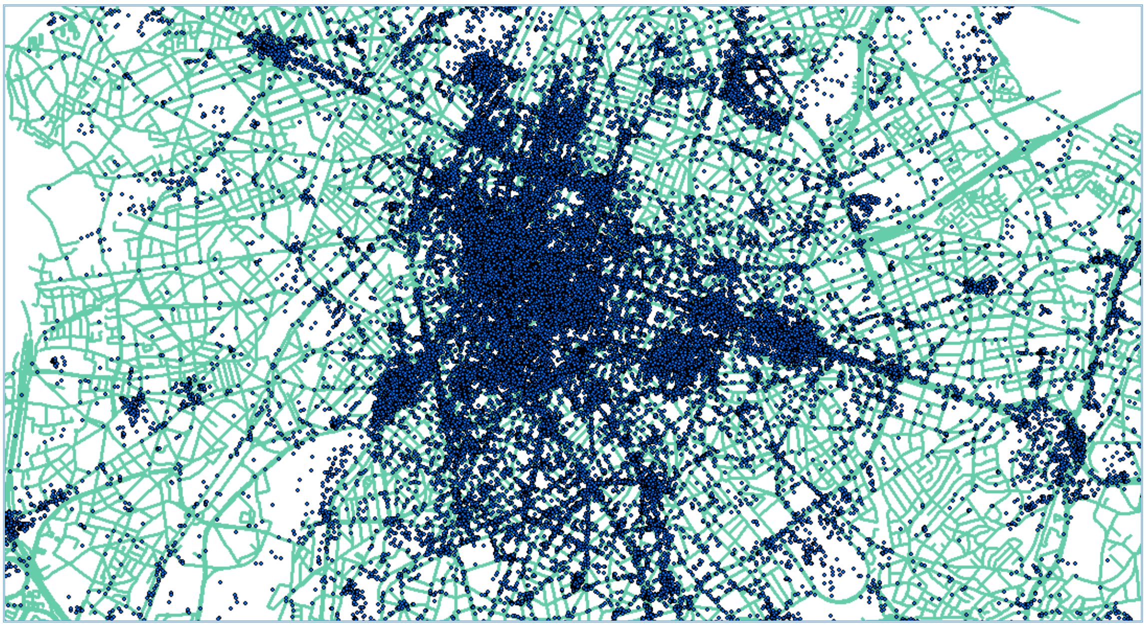

Figure 4. Flickr points and Brussels street network (Screenshot by author)

In order to define which countries of origin are in the dataset and the number of users per each country, following query was used:

```
CREATE table country_count as
        select country, count(distinct photo_owner) as counts_owner
        from f_brussels_coun group by country order by counts_owner desc
```

After defining countries and number of users, dataset was converted to an .xml file and further calculations were done in Excel. It was calculated how many users are per group and how many images are per country and per group.

To perform NKDE analysis in ArcGIS, database needed to be converted into a shapefile. To manage this, QGIS was used because of its easier approach in converting databases to shapefile. Shapefile includes geolocations of the pictures as points. To the shapefile was later assign a spatial reference system EPSG: 3857 – WGS84 Web Mercator (Auxiliary Sphere).

The street network of Brussels-Capital Region was downloaded from Geoportal of the Brussels Capital Region as a shapefile and was assigned the same spatial reference system as Flickr shapefile. The shapefile "Public way" was created 24th of June 2013 by the Brussels Regional Informatics Centre (Le Centre d'Informatique pour la Région Bruxelloise - CIRB) and contains the database reference name and official codification of public roads within the territory of the Brussels-Capital ("Geoportal of the Brussels Capital Region," 2013).

The similar approach of collecting Flickr data was explained in an article "EURECA - EUropean Region Enrichment in City Archives and collections" in order to define AOIs and Regions of interest (ROIs). Flickr database was collected from two of its APIs. From one API photo owner, uploading date and geolocation metadata of images was retrieved, from second user name, location and other attributes. Around 66 million images (points) were retrieved from 62 countries and covered a period from 2004 to 2018. Research was done for the cities of Vienna and Ghent in Belgium (Verstockt et al., n.d.) (Porras-Bernardez, Gartner, Van de Weghe, & Verstockt, 2019).

3.3. SANET TOOLBOX

SANET is a Plug-in program that statistically analyzes spatial patterns of events that occur on or alongside networks. It was developed by Atsu Okabe and his SANET Team in Tokyo, Japan. SANET Version 4.1 was used in the research. This version is only supported in ArcGIS 10.2. SANET Team developed a toolbox plugged in GIS in order to simplify the analysis of events on or along a network. This kind of analysis requires heavy geometrical and topological computations, and using this toolbox GIS experts who are not skilled in programming can now easily perform network spatial analysis with detailed data (SANET Team, 2013).

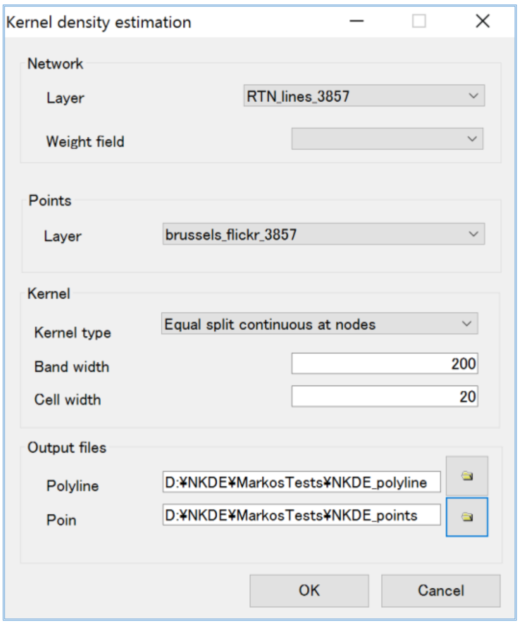

Figure 5 Steps in calculating Network Kernel Density (Screenshot by author)

SANET Toolbox includes 16 tools. These tools are:

1. Voronoi diagrams
2. Kernel density estimation
3. Global auto nearest neighbor distance method
4. Global cross nearest neighbor distance method
5. Local cross nearest neighbor distance method (in preparation)
6. Global auto K function method
7. Global cross K function method
8. Local cross K function method
9. Global Voronoi cross K function method
10. Interpolation
11. Delaunay diagram (in preparation)
12. Point clustering method
13. Random points generator
14. Shortest path distance between points in a set of points
15. Shortest path distance between A points to B points
16. Network Characteristics: polylines, points and links

The tool that was used in the research was Kernel density estimation. This tool estimates the density of points on or along a network. In order to perform the analysis, Network and Points layers need to be selected, in this case shapefiles of Brussels' street network and Flick points. Kernel type that was used for the analysis was "Equal split continuous at nodes". After selecting Kernel type, bandwidth and cell width have to be specifies, in the research bandwidth of 200 and cell width of 20 was used. In the end, folders where outputs will be stored have to be selected. The analysis creates two outputs: polylines and points. Outputs of polylines were visualized.

3.4. KERNEL DENSITY SPATIAL ANALYST TOOL

The Kernel Density Spatial Analyst Tool is a geoprocessing tool in ArcGIS that calculates density from point or polyline features using a kernel function, in a neighborhood around those features. It can be used in finding density of houses, crime reports, or roads or utility lines influencing a town or wildlife habitat. In the research, Kernel Density tool was used to calculate density of points and to define AOIs.

Kernel Density calculates the density of point features around each output raster cell. A smoothly curved surface is fitted over each point. The surface is the highest and diminishes with increasing distance from the point, reaching zero at the Search radius distance from the point. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell center. The kernel function is based on the quartic kernel function (How Kernel Density works, 2016).

For the calculation of Kernel Density for the thesis, the inputs were shapefiles of Flickr points, for each group separately and all together. Cell size was stated as 10 and search radius or bandwidth 200. Area units were square kilometers, output values were densities and method was geodesic.

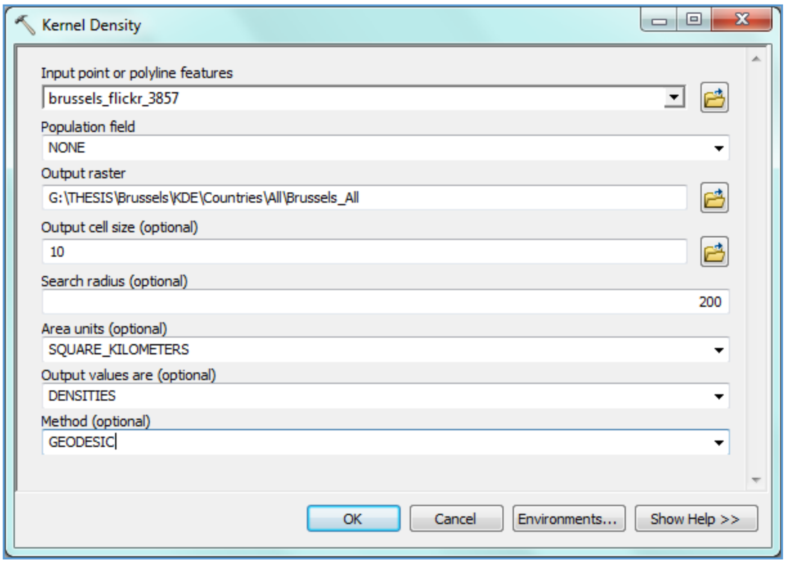

Figure 6. Steps in calculating Kernel Density (Screenshot by author)

3.5. BRUSSELS' TOURIST ATTRACTIONS

One of the objectives is to collect tourist information from different sources and compare it with the results of KDE and NKDE. This is important because with the predefined areas of landmarks it is easy to establish which tourist attractions are of great interest for each group of countries of origin, according to the results of KDE and NKDE analysis. In that way it would be clear to define a specific tourist product for each group. Tourist maps for each group were made according to the results.

To be able to define the most popular tourist attractions in Belgium for each group, a shapefile with digitized areas of tourist attractions was necessary. Shapefile was made in ArcGIS and includes 81 tourist attractions. All 81 landmarks are presented in the table 1. The list was made out of the suggestions from official travel agency of Brussels, online travel guides, travel magazines and travel platforms:

1. visit.brussels - travel agency (https://visit.brussels/en)
2. Brussels.info - tourist information and travel guide (https://www.brussels.info/attractions/)
3. PlanetWare - tourist information and travel guide (https://www.planetware.com/tourist-attractions-/brussels-b-br-bbb.htm)
4. Culture Trip - startup operating in travel, media and entertainment

(https://theculturetrip.com/europe/belgium/articles/20-must-visit-attractions-in-brussels/)

5. TripAdvisor - the world's largest travel platform (https://www.tripadvisor.rs/Attractions-g188644-Activities-Brussels.html)
6. Travel Magazine – travel portal (https://www.thetravelmagazine.net/brussels-top-10.html)
7. Lonely Planet – travel guide (https://www.lonelyplanet.com/belgium/brussels#experiences)
8. The Crazy Tourist – online travel magazine (https://www.thecrazytourist.com/15-best-things-brussels-belgium/).

Table 1. Tourist attractions of Brussels

Bruxelles-Central (Brussels Central Station)	Flagey Square	Place du Nouveau Marche aux Grains
Grand-Place	Ixelles Ponds	MAD - Fashion and Design Platform
Cathedral of St. Michael and St. Gudula	The European Parliament	Archives et Musée de la Littérature - AML
The Belgian Comic Strip Center	Leopold Park	La Fonderie - Museum of work and industry
Centre for Fine Arts - BOZAR	Museum of Natural Sciences	Bois de la Cambre
Charles Rogier Square	Parc du Cinquantenaire	Mont des Arts
Royal Greenhouses of Laeken	Autoworld	Notre-Dame du Sablon
Castle of Laeken	Art & History Museum	Le Cambre Abbey
Japanese Tower	Royal Museum of Armed Forces and Military History	Hotel van Eetvelde (Victor Horta's MTH)
Chinese Pavillion	Arcade du Cinquantenaire	Hotel Tassel (Victor Horta's MTH)
Atomium	European Union institutions	Hotel Solvay (Victor Horta's MTH)
Mini-Europe	Brussels Park	Villa Empain
Océade	Le Botanique	Royal Gallery of Saint Hubert
Planetarium	De Brouckère Square	L'Archiduc bar
René Magritte Museum	Saint Catherine Square, Saint Catherine Church	Van Buuren Museum
National Basilica of the Sacred Heart	Bruxelles-Nord (Brussels-North railway station)	Sonian Forest
Brussels Stock Exchange	Laeken Cemetery	Brussels Beer Project

Halles Saint-Géry	Brussels Expo	House of European History
Place du Jeu de Balle (Marolles Flea Market)	Kanal - Centre Pompidou	Square of Petit Sablon
Manneken-Pis	Train World	Cantillon Brewery, Brussels Gueuze Museum
Palais Royale	Coudenberg Palace, BELvue Museum	Royal Puppet Theatre Toone
Place Royal	Museum of the City of Brussels (Maison du Roi)	Josaphat Park
Musical Instruments Museum - MIM, Old England	MIMA - The Millennium Iconoclast Museum of Art	Brussels Town Hall (Hotel de Ville)
Magritte Museum (Royal Museums)	ADAM - Brussels Design Museum	La Monnaie Royal Theatre, Opera
Royal Museums of Fine Arts of Belgium	Belgian Chocolate Village	Tour & Taxis
Law Courts of Brussels (Palais de Justice)	Parlamentarium	Bruxelles-Midi (Brussels-South railway station)
Horta Museum (Victor Horta's Major Town Houses)	Station Europe	Notre-Dame-de-la-Chapelle (Chapel Church)

3.6. COUNTRIES OF ORIGIN

As it was mentioned before, out of 12,261, only 9,987 photo owners had a country of origin in the dataset. There are total of 121 countries in the dataset. The initial idea was to include only top 10 countries and make tourist maps only for them. But uneven number of photo owners between countries influenced in creating groups. In top 10 countries, almost all are European countries. As it was expected, Belgium is the first country with 2,187 photo owners, followed by the United Kingdom with 1,378 photo owners, the next are France and Spain. On the fifth place are United States, then Netherlands, Italy, Germany, Canada and Switzerland. Out of these top 10 countries, the United States and Canada are not European countries, and other countries are in Western Europe. Results shows that the arrangement of numbers is not diverse, it does not include countries from different continents and users of different cultural background. In order to get more interesting and different results and make personalized tourist product for specific cultures, all countries needed to be included.

The assumption is that visitors from countries that are classified in one group (people have similar cultures, interests, etc.) have a similar pattern of movements.

Regarding the number of images per country, the highest number of images is from local photo owners, Belgium with 79,956 images. The next is the United Kingdom with 10,941 images, followed by France with 8,554 images, United States, Germany, Spain, Netherlands, Italy, Sweden and Switzerland. The same pattern is evident here; in top 10 countries only the United States is not a European country. It can also be indicated that on average one user made 14 images in Brussels. Belgium has the highest average number of images by a user, 34. Other groups have an average between 5 and 11 images per user.

Countries were classified in 12 groups. Belgium is not classified in any group and it is included as a separate country. The groups are: West Europe, South Europe, Central Europe, North Europe, Southeast Europe, East Europe, Asia, Middle East, Africa, Anglo-America, Latin America, and Oceania (including Antarctica). Groups were made according to the continents. Asian countries were divided into two groups: Asia and Middle East (in this group Egypt was also included); American countries were divided by languages and cultures: Anglo-America, with the dominant English language, and Latin America, with the dominant Spanish and Portuguese languages. In Anglo-America was also included Curacao and Suriname, where the official language is Dutch. Antarctica was also displayed as a country of origin with 2 photo owners; these 2 users were included in the group Oceania. European countries were divided in 6 groups based on the recommendation by the Standing Committee on Geographical Names from Germany (StAGN)[1].

Table 2. Groups of countries of origin

Group	Countries	Flickr users	Number of images
West Europe	Andorra, France, Ireland, Isle of Man, Netherlands, United Kingdom	3,226	24,693
South Europe	Gibraltar, Italy, Malta, Portugal, Spain	1,579	8,040
Central Europe	Austria, Croatia, Czechia, Estonia, Germany, Hungary, Latvia, Lithuania, Luxembourg, Poland, Slovakia, Slovenia, Switzerland	1,055	8,734
North Europe	Denmark, Faroe Islands, Finland, Iceland, Norway, Svalbard and Jan Mayen, Sweden	285	3,259

[1] StAGN adopted the classification based on the suggestion by Peter Jordan and his article "Großgliederung Europas nach kulturräumlichen Kriterien" (Jordan, 2005).

Southeast Europe	Albania, Bosnia and Herzegovina, Bulgaria, Greece, Moldova, Romania, Serbia	161	1,565
East Europe	Belarus, Russia, Ukraine	85	748
Asia	Armenia, Bangladesh, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Japan, Kyrgyzstan, Macao, Malaysia, Mongolia, Myanmar (Burma), North Korea, Pakistan, Philippines, Singapore, South Korea, Taiwan, Thailand, Vietnam	195	1,475
Middle East	Bahrain, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Qatar, Saudi Arabia, Turkey, United Arab Emirates	90	968
Africa	Algeria, Angola, Central African Republic, Ethiopia, Ghana, Guinea-Bissau, Kenya, Libya, Malawi, Morocco, Mozambique, Namibia, Réunion, South Africa, Tunisia	46	327
Anglo-America	Bermuda, Canada, Curacao, Grenada, Guyana, Saint Lucia, Suriname, United States	806	6938
Latin America	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Panama, Paraguay, Peru, Puerto Rico, Uruguay, Venezuela	187	1574
Oceania	Antarctica, Australia, New Zealand, Papua New Guinea	85	722

4. RESULTS

After explaining methodology, results will be shown in the following chapter. The final result of the research is 28 maps, first 14 present combined results of NKDE and KDE analysis, and other 14 are suggested maps of tourist attractions per each group of countries of origin. Tourist maps were made from the final results of both density analyses. All maps are included in the Appendix in order to present them on the whole page and together as a collection of maps.

4.1. KDE AND NKDE RESULTS

Maps present results of KDE and NKDE analysis together. The 14 maps include 12 for each group, one for Belgium as country of origin and one for all Flickr points, not specifying any country of origin.

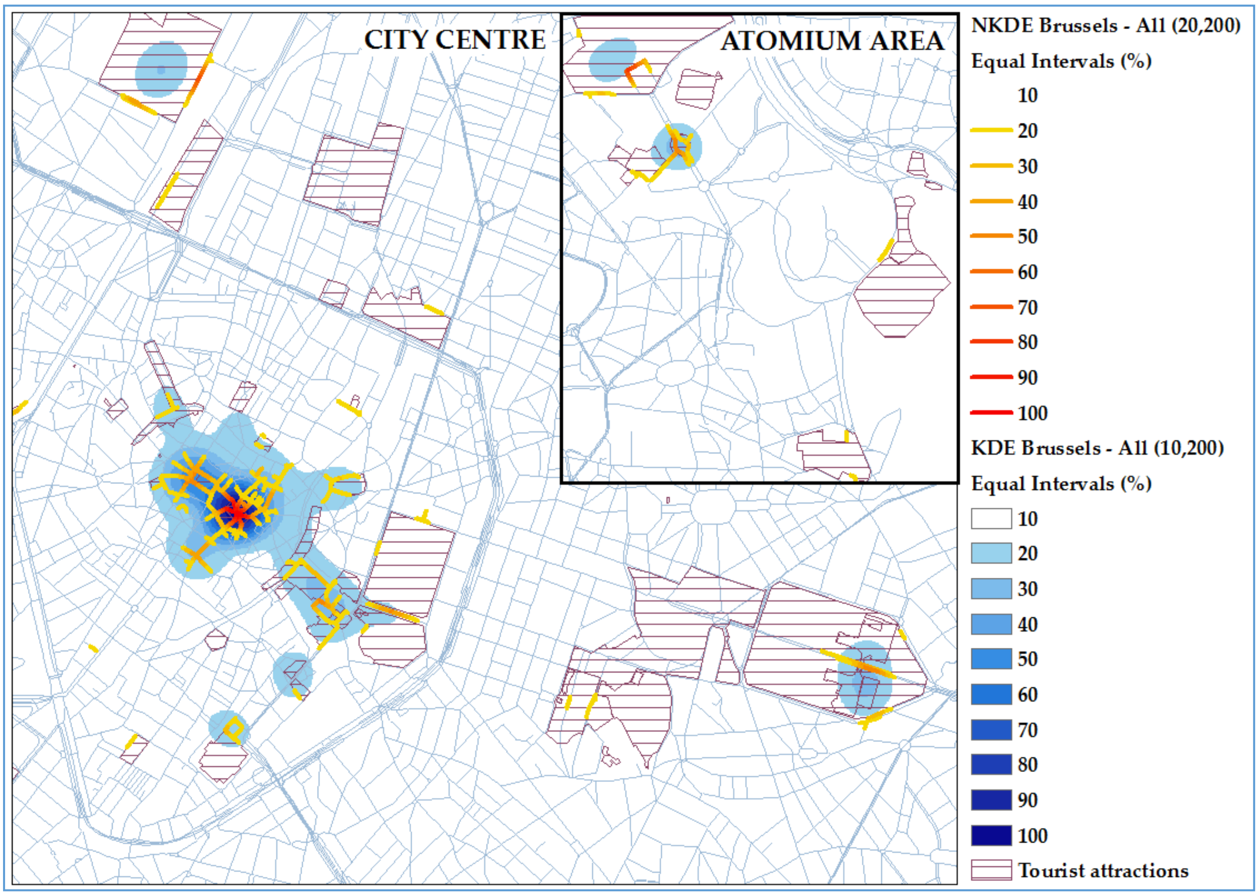

Figure 7. KDE and NKDE analysis results, all Flickr points

For the purpose of explaining maps, map in figure 7 will be used as an example for better understanding of the results. Presented density values are classified in 10 classes by equal intervals. Each class presents percentages from 10 to 20%, from 20 to 30%, etc. up to 100%. Percentages bellow 10% are not included in both density analyses results. Values of NKDE analysis are presented as average. Maximum density values

(100%) are presented in the table 3. With equal intervals and the same number of intervals for every group, classes are normalized. Normalizing data enables comparing different data more easily.

Layout of the maps is focused on the city centre of Brussels and Atomium area, where the biggest concentration of tourist attractions is and where the density values are the highest. Tourist attractions are also included on maps for better comparison.

Table 3. Maximum density values per analysis, per group

Group	Max KDE density value	Max NKDE density value
All	296,434.5	2,759.76
Africa	1,513.88	14.66
Anglo-America	25,552.85	235.48
Asia	5,754.69	50.06
Belgium	96,940.58	1,858.8
Central Europe	25,912.64	236.91
East Europe	2,034.34	35.62
Latin America	4,938.83	48.45
Middle East	3,429.81	35.8
North Europe	6,683.76	175.33
Oceania	2,181.21	18.83
Southeast Europe	4,470.3	39.28
South Europe	30,004.9	285.62
West Europe	76,111.93	716.61

As it is evident in the figure 7, KDE analysis results show that the areas in the inner city centre (around the main city square Grand-Place, museums of the Parc du Cinquantenaire and Atomium) are the main AOIs of Brussels. These areas are the most touristic in Brussels according to the sources from travel agencies, guides, magazines, etc., and results for each group show the same. There are minor differences, but all groups are interested in the same areas.

Regarding the NKDE analysis, its results follow KDE results almost uniformly. However, NKDE results show SSOIs inside the city centre more precisely than KDE show AOIs (Figure 8). Furthermore, some SSOIs are defined outside of AOIs. This is probably one of the indicators of the difference between KDE and NKDE, as KDE calculates density on a 2D planar surface, while NKDE calculates it on network. It is also evident that in some places AOIs are inside of a city block, while SSOIs are around the city block (Figure 9). This could be interpreted that the area inside city block is of interest, but not the street. As it was defined before, NKDE algorithm analyses point events on a network, and these point events that do not follow network will be matched to the nearest point on the edge of network. Therefore the result will be the calculated high density on a network and a created SSOI. In some cases, this interpretation could be different and it could show part of a street that should be avoided for the sake of security, or could be used to show from which part of a street an AOI is approachable.

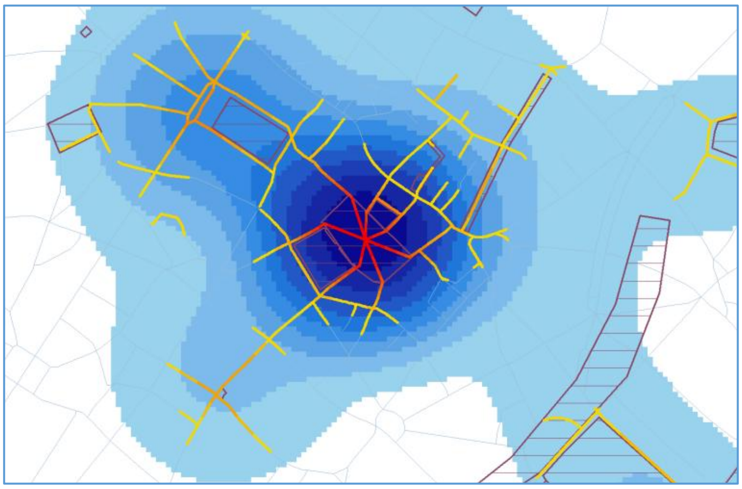

Figure 8. Zoom of the City Centre

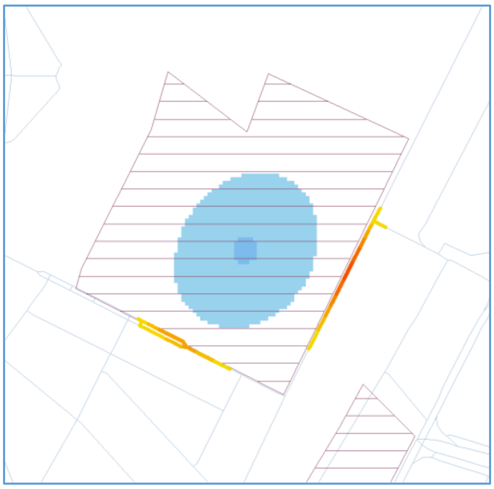

Figure 9. Zoom of Tour & Taxis

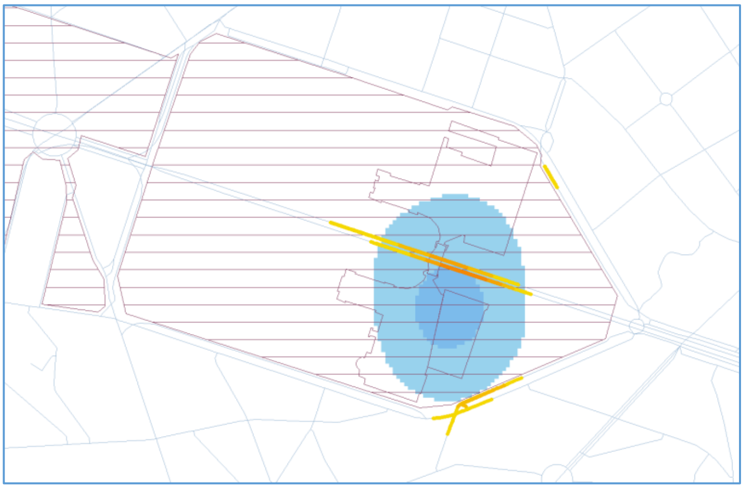

Figure 10. Zoom of Cinquantenaire Park

Density values on table 3 show different results between KDE and NKDE. This is another difference in the calculation of density. During the calculation of density on a surface, all points that are inside the specified bandwidth will be summed, while points on network and those points that are closer and matched onto the network will be summed. Number of points in calculating density is not equal in both KDE and NKDE. However, absolute density values were not specified on maps because it would be difficult to compare results between groups. That is why the normalization was required.

4.2. TOURIST MAPS

After showing results of NKDE and KDE analyses with Brussels' tourist attraction, it is clear to define which tourist attraction are of great interest to each group of countries of origin. It can be concluded that it is possible to recognise tourist patterns and interests by using KDE to define AOIs and NKDE to define SSOIs. After comparing and overlapping analyses results with the predefined list of popular Brussels' landmarks, it is possible to name all landmarks that are considered as AOIs and SSOIs per each group. All tourist maps are included in the Appendix. All landmarks of great interest, according to the Flickr users for each group, are listed in the table 4 below.

Table 4. Tourist attractions per group

Africa
1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels), 2. Manneken-Pis, 3. Cathedral of St. Michael and St. Gudula, 4. Royal Gallery of St. Hubert, 5. Brussels Stock Exchange, 6. La Monnaie Royal Theatre, 7. Royal Puppet Theatre Toone, 8. The Belgian Comic Strip Centre, 9. St. Catherine Church, 10. Mont des Arts, 11. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts), 12. Notre-Dame-de-la-Chapelle, 13. MIMA - The Millennium Iconoclast Museum of Art, 14. Kanal, 15. Van Buuren Museum, 16. Cinquantenaire Park (incl. Arcade), 17. Atomium.
Anglo-America
1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels), 2. Manneken-Pis, 3. Cathedral of St. Michael and St. Gudula, 4. Royal Gallery of St. Hubert, 5. Brussels Stock Exchange, 6. Royal Puppet Theatre Toone, 7. The Belgian Comic Strip Centre, 8. Mont des Arts, 9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts), 10. Palais du Justice,

11. Cantillon Brewery and Gueuze Museum,
12. Cinquantenaire Park (incl. Arcade),
13. Atomium,
14. Mini-Europe.

Asia

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Mont des Arts,
8. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
9. Notre-Dame du Sablon,
10. Notre-Dame-de-la-Chapelle,
11. Palais de Justice,
12. Marolles Flea Market,
13. Cinquantenaire Park (incl. Arcade),
14. The European Parliament,
15. Atomium.

Belgium

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Royal Gallery of St. Hubert,
4. Brussels Stock Exchange,
5. Royal Puppet Theatre Toone,
6. La Monnaie Royal Theatre,
7. De Brouckère Square,
8. Halles Saint-Géry
9. St. Catherine Church and Square,
10. Mont des Arts,
11. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
12. BOZAR - Centre for Fine Arts,
13. Notre-Dame du Sablon and Petit Sablon Square,
14. Notre-Dame-de-la-Chapelle,
15. Palais de Justice,
16. Marolles Flea Market,
17. MIMA - The Millennium Iconoclast Museum of Art,
18. La Fonderie,
19. Cinquantenaire Park (incl. Arcade, Autoworld, Art & History Museum and Royal Museum of Armed Forces and Military History),

20. Le Botanique,
21. Kanal and Centre Pompidou,
22. Tour & Taxis,
23. Laeken Cemetery,
24. Castle of Laeken and Royal Greenhouses of Laeken,
25. Expo

Central Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Notre-Dame du Sablon and Petit Sablon Square,
11. Palais de Justice,
12. The European Parliament,
13. The EU Institutions,
14. Cinquantenaire Park (incl. Arcade),
15. Atomium,
16. Mini-Europe,
17. Expo.

East Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Brussels Park,
11. Notre-Dame du Sablon,
12. Palais de Justice,
13. Le Botanique,
14. Leopold Park,
15. Cinquantenaire Park (incl. Arcade and Royal Museum of Armed Forces and Military History),

16. Castle of Laeken and Royal Greenhouses of Laeken,
17. Chinese Pavillon and Japanese Tower,
18. Atomium,
19. Mini-Europe.

Latin America

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Le Monnaie Royal Theatre,
8. St. Catherine Church and Square,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Brussels Park,
12. Notre-Dame du Sablon and Petit Sablon Square,
13. Palais de Justice,
14. Marolles Flea Market,
15. Cinquantenaire Park (incl. Arcade),
16. Flagey Square,
17. Laeken Cemetery,
18. Atomium,
19. Mini-Europe.

Middle East

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Royal Gallery of St. Hubert,
4. Brussels Stock Exchange,
5. Royal Puppet Theatre Toone,
6. Mont des Arts,
7. Palais Royale,
8. The European Parliament,
9. Le Botanique,
10. Cinquantenaire Park (incl. Arcade),
11. Tour & Taxis,
12. Laeken Cemetery,
13. Atomium.

North Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,

3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale and Old England (MIM))
10. Charles Rogier Square,
11. Atomium.

Oceania

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Le Monnaie Royal Theatre,
8. St. Catherine Square,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Brussels Park,
12. Notre-Dame du Sablon and Petit Sablon Square,
13. Notre-Dame-de-la-Chapelle,
14. Palais de Justice,
15. The European Parliament,
16. The EU Institutions,
17. Cinquantenaire Park (incl. Arcade),
18. National Basilica of the Sacred Heart,
19. Atomium.

Southeast Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. St. Catherine Church,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. BOZAR – Centre for Fine Arts,

12. Brussels Park
13. The European Parliament,
14. Leopold Park,
15. Cinquantenaire Park (incl. Arcade, Art & History Museum and Royal Museum of Armed Forces and Military History),
16. National Basilica of the Sacred Heart,
17. Atomium,
18. Mini-Europe.

South Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Notre-Dame du Sablon,
11. Palais de Justice,
12. The European Parliament,
13. Cinquantenaire Park (incl. Arcade),
14. Atomium.

West Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. St. Catherine Church,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Notre-Dame du Sablon,
12. Palais de Justice,
13. Cinquantenaire Park (incl. Arcade, Autoworld, Art & History Museum and Royal Museum of Armed Forces and Military History),
14. Atomium,
15. Mini-Europe.

5. DISCUSSION

After completing the research and presenting results, several conclusions stood out. In the chapter Discussion, it is necessary to remember the research questions and repeat them. Based on the conclusions from results, it is of great importance to answer each of them and therefore complete the research. The study started with the hypothesis is it possible to use density analyses, e.g. KDE and NKDE, in tourism to identify tourists' patterns and interests and accordingly improve or create better marketing strategies in tourist destination management. In order to answer research questions, research objectives were specified. First, it is necessary to get reminded of them:

1. Identify areas of interest (AOIs) and streets segments of interest (SSOIs) of Brussels based on the use of KDE and NKDE.
2. Collect touristic information from different sources of Brussels and compare them with the results of the KDE and NKDE analysis.
3. Determine areas of interests (AOIs) and street segments of interest (SSOIs) for visitors from different countries of origin.
4. Generate city maps with tourist routes and areas of interest according to the results of previous analyses.

It can be said that all objectives were accomplished. Using KDE and NKDE analysis AOIs and SSOIs were successfully identified and mapped. AOIs and SSOIs were defined for each group and maps were made with both results of KDE and NKDE. Results were compared with collected tourist information as well, and tourist attractions per each group were specified and presented on tourist maps. These maps are actually final product which demonstrates that density analyses can indeed be used in tourism management and marketing. All maps can be found in the Appendix. This way, by categorizing users based on their countries of origin, it is possible to make a personalized tourist product according to the cultural preferences and offer it to a holiday maker who comes from a specific country.

5.1. ANSWERING RESEARCH QUESTIONS

All research objectives were met and completed. Their successful completing leads to the correct answers of the research questions. In the following text, it is of great importance to respond to all research questions and therefore completing the research with final conclusions. These conclusions will help other researchers and scientists in further studies related to the topic of this master's thesis.

1. *Can the NKDE analysis of Flickr datasets be a suitable technique to identify touristic streets in a city?*

Based on the final results of NKDE analysis and maps that were made based on these results, NKDE analysis is a suitable technique to identify tourist streets in a city. NKDE analysis proved to be more successful in defining tourist places than KDE analysis. It gave more precise results and calculations. It can also be concluded that NKDE results can give information about the most occupied street segments around a tourist landmark. This can be interpreted as valuable information for tourists to avoid certain streets because of overcrowding, or as a hint from which part of a street they can approach landmark. Besides identifying tourist streets in a city, NKDE can be used in defining security measures on destination.

2. *Which are the main differences in the results of an analysis based on KDE vs. NKDE?*

Despite using KDE to identify AOIs and using NKDE to recognise SSOIs, differences in results between these analyses are mostly in density. KDE calculates density of a 2D planar surface, while NKDE calculates density on a network. And those densities do not visually match in all cases, because of the nature of the technique themselves as well as the different optional bandwidths. In this research, the bandwidth for both density analyses was 200 meters. Calculating density with the same bandwidth on a surface and on a network will give different results. The distribution of points on a surface is more spread, and those points which are more clustered, inside the bandwidth of 200 from each point, will give a density value and therefore a density surface. On the other hand, not all points are inside the street network, because not all pictures are taken in the street. There is also a possibility of GPS errors of the user's devices. Those points that are outside the network needed to be matched to it. This will give a situation that their matched nodes will be clustered on a network and will be included inside the bandwidth of 200, while on a surface it appears that they are not inside the bandwidth. According to that, results could be different in presenting AOIs and SSOIs, where in some cases they both match, while on the other hand results will show SSOIs but not AOIs, even though points are on a surface and not on a network.

3. *Which are the pros and cons of both approaches for this type of analysis?*

The main advantage for both analyses is their wide use. In this research, they were focused on their use in tourism, but their benefit to other fields such as police investigation, traffic, urban planning, etc. is significant. The advantage is that they could be used in marketing research and in tourism management and it should be encouraged to use them in defining tourists' interests and movements around a tourist destination. By using Flickr database, both analyses successfully defined AOIs and

SSOIs. The results overlap with the tourist offer of Brussels; results show that the most visited places in Brussels are actually tourist attractions and areas. Another advantage was specified in the answer of the first question that besides defining AOIs and SSOIs, KDE and NKDE could be used to help DMO to improve security and administration and to set carrying capacity.

The disadvantage of both analyses is that the results could not be 100% correct. KDE could give a result with a large density surface which will lead to a difficult defining of AOIs because a large area will be covered. In the beginning of this research, a bandwidth of 100 m was specified and the results were clearer, with smaller and emphasized areas. This gives a better conclusion and better defined AOIs. However, these results were not visible on a map, especially in integration with NKDE results. Therefore, a larger bandwidth was required to make the results more recognizable on a map. Regarding NKDE, the disadvantage of this density analysis is that the points that are not considered part of network will be matched to the nearest point on the edge of network. This will create a result where the segment of street will be defined as SSOI, but the street is not considered of interest in reality. One example is Cinquantenaire Park with Arcade and Museum (Figure 10). According to the results, area around Arcade and Museums is AOI, which is correct, and the street that goes through parks is defined as SSOI. But if the area is observed from satellite images it is clear that this street does not go through the park, but under, in a tunnel. Street network does not include information regarding tunnels, motorways and bridges, and therefore NKDE cannot recognize them during the analysis. It will calculate the results based on the assumption that edges and nodes are identical. Thus, researchers need to have some knowledge about the city to find these errors and interpret the results correctly.

4. *Is there a possibility to integrate both: KDE for areas of interest (AOIs) and NKDE for street segments of interest (SSOIs)? How would such integration look?*

After obtaining the results of analyses, it was necessary to present them in the most suitable way. As this is one of the research questions, the idea was to integrate both results, preferably on a map. The final answer is yes, it is possible to integrate both density analyses and present them on a map. The maps with integrated KDE and NKDE are included in the Appendix. To accomplish the integration, a good visualization is the key. With the appropriate colour schemes and numbers of intervals, the integration can be very well presented. However, there is a disadvantage. Although maps look aesthetically pleasing, not all details are visible. A larger zoom is required to make results better detectable.

Besides the integration of KDE and NKDE, it would be adequate to define a couple of criteria to compare them and understand which of these analyses is more effective to visualize. Seven criteria of Data Visualization Effectiveness Profile are recommended by Stephen Few (Few, 2017). They are used for assessing and comparing the effectiveness of data visualization. Two general categories are considered, first is informative (can visualization be understood) and emotive (can visualization produce a useful emotional response). Criteria are:

1. Informative
    a. Usefulness – is the provided information useful and important,
    b. Completeness – is the all of the important context provided to understand the information,
    c. Perceptibility – is the displayed information perceivable with minimal effort,
    d. Truthfulness – is the displayed information accurate and valid,
    e. Intuitiveness – is the information familiar and easily understood,
2. Emotive
    a. Aesthetics – is the visualization pleasing to the eye
    b. Engagement – a quality that can be achieved by various means.

In the following table KDE and NKDE were evaluated and compared using the above mentioned criteria.

Table 5. Data Visualization Effectiveness Profile

	KDE					NKDE				
Usefulness	1	2	**3**	4	5	1	2	3	**4**	5
	Useless				Very useful	Useless				Very useful
Completeness	1	2	3	**4**	5	1	2	3	**4**	5
	No relevant data				All relevant data	No relevant data				All relevant data
Perceptibility	1	2	3	**4**	5	1	2	**3**	4	5
	Unclear and difficult				Clear and easy	Unclear and difficult				Clear and easy
Truthfulness	1	2	3	**4**	5	1	2	3	**4**	5
	Inaccurate and/or invalid				Accurate and valid	Inaccurate and/or invalid				Accurate and valid
Intuitiveness	1	2	3	**4**	5	1	2	3	**4**	5
	Difficult to understand				Easy to understand	Difficult to understand				Easy to understand
Aesthetics	1	2	3	4	**5**	1	2	**3**	4	5
	Ugly				Beautiful	Ugly				Beautiful
Engaging	1	2	3	**4**	5	1	2	**3**	4	5
	Distracts from data				Draws one into the data	Distracts from data				Draws one into the data
Average score	**4**					**3.6**				

After completing the table, the average score was calculated for each density analysis. KDE got an average score of 4, while NKDE got 3.6. This gives a conclusion that KDE is more effective in visualizing Flickr data. It gives clearer and aesthetically more pleasing visualization, while visualized NKDE results are more difficult to perceive.

5.2. STUDY LIMITATIONS

Most of the limitations that were encountered during the research are related to the Flickr dataset. First and foremost, can Flickr dataset be sufficient in this kind of a research? Can the dataset give enough information to be analysed? Although it was proven in this study that Flickr dataset can be an appropriate means in the research analysis, it needs to have enough data in order to be used in a research. Flickr is not widely used, mostly by professional photographers, and this can be an obstacle if a dataset of a city with not enough uploaded images is needed for a research. This could lead to a problem in performing any analysis because dataset does not have enough information. Luckily, the dataset of Brussels had enough necessary information to be used in a research. However, information regarding countries of origin is not evenly distributed or there is not enough information. It was expected that the largest number of users is from Belgium and Western European countries, but in some countries there were not enough users to perform the analysis. Thus groups had to be made to include all countries in order to have higher number of users and have enough Flickr points to perform density analyses successfully. Besides not having enough users from a specific country, a huge number of users did not have a defined country of origin. A total of 2,274 users had to be discarded from analyses because they did not have a country of origin in the dataset. Another limitation refers to NKDE and its processing. To calculate network density with SANET toolbox takes a lot of time, particularly if point layer has a large number of points.

5.3. FUTURE IMPROVEMENT

One of the possible improvements of the research could be adding temporal components into the analysis. Density analyses could be performed per year, season or month, which would lead to more precise results. Tourist preferences would be observed and the tourist offer could be adapted per each month or season. This could give an insight of the changing number of tourists by observing Flickr users, and give important information to DMO in what period of a year the tourist promotion should be more emphasized.

Another possible improvement could be conducting a survey, where respondents would evaluate visualization of KDE and NKDE results. Survey would include criteria similar to Data Visualization Effectiveness Profile and more, also a couple of maps with different visualization approaches could be evaluated. Survey could also include recognizing AOIs and SSOIs by respondents. It is also a suggestion to use eye tracking devices and to measure how much time were needed to identify AOIs or SSOIs.

6. CONCLUSION

In this paper it was important to highlight the potential of using density analysis, in this case NKDE, in tourism management by using GSM data. In order to achieve it, a research was conducted where NKDE was used to identify SSOIs and KDE was used to determine AOIs. At the beginning, the idea was to use NKDE to define AOIs and SSOIs together, but this was not possible because NKDE does not identify point patterns on a 2D planar surface but on a network. Therefore it was necessary to use both approaches and divide detection of AOIs and SSOIs by using two density analyses. Their integration and comparison was included in the research as well in order to distinguish them and present why they are both crucial in defining tourist attractions separately. As the results demonstrate, they both accomplished the task and identify AOIs and SSOIs in Brussels, using all Flickr points and per each group of countries of origin. It was discovered that NKDE provide more precise results than KDE, but its visualization is not perfectly clear to distinguish density intervals. Besides giving precise results in defining SSOIs, in some cases results can be incorrect, as NKDE cannot recognize the actual state of street network in a city. In reality, street network include tunnels, motorways, etc. and NKDE can show SSOIs in these parts of network. Therefore in results interpretation, researcher needs to know the street network in reality in order to interpret results correctly. In conclusion, can NKDE be used in tourist management to identify touristic streets and can be used to improve and create tourist product in a city? Yes, absolutely. With minor corrections in visualization technique, with more knowledge and understanding of this method and with more openness to new innovations, tourism managers could find NKDE a very valuable asset in improving tourism business in a tourist destination.

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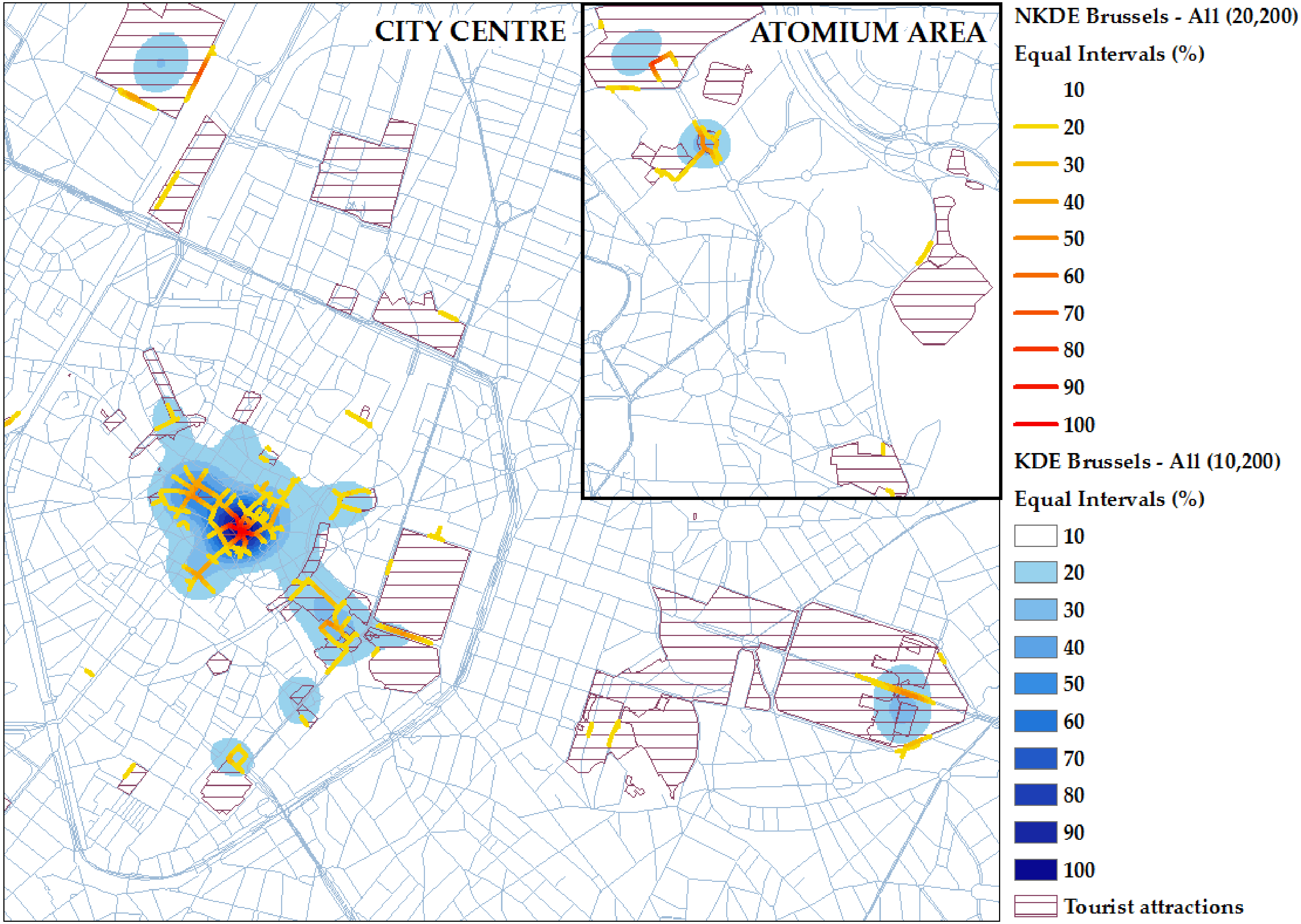
APPENDIX I

Maps with NKDE and KDE results:

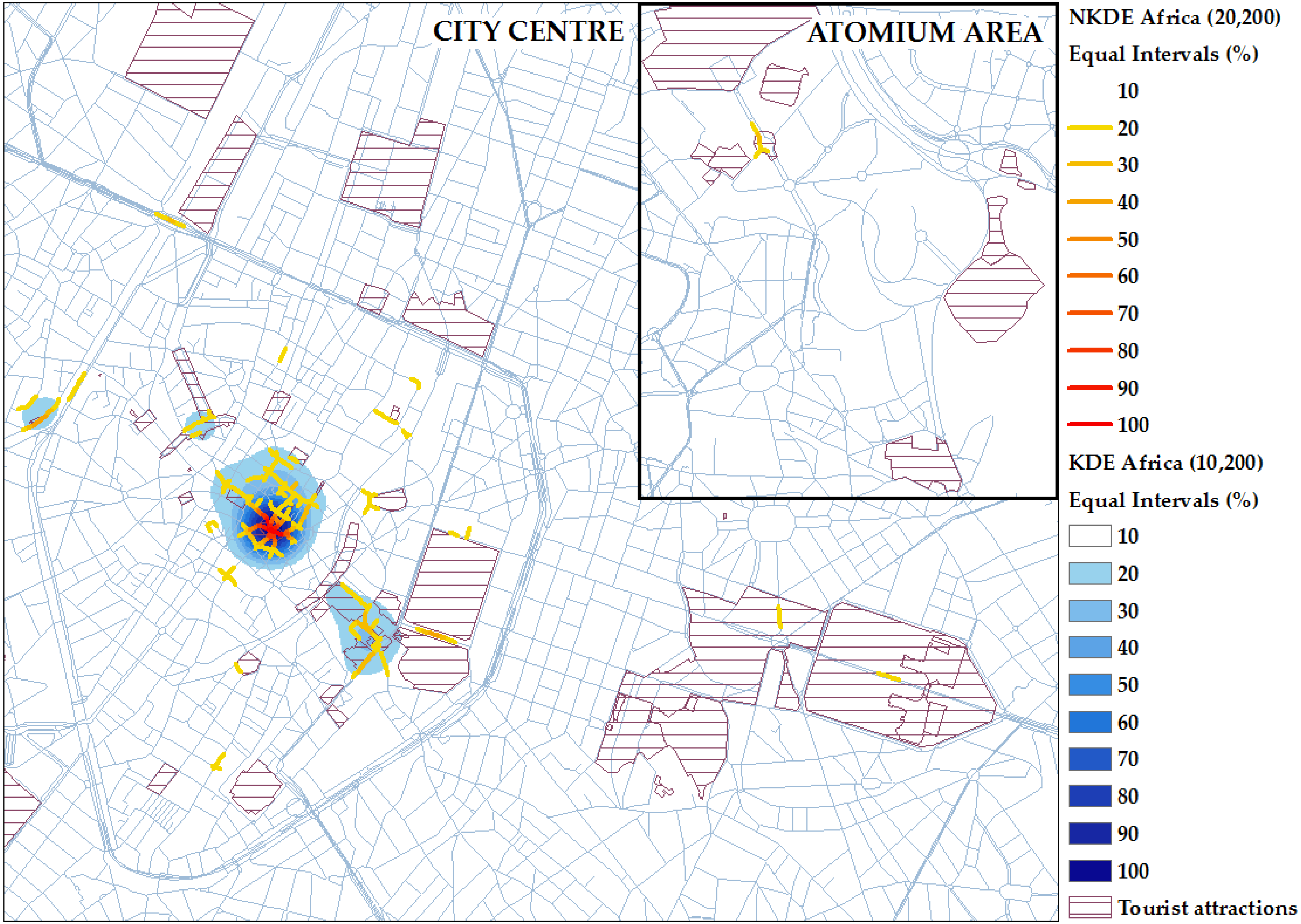
a. Brussels – All
b. Africa
c. Anglo-America
d. Asia
e. Belgium
f. Central Europe
g. East Europe
h. Latin America
i. Middle East
j. North Europe
k. Oceania
l. Southeast Europe
m. South Europe
n. West Europe

a.

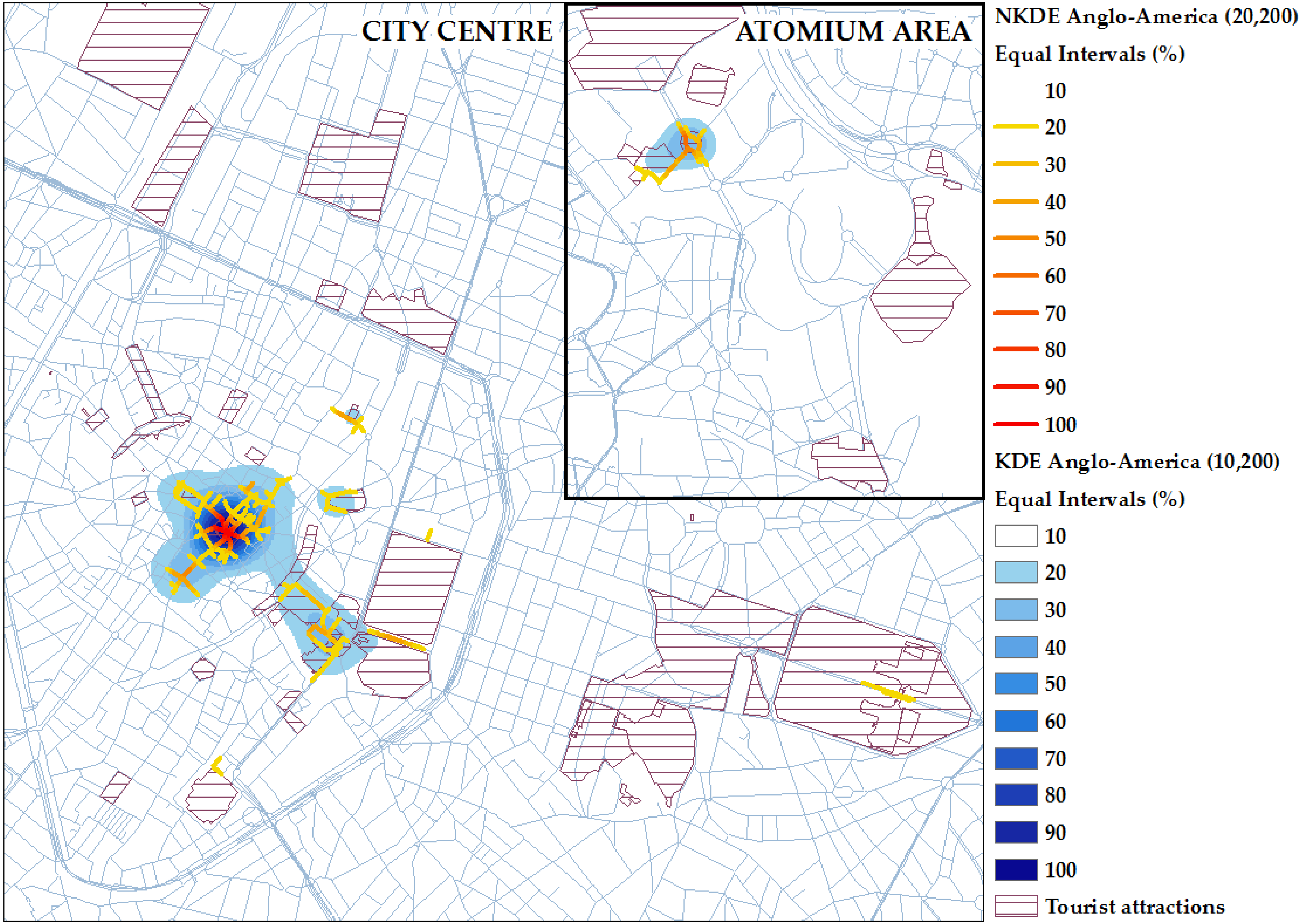


CITY CENTRE
ATOMIUM AREA
NKDE Brussels - All (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Brussels - All (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

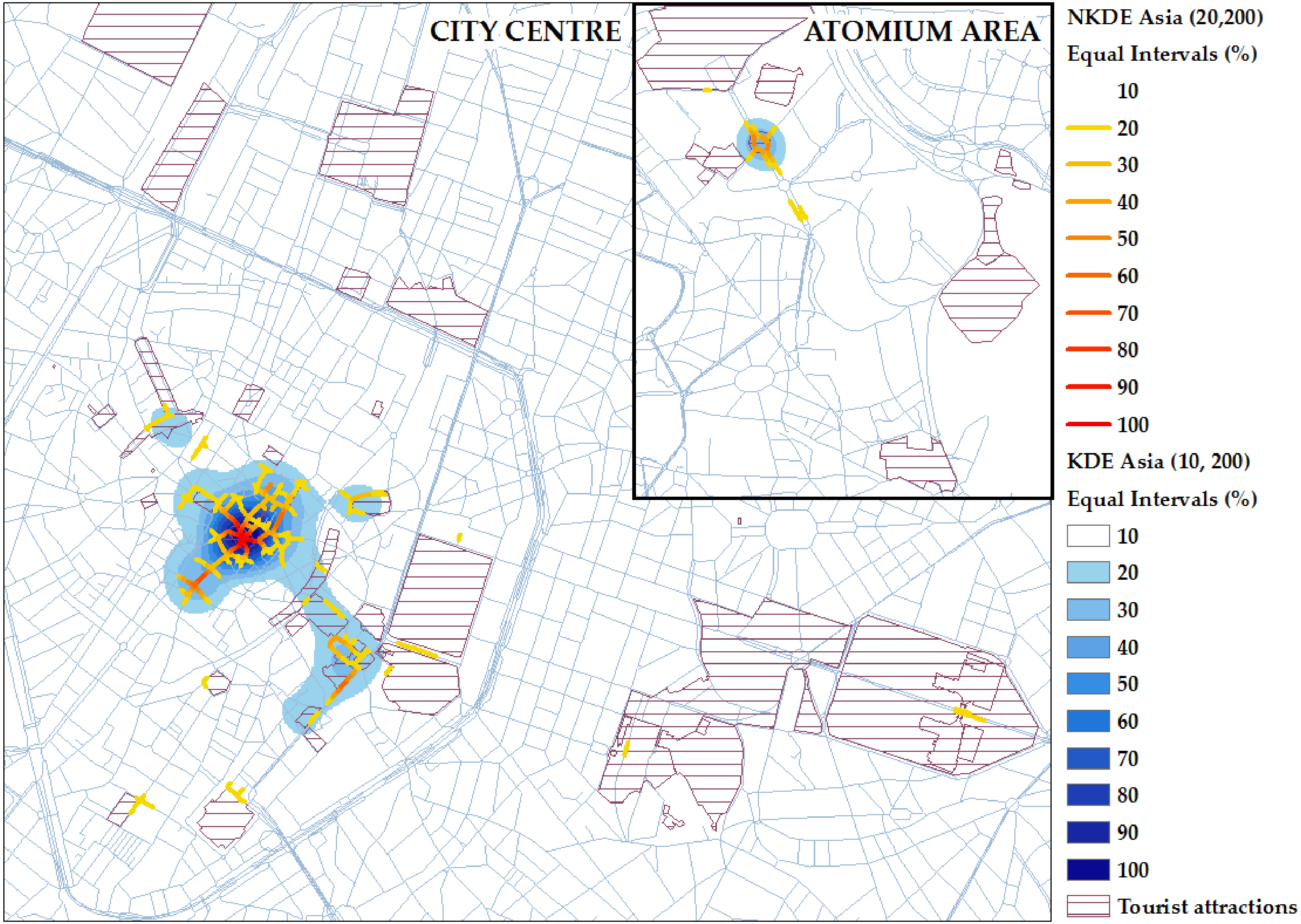
b.


CITY CENTRE
ATOMIUM AREA
NKDE Africa (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Africa (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

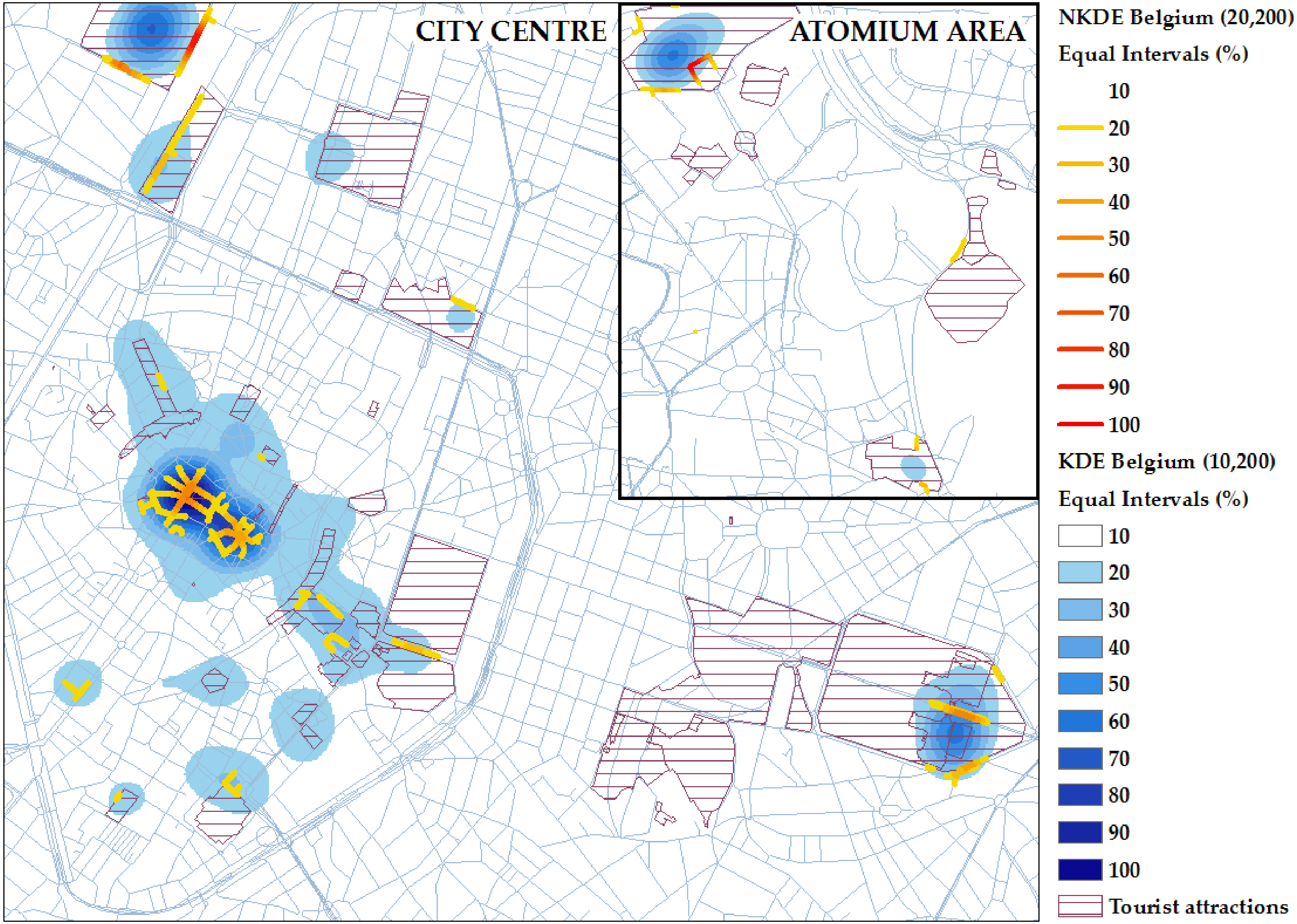
c.


CITY CENTRE
ATOMIUM AREA
NKDE Anglo-America (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Anglo-America (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

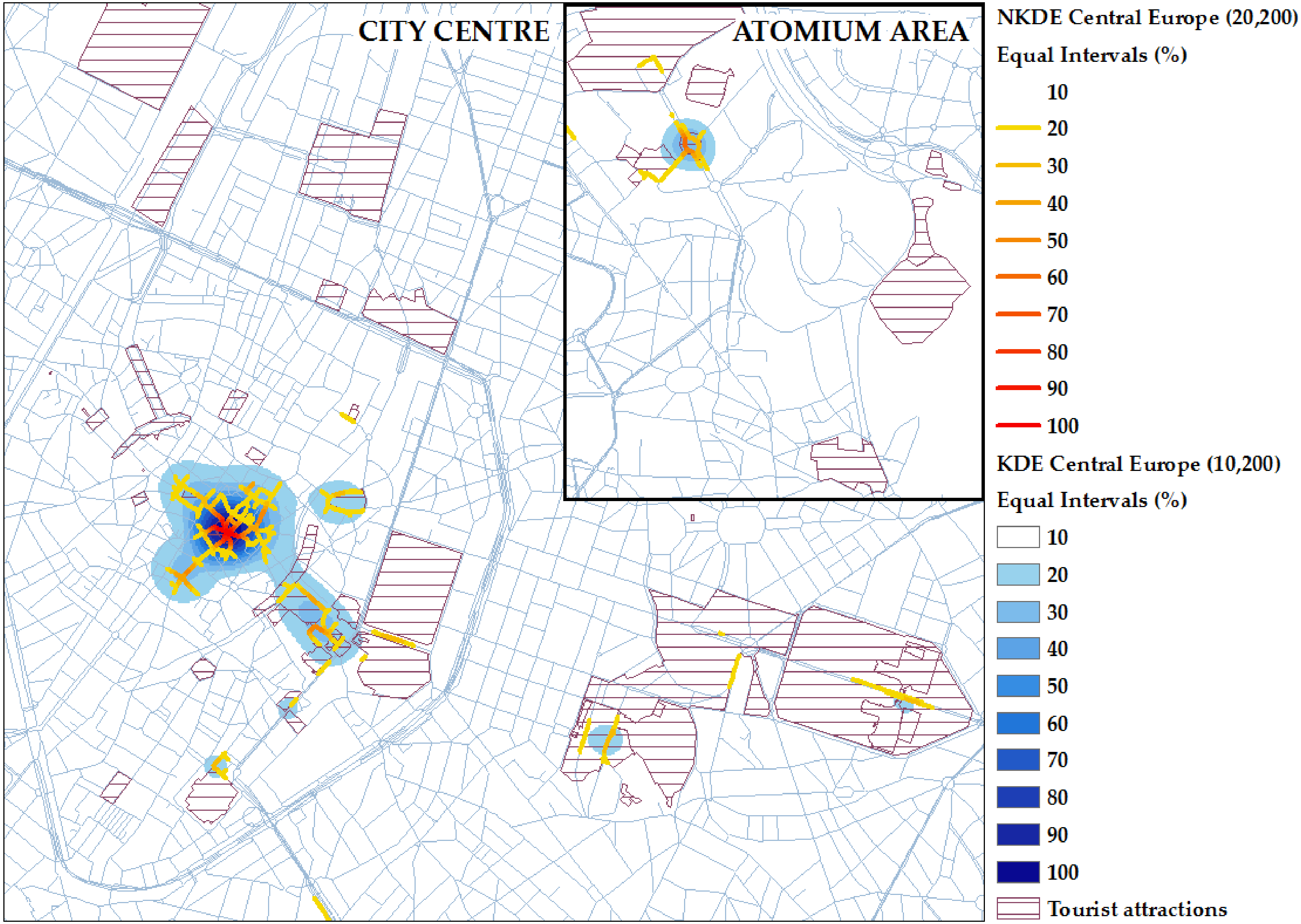
d.


CITY CENTRE
ATOMIUM AREA
NKDE Asia (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Asia (10, 200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

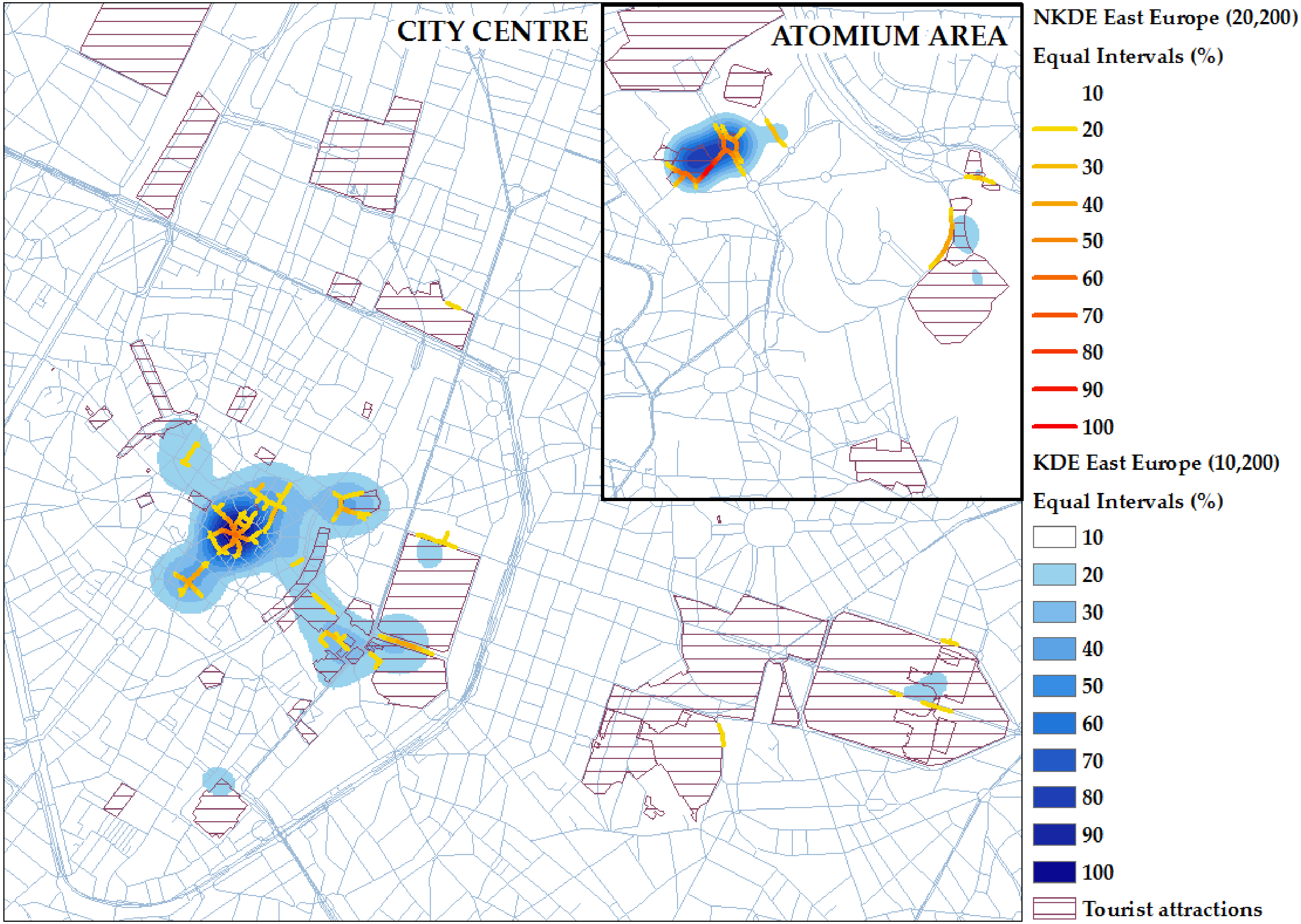
e.


CITY CENTRE
ATOMIUM AREA
NKDE Belgium (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Belgium (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

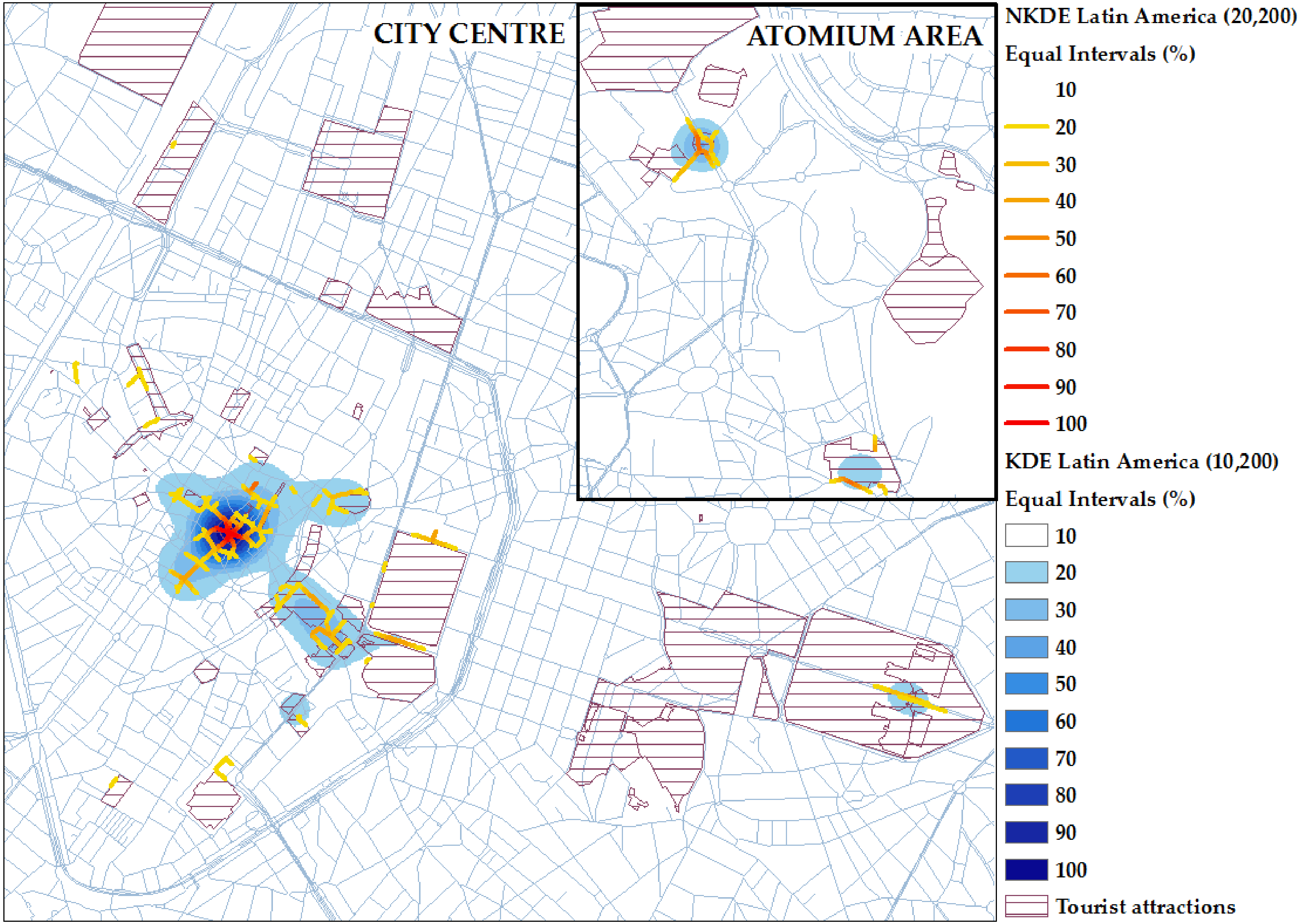
f.


CITY CENTRE
ATOMIUM AREA
NKDE Central Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Central Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

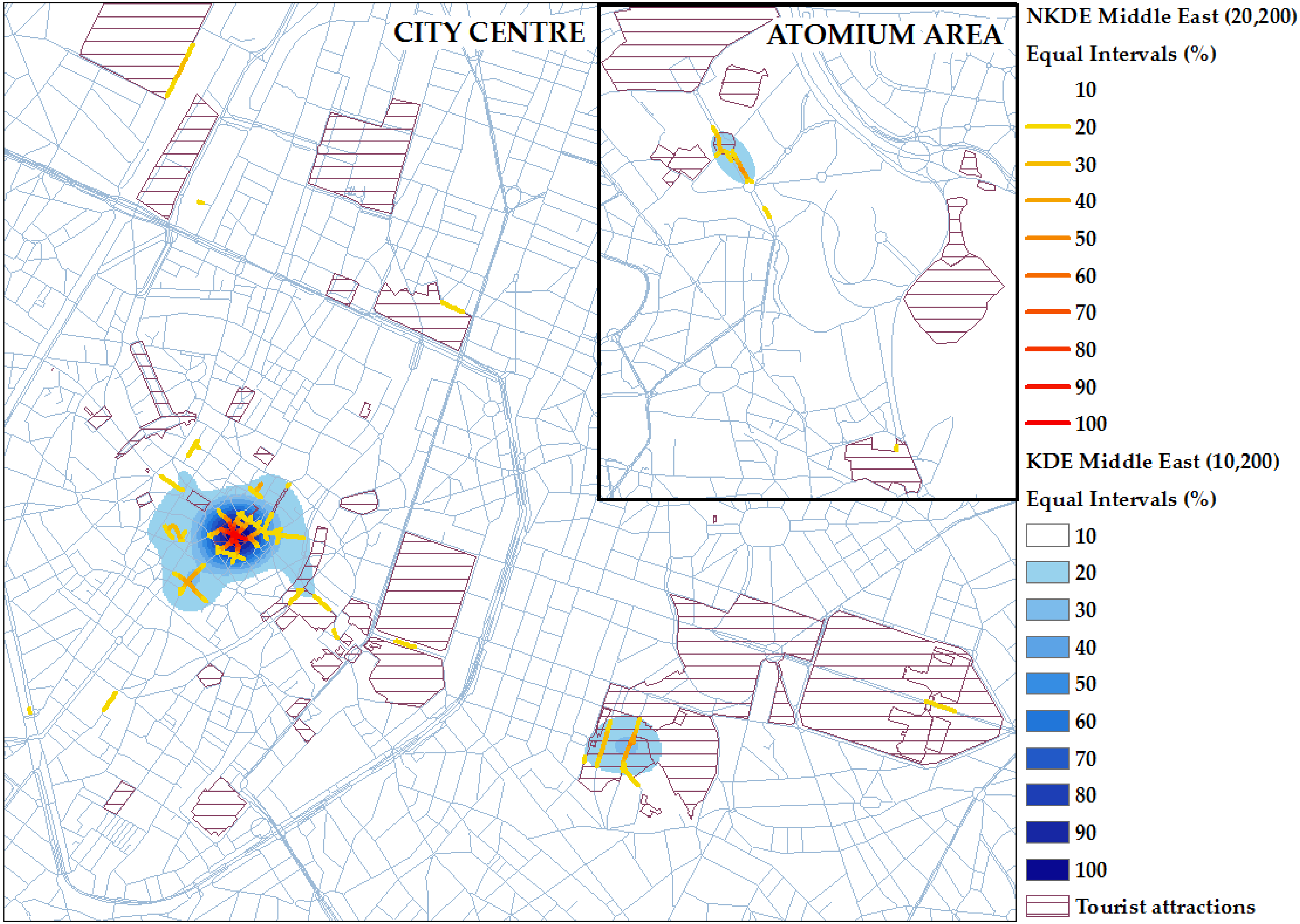
g.


CITY CENTRE
ATOMIUM AREA
NKDE East Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE East Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

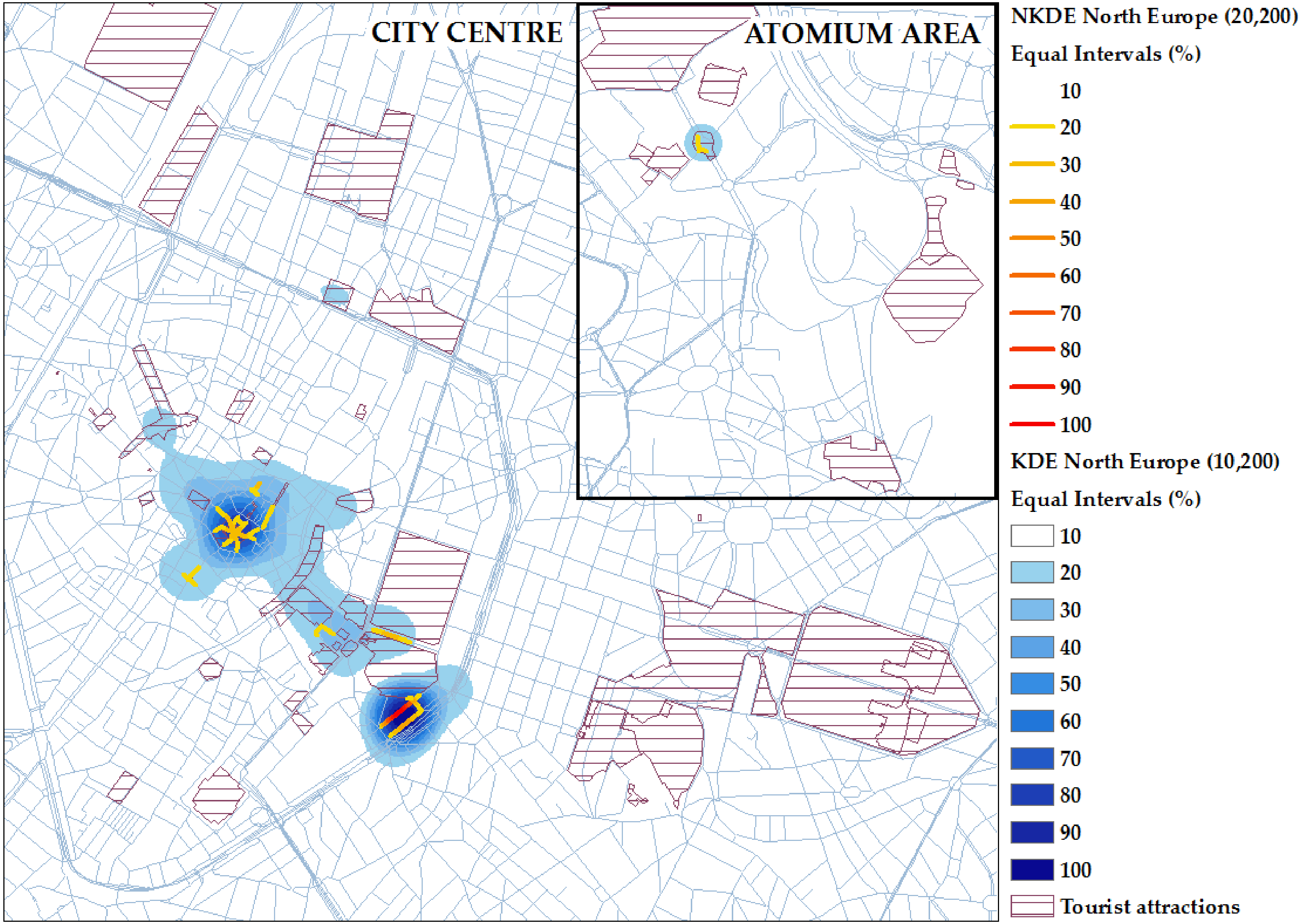
h.


CITY CENTRE
ATOMIUM AREA
NKDE Latin America (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Latin America (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

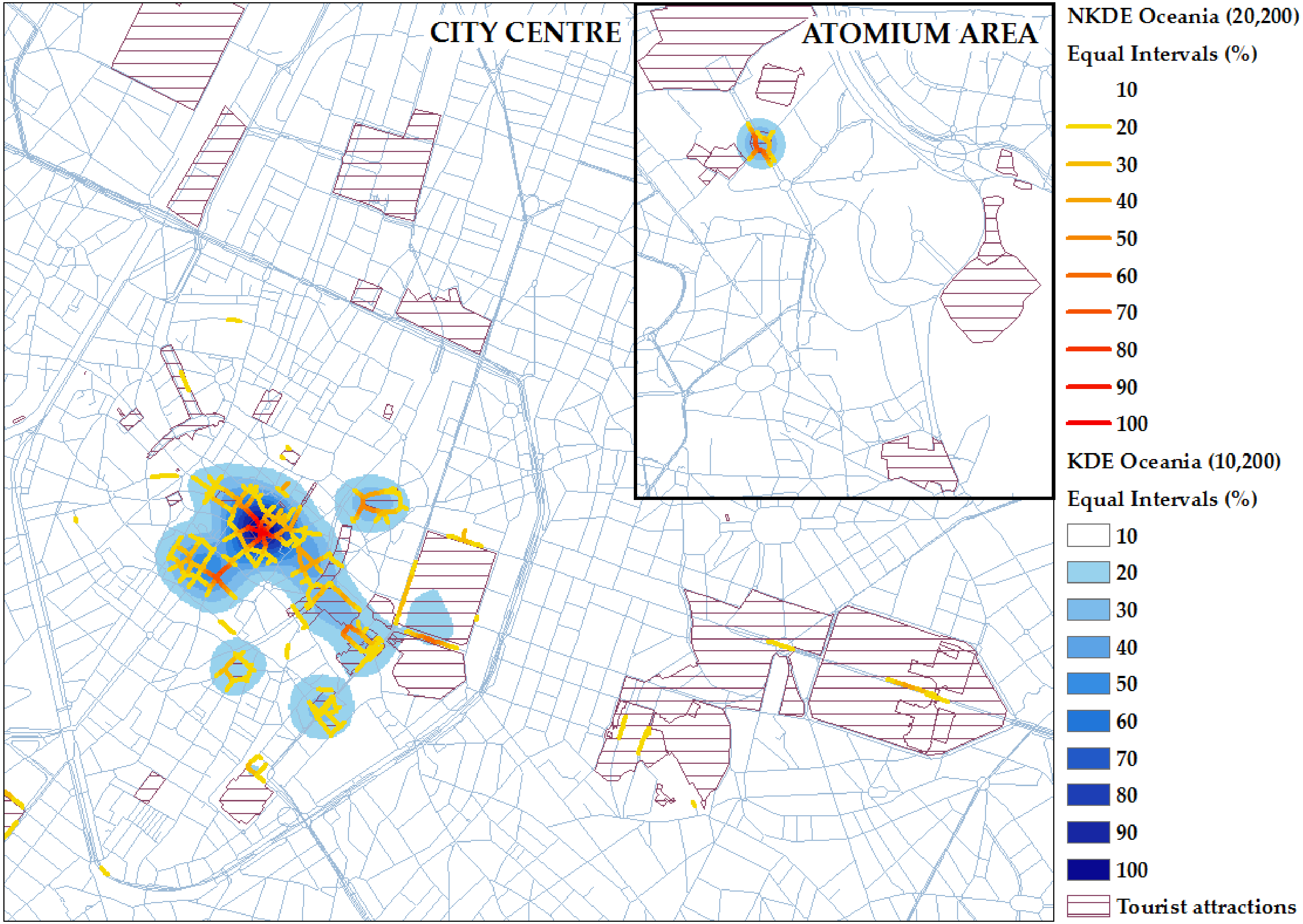
i.


CITY CENTRE
ATOMIUM AREA
NKDE Middle East (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Middle East (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

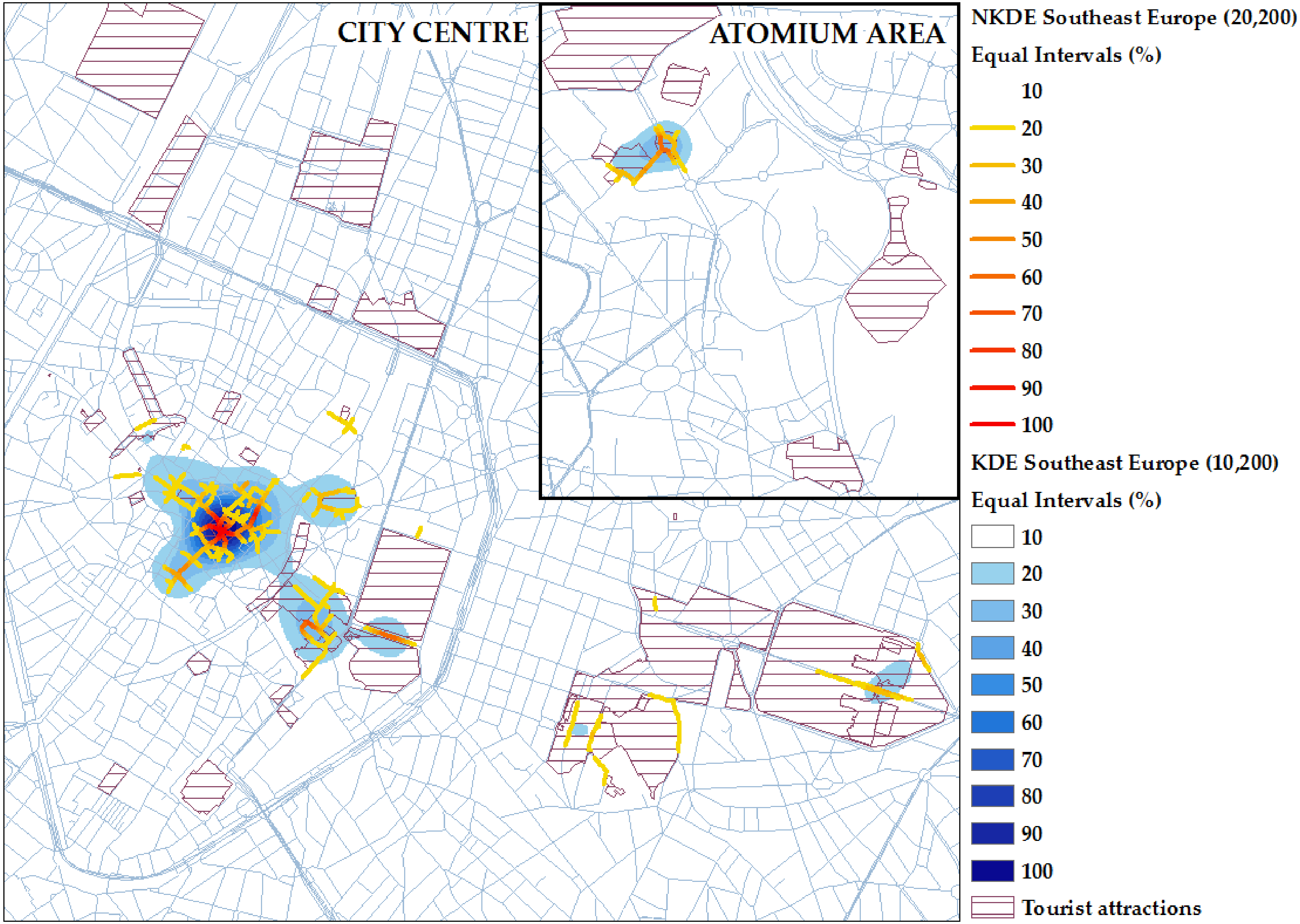
j.


CITY CENTRE
ATOMIUM AREA
NKDE North Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE North Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

k.

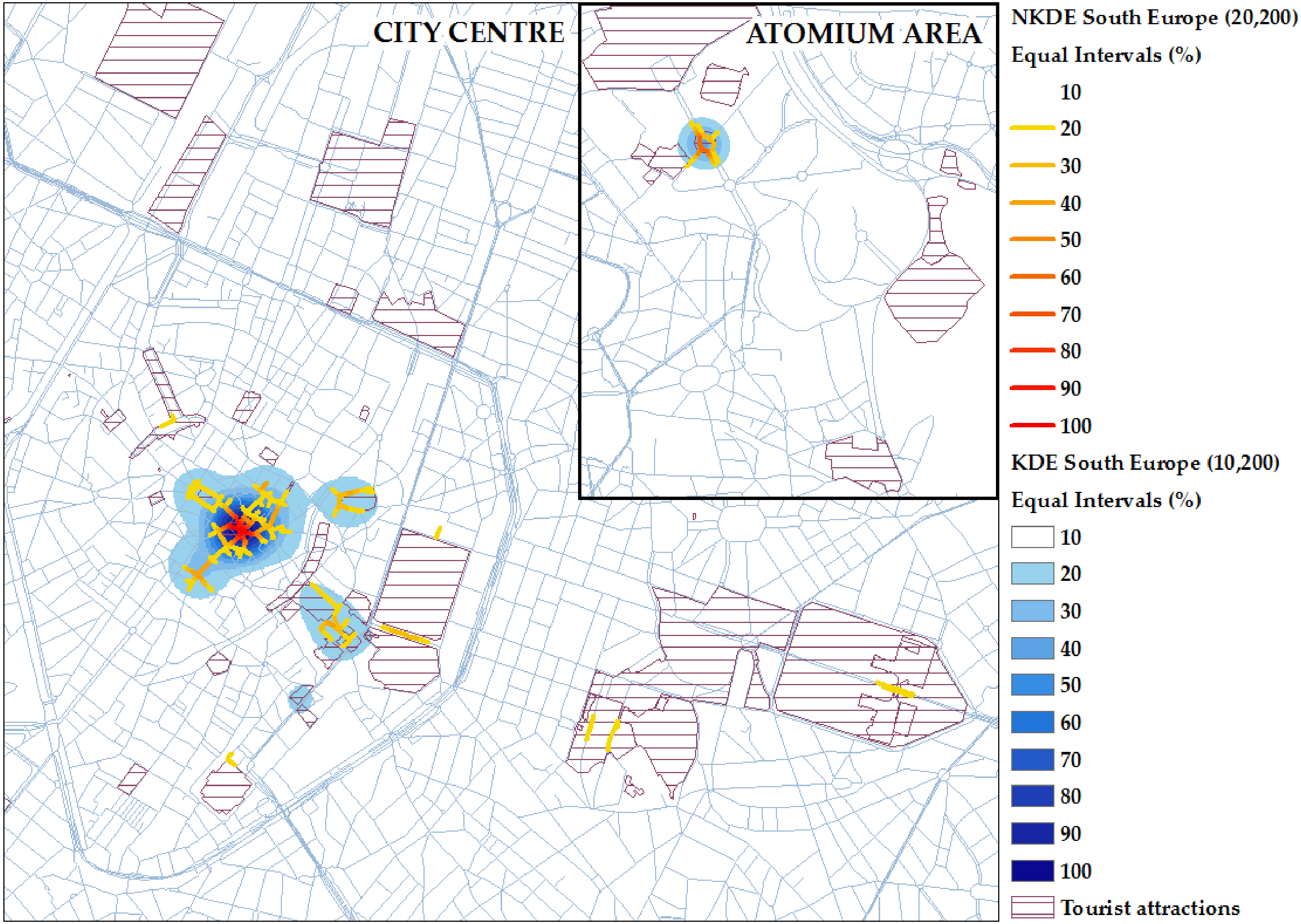

CITY CENTRE
ATOMIUM AREA
NKDE Oceania (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Oceania (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

1.

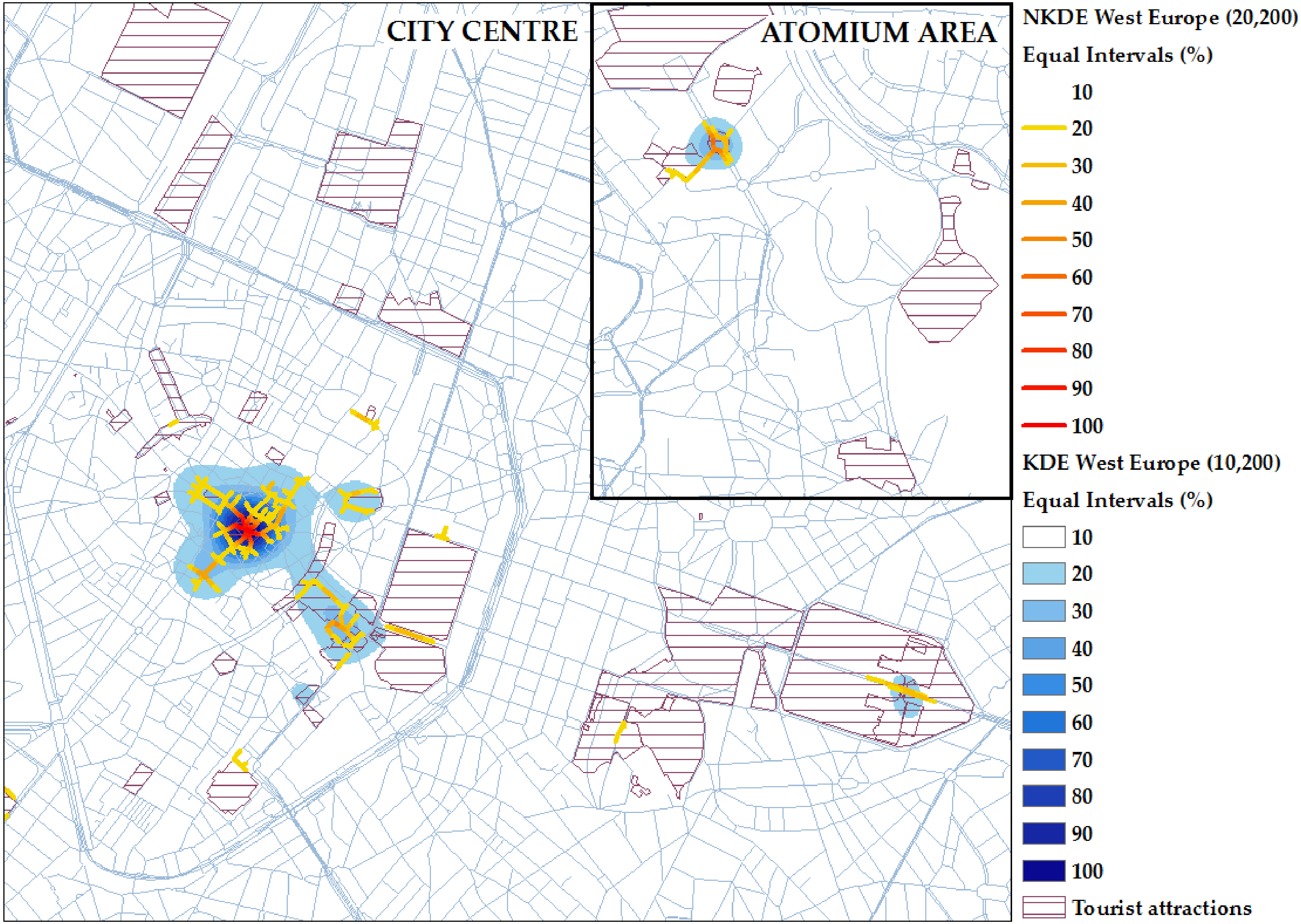


CITY CENTRE
ATOMIUM AREA
NKDE Southeast Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE Southeast Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

m.


CITY CENTRE
ATOMIUM AREA
NKDE South Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE South Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

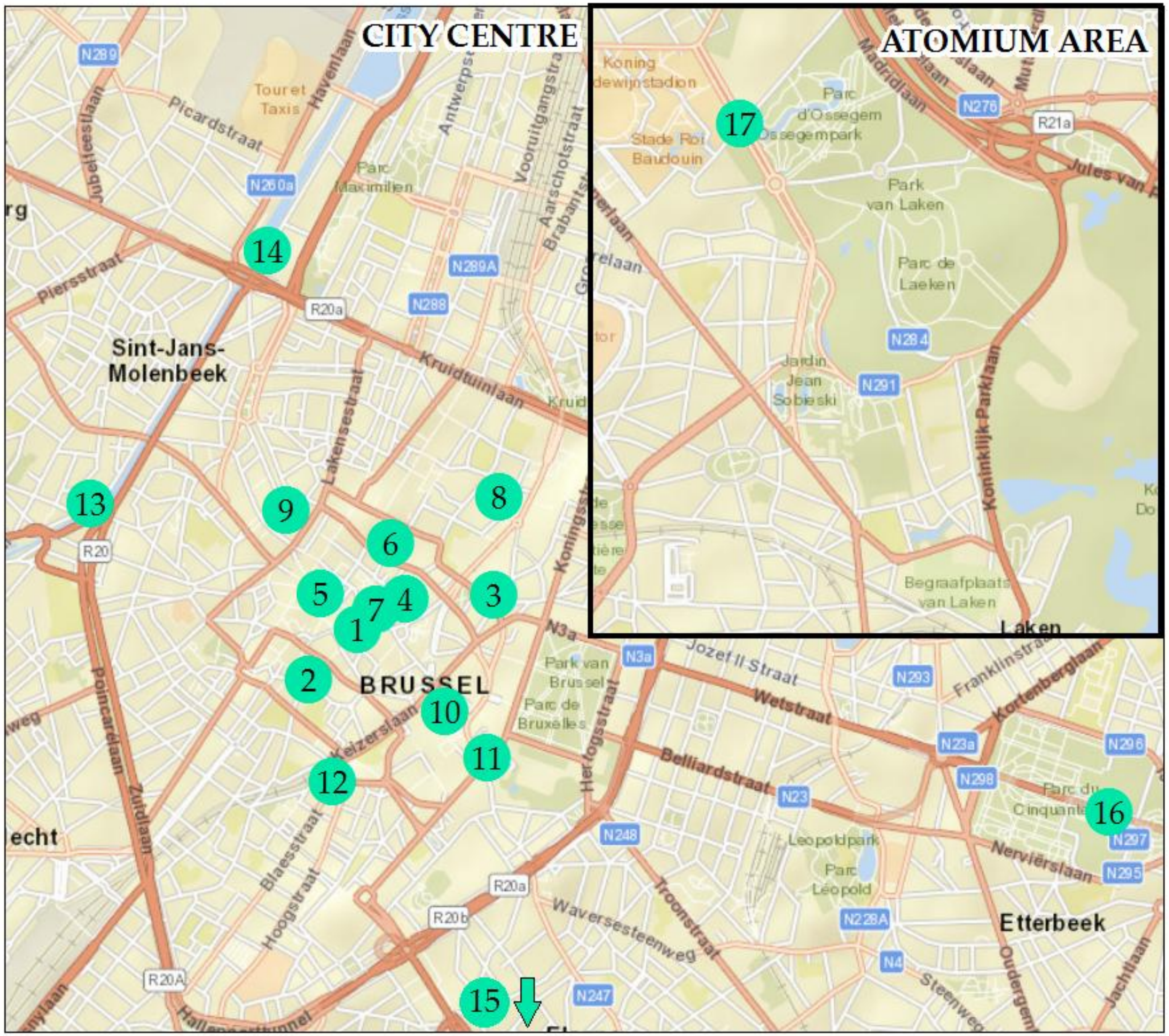
n.


CITY CENTRE
ATOMIUM AREA
NKDE West Europe (20,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
KDE West Europe (10,200)
Equal Intervals (%)
10
20
30
40
50
60
70
80
90
100
Tourist attractions

APPENDIX II

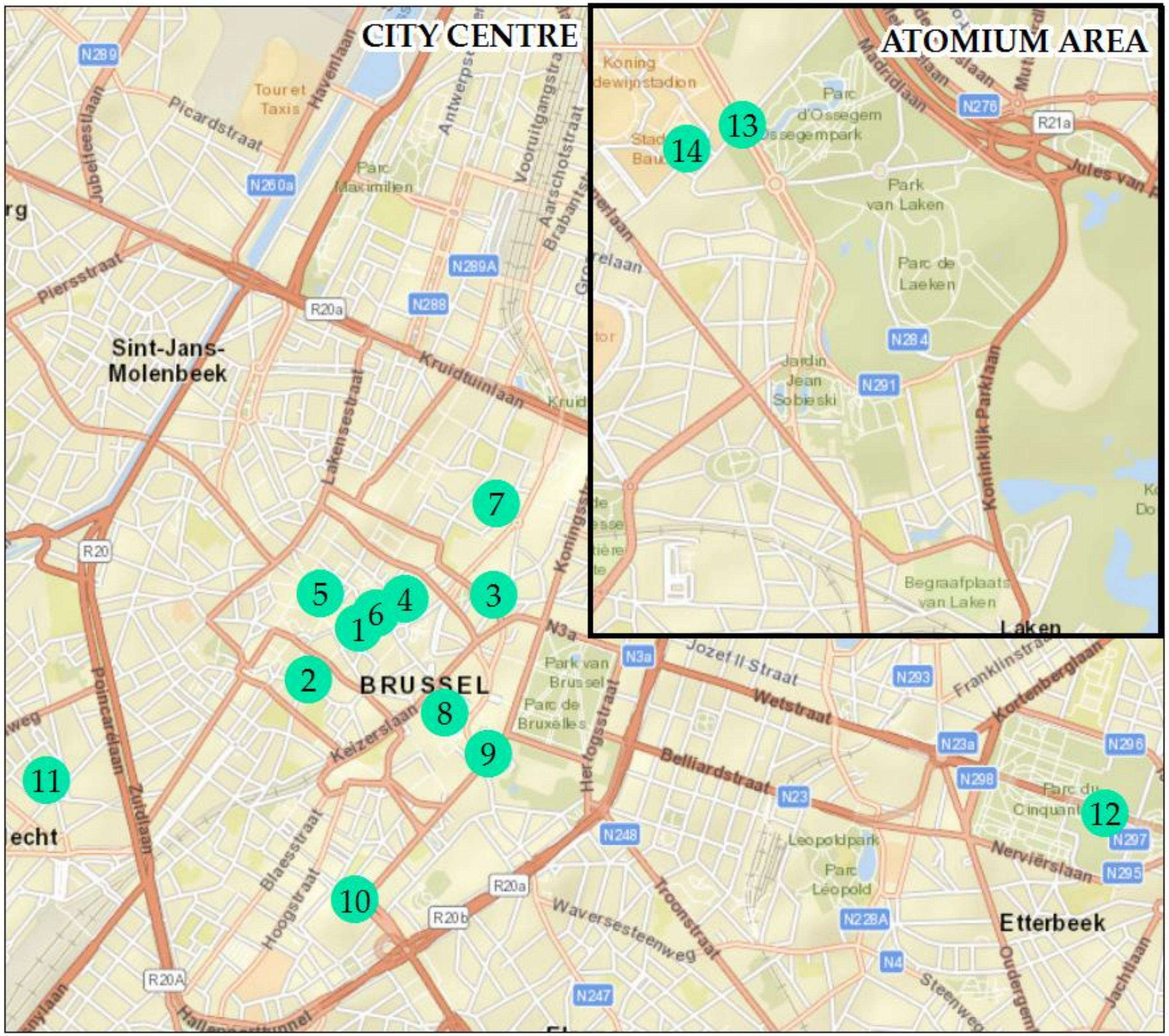
Tourist maps:

a. Africa
b. Anglo-America
c. Asia
d. Belgium
e. Central Europe
f. East Europe
g. Latin America
h. Middle East
i. North Europe
j. Oceania
k. Southeast Europe
l. South Europe
m. West Europe



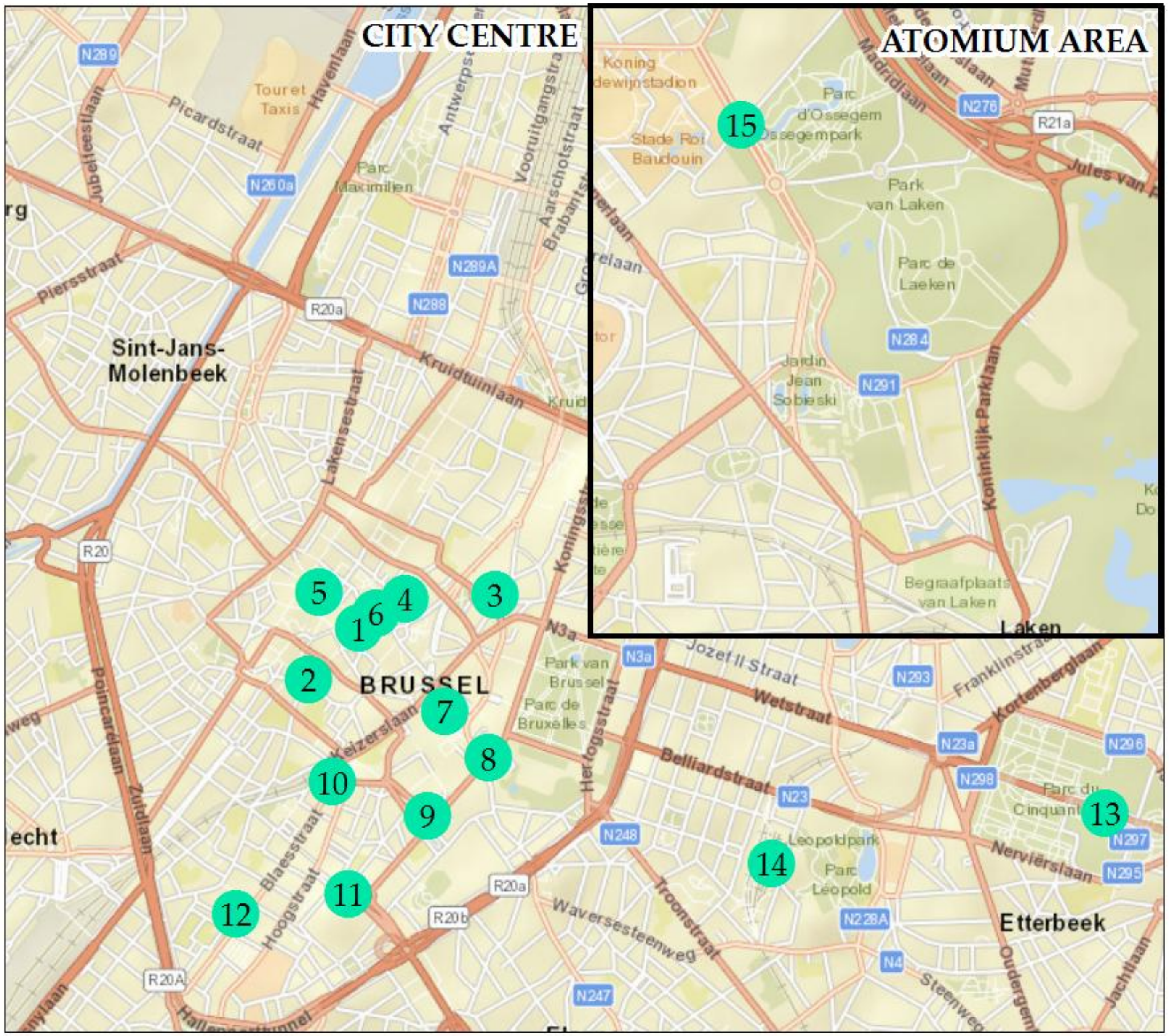
a. **Africa**

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. La Monnaie Royal Theatre,
7. Royal Puppet Theatre Toone,
8. The Belgian Comic Strip Centre,
9. St. Catherine Church,
10. Mont des Arts,
11. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
12. Notre-Dame-de-la-Chapelle,
13. MIMA - The Millennium Iconoclast Museum of Art,
14. Kanal,
15. Van Buuren Museum,
16. Cinquantenaire Park (incl. Arcade),
17. Atomium.



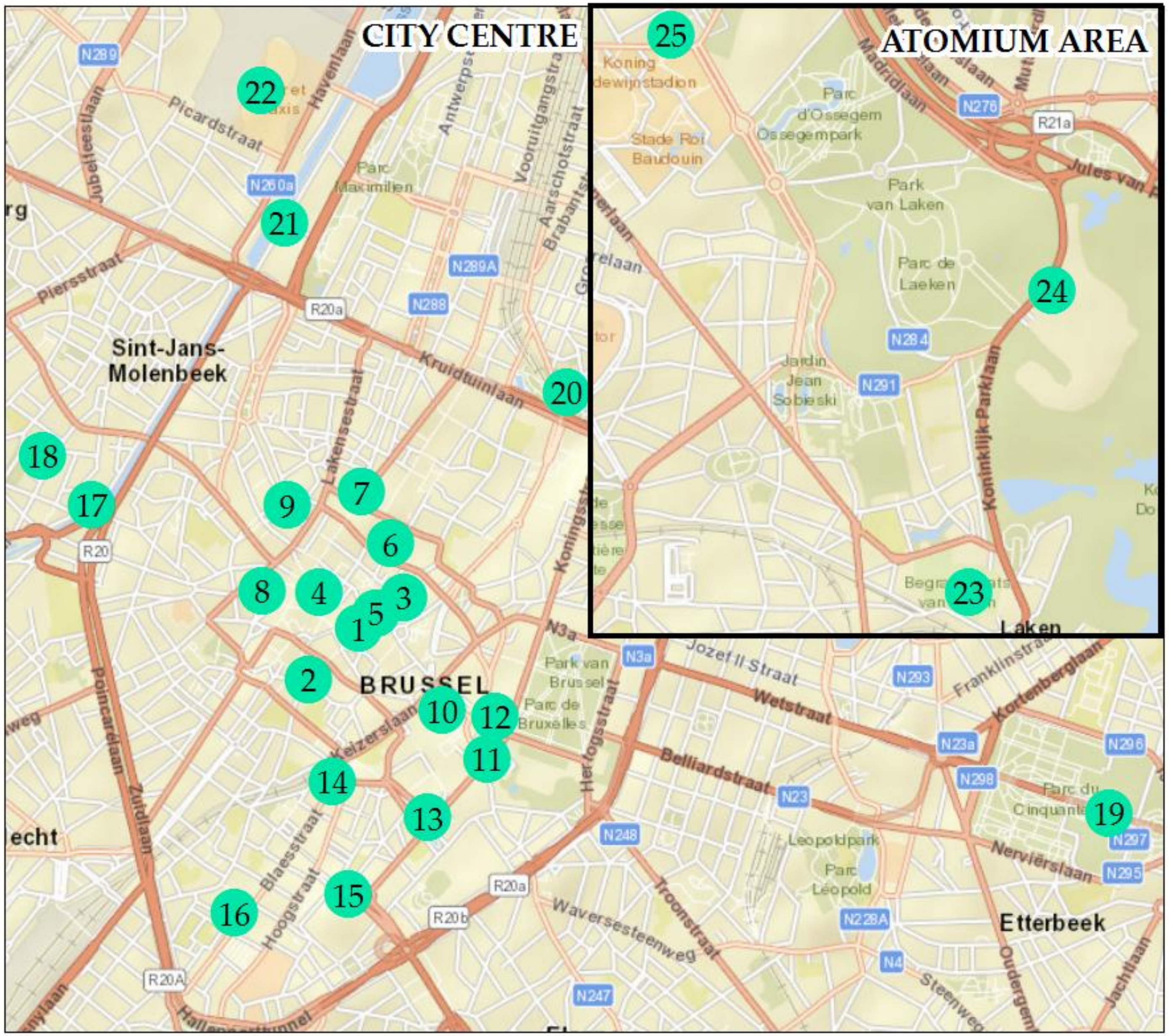
b. **Anglo-America**

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Palais du Justice,
11. Cantillon Brewery and Gueuze Museum,
12. Cinquantenaire Park (incl. Arcade),
13. Atomium,
14. Mini-Europe.



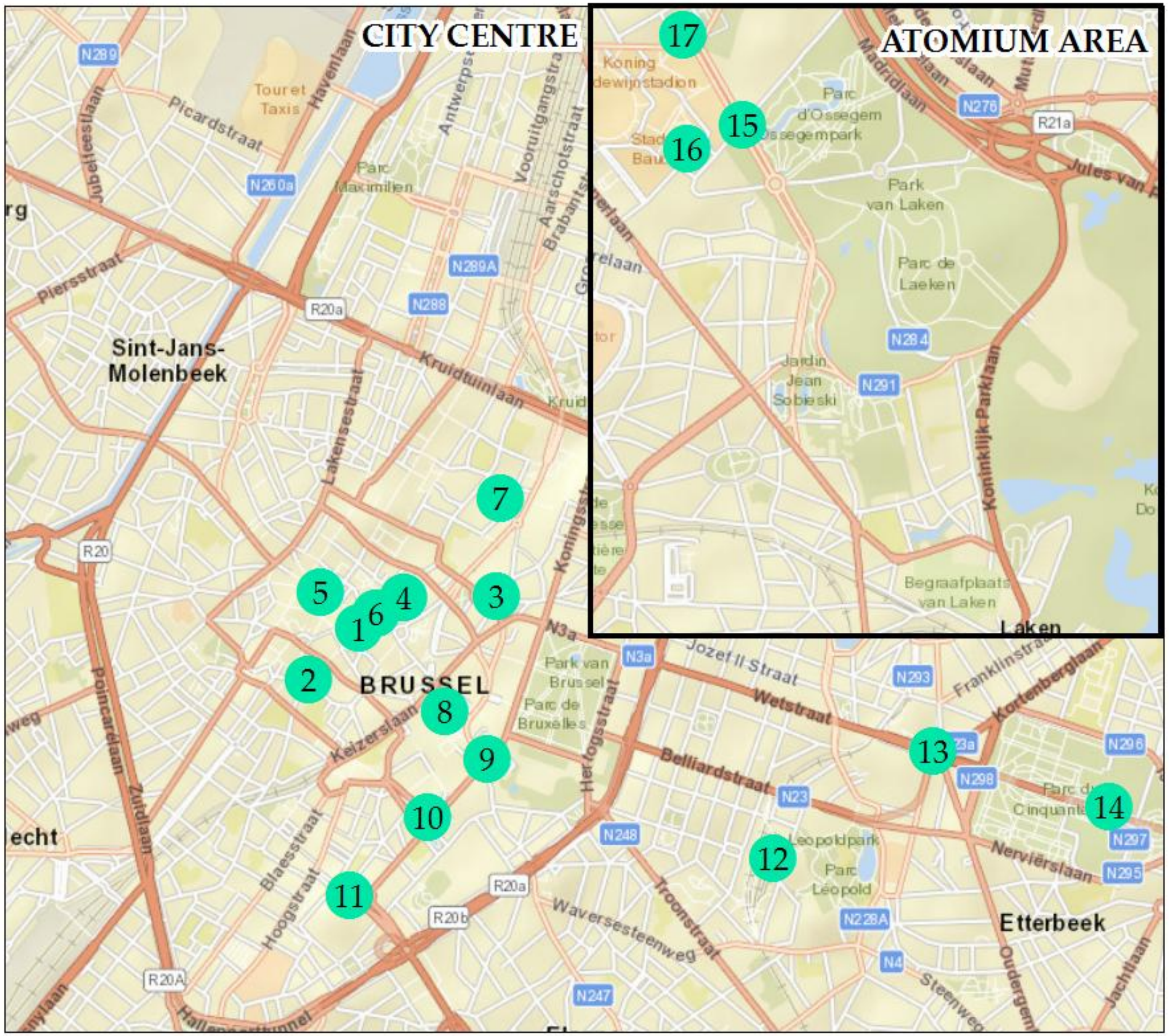
c. Asia

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Mont des Arts,
8. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
9. Notre-Dame du Sablon,
10. Notre-Dame-de-la-Chapelle,
11. Palais de Justice,
12. Marolles Flea Market,
13. Cinquantenaire Park (incl. Arcade),
14. The European Parliament,
15. Atomium.



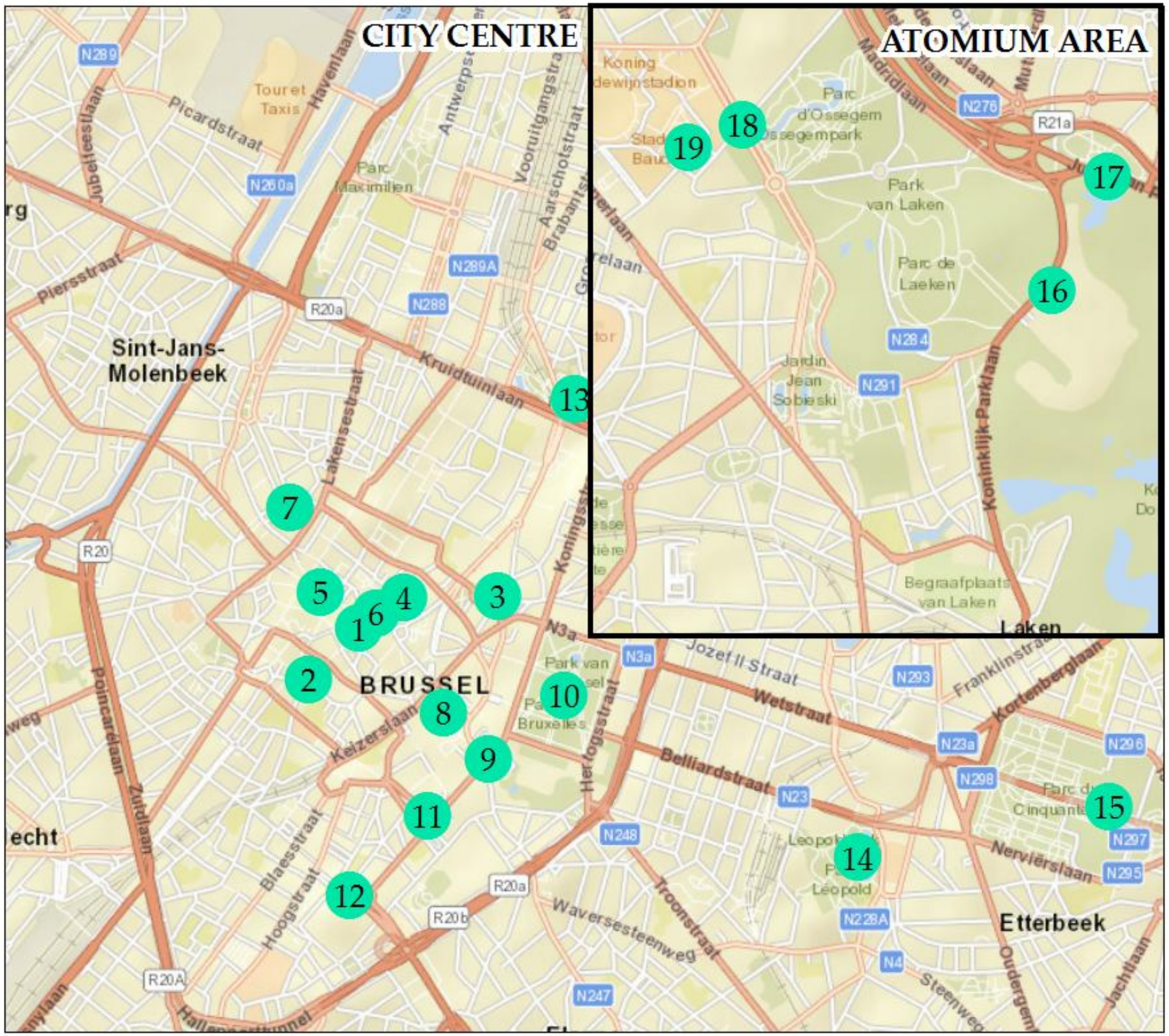
d. Belgium

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Royal Gallery of St. Hubert,
4. Brussels Stock Exchange,
5. Royal Puppet Theatre Toone,
6. La Monnaie Royal Theatre,
7. De Brouckère Square,
8. Halles Saint-Géry
9. St. Catherine Church and Square,
10. Mont des Arts,
11. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
12. BOZAR - Centre for Fine Arts,
13. Notre-Dame du Sablon and Petit Sablon Square,
14. Notre-Dame-de-la-Chapelle,
15. Palais de Justice,
16. Marolles Flea Market,
17. MIMA - The Millennium Iconoclast Museum of Art,
18. La Fonderie,
19. Cinquantenaire Park (incl. Arcade, Autoworld, Art & History Museum and Royal Museum of Armed Forces and Military History),
20. Le Botanique,
21. Kanal and Centre Pompidou,
22. Tour & Taxis,
23. Laeken Cemetery,
24. Castle of Laeken and Royal Greenhouses of Laeken,
25. Expo



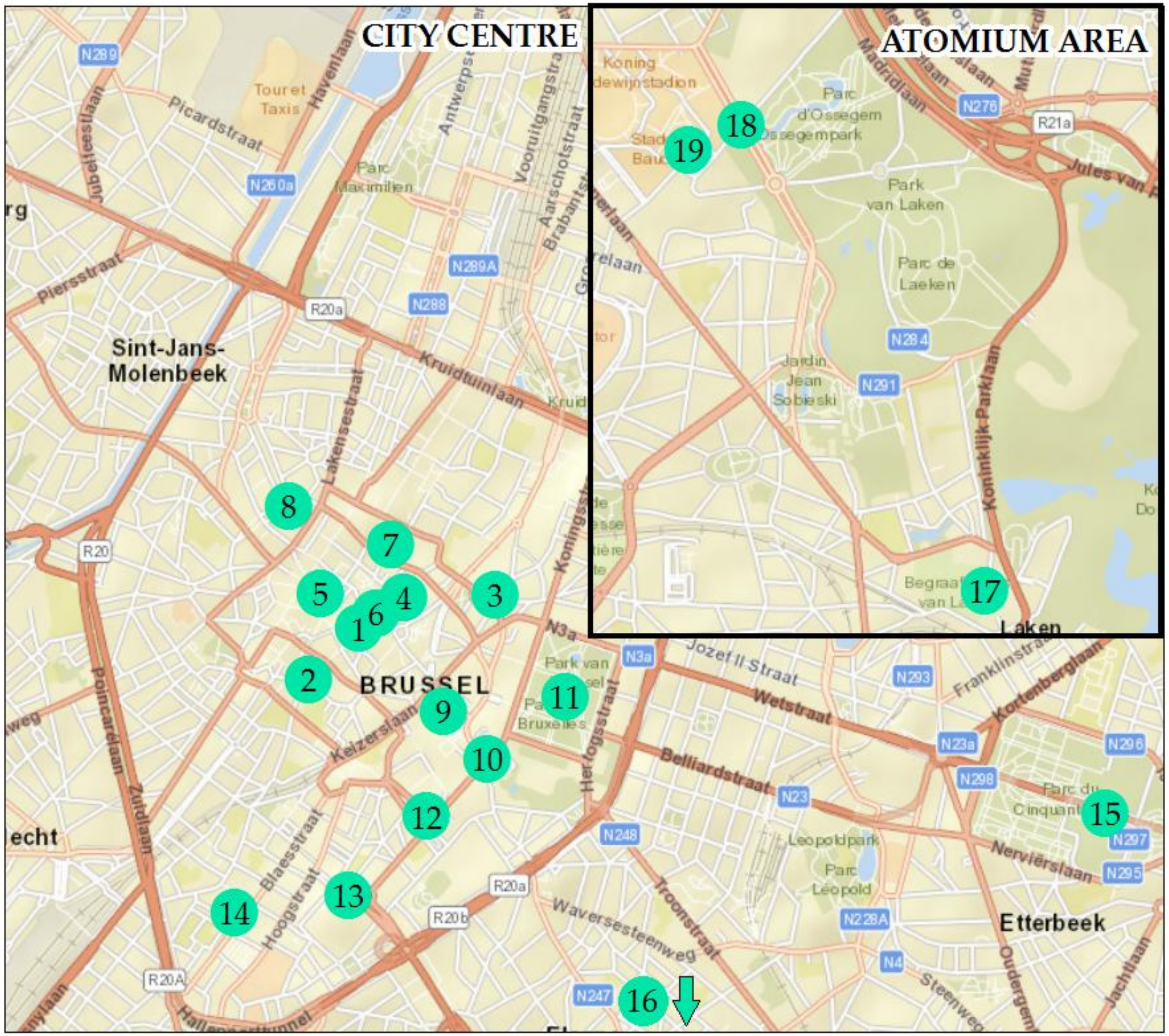
e. Central Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Notre-Dame du Sablon and Petit Sablon Square,
11. Palais de Justice,
12. The European Parliament,
13. The EU Institutions,
14. Cinquantenaire Park (incl. Arcade),
15. Atomium,
16. Mini-Europe,
17. Expo.



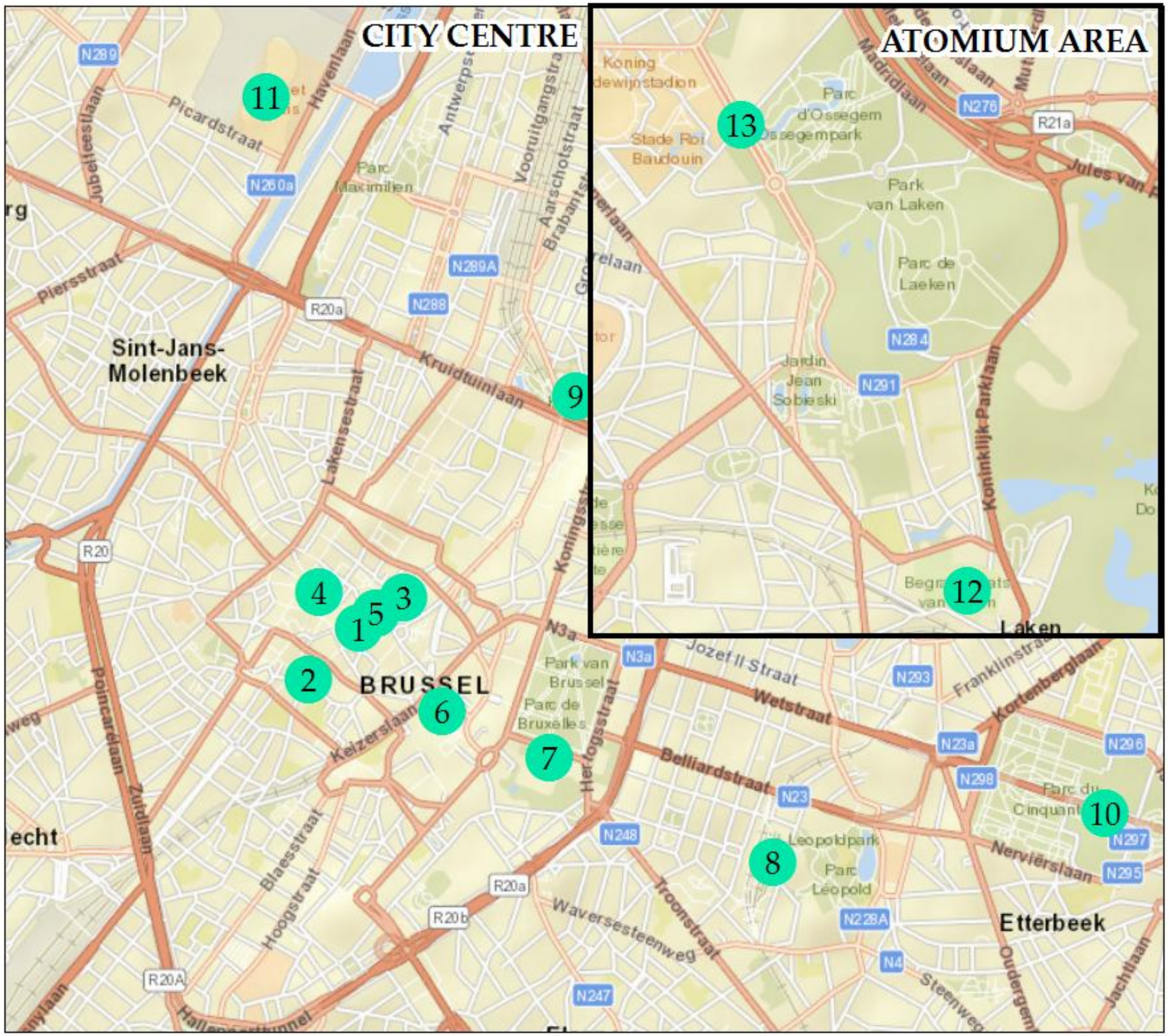
f. East Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Brussels Park,
11. Notre-Dame du Sablon,
12. Palais de Justice,
13. Le Botanique,
14. Leopold Park,
15. Cinquantenaire Park (incl. Arcade and Royal Museum of Armed Forces and Military History),
16. Castle of Laeken and Royal Greenhouses of Laeken,
17. Chinese Pavillon and Japanese Tower,
18. Atomium,
19. Mini-Europe.



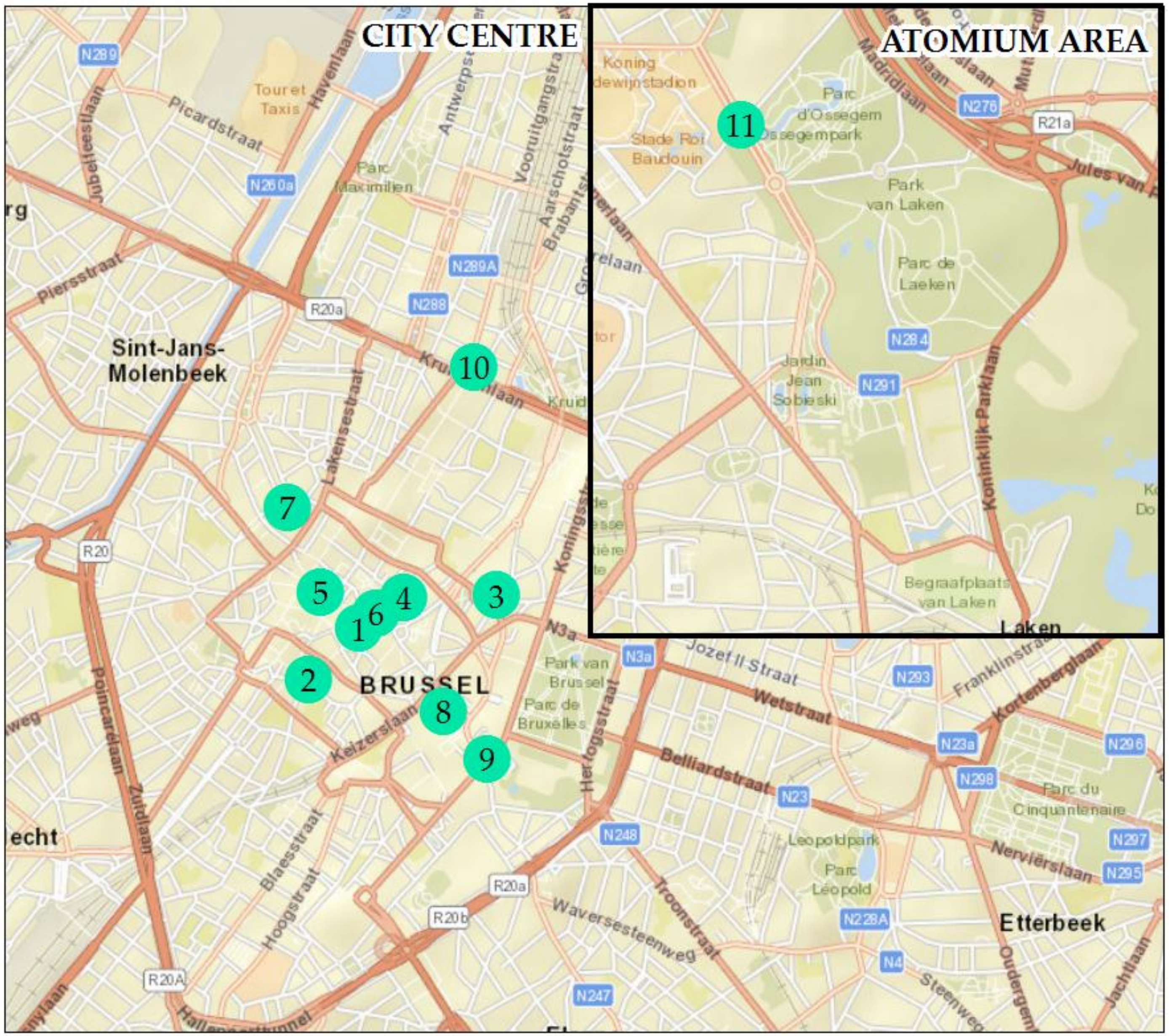
g. Latin America

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Le Monnaie Royal Theatre,
8. St. Catherine Church and Square,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Brussels Park,
12. Notre-Dame du Sablon and Petit Sablon Square,
13. Palais de Justice,
14. Marolles Flea Market,
15. Cinquantenaire Park (incl. Arcade),
16. Flagey Square,
17. Laeken Cemetery,
18. Atomium,
19. Mini-Europe.



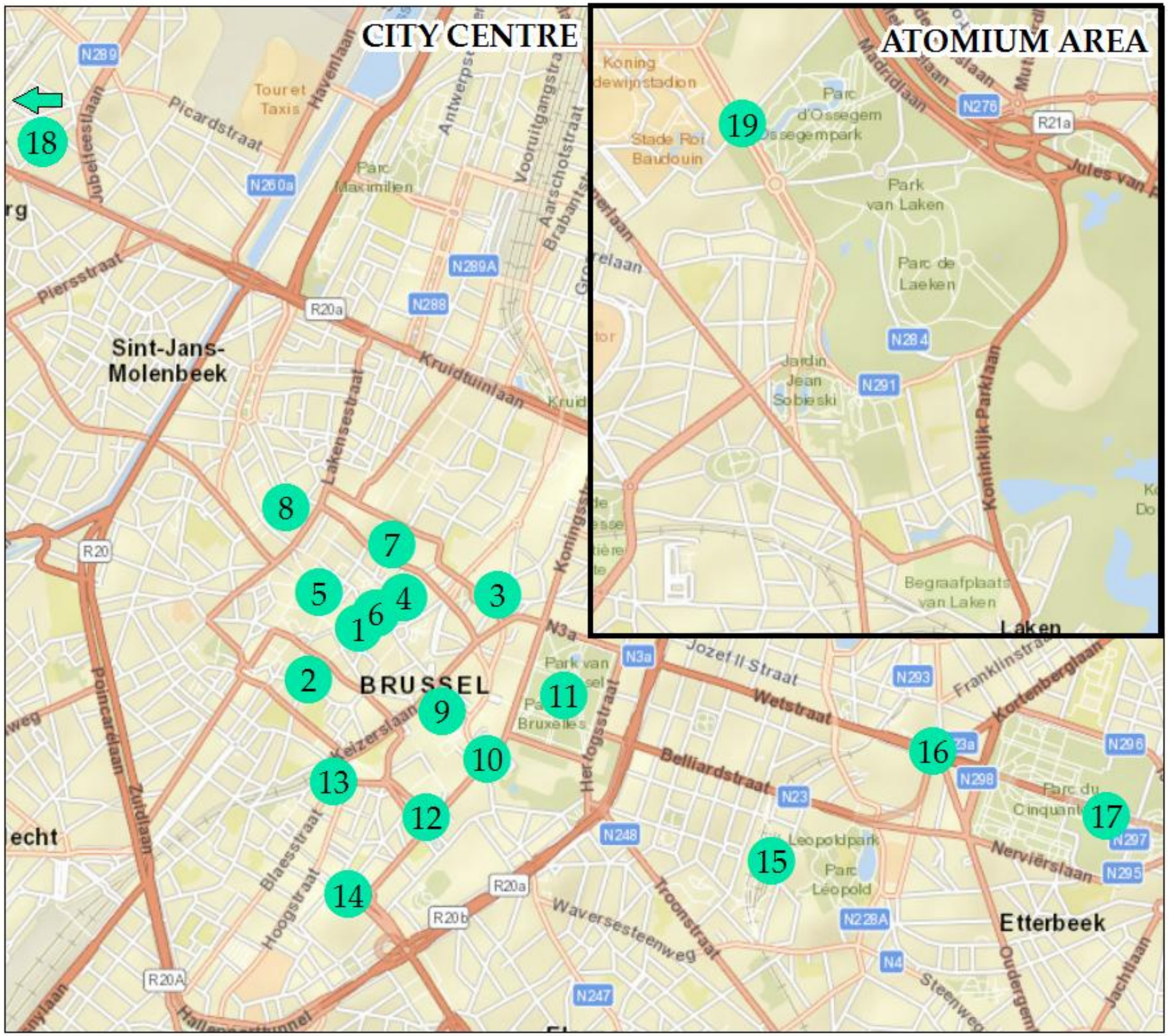
h. Middle East

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Royal Gallery of St. Hubert,
4. Brussels Stock Exchange,
5. Royal Puppet Theatre Toone,
6. Mont des Arts,
7. Palais Royale,
8. The European Parliament,
9. Le Botanique,
10. Cinquantenaire Park (incl. Arcade),
11. Tour & Taxis,
12. Laeken Cemetery,
13. Atomium.



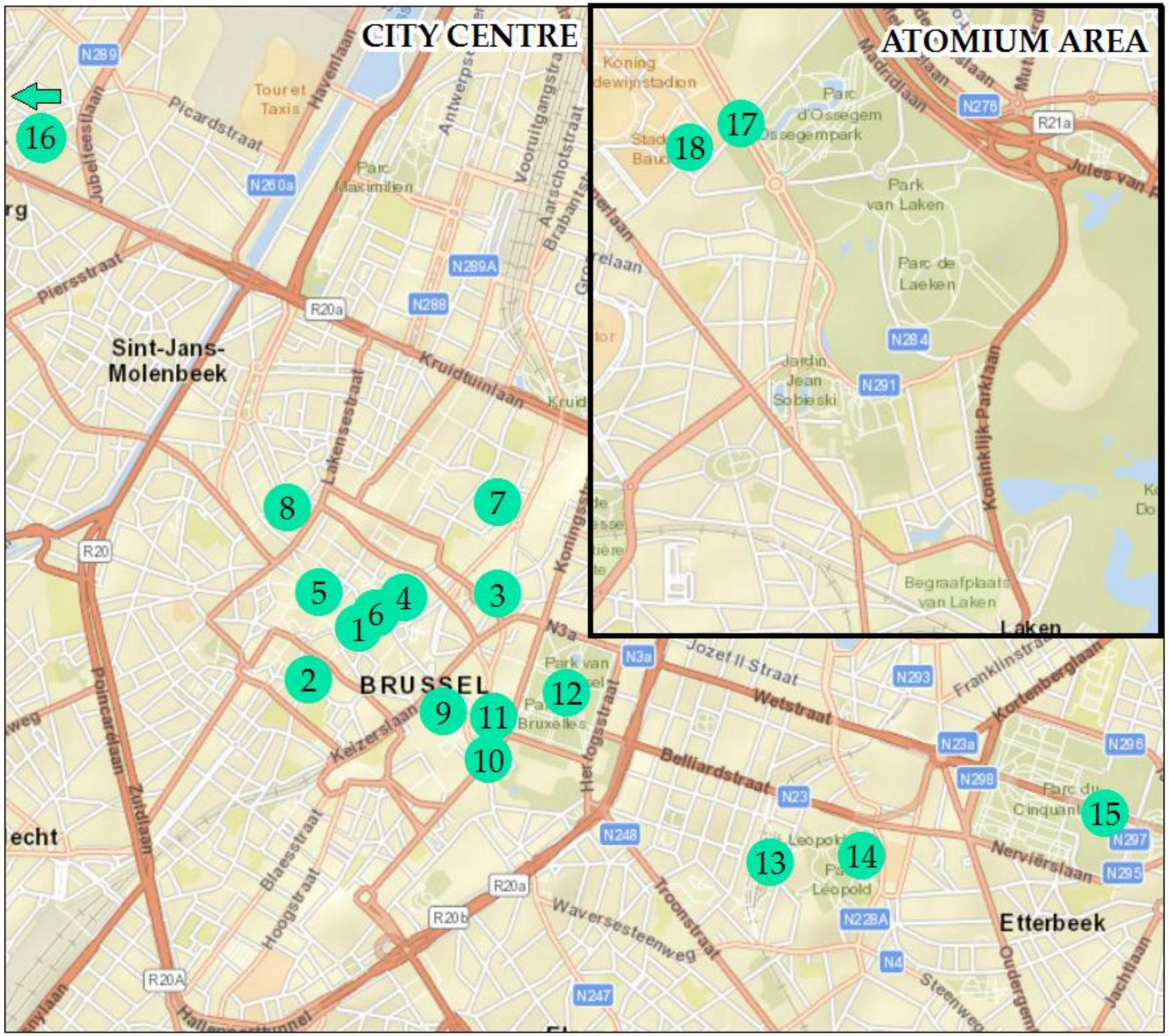
i. North Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale and Old England (MIM))
10. Charles Rogier Square,
11. Atomium.



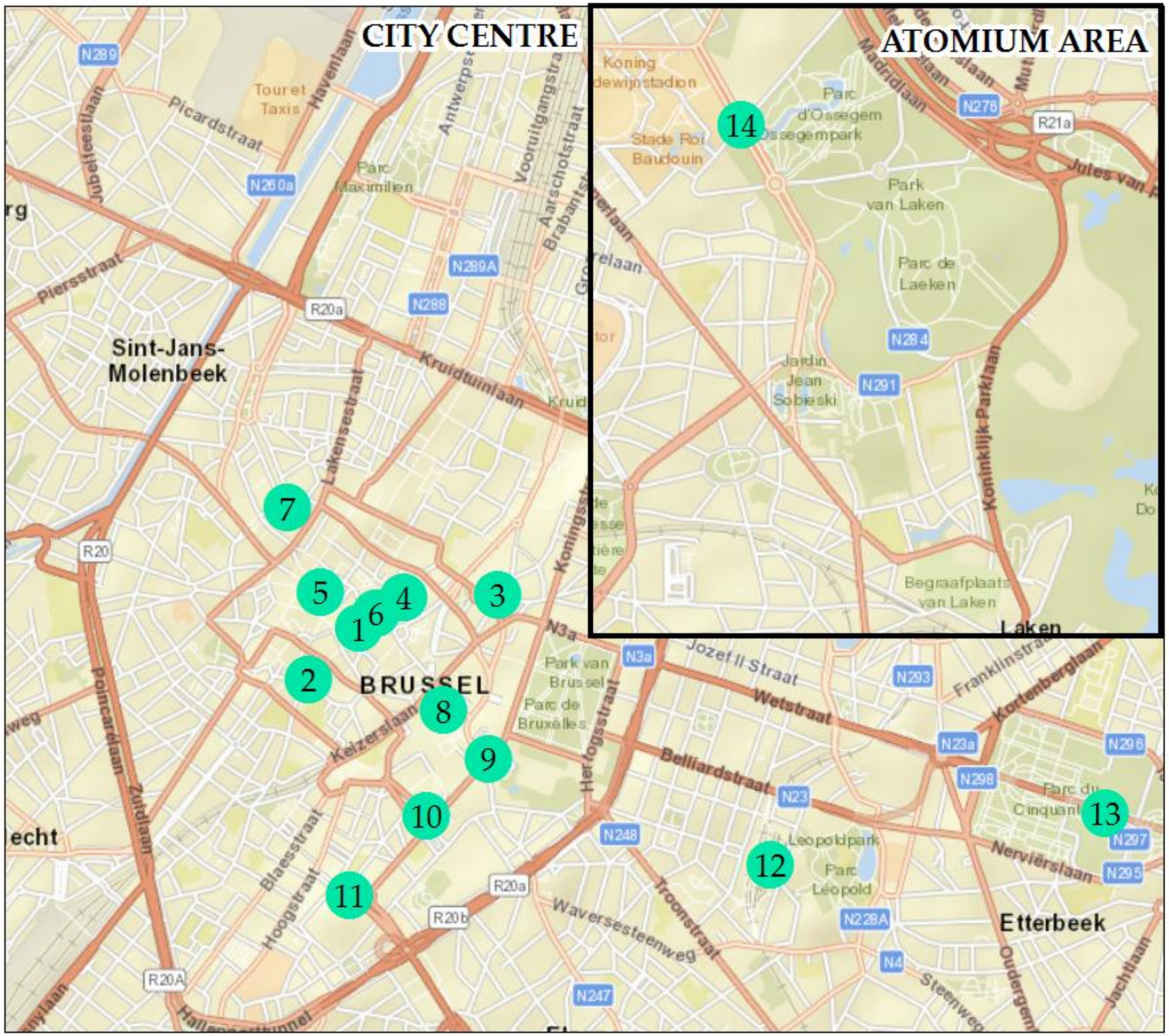
j. **Oceania**

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. Le Monnaie Royal Theatre,
8. St. Catherine Square,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Brussels Park,
12. Notre-Dame du Sablon and Petit Sablon Square,
13. Notre-Dame-de-la-Chapelle,
14. Palais de Justice,
15. The European Parliament,
16. The EU Institutions,
17. Cinquantenaire Park (incl. Arcade),
18. National Basilica of the Sacred Heart,
19. Atomium.



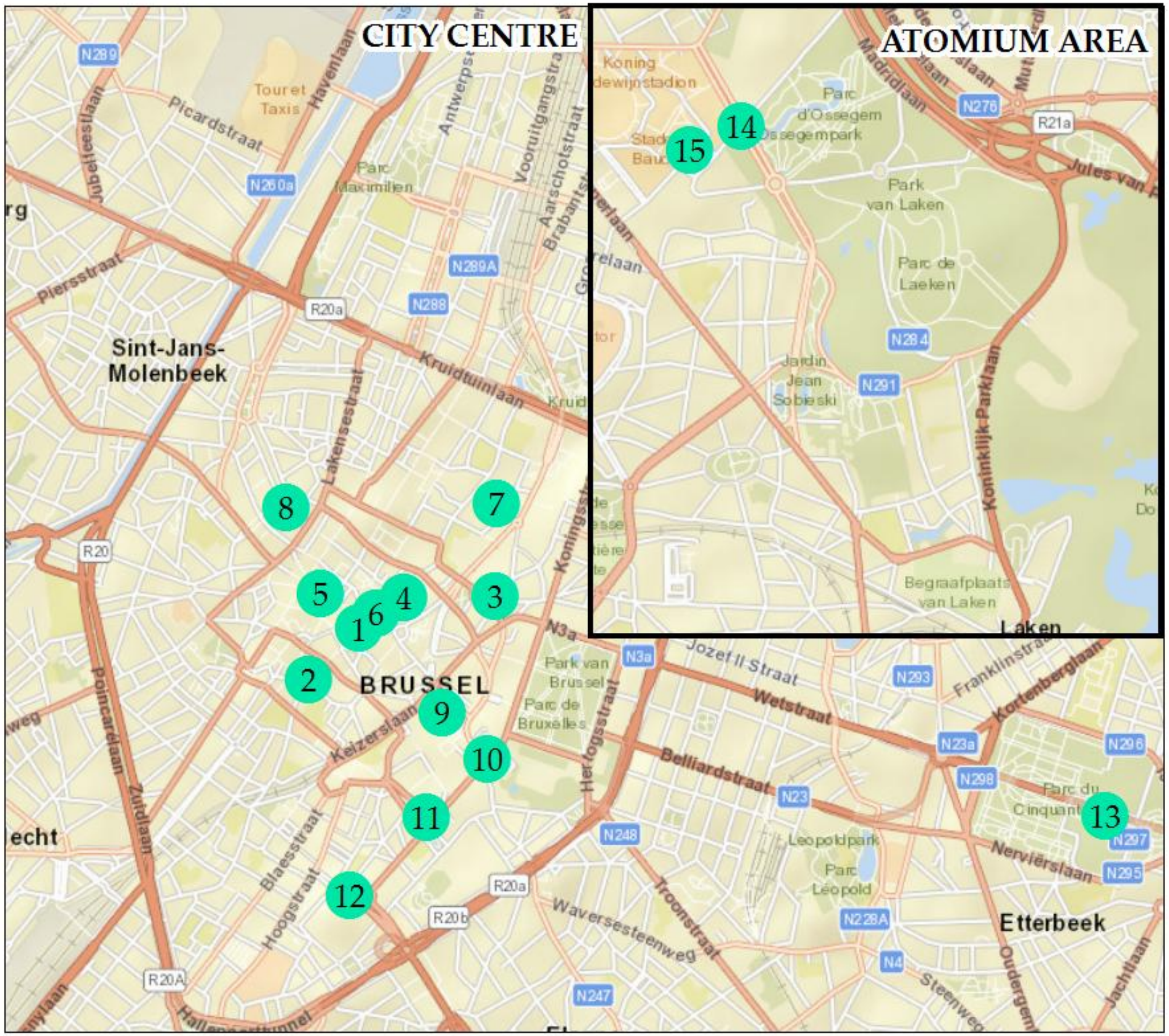
k. Southeast Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. St. Catherine Church,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. BOZAR – Centre for Fine Arts,
12. Brussels Park
13. The European Parliament,
14. Leopold Park,
15. Cinquantenaire Park (incl. Arcade, Art & History Museum and Royal Museum of Armed Forces and Military History),
16. National Basilica of the Sacred Heart,
17. Atomium,
18. Mini-Europe.



1. South Europe

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. St. Catherine Church,
8. Mont des Arts,
9. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
10. Notre-Dame du Sablon,
11. Palais de Justice,
12. The European Parliament,
13. Cinquantenaire Park (incl. Arcade),
14. Atomium.



m. **West Europe**

1. Grand-Place (incl. Brussels Town Hall and Museum of the City of Brussels),
2. Manneken-Pis,
3. Cathedral of St. Michael and St. Gudula,
4. Royal Gallery of St. Hubert,
5. Brussels Stock Exchange,
6. Royal Puppet Theatre Toone,
7. The Belgian Comic Strip Centre,
8. St. Catherine Church,
9. Mont des Arts,
10. Place Royal (incl. Palais Royale, Old England (MIM) and Royal Museums of Fine Arts),
11. Notre-Dame du Sablon,
12. Palais de Justice,
13. Cinquantenaire Park (incl. Arcade, Autoworld, Art & History Museum and Royal Museum of Armed Forces and Military History),
14. Atomium,
15. Mini-Europe.