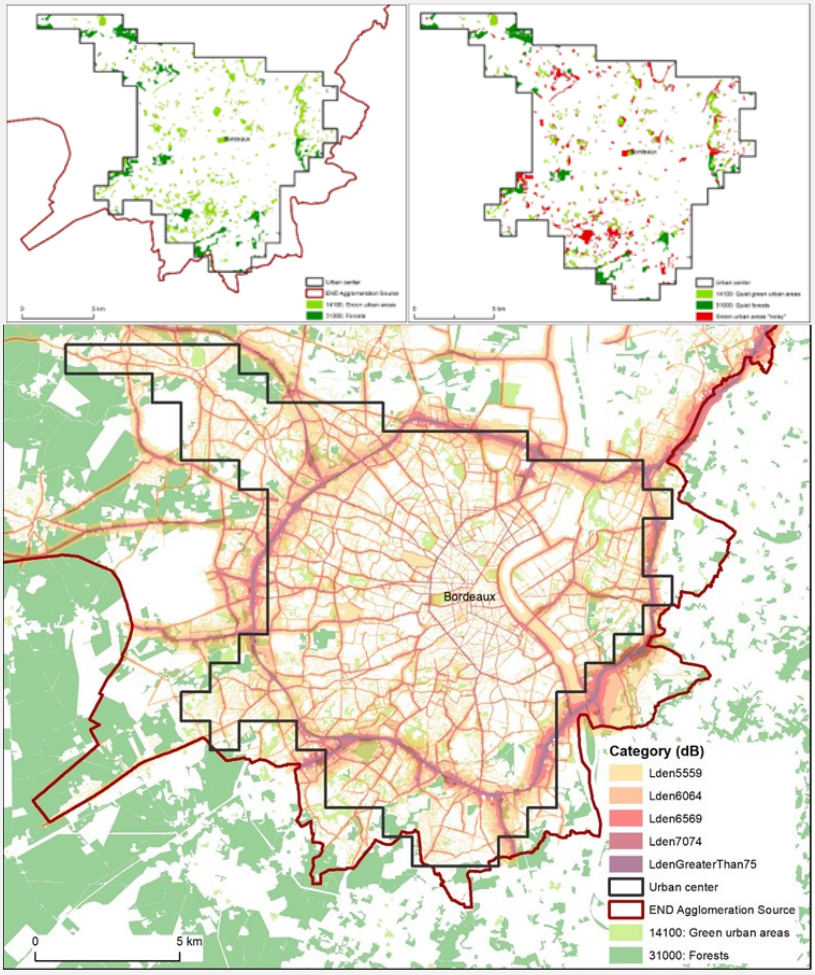
3.2.5.2 Noise assessment: Methodology and scripts for the analysis of quiet areas in urban centres Sub-task 1



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Summary

The Directorate-General for Regional and Urban Policy (DG REGIO) is working on indicators to assess access to green spaces in European cities. The Universitat Autònoma de Barcelona (UAB) has published a report applying a methodology to evaluate accessibility to quiet green spaces, integrating noise maps and data from Urban Atlas 2018 (ETC/ATNI Report 4/2021). This document introduces a methodology aiming to bring together noise and green approaches, emphasizing a new delineation—urban centres—based on population size and density for more reliable comparisons among European cities.

1 Introduction

Green urban spaces play a crucial role in improving the quality of life for city residents. Recognizing this significance, the Directorate-General for Regional and Urban Policy (DG REGIO) has undertaken the development of indicators focusing on access to green urban areas for populations across European cities (Poelman, H., WP 01/2018). The aim is to understand the spatial distribution of green urban areas in relation to the population.

Following this approach, and with the UAB's expertise in evaluating quiet areas across Europe through the utilization of noise maps from the Environmental Noise Directive (END), the UAB team published a comprehensive report (ETC/ATNI Report 4/2021). This report details and applies a methodology designed to assess the accessibility of the population to quiet green spaces in urban agglomerations. The assessment incorporates road and air traffic noise contour maps, focusing on the L_{den} indicator, and utilizes data from Urban Atlas 2018.

The new presented document introduces and elaborates on a methodology that integrates the objectives outlined in the aforementioned documents. This methodology is designed to identify quiet green urban areas, characterized by low levels of traffic noise (<55dB L_{den}).

These two approaches have much in common but also some differences. The main differences in these works are the delineation of the study area and the selection of the green areas to be included in the analysis. It is important to mention that we use a delineation, urban centres, which is based on criteria of population size and population density and will allow for more reliable comparisons among European cities.

While these two approaches share many similarities, there are some notable distinctions between them. The primary divergences lie in the definition of the study area and the criteria for selecting green areas from Urban Atlas database for analysis. The methodology presented in this document aims to reconcile these two studies by adjusting the assessment of quiet areas' accessibility to a new delineation: urban centres.

Focusing on the delineation of urban centres based on criteria such as population size and density ensures greater comparability across European cities.

2 Objectives

The aim of this work is to refine and update the methodology for calculating accessibility to green and quiet areas, originally developed in 2021 (ETC/ATNI Report 4/2021) with END reference year 2017, by transitioning to a more consistent and comparable urban delineation: urban centres. Agglomeration is the current urban delineation used in noise assessment since it is the unit defined by the Environmental Noise Directive: "part of a territory, delimited by the Member State, having a population in excess of 100 000 persons and a population density such that the Member State considers it to be an urbanised area". However, this definition can vary among Member States, posing challenges for comparability. In contrast, urban centres provide a more stable and comparable delineation based on the degree of urbanization (Eurostat). This approach is employed by DG Regio in their assessments, ensuring a more standardized and reliable methodology.

Definitions

- **Quiet areas**: Potential quiet areas in relation to road traffic noise below 55 dB L_{den}. We refer to potentially quiet areas since not all noise sources are considered.
- **Green area**: Green urban areas (Urban Atlas code 14100 and 31000 Forest). Public green areas for predominantly recreational use such as gardens, playgrounds, zoos, parks, castle parks and cemeteries. Suburban natural areas that have become and are managed as urban parks.
- **Green-quiet area**: Green areas below 55 dB L_{den}
- **Agglomerations**: Part of a territory, delimited by the Member State, having a population in excess of 100 000 persons and a population density such that the Member State considers it to be an urbanised area. In this assessment the terms city, urban area and urban agglomeration are used interchangeably.

Urban centres: (or a high-density cluster) consists of contiguous grid cells with a density of at least 1 500 inhabitants per km^2. An urban centre has population of at least 50 000.

- **L_{den} (day-evening-night noise level)**: the long-term average indicator designed to assess annoyance and defined by the Environmental Noise Directive (END). It refers to an A- weighted average sound pressure level over all days, evenings and nights in a year, with an evening weighting of 5 dB and a night weighting of 10 dB.

Table 1: Information to be obtained through the analysis

For each urban centre, we will gather the following information:

Field	Description
Urban centre	Name of the urban centre
Country code	Country code
Total population (inhabitants 2021)	Inhabitants in the urban centre (2021)
Total green area	The overall extent of green spaces within the urban centre. e.g. (19 380 ha)
Total quiet green area (ha)	The overall extent of quiet green spaces within the urban centre.
Percentage of quiet area below ≤ 55dB L_{den}	Percentage of green area in the urban centre that does not overlap with noise contour maps from the END. That is any green area that is not affected by road traffic noise levels above 55 dB L_{den} . When calculating the mentioned percentage, the green urban areas labelled as "no data" are not considered. The percentage is determined based on the exclusion of these areas, focusing only on the known and assessable green urban areas with available noise contour maps data in the urban centre.
Total green area excluded “no data” (ha)	Total green urban areas (ha) where noise data is unavailable due to the absence of overlap with the END agglomeration. The portion of green urban areas that are excluded from the analysis due to lack of noise data ("No Data" areas).
Number of people with accessibility to quiet green area (< 55dB L_{den})	Number of people with accessibility to quiet green areas at a distance of 400m.
% of people with accessibility to quiet green area (< 55dB Lden)	Percentage of people with accessibility to quiet green areas at a distance of 400m
Weighted median of quiet green urban areas	Weighted median surface of quiet green urban areas in the urban centre

Table 1 summarizes the attributes to calculate per Urban centre through the analysis described in this document.
These metrics provide a detailed breakdown of the green areas within each urban centre, considering noise data availability.

3 Data and methodology

In the following section we will explain the methodology applied as well as the data used.

3.1 Input data

The following datasets are used in this analysis:

Noise contour maps 2022: for road traffic noise inside END agglomerations. This data allows us to differentiate between quiet and non-quiet areas as regards to road traffic noise, setting the threshold at 55 dB $L_{den.}$ Noise contour maps inside urban areas are only reported by member states on voluntary basis.

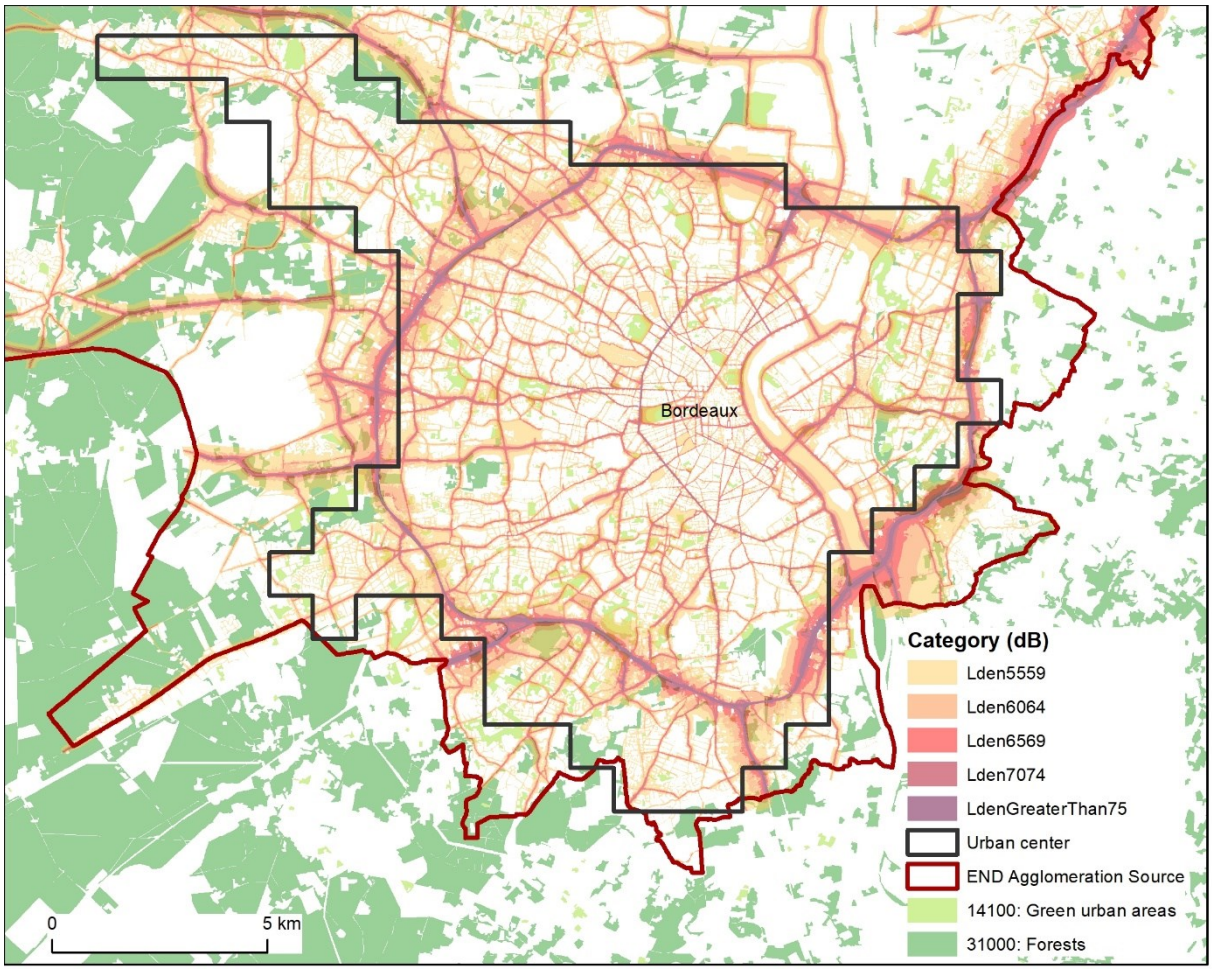
Agglomerations: urban areas of > 100 000 inhabitants. Delineation from Environmental Noise Directive (END) noise sources from 2020.

Urban centres. Consists of contiguous grid cells with a density of at least 1 500 inhabitants per km^2. An urban centre has population of at least 50 000.

Urban Atlas 2018 (UA) high-resolution land use and land cover data with integrated population estimates for 788 Functional Urban Areas (FUA) with more than 50 000 inhabitants for the 2018 reference year in EEA38 countries and the United Kingdom. Contains population estimates for reference year 2018 at polygon level. Selection of green urban areas (codes 14100 Green urban areas and 31000 Forest).

Road network data. This analysis requires a road network that contains attributes to enable selection of streets accessible to pedestrians. We used the TomTom Multinet data 2019.

Figure 1: Noise contour map for agglomeration roads L_{den}, END agglomeration, urban centre and green urban areas from Urban Atlas 2018 for the city of Bordeaux (France)



3.2 Methodology

The first step in the analysis is the characterisation of green quiet areas within the urban centres by excluding green areas intersecting road noise contour maps ≥ 55dB. These results reflect the maximum potential available green quiet areas from noise source considered, road traffic noise inside urban centre.

3.3 Workflow

The following diagram represents the actions necessary to develop the methodology proposed here.

Figure 2: Flowchart of quiet green urban areas accessibility inside urban centres

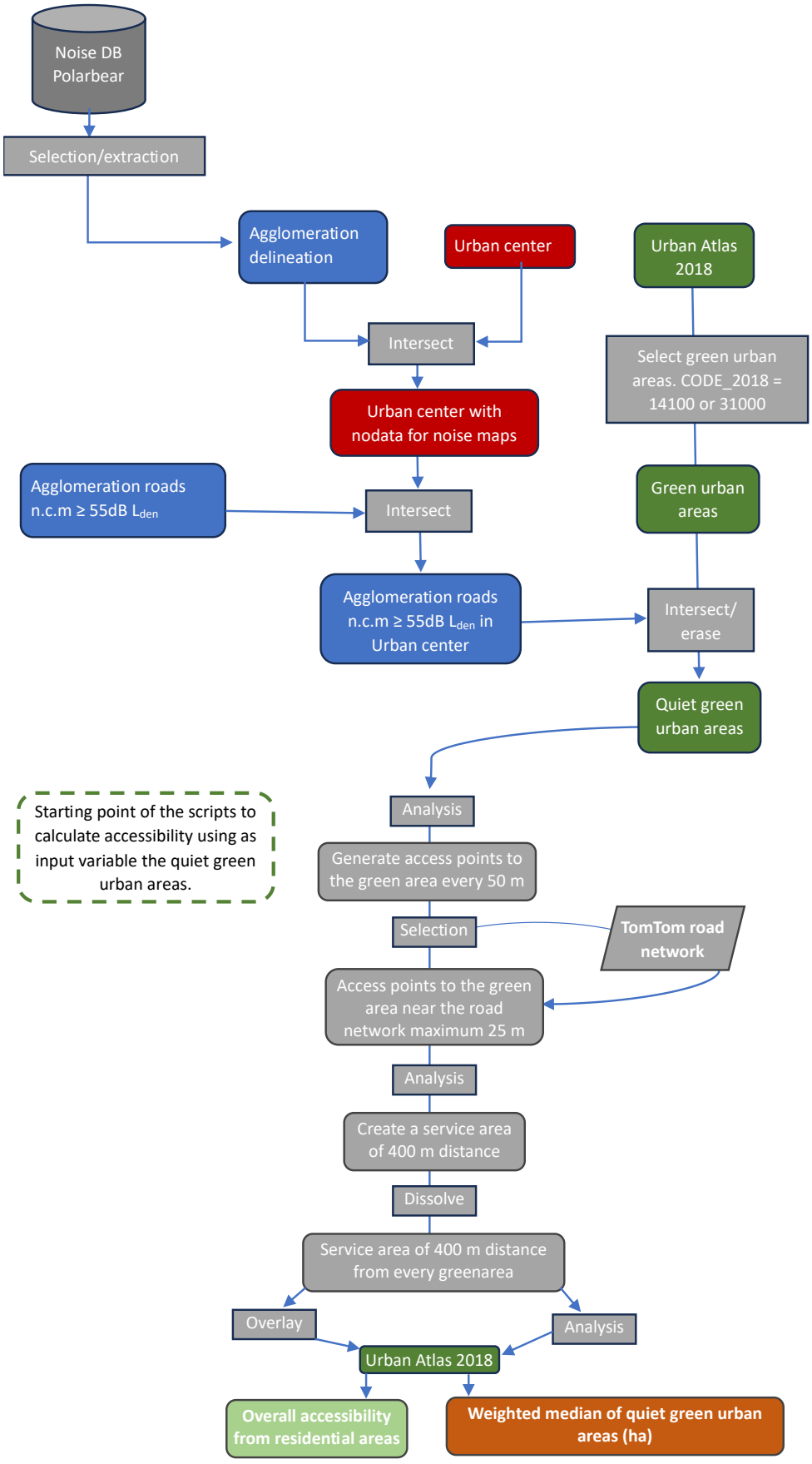


Figure 3: Green urban areas 1938 ha (left). Quiet green areas 1105 ha (right) in the urban centre of Bordeaux, France

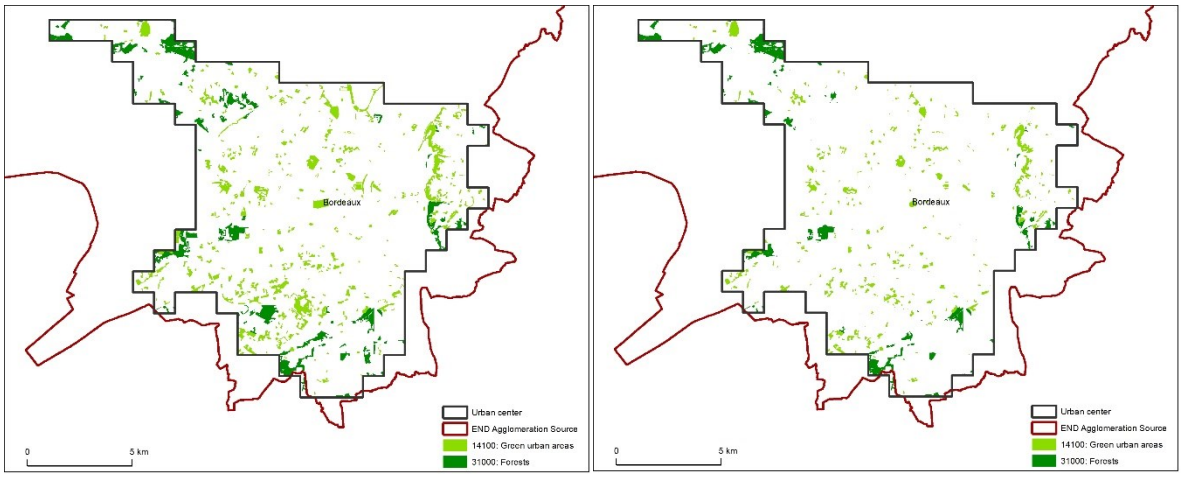


Figure 3 shows that in Bordeaux urban centre, 833 ha of green areas are above the stablished threshold of 55 dB noise from road (1938-1105ha).

Figure 4: In red the areas above 55dB excluded from the accessibility analysis

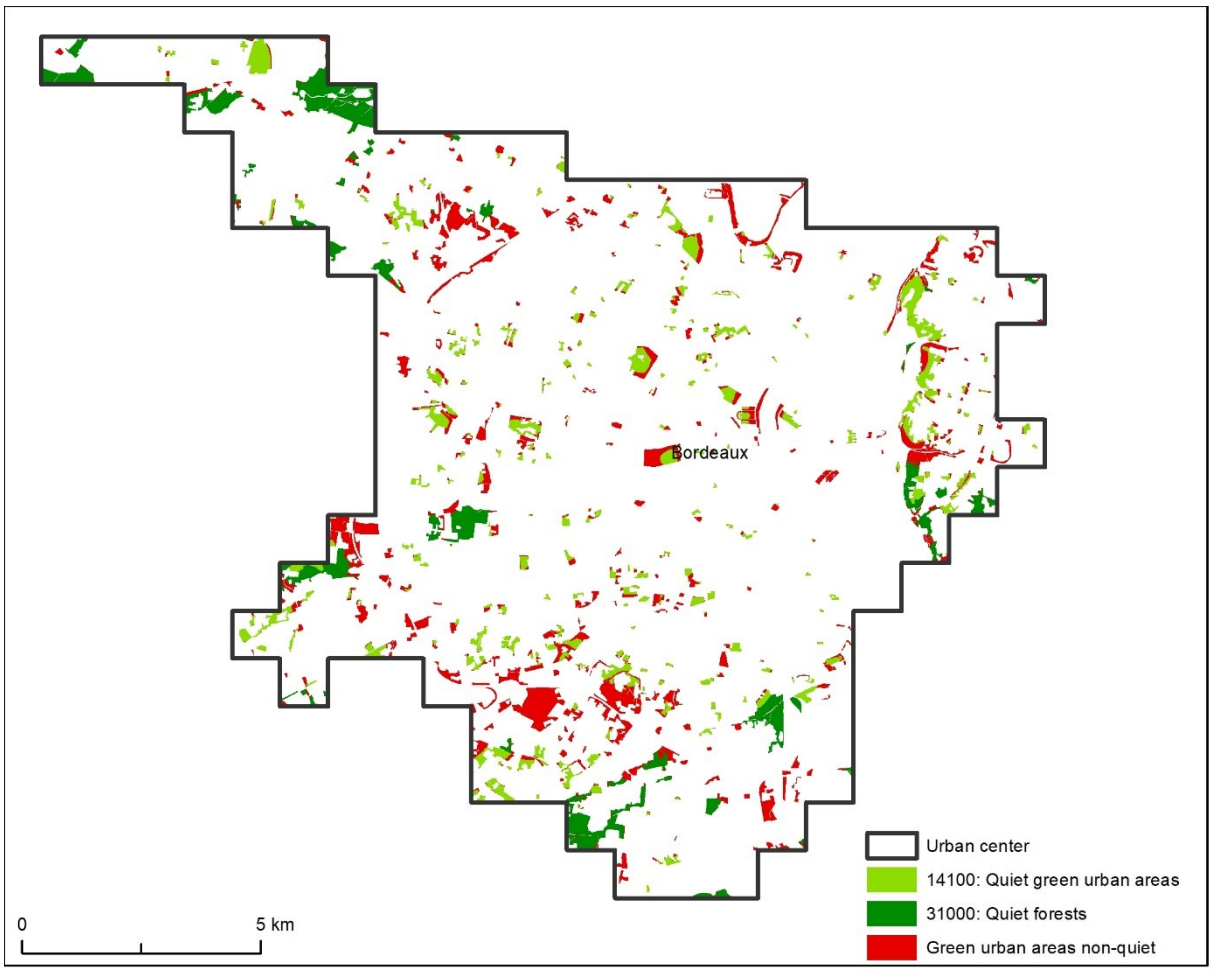


Figure 5: Urban centre outside END agglomeration

In Figure 5 there's a scenario where the urban centre lacks information from the Environmental Noise Directive (END) agglomeration. The red area (48.98 hectares) within the urban centre exceeds the END agglomeration limits, making it uncertain if there's a noise contour map for this region. Consequently, the 8.86 hectares of green urban areas within these zones will be labelled as "No data" and excluded from the accessibility analysis due to the absence of noise information. Also are not included in the calculation of the percentage of quiet green area result.

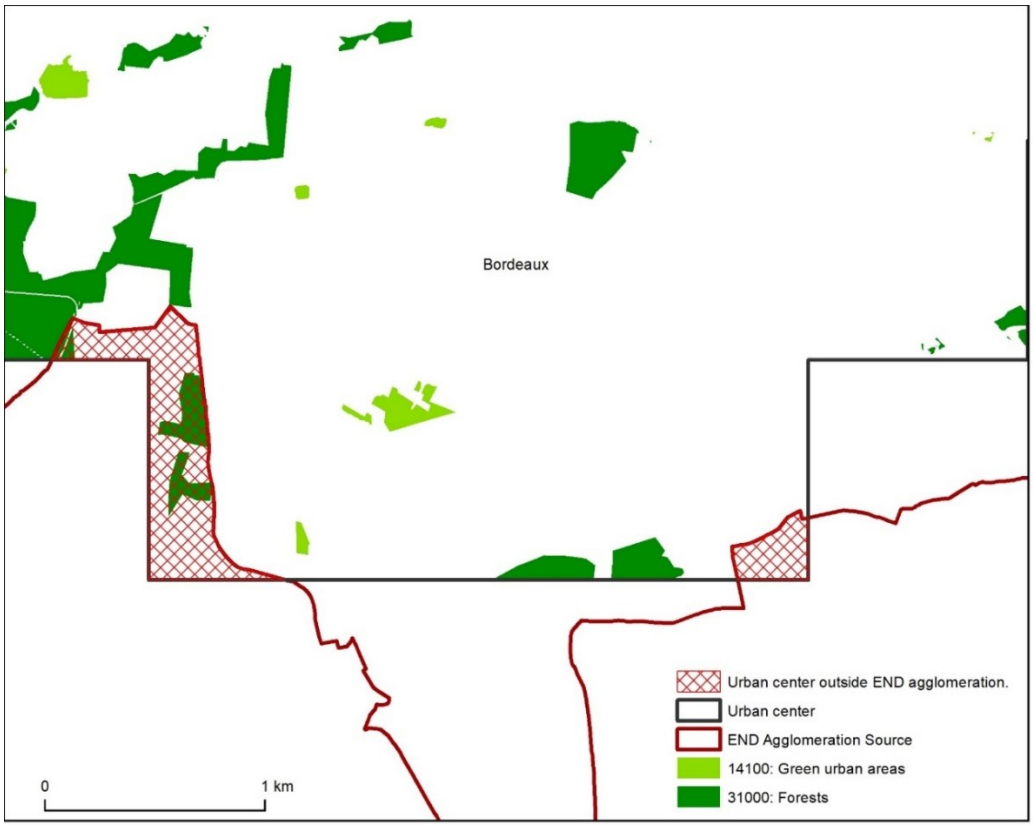


Figure 6: Detail of the quiet green areas outside noise contour maps

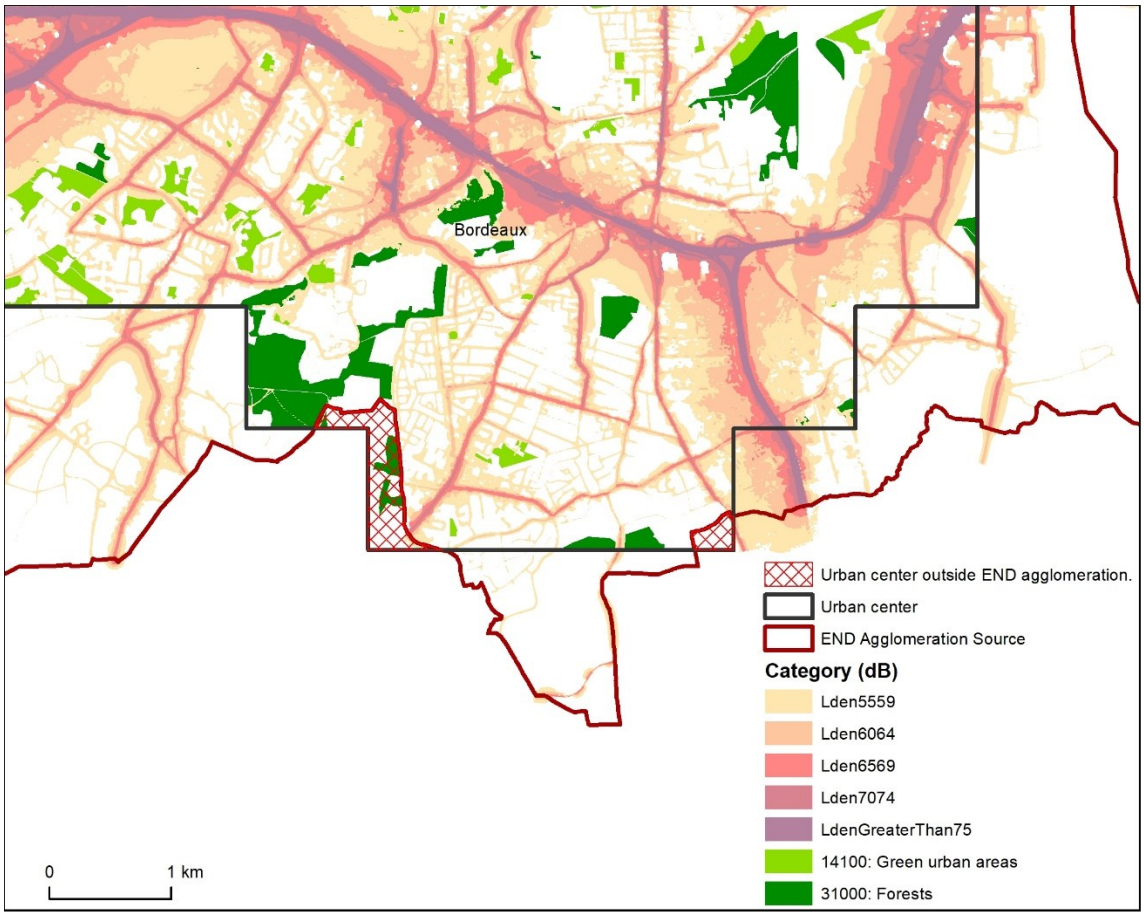


Figure 7: Green urban areas inside noise contour maps (left) and green urban areas excluded for been inside noise contour maps >55dB L_{den} (right)

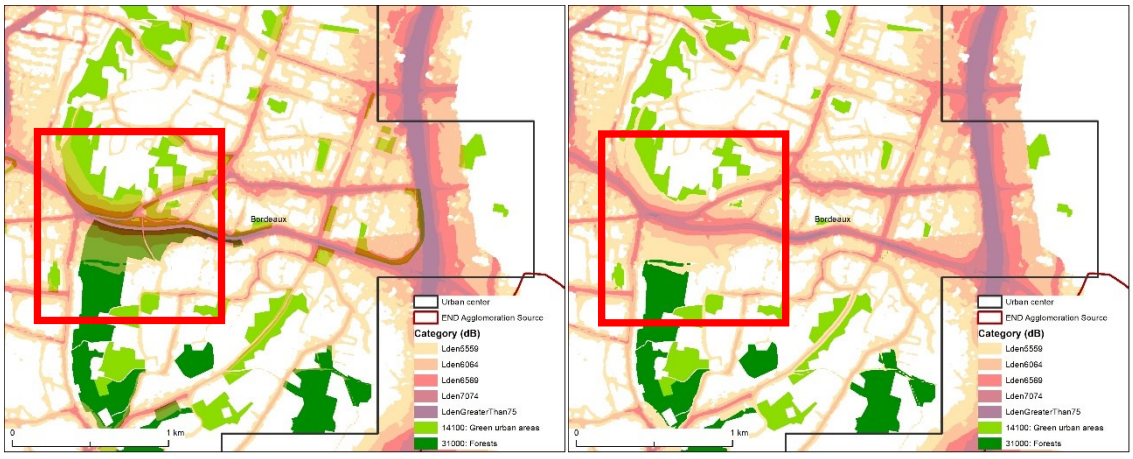


Figure 7 shows green urban areas that intersect with noise contour maps exceeding 55 dB L_{den} from roads are excluded from the analysis. These areas are considered non-quiet areas and, as a result, are excluded in the assessment of accessibility to green urban areas (codes 14100 Green urban areas and 31000 Forest).

4 Assessing access to green urban areas

4.1 Overview

This part follows and adapt the methodology developed and described in (Poelman, H et al. 2018). The first step to calculate the accessibility to green urban areas is to define the threshold of walking time or distance from residential areas to the green urban areas. In previous studies (Poelman, H et al. 2018; ETC/ATNI Report 10/2019) the criterion of 10 minutes on foot was used but, recently, this criterion has been modified to 400 m walking distance following the recommendations of UN-Habitat (UN-Habitat 2020). They defined an acceptable walking distance to open public spaces of 400 meters - equivalent to 5 minutes' walk as a practical and realistic threshold for all groups of people. Our analysis also implements this threshold of 400 meters. The proximity parameter used has been aligned with the SDG 11.7.1 metadata from UN-Habitat: These metadata suggest the use of 400 meters walk to define proximity to open and public areas, of which green urban areas are part.

4.2 Input data

Potential quiet green urban areas in the urban centre (14100: Green urban areas and 31000 Forest below the road noise threshold of 55dB L_{den}).

Road network data. This analysis requires a road network that contains attributes to enable selection of streets accessible to pedestrians. We used the TomTom Multinet data 2019.

Population estimates for reference year 2018 at polygon level from Urban Atlas 2018.

To evaluate pedestrian access to green urban areas, we utilize a street network dataset designed to cover all relevant streets in the urban areas. From the TomTom MultiNet network (2018), we have chosen street segments that are considered as walkable, predominantly excluding motorways.

4.3 Methodology

For each green areas' polygon, we create points along lines, using a fixed distance of 50 m between the points, using the option to include the endpoints of the polygon contours. This method obviously produces many contour points.

Figure 8: Contour points representing green quiet areas and service areas of 400 m walking

This number can be reduced by selecting those close to the street network. Contour points that are far from the streets are in principle useless, because they are supposed to be in places where one cannot access the green area (for instance along rivers, railways, motorways, etcetera). Hence, we select the contour points that are within 25 meters from a street. For each of the green quiet areas a service area of 400 m walking distance is created.

The next step involves intersecting all dissolved service areas, generating numerous overlapping sections. Within each overlapping region, we calculate the cumulative surface area of green areas. This process allows us to determine the total surface area of accessible green urban spaces within a 400-meter walking distance for each part of the territory covered by one or more service areas.

In the final step, we intersect the service areas with the inhabited Urban Atlas polygons, calculating the population residing in each service area polygon by means of area-weighting method. We consider each Urban Atlas polygon inside the urban centre.

Then we estimate the median surface area of quiet green urban areas than can be reached at this distance by population. Finally, calculation of population-weighted median surface of quiet green urban areas in the urban centre that can be reached within 400 m of walking distance is solved.

5 Results

We have used the Bordeaux urban centre as an illustrative example to showcase the applied methodology. The results for this city are as follows.

Bordeaux France

Field	Attributes
Urban centre	Bordeaux
Country code	FR
Total population (inhabitants 2021)	690408
Total green area (ha)	1938.04
Total quiet green area (ha)	1105.44
Percentage of green area below 55dB L_{den} (%)	57,3
Total green area “no data” (ha)	8,86
Number of people with accessibility to quiet green area (< 55dB L_{den})	301394
Percentage of people with accessibility to quiet green area (< 55dB Lden) (%)	46
Weighted median of quiet green urban areas (ha)	9,78

6 Next steps

The proposed methodology is scheduled for implementation in 2024 across all urban centres (697) with available data, utilizing noise contour maps from 2022. The scripts presented here has flexibility to adapt the methodology to incorporate additional datasets, including new noise sources maps, such as those pertaining to airport noise.

This scalability ensures the applicability of the methodology in response to changing data requirements and research objectives.

List of abbreviations

Abbreviation	Name	Reference
EEA	European Environment Agency	www.eea.europa.eu
END	Environmental noise directive	data.europa.eu/eli/dir/2002/49/oj
DGRegio	Directorate-General for Regional and Urban Policy	https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/regional-and-urban-policy_en
UAB	Universitat Autònoma de Barcelona	Universitat Autònoma de Barcelona - UAB Barcelona
WHO	World Health Organization	www.who.int

References

Poelman, H., 2018, A walk to the park? Assessing access to green areas in Europe's cities. DG Regional and Urban Policy Working Paper 01/2018. http://ec.europa.eu/regional_policy/en/information/publications/working-papers/2018/a-walk-to-the-park-assessing-access-to-green-areas-in-europe-s-cities

EU, 2002, Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise (OJ L 189, 18.7.2002, pp. 12-25).

ETC/ATNI Report 4/2021: Potential quiet areas in END agglomerations. Population accessibility to quiet green urban areas using road and air traffic noise contour maps and Urban Atlas 2018.

UN-Habitat, 2020, *Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities*. United Nations programme working towards a better urban future, Nairobi, Kenya.

UN-Habitat, 2021, Metadata on SDG Indicator 11.7.1, https://data.unhabitat.org/documents/GUO-UN-Habitat::metadata-on-sdg-indicator-11-7-1/explore

Annex 1 Scripts

The workflow is divided into three scripts in python, which have been updated from previous work, using open source libraries as much as possible, to make the process more accessible, simpler and faster, and easier to update, adapt and scale. The scripts are distributed as:

- 01_PreprocessingData_clean.ipynb
- 02_GUA_POPL_2018_Calculate_SA_400m_UAB_adaptation.py
- 03_Postprocessing_SA_Calc_stats_clean.ipynb

Two scripts are presented in separated jupyter notebooks (.ipynb), which have run using python 3.9.15. These are using the following libraries: os, geopandas, Fiona, shapely, numpy, and matplotlib to plot results for visual validation purposes.

The first notebook is divided into 8 steps which basically load the required spatial datasets to identify those green quiet areas that are located within the boundaries of the urban centre. Therefore, input variables are the paths to data folders both input folder (indata_f), where the input datasets are located, and output folder (outdata_f), where the produced datasets are meant to be stored.

The second script is running under python 2.7, and it is still using proprietary tools from ArcGIS, which was run using ArcMap 10.8.2. This is an adaptation of a script developed by DG REGIO in May 2012, authored by Veerle Martens. The objective of this script is to create service areas from selected green urban areas. Here, the target has been modified to generate service areas from each of the green quiet areas located within the boundaries of urban centres. The script has been also updated using available libraries to make the process more efficient in terms of processing. The input variables for this script are again the paths to the data folders, but also those related to the network and the parameters for the creation of service areas.

Finally, the last notebook gathers the calculations to obtain the variables related to the accessibility to green quiet areas, such as the number of people with access, the percentage of population, the area that is green and quiet in the urban centre, the percentage that it represents and the weighted mean area, as well as those variables that characterise the urban centre that is analysed (name, code, population, etc). Again, the input variables are related to the paths where data is stored. And the final outputs are those variables that will build the final output table.

An export of the jupyter notebooks to HTML is provided as additional documentation.

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