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Status of quiet areas in European urban agglomerations

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Summary

This report assesses the available (potential) quiet areas in European cities and its accessibility. Data for the assessment were collected using an online questionnaire completed by noise experts from different countries, regions and cities identified though the EEA Eionet network. In parallel, an analysis of availability and accessibility of quiet areas was undertaken using a combined spatial assessment of noise exposure and land use and land cover data for selected European cities.

About 60 % of the respondents declared having designated quiet areas inside urban areas. The most common criteria used to define these areas are (1) noise limit values, (2) land use and land cover types, and (3) the size of the area. But other criteria such as the type of use of the area, where it is located, its accessibility, the presence of vegetation, and the different elements that can be encountered in the area, its degree of protection or citizens' perception of the space have been also mentioned as criteria used to define quiet urban areas.

The majority of the designated quiet areas inside urban areas are protected against an increase of noise and have been included in an Environmental Noise Directive (END) action plan. Instruments used for this protection range from traffic planning to a more strategic urban planning development that should include noise zoning (according to the land uses), establishment of noise limits for various activities and zones, and defining noise abatement measures.

The result of the questionnaires indicates that it is important to establish the role of the different competent administrations, the legal basis needed for quiet areas protection, to define the approach to designate quiet areas, the measures to be implemented in those areas for its protection and how to make an appropriate dissemination and raise public awareness about urban quiet areas.

Concerning the analysis of status and changes of potential quiet areas in urban areas, results show that the amount of quiet areas is higher than noisy urban areas in half of the 15 cities analysed, although those areas are fragmented mainly by the road network in the core city but also in the surroundings.

Three main groups of cities emerge based on a cluster analysis with the reclassified land uses:

- Cities with a high share of green and blue areas (Green and blue include green urban areas, parks, forests, rivers and lakes) (above 75%) and most of residential areas located in potential quiet zones.
- Cities with most of green and blue areas and residential areas located in potential quiet zones but the share of the green and blue areas is lower (between 17 and 65%).
- Cities where most of the residential areas are located in noisy neighbourhoods.

Changes between 2012 and 2017 show that in those cities where there have been an increase of potential quiet urban areas, this increase occurred mainly in areas categorised as green and blue; while in cities where there have been a decrease of potential quiet surface, this decrease occurred both in areas categorised as green and blue and residential.

Considering the percentage of change, residential areas count for a net increase of 1,5% in potential quiet urban areas while the net increase for green and blue areas as well as for commercial and recreational areas is of 0,2%. With this figures, it is important to highlight that area of total change is very small compared to the total area of no change per city (quiet in 2012 and 2017, and noisy in 2012 and 2017), meaning that changes in noise exposure situation are directly linked to urban developments and traffic management which has a longer period than the 5 years reporting cycle of the END. Also, it has to be taken into consideration that changes in noise modelling can introduce some differences in the analysis.

Finally, concerning accessibility to potential green quiet areas, there exist a large variability between European cities and could be described as a combination of factors :

- Local conditions and history determine to a large extent availability, size and distribution of green quiet areas. For example compact coastal Mediterranean cities tend to have smaller green areas inside the city. In those cases, traffic management is almost the only option to have quiet neighbourhoods uin teh city center since there are few opportunities for new park developments.
- Percentage of green areas is important. But alone does not ensure good accessibility. There are cases with high share and low accessibility because most of the green areas are concentrated on the periphery (e.g. Sofia).
- Median accessible area needs to be considered together with the percentage of people without quiet areas nearby. In fact, all the analysed cities have at least 55% of the populatino without quiet areas nearby.

These results should be considered with caution since the delineation of the agglomerations is not standardized at European level.

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1 Introduction and objectives

Noise pollution is a growing environmental concern, caused by a varied number of sources and widely present not only in the busiest urban environments but also in natural environments (EEA, 2014b).

The definition of quiet area is not explicit concerning the properties and characteristics of a quiet area since this is left to the criteria of the competent authority according to the principle of subsidiarity. However, it is clear that quiet areas are not areas of complete silence, but the ones that are undisturbed by unwanted or harmful outdoor sound created by human activities (EEA, 2014a).

It is widely recognised that quiet areas in the urban context may include parks, areas within building blocks, courtyards, unused land or green areas (EEA, 2014a; EEA, 2014b). The idea of quietness currently encompasses many factors including sound pressure levels, human perception, visual interactions, recreational value, the balance between wanted and unwanted sound, the appropriateness of sound to a given area, and human expectation.

The objective of the report is to present an overview of how quiet areas are defined, designated and protected in urban areas as well as to assess accessibility and availability of quiet areas in cities for which data is available. A conceptual framework is proposed to encompass the current situation of potential quiet areas in urban areas, the changes occurring when comparing the results between 2012 and 2017 reference years and an accessibility analysis to those potential quiet areas. The final aim of this proposal is to obtain the results that could facilitate the characterization of potential quiet areas at city level and the dynamics occurring in urban areas from the environmental noise point of view.

Box 1.1

Definitions

European legislation aims to reduce noise pollution and highlights the need to preserve currently unaffected areas. In this context, article 3 of the END (Directive 2002/49/EC) defines 'quiet area in an agglomeration' as an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source. Based on this definition 33 member states responded a questionnaire about criteria, characteristics and legal instruments for protecting quiet areas and the results are presented in Chapter 3, *Current practices on planning quiet areas in European urban areas.*

Due to data availability and following the END reporting thresholds, for Chapter 4 and 5, in this report quiet areas inside agglomerations are defined as those with less than 55dB L_{den}, from road, rail, aircraft and industrial sources. Since data covering other noise sources has not been considered, we use the term "potential quiet areas".

Agglomeration shall mean 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.

2 Conceptual framework

There is not one common definition of quiet areas, and very often the outcome is based more on the experience and planning regulations than a well-defined set of criteria.

The designation of "quiet" may accidentally lead to the assumption that a quiet area is an area with a very low noise level. However, noise levels below 45 dB L_{day} or 40 dB L_{night} are hardly ever found. This is confirmed by the existing literature and practices in Europe concluding that a quiet urban area cannot be defined only based on the noise level (EEA, 2014a). Aspects such as perception by citizens, accessibility, qualities of the areas such as natural, cultural and recreational characteristics, and also the land cover composition of the area (e.g. green area versus built-up area) should be taken into consideration to define a quiet area inside an urban area.

It is also important that citizens' health should be taken into consideration when planning quiet places in urban environments, in order to provide spaces that can offer opportunities for rest and relaxation and relief from environmental noise and stress mainly produced by road traffic noise (Gidlöf-Gunnarsson, 2007; Pheasant, 2008; Booi, 2012; Cerwén, 2018). In Cerwén (2018) it is shown that the exposure to natural sounds may have positive health effects by reducing stress, so it is important to modify the focus of the analysis and highlight the potential positive qualities of the sound environment.

Provided then, that cities constitute a mix of uses, activities and interests, quiet urban areas should follow the same pattern and become elements integrated in the urban structure and not isolated spots. It is important not to limit solely to green urban areas, as the existence of quiet neighbourhoods or commercial districts, that could develop the restorative function mentioned above, should also be taken into consideration.

Therefore, in our approach, we do not limit to green urban areas, although they tend to be the primary objective given the multiple benefits that they provide. The availability of greenery (nearby trees, opportunities for gardening and places for taking walks) in the different spaces of the city also plays

an important role and it is a highly valued component of urban nature that increases satisfaction and well-being in urban residents, although maybe located in the noisy areas of the city (Braubach, 2017; Gidlöf-Gunnarsson, 2007). Furthermore, different types of urban spaces like court yards, pedestrian street, square, small park or resting area with little traffic contribute to the quiet areas as a network.

Against the background explained before, we have identified a set of characteristics that could define (to different degree) potential quiet urban areas, which are summarized in Table 2.1.

Table 2.1. Set of criteria to define potential quiet urban areas

CRITERIA	Definition	Observations
Noise limit values	The noise limit value is defined following the END threshold of 55 dB L_{den}. Areas with lower noise values than 55 dB are considered potential quiet zones.	Noise limit values are intended for man-made sounds and not natural sounds such as running/falling water or bird song. Lower noise limits are required as the degree of natural features falls. Apparently, higher noise levels than 55 dB L_{den} (e.g. 60 dB L_{den}) do not exclude an experience of quietness if the surrounding sound pressure level is 10-20 dB (A) higher. Different limits are specified in national legislations concerning not solely quiet areas but also other types of urban areas (recreational, schools, hospitals, etc.)
Open spaces	Areas outside buildings	
Aesthetic values of quiet areas	Attributes related to people's perception of quietness and percentage of natural features present within a scene	Perception indicators such as pleasant nature, nice colours and odours, clean,…) Presence of natural features such as trees, gardening,… Availability of this information at European level
Accessibility and walking distance	Accessibility to the area	
Minimum area (size)	Size of the area 1ha	Not necessarily exclusive criteria.
Ownership	Public or private area	It could be relevant to know the ownership in terms of capability to be a quiet area for a reduced number of people or a public space freely accessible

Provided all the criteria proposed, it is clear that there is not a unique typology of quiet areas. These criteria would help to analyse minimum homogeneous units defined by the different elements within the city that could constitute potential quiet urban areas (e.g. street with trees, backyard, inner yard, green urban area, buildings' area,…). The objective would be to group the minimum homogeneous units into main categories that potentially could help in establishing a criteria to classify the different cities analysed.

Nevertheless, the translation of all these elements to the European context is not feasible since some aspects require information or intervention (such as questionnaires to citizens) at a scale out of the

scope of this proposal. Therefore, the criteria used to define potential quiet areas in Europe is defined as follows:

- Certain acoustic quality: use of noise contour maps provided by member countries to fulfil the END requests to identify as potentially quiet those areas below 55 dB L_{den} and potentially noisy those areas above 55 dB L_{den}
- Areas not limited to green urban areas, neither isolated spots. Consider urban fabric also as a component of potentially quiet, and relevant to establish connections within the different spaces.

3 Current practices on planning quiet areas in European urban areas

In order to get a better understanding of current practices on planning quiet areas in European cities, a consultation to EEA 33 Member States was conducted between February and May 2019. The consultation was structured in a questionnaire, using the EU Survey Platform, addressing three administrative levels: national, regional and local authorities.

The questionnaire focussed on three main topics:

- Criteria to define quiet areas
- Main characteristics of the quiet areas
- Legal instruments for protection of quiet areas

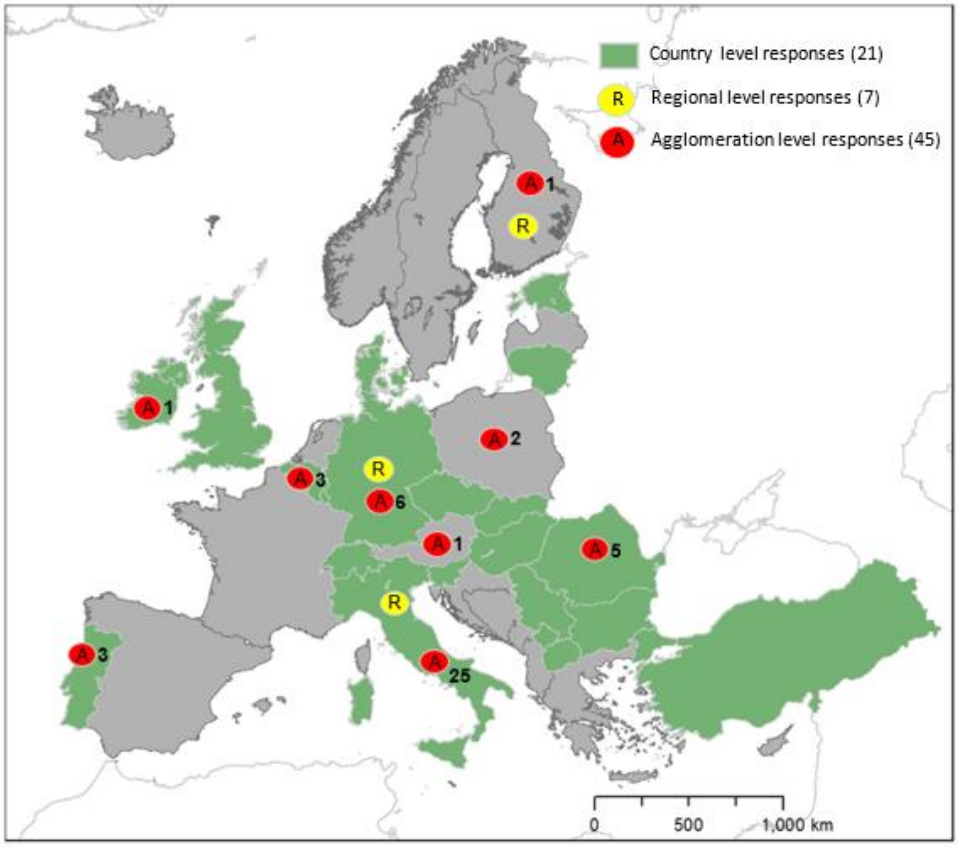
The detailed analysis of the responses provided at different administrative levels can be found in ETC/ATNI, 2019.

3.1 Results for quiet areas inside urban areas

Geographic distribution of responses are presented in Map 3.1. The compiled information accounts for 10% of the cities that should report according to END. However, it should be noted that the responses also included cities not included in the END.

Although the reported agglomerations cover a broad range of geographic distribution and typologies (size,...), information for substantial parts of Europe are still missing.

Map 3.1Responses to the questionnaire on quiet areas inside urban areas by administrative level. In grey, countries that did not provide feedback.



3.1.1 Definition of quiet areas

The most common criteria used to define quite areas are the following ones:

- noise limit values (acoustic classification, noise threshold,...)
- land use and land cover types (presence of settlements, infrastructures, mountain pastures, wooded areas, etc)
- size of the area

Table 3.1 provides a complete overview of all the criteria identified in the questionnaires to designate quiet areas inside urban areas.

Table 3.1. Criteria to designate quiet areas inside urban areas (reported under the questionnaires 2019)

CRITERIA	(DIFFERENT) ASPECTS CONSIDERED TO DEFINE QUIET AREAS INSIDE AGGLOMERATIONS
Noise limit values	- Noise threshold (in general), by using: o Strategic noise maps of the END o Acoustic classification plan / Acoustic zoning of the city - Where to apply the noise threshold o In the full extensions of the quiet area o In at least 50% of the complete extension of the quiet area o In at least an extension of 1000 m^2 - Consider difference of noise levels: o of at least 6 dB(A) between the inner point of the area and its boundary o of 10-15 dB(A) compared with surrounding areas

CRITERIA	(DIFFERENT) ASPECTS CONSIDERED TO DEFINE QUIET AREAS INSIDE AGGLOMERATIONS
	○ quieter in the core area than at the periphery if the size is adequate
Land cover / land use	- Forests - Green areas - Natural parks - Agricultural areas - Natural areas - Archaeological areas / historic and cultural areas - Urban squares - Cemeteries - City parks - Gardens - Green urban areas - Open spaces (included outdoor theatres)
Size / extension	- Minimum size of: ○ 3000 m^2 ○ above 5000 m^2 (quiet areas in inner city) ○ 1 ha ○ 3 ha ○ 4,5 ha ○ 5 ha ○ 9 ha - 350 meters linear
Use of the area	- Recreational function, allowing leisure time entertainment - Recovery function - Schools - Hospitals - Nursing homes - Rural residential areas - Public areas
Location	- Areas within or adjacent to densely populated settlement areas - Contiguous to metropolitan area - Near to residential areas
Accessibility	- Publicly accessible (no physical barrier to entry) - Enable connections to low noise landscapes - At least 10.000 inhabitants should have access to the relatively quiet area within a walking distance (1 km)
Vegetation	- Ground vegetation rate greater than 50%
Elements	- Street furniture - Paths within the area (at least 100 m or 1 ha) - No bars, kiosks or recreational activities, where people love to spend time relaxing - Areas containing children's play grounds, football and other sporting and recreational facilities, as long as these are not the primary use to which the area is being dedicated
Protection	- Already protected areas from landscape point of view - Protected areas with a scenic value and/or historical character
Type of connecting pathways	- Quiet axes with recovery function - Quiet axes with networking function: connecting routes away from the main traffic routes in attractive inner city open spaces.

CRITERIA	(DIFFERENT) ASPECTS CONSIDERED TO DEFINE QUIET AREAS INSIDE AGGLOMERATIONS
	- Contiguous open spaces and forest areas: allowance of stays and long walks in quiet areas - Interconnected natural spaces connecting with inter-urban links to adjacent landscape areas through forests, green spaces, parks, fields and meadows.
Perception	- Perception of the sound landscape - Perception of tranquillity / surveys to citizens - People's expectations
Other	- Urban land planning - Distance from noisy activities (e.g. industrial activities, major roads)

The questionnaires also show a great variability of noise thresholds, and noise indicators, used to designate quiet areas (Table 3.2). These thresholds are presented in two forms: either as a single value or a range.

Table 3.2. Noise thresholds (in dB(A)) specified to delineate quiet areas

	Maximum noise values used to designated quiet areas (single dB(A) value)								Noise values (in ranges) to designate quiet areas (ranges of dB(A))		
	≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	30-35	40-45	50-55
L_{den}			■	■	■	■	■		■	■	■
L_{day}			■	■	■	■	■	■			■
L_{night}	■	■	■	■	■					■	
$L_{evening}$		■	■		■	■					
$L_{Aeq, day}$					■						
$L_{Aeq, night}$			■								

It is important to highlight that most of the regulations described in the questionnaires take into account the differential noise level between the core part of the quiet area compared to the outside part and to the surroundings, without taking into account a specific noise level to be reached because the importance lies in teh difference between noise values and therefore, the difference in noise perception. Moreover, the surface of the quiet area that should be included under a certain noise level, ranging from 50 to 75% of the total surface of the quiet area delineated, is another important aspect being highlighted. Therefore, both criteria need to be considered when designing quiet areas in the inner city. Areas with relatively lower noise levels in comparison with the surroundings can be designated as quiet urban areas and those are spaces considered highly relevant for the recreation of the inhabitants, for the establishment of potentially quiet neighbourhoods in the city and consequently, the availability of the city to increase the quality of life of its inhabitants.

3.1.2 Characteristics of quiet areas inside urban areas

60% of the responses (considering responses at country level, regional level and city level) declared having designated quiet areas in their territory. The majority of them have been designated linked with the second reporting cycle of the END (2010-2014) and declared as reported through the requirements of this Directive.

Declared size of those quiet areas is quite variable, and the specific responses can be consulted in ETC/ATNI, 2019.

Considering that there are different types of quiet areas in the same city, and answering the question on typology of quiet areas being designated, the results can be summarized as follows:
At least all of them designate one quiet area as green and blue area, being the majority of areas being reported

- The rest of quiet areas have been classified as:
    - Health sensitive areas
    - Ecological areas
    - Recreational areas
    - Cultural heritage areas
    - Other: mainly cemeteries but peri-urban areas are also mentioned

3.1.3 Protection of quiet areas inside urban areas

Road traffic noise is considered the major and, in the majority of the cases, the unique threat to quiet areas. A combination of noise sources but always including road traffic noise also has been declared as threat to quiet areas in some cases.

At city level, less than half of the cities declared having a legal instrument to protect quiet areas in addition to the END. The figure raises to more than 60% if we consider the answers also at country level, but always referring to a legal instrument at national level (and not specifically per each city). Among the instruments highlighted we found: traffic planning, urban planning and development, environmental noise monitoring network and measurements, noise zoning and strategic urban development master plan. At country level, both Estonia and England (in UK) described more in depth the type of measures that were conducted to specifically protect quiet areas focus on preservation of the areas and preventing any deterioration of existing quietness.

In the case of cities, 32 cities provided information on the specific noise measures that were conducted to protect quiet areas, and 12 of those 32 cities mentioned that the measures are included in a current action plan. A summary of the different measures applied in the different action plans can be found in Table 3.3.

Table 3.3. Specific noise measures conducted to protect quiet areas (questionnaires responded by cities, 2019)

TYPE OF MEASURE	TYPE OF ACTIONS MENTIONED
Measures on the propagation path	- Sound-absorbing barrier - Green barriers - Protection screens
Measures at the receiver	- New windows on health sensitive buildings
Promotion and awareness	- Promotion of cycle mobility - Creation of a cycle track/path/infrastructure - Further limitations (linked to their use) in those areas (e.g. large concerts) / Restriction of certain noise-making activities - Signage - Increase and prioritize the use of public transport
Socio-economic measures	- Installation of electronic speed detection system - Sustainable development of the urban transport system
Land use and urban planning	- Increase and widen pedestrian areas - Avoidance of settlements into quiet areas

TYPE OF MEASURE	TYPE OF ACTIONS MENTIONED
	- Creation of buffer zones within quiet areas with a scale of use from inside to outside - Traffic bans / restricting car access to the central parts of the city and organizing car parks near the start and end stops of public transport - Limit the creation and development of ground infrastructures (roads, rail, recreation) - Designing sites for public use, afforestation of free areas and construction of landscaping zones and parks
Traffic management (including road, railways and airports)	- Sound-absorbing asphalt / improve of road surfaces - Creation of 30 km/h zones - Speed control - Road movement reorganization in some areas / reorganization of spaces - Interventions for a more fluid traffic flow / traffic calming - Replacement of intersections with roundabouts - Green wave light / optimization of traffic lights
Perception	- Measures to improve the soundscape of acoustic environment of the area
Others	- Monitor noise levels in quiet areas and urbanised areas - Consider quiet areas in (environmental) planning / development decisions - Consider environmental noise in new plans

To conclude this section related to protection, the majority of the designated quiet areas have been declared as protected against an increase of noise and included in an END action plan.

3.2 Conclusions

60% of the responses (considering responses at country level, regional level and city level) declared having designated quiet areas inside urban areas.

The most common criteria used to define quite areas are:

- noise limit values (acoustic classification, noise threshold,...)
- land use and land cover types (presence of settlements, infrastructures, mountain pastures, wooded areas, etc)
- size of the area

But other criteria such as the type of use of the area, where it is located, its accessibility, the presence of vegetation, the different elements that can be encountered in the area, its degree of protection or citizens' perception of the space have been also mentioned as criteria used to define quiet urban areas.

It has been declared that the majority of the designated quiet areas are protected against an increase of noise and have been included in an END action plan. Instruments used for this protection ranges from traffic planning to a more strategic urban planning development that should include noise zoning as an important aspect to take into consideration.

It is considered important to establish the role of the different competent administrations, the legal basis needed for quiet areas protection, to define the approach to designate quiet areas, the measures to be implemented in those areas for its protection and how to make an appropriate dissemination and raise public awareness about urban quiet areas.

Those arguments were provided by the respondents when explaining the criteria to develop a best practice guidance to designate and protect quiet urban areas, and are the same main reasons indicated by those repondents who were declaring not having designated or protected any quiet urban areas (40% of the responses gathered).

4 Status and changes of potential quiet areas

Based on the different approaches on how quiet areas are being addressed across Europe and the previous work (EEA, 2014a and EEA, 2016), a methodology has been developed to assess potential quiet urban areas in Europe and changes occurring from 2012 to 2017.

With a common approach, a general understanding of potential quiet areas in European cities will be facilitated, although the constraints of data available at European level imply a limited analysis in terms of the number of cities being included in this report.

4.1 Data and methodology

4.1.1 Data

According to the criteria set in the conceptual framework (section 2, page 7), delineation, characterisation and analysis of status and changes of quiet areas require two major type of data : noise level and land cover data. Table 4.1 summarises the available data sets for the analysis. It shoudl be noted that Copernicus Urban Atlas is the most appropriate land use data for agglomerations in terms of resolution (0,25 ha minimum mapping unit). However, currently it only covers years 2006 and 2012. Therefore Corine Land Cover has been used as a proxy, since available reported dates are aligned with the reporting dates of END. Corine Land Cover has a resolution of 25 ha (minimum mapping unit). Therefore the analysis should be taken with caution given its coraser resolution.

Table 4.1. Datasets used for the analysis of potential quiet urban areas at EU level

Criteria	Dataset
Area of the analysis	Agglomeration delineation from Environmental Noise Directive
Noise level	• Noise contour maps 2012: Agglomeration all sources L_{den} (END) • Noise contour maps 2017: Agglomeration all sources L_{den} (END)
Land cover data	• Corine Land Cover (CLC) 2012, version is v.20 datasets. • Corine Land Cover (CLC) 2018, version 20b2 datasets.

Noise levels are obtained from noise contour maps reported to END (years 2012 and 2017). The best data for doing the analysis is the data delivered considering all noise sources inside an agglomeration (agglomeration all). This data is completed on voluntary basis, and it is designed to contain information for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area. When this data was not delivered by the country we selected the agglomerations with data available for all the sources (road, railways, air, industry and also for the major sources) when mandatory for these agglomerations. Noise contour maps (isophones) in line format has been discarded for the analysis. Only data in polygon format has been used. The final selection of the agglomerations and the different noise sources used in the analysis are listed in the Table 4.2.

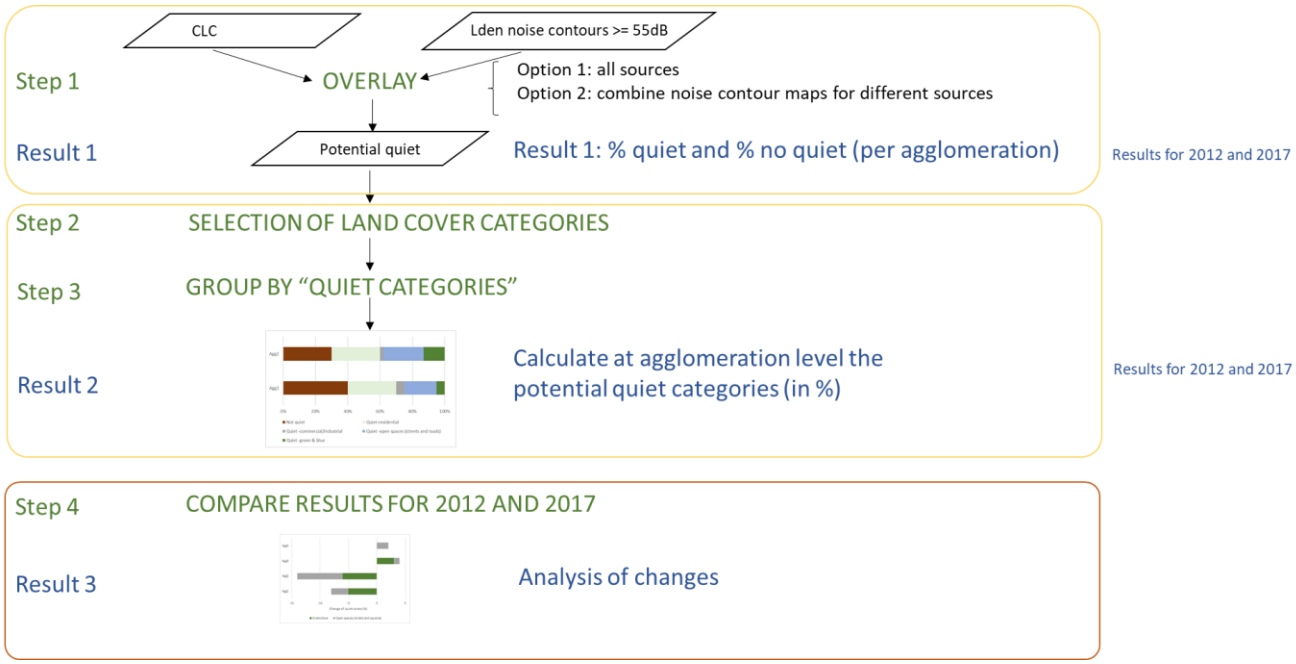
Table 4.2. Final selection of agglomerations included in the analysis, specifying the noise sources used per each agglomeration

		Noise contour maps 2012								Noise contour maps 2017							
Country	Agglomeration	Agglomeration road	Agglomerationrailways	Agglomeration Air	Agglomeration Industry	Agglomeration all	Major road	Major railways	Major airports	Agglomeration road	Agglomeration railways	Agglomeration Air	Agglomeration Industry	Agglomeration all	Maior road	Major railways	Major airports
Switzerland	Bern	■	■				■	■	■	■	■				■	■	■
Switzerland	Zurich	■	■	■			■	■	■	■	■				■	■	■
Switzerland	Lausanne	■	■				■	■	■	■	■				■	■	■
Czechia	Prague					■								■			
Germany	Hamburg	■	■		■		■	■	■	■	■	■	■		■	■	■
Germany	Munich	■	■		■		■	■	■	■	■	■	■		■	■	■
Germany	Cologne	■	■		■		■	■	■	■	■	■	■		■	■	■
Germany	Dusseldorf	■	■		■		■	■	■	■	■	■	■		■	■	■
Denmark	Copenhagen					■				■	■				■	■	■
Denmark	Aalborg					■				■	■				■	■	■
Denmark	Aarhus					■				■	■				■	■	■
Ireland	Dublin	■	■	■			■	■	■	■	■	■	■		■	■	■
Ireland	Cork	■	■	■			■	■		■	■	■	■		■	■	■
Lithuania	Vilnius	■	■	■	■		■	■		■	■	■	■		■	■	
Malta	La Valletta	■					■		■	■		■	■		■		■

4.1.2 Methodology

The methodology for identifying potential quiet urban areas is described in Figure 4.1.

Figure 4.1. Methodology followed for the identification of potential quiet urban areas



The methodology applied consist on different steps and results:

- Overlay analysis of noise contour maps $\geq$ 55 dB L_{den} with land cover (CLC), combining the attributes of all datasets involved in this process.
    - It allows the identification of all land uses inside and outside areas greater than or equal to 55 dB.
    - CLC was previously clipped with the END agglomeration delineation
    - Noise contour map layers being used:
        - First option: one layer covering all noise sources mapped in the agglomeration (agglomeration all)
        - Second option: combination of noise contour maps layers for all the different sources present in an agglomeration and to be mapped in the END context (road, rail, air, industry) greater than or equal to 55 dB. Polygons representing the geometric union of all the areas above 55 dB in the agglomeration.
- The results of this first step would be a potential quiet and potential noisy areas inside agglomeration with the different CLC polygons.
- The information obtained is then reclassified into 4 categories, following the next reclassification:

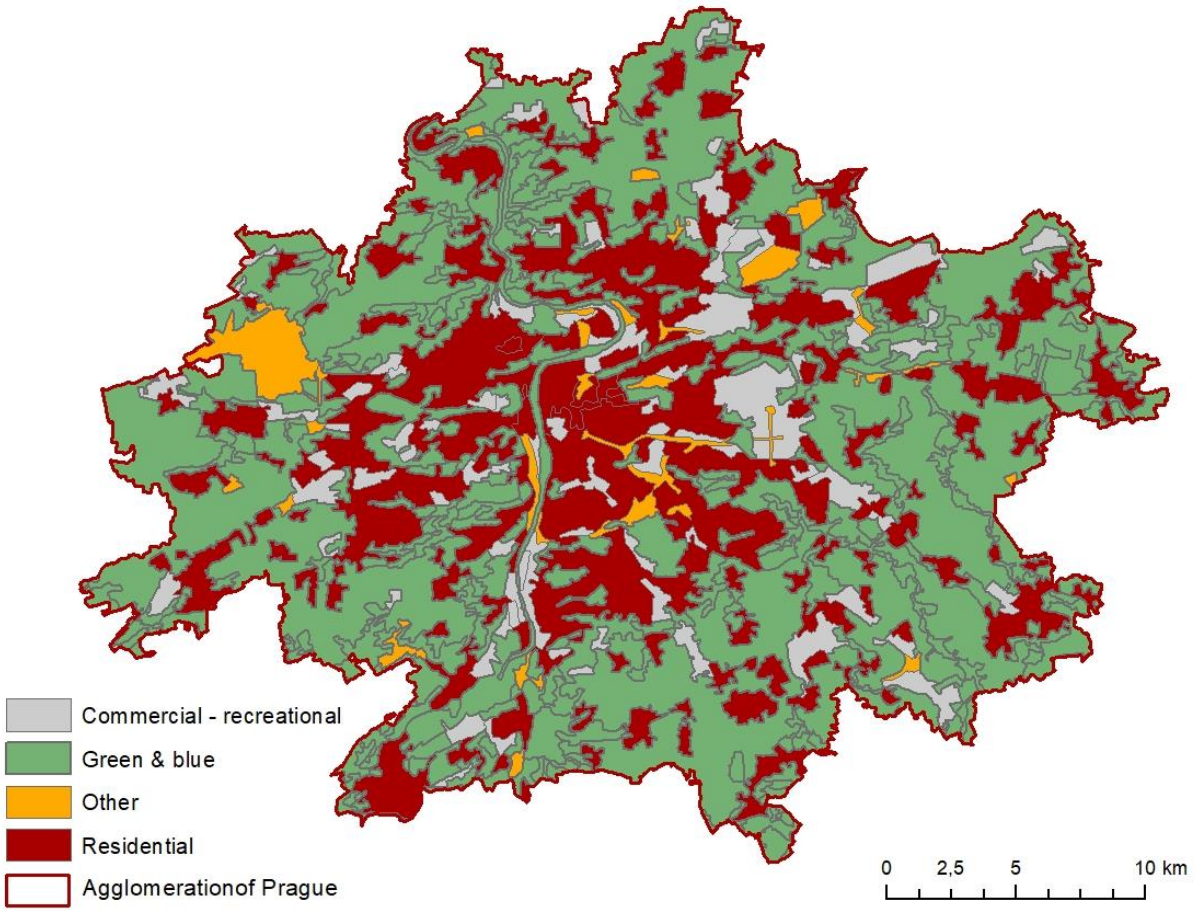
Table 4.3. Proposed classes for the analysis (from CLC classes)

PROPOSED CLASSES	CORINE LAND COVER CLASSES
Residential	Areas mainly occupied by dwellings and buildings used by administrative/public utilities, including their connected areas (associated lands, approach road network, parking lots)
Commercial – recreational	Industrial or commercial units and public facilities. Includes also areas used for sports, leisure and recreational purposes. Camping ground, sports grounds, leisure parks, golf courses, racecourses, etc. belong to this class, as well as formal parks not surrounded by urban areas. Although Industrial units can be in conflict with quiet areas we incloude this class in order to take into account facilities like science and education (schools, universities) and health services (hospitals, spas). The overlay with noise contour maps should eliminate industrial areas.
Green and blue	Green urban areas. This class is assigned for urban greenery, which usually has recreational or ornamental character and is usually accessible for the public. Includes also CLC classes from 211 to 523 and contains forests and water courses.
Other	Contains classes not included in the other categories

* If the analysis would be performed using Urban Atlas, an extra category to identify open spaces (streets and narrow roads) could be distinguished, enabling the analysis of potential quiet connections and potential quiet neighbourhoods in residential areas but also connecting with other areas such as green and blue or commercial-recreational. Currently, this category is mainly included in the continuous and discontinuous urban fabric of CLC (classes 111 and 112).

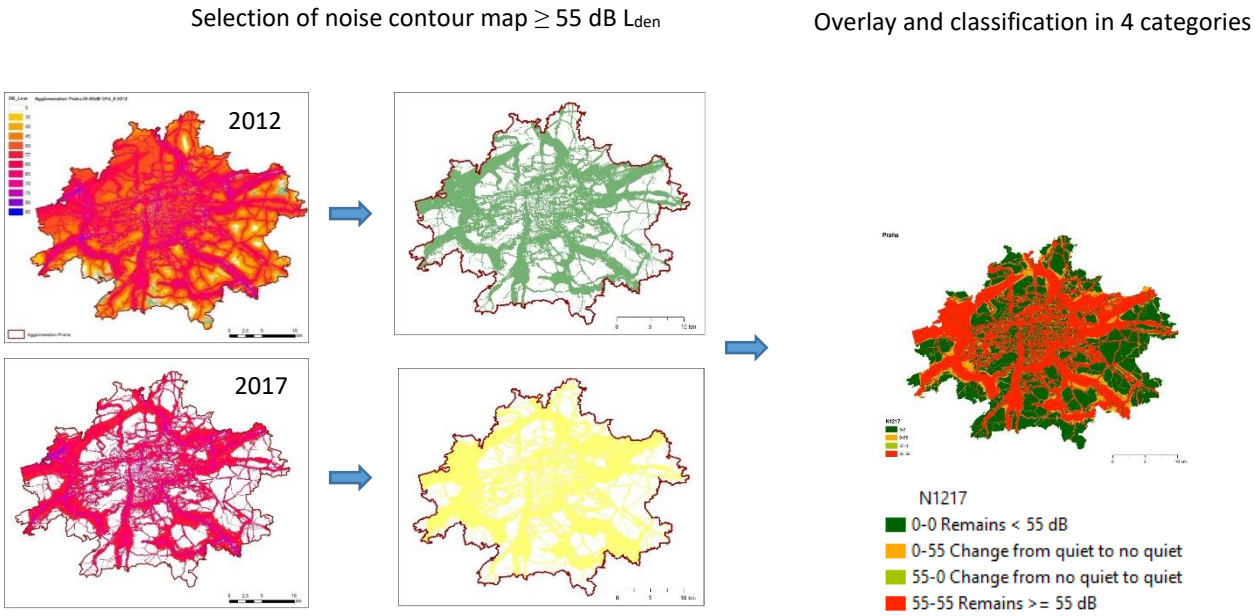
The CORINE Land Cover (CLC) consists of an inventory of land cover in 44 classes at the most detailed level. CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena.

Map 4.1. Resulting map after reclassification of CLC classes in the proposed 4 categories (example: Prague agglomeration)



- Once the land cover data is grouped into 4 categories, a statistical analysis of the results obtained is undertaken, and summarized in section 4.3.
- The same analysis is done considering 2012 dataset (both noise contour maps and CLC) and 2017 – 2018 datasets (noise contour maps and CLC respectively)
- For changes analysis':
    - A specific layer containing changes of noise contour maps between 2012 and 2017 has been created per each city analysed distinguishing between:
        - Areas remaining quiet (i.e. in 2012 and 2017 levels were below 55 dB L_{den})
        - Areas remaining noisy (i.e. in 2012 and 2017 levels were 55 dB L_{den} or higher)
        - Areas changing from quiet to noisy (i.e. in 2012 levels were below 55 dB L_{den} and in 2017 levels were 55 dB L_{den} or higher)
        - Areas changing from noisy to quiet (i.e. in 2012 levels were 55 dB L_{den} or higher and in 2017 levels were below 55 dB L_{den})

Figure 4.2. Data preparation for analysis of changes 2012-2017. Noise contour maps.



- The resulting layer has been overlaid with reclassified land cover layer (4 categories)
- Analysis of the results obtained are summarized in section 4.4.

4.2 Availability of potential quiet urban areas in 2017

The surface of potential quiet areas is higher than potential noisy urban areas in half of the 15 cities analysed (Figure 4.3). Area below 55 dB L_{den} ranges from 30% in Cologne, to 80% in Lausanne.

As can be seen in the maps produced per each city (see Annex 1), the distribution of the potential quiet areas is highly dependent of road infrastructure in the core city and surroundings. Very often the main road network (including circular rings, for example) fragment the potential quiet urban areas. It should be noted that when an airport contributes to the noise of a city, the corresponding noise contour map covers a substantial area of the city (e.g. Zurich and Dusseldorf).

Figure 4.3. Potential quiet versus potential noisy areas per city (percentage)

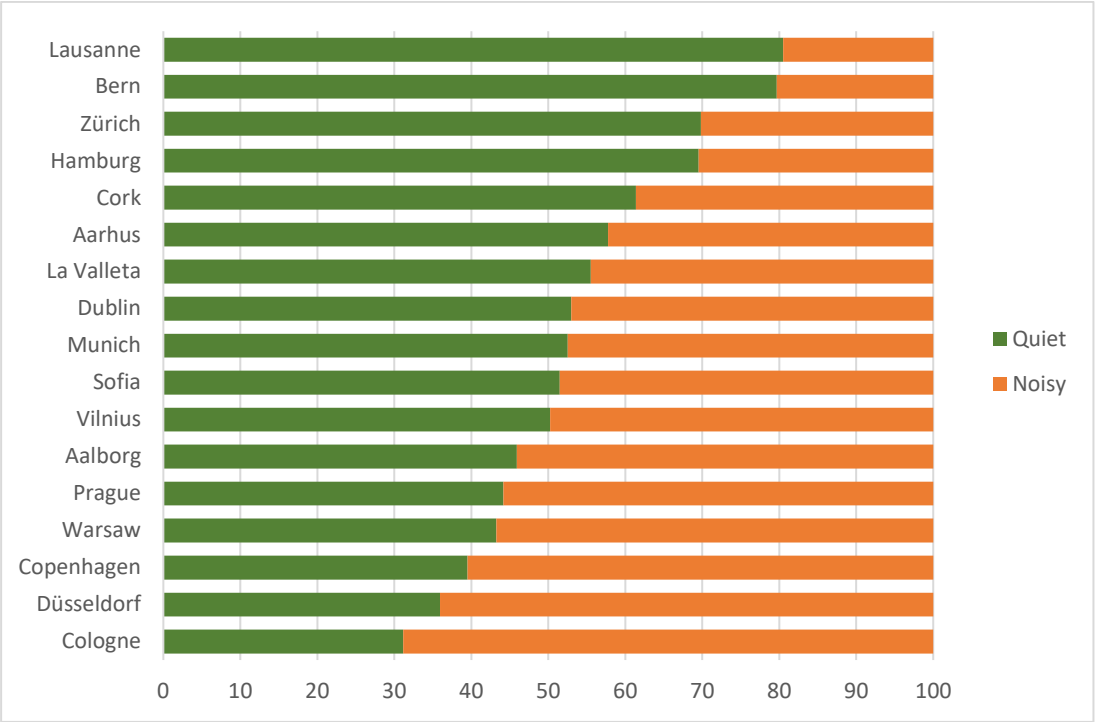


Table 4.4. Distribution of land uses in agglomerations (percentage)

Agglomeration	Residential %	Green&Blue %	Commercial %	Other %
Aalborg	59,3	17,0	22,3	1,5
Aarhus	63,8	16,6	18,0	1,7
Bern	12,2	86,2	1,3	0,2
Cologne	33,8	43,6	18,9	3,7
Copenhagen	50,9	28,3	14,3	6,5
Cork	26,3	66,5	5,8	1,4
Dublin	41,8	40,9	12,3	5,0
Düsseldorf	35,3	44,9	14,8	5,0
Hamburg	35,0	48,6	12,4	4,0
La Valleta	63,0	23,4	11,0	2,6
Lausanne	12,5	85,7	1,6	0,2
Munich	51,4	30,7	15,0	2,9
Prague	29,9	58,0	8,7	3,4
Sofia	12,0	80,3	5,6	2,1
Vilnius	20,8	64,9	10,6	3,7
Warsaw	45,8	36,3	13,4	4,5
Zürich	20,5	74,9	3,1	1,4

The distribution of land uses according to the level of noise show the following patterns, which are relevant in terms of noise management (Table 4.4, Figure 4.4, Figure 4.5, Figure 4.6 and Figure 4.7) Green and blue areas (including agricultural areas). This class ranges from 17% of the total area of the city in Alborg and Aarhus, to 86% in Bern and Lausanne. In most of the cities the majority of green and blue is located in potential quiet areas. Only Cologne and Dusseldorf differ from this pattern, having most of the green and blue in areas with $\geq$ 55 dB. The fact that most green areas are

in zones below 55 dB is important considering the role that green and blue areas play in terms of human health and quality of life. Green and blue areas in zones with $\geq$ 55 dB L_{den} could also play a certain role since perception and difference in dB with neighbouring streets are also important as seen from the responses of the countries to the questionnaire.

- Residential areas. Percentage of residential areas, in relation to the total area of the city, ranges from 12% in Lausanne and Bern (with high share of green areas), to 64% in Aarhus. In 6 cities, residential areas are predominantly located in zones with $\geq$ 55 dB L_{de}, being Dusseldorf the city with highest proportion of residential areas in noisy neighbourhoods. Hamburg represent the opposite case: more than half of the residential areas are located in zones below 55 dB. This results could not be directly translated into noise impacts since other factors interact like noise abatement measures at building level, which are not captured in our analysis. Moreover, the resolution of the land cover data also requires to consider with caution these results. In any way, the distribution of residential areas in noisy or potential quiet areas highlights the context where these residential areas are located. Therefore, accessibility to green and quiet areas is important for the population living in noisy neighbourhoods. These results should be considered with caution since the delineation of the agglomerations is not standardized at European level.
- Commercial and recreational areas. It should be noted that we refer to industrial, commercial and recreational areas as they are delineated in CLC. Therefore, small elements or mixed uses that could have different implications for noise management perspective are not captured here. Industrial and commercial areas tend to be in busy zones, well connected with good road network. Therefore, most of this areas are located in noisy neighbourhoods.

Considering the combination of these three land uses, three groups of cities emerge as a result of cluster analysis:

- High share of green and blue areas (above 75%), and most of the residential areas located in quiet zones: Lausanne, Bern , and Zurich. These cities are represented in green in Figure 4.6, and Figure 4.7.

The largest group of cities has similar characteristics as the previous one (most of green and residential areas are located in zones below 55 dB L_{den}), but with a much lower share of green areas (between 17% and 67%): Aarhus, Valleta, Munich, Dublin, Vilnius, Hamburg, Cork. These cities are represented in blue in Figure 4.5, Figure 4.6 and Figure 4.7.

Cities where most of the residential areas are located in noisy neighbourhoods ($\geq$ 55 dB L_{den}): Prague, Cologne, Copenhagen, Dusseldorf, Aalborg. These cities are represented in red in Figure 4.5, Figure 4.6 and Figure 4.7.

Figure 4.4. Distribution of land use in potential quiet areas and areas ≥55 dB (in %), sorted by the total share of quiet areas.

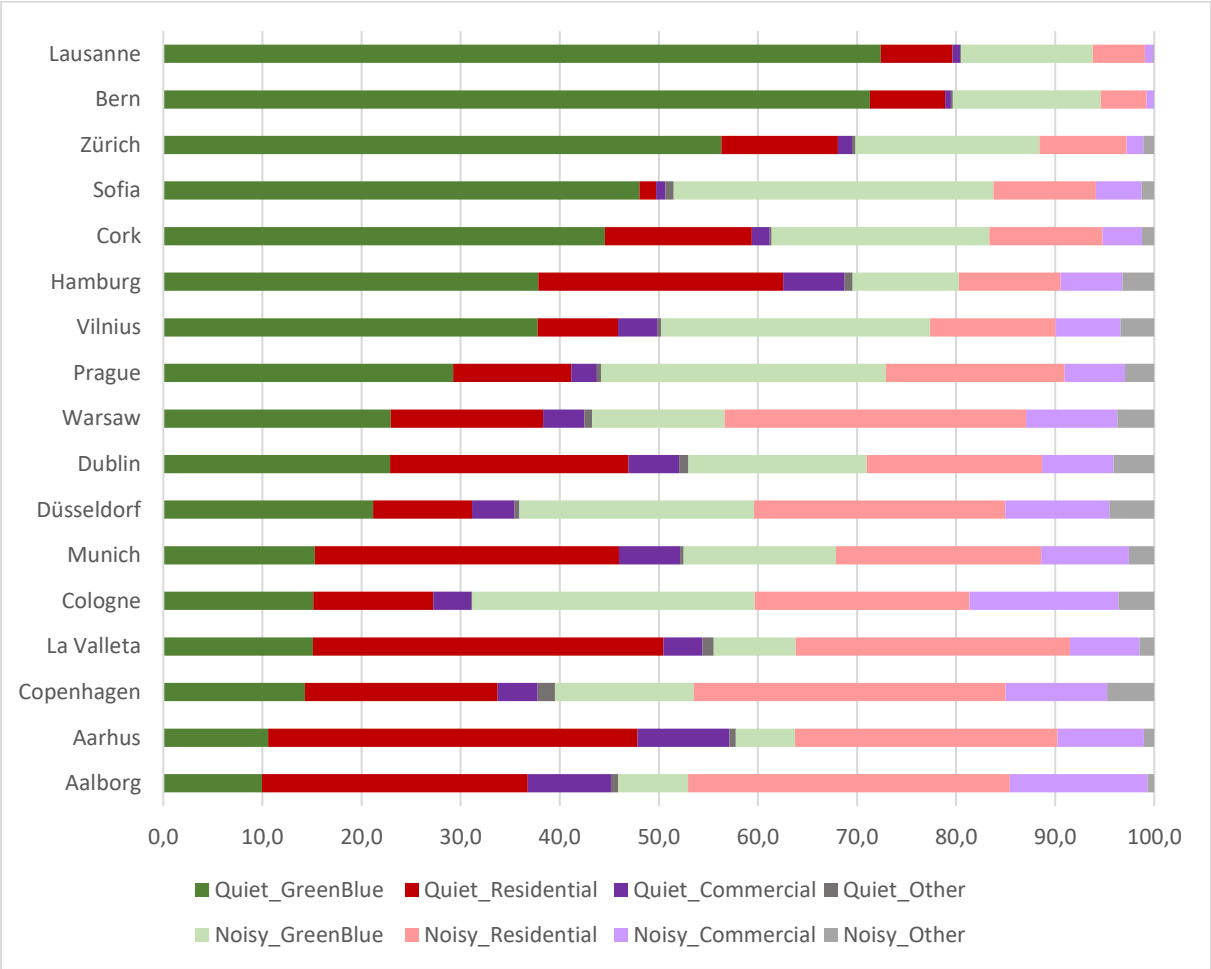


Figure 4.5. Distribution of green and blue areas in quiet zones of the city (horizontal axis) and zones with ≥55 dB (vertical axis). Dotted line shows the equal distribution in both areas. Values refer to the percentage of green and blue as part of the total area of the city. Legend: the colour relates to the three groups identified by cluster analysis. Green, high share of green areas and most of residential in quiet areas; blue, medium to low green areas and residential mainly in quiet neighbourhoods; red, most residential in noisy areas.

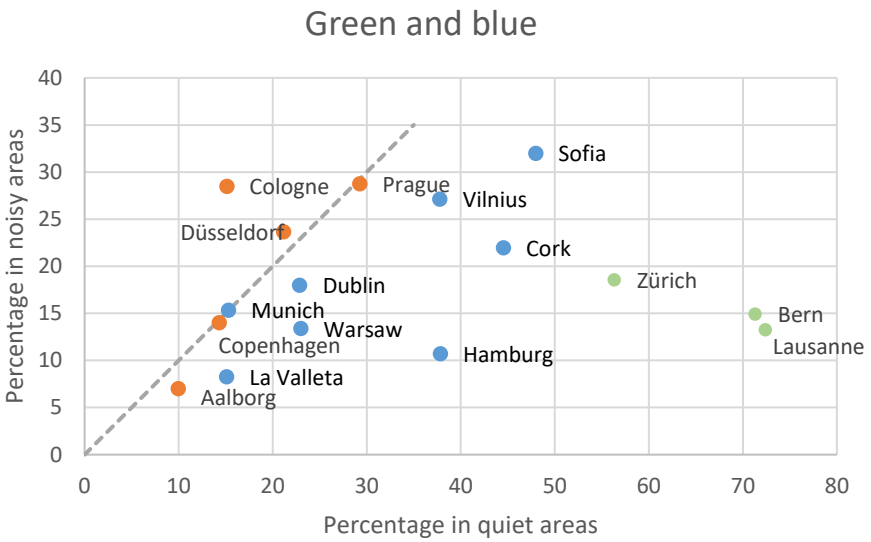


Figure 4.6. Distribution of residential areas in quiet zones of the city (horizontal axis) and zones with ≥55 dB (vertical axis). Dotted line shows the equal distribution in both areas. Values refer to the percentage of residential areas as part of the total area of the city. Legend: the colour relates to the three groups identified by cluster analysis. Green, high share of green areas and most of residential in quiet areas; blue, medium to low green areas and residential mainly in quiet neighbourhoods; red, most residential in noisy areas.

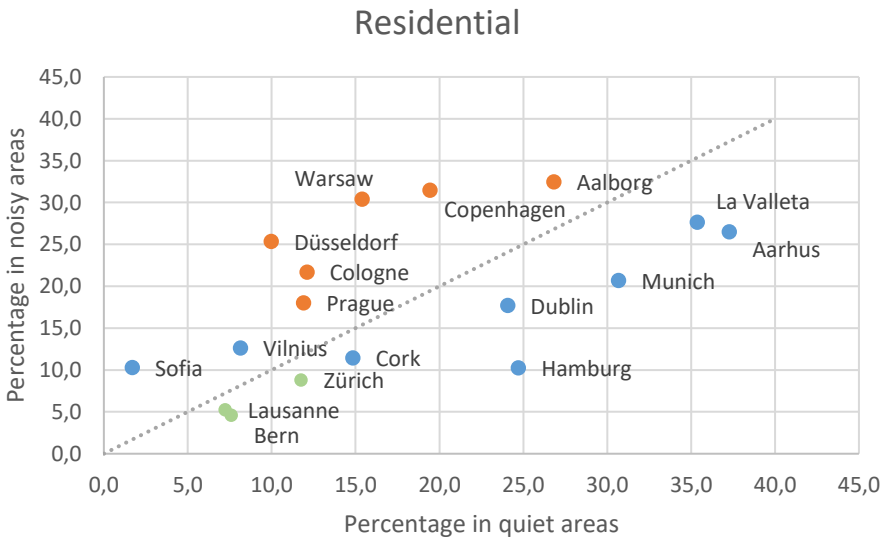
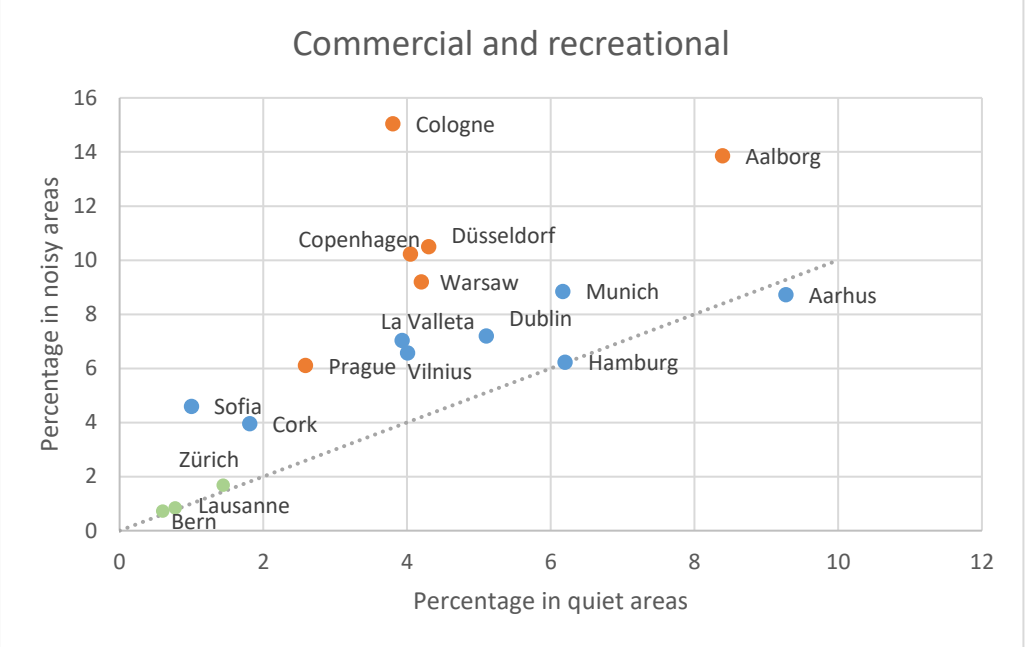


Figure 4.7. Distribution of commercial and recreational areas in quiet zones of the city (horizontal axis) and zones with ≥55 dB (vertical axis). Dotted line shows the equal distribution in both areas. Values refer to the percentage of commercial and recreational as part of the total area of the city. Legend: the colour relates to the three groups identified by cluster analysis. Green, high share of green areas and most of residential in quiet areas; blue, medium to low green areas and residential mainly in quiet neighbourhoods; red, most residential in noisy areas.



Green and blue areas are the ones that would play a major role as quiet, since integrate the benefit of the green. As shown in the maps of Annex 1, the distribution of green and blue areas is not homogeneous and is highly influenced by the road network structure, but in all the cases we can see green spaces close to city centres.

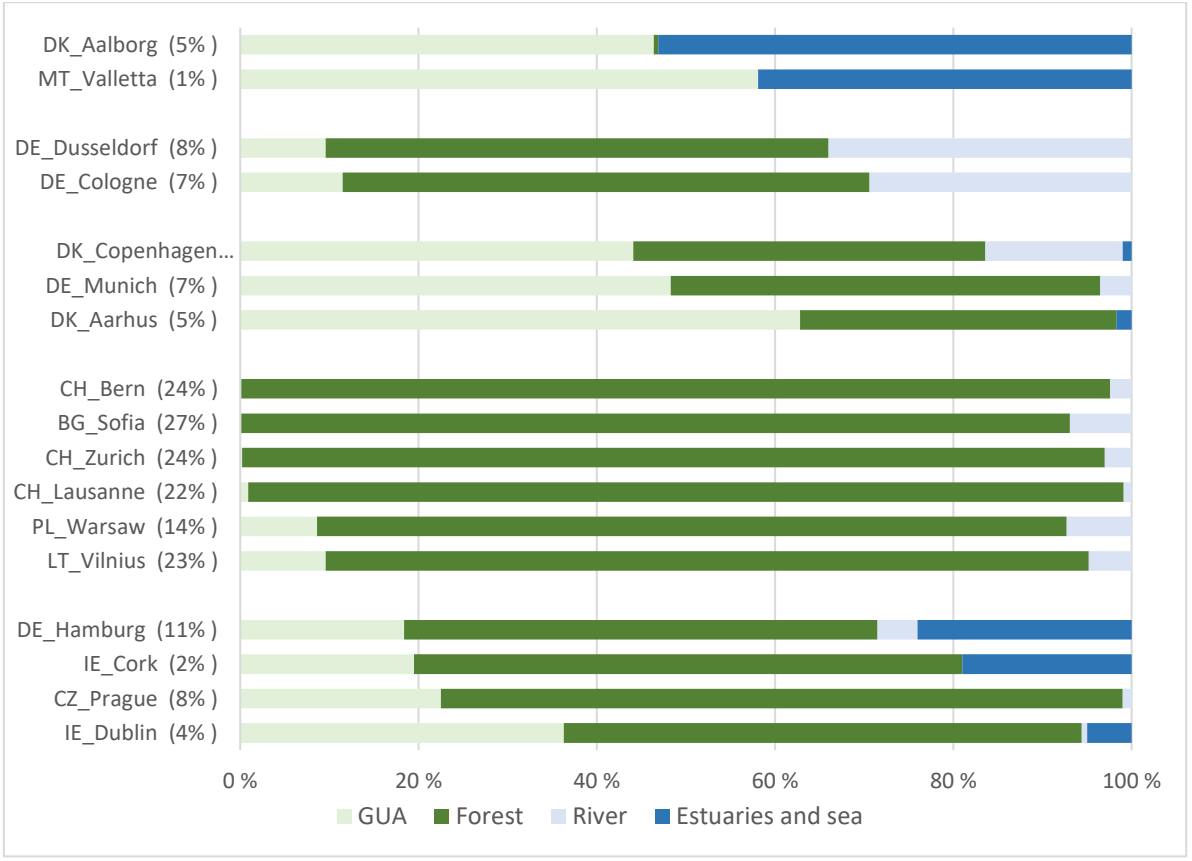
Annex 2 details the CORINE Land Cover classes that have been included in the category Green and blue areas of the proposed reclassification. As can be seen, agricultural areas have also been included in it, considering them as sufficiently quiet to be taken into consideration in this category. Nevertheless, it is important to take into account that those areas are normally not publicly accessible to the general population. Therefore, agricultural areas could not directly serve as restorative spaces once visiting them, but may have an important role as potential quiet areas or reserve of potential quiet areas. It also needs to be acknowledged that the use of the delineation declared by the competent authority in response to the Environmental Noise Directive requests as limits to be considered for the analysis increases the variability of the city areas and the percentage of area occupied by agricultural areas.

Considering all the reasons above, we have analysed the characteristics of green and blue category inside potential quiet areas but discarding the agricultural areas. As can be seen in Figure 4.8, we can distinguish 5 groups of cities as a result of cluster analysis[1]:

[1] Cluster analysis based on k-means methodology. The variables used to obain the cluster area the percentages of the following classes: green urban areas, forest, river, sea, quiet area.

- Group 1 (Alborg and Valletta): estuaries and sea contribute to more than 40% to the potential quiet areas. In addition, being coastal cities, the percentage of potential quiet is the lowest one.
- Group 2 (Dusseldorf and Cologne) : those are cities where there is a high percentage of a river area, followed by forests.
- Group 3 (Copenhagen, Munich, Aarhus) : cities were predominantly we find green urban areas (GUA) in the areas classified as potentially quiet. GUA refers mainly to urban parks, and not to forest areas.
- Group 4 (Bern, Sofia, Zurich, Lausanne, Warsaw, Vilnius): this group of cities is characterized for having nearly all potential quiet areas classified as forest. Those are also the cities where we find the highest percentage of potential quiet areas, but discarding the agricultural areas (from 13 to 24% of the total area of the agglomeration)
- Group 5 (Hamburg, Cork, Prague, Dublin): this is a mixed group, having characteristics from all the above groups. The cities show a considerable amount of forest areas and also green urban areas. In this case, one would tend to think that Prague would be part of group 4 but the total percentage of potentially quiet is lower than in group 4 (8%) and also that Hamburg would be part of group 1 but the total percentage of potentially quiet is higher (10%).

Figure 4.8. Characteristics of green and blue category in potential quiet areas (in brackets, percentage of potential quiet areas per city discarding CLC agricultural classes)



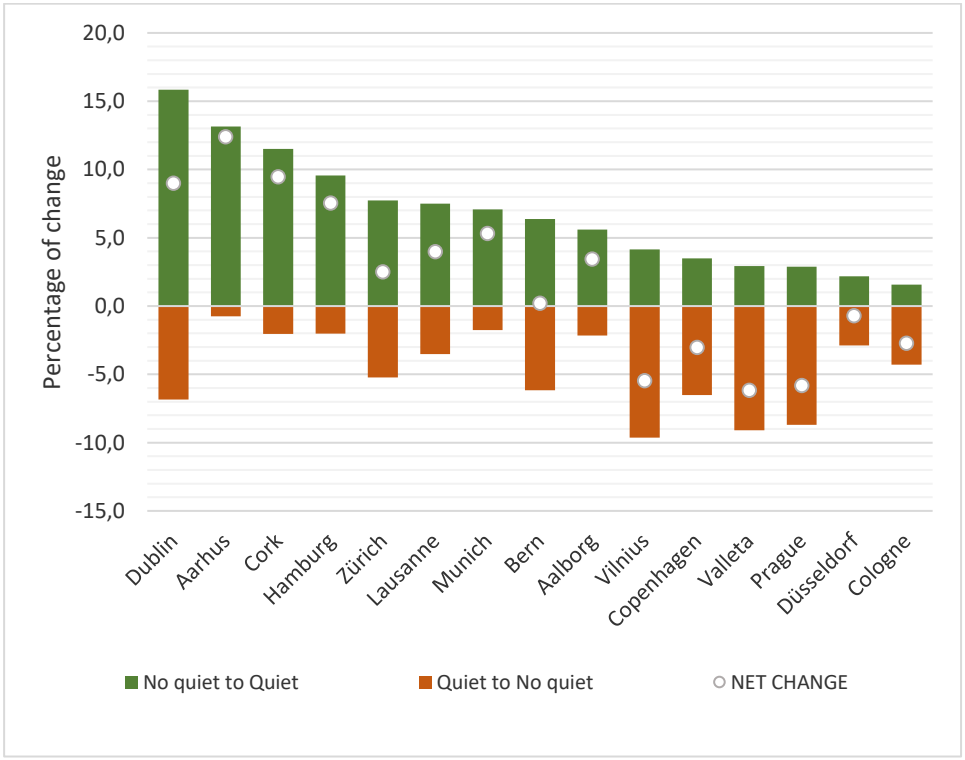
4.3 Changes of potential quiet urban areas between 2012 and 2017

Potential quiet areas increased between 2012 and 2017 in 60% of the studied cities (net increase in Figure 4.9. The highest net increase is observed in Aarhus (12,5%). On the other side Valletta is the city with the highest decrease (6,2%). It should be noted that, independently of the net changes, all cities show both increase increase of quiet areas and increase of noisy areas. Changes in both processes are very dynamic and could affect, in five years time, at least 5% of the total area of the city.

When there is an increase, it is due to the increase on the surface of green and blue areas (in 66% of the cases) and in the rest, due to the increase of residential areas (33%). On the other hand, cities where a decrease of potential quiet surface is observed, the decrease is occurring both in green and blue areas and residential areas (50%-50%).

The level of analysis of this report does not allow to establish a direct causality of changes. A change in urban delineation as well as the modelling methodologies used for traffic could also lead to changes that are not strictly related to a real increase/decrease of noise. But could also be taken into consideration that local noise action plans, nature conservation plans as well as measures related to urban planning can have an effect on the gain or loss of quiet areas in urban settings.

Figure 4.9. Areas becoming quiet/noisy between 2012 and 2017 (in percentage).The dots indicate the net change occurring at city level. Sorted by increase of quiet areas.



This increase and/or decrease occurring in each city can also be analysed from the territorial point of view in the maps included in Annex 1, where we will be able to see where potential quiet or noisy areas have increased or decreased and if the different situations observed can be linked to different urban development typologies. Changing areas range from 5% in Prague to 22% in Dublin.

In Figure 4.10., Figure 4.11. and Figure 4.12. can be analysed at city level and per each category, which are the changes occurring between 2012 and 2017, and the area of that category with no change (in percentage).

Figure 4.10. Changes occurring between 2012 and 2017 for land cover type category Green and blue.

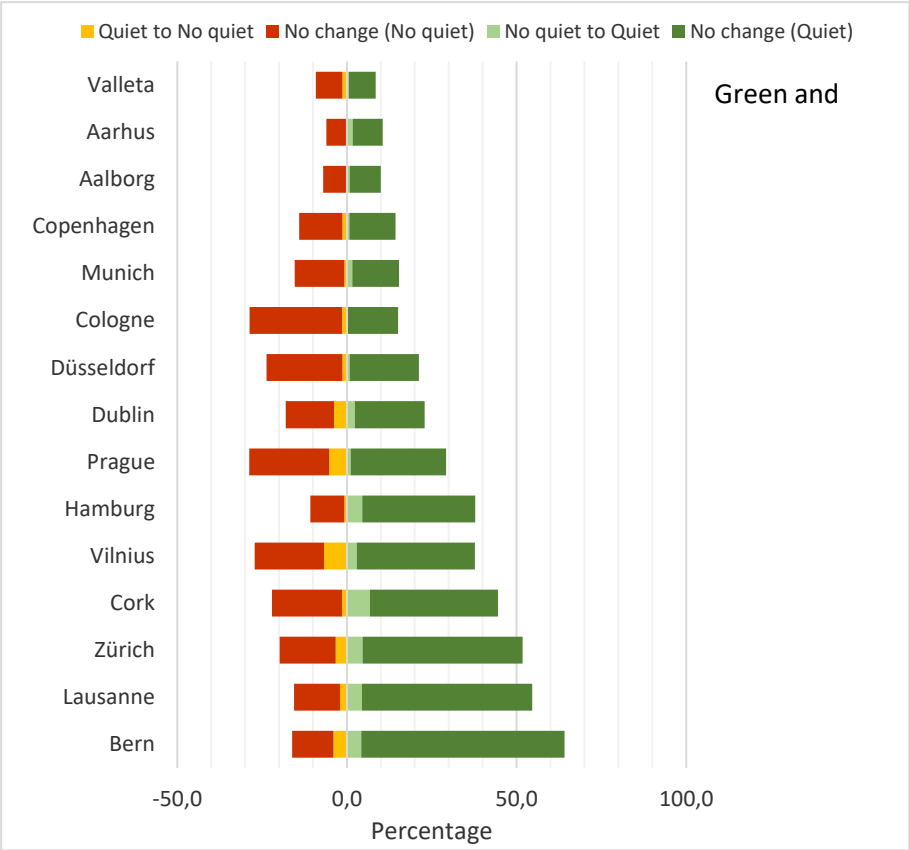


Figure 4.11. Changes occurring between 2012 and 2017 for land cover type category Residential

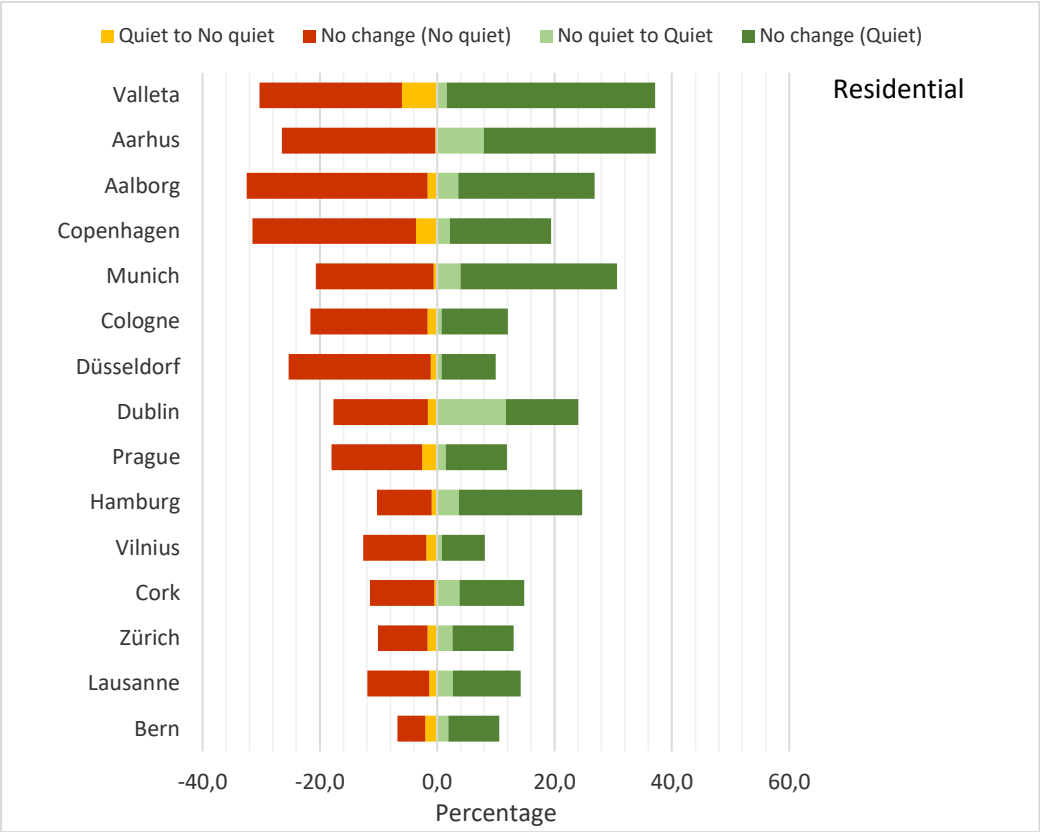
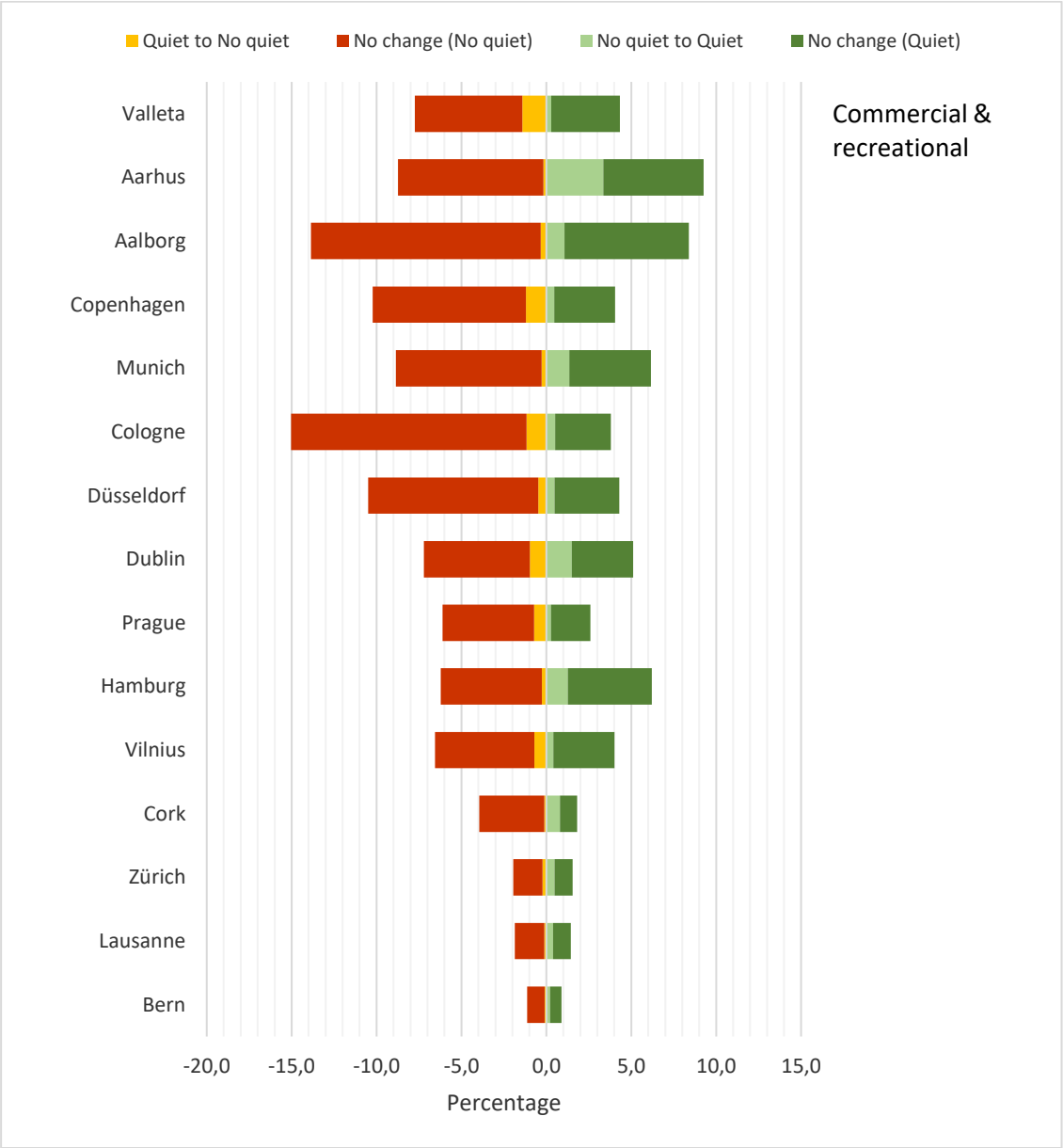


Figure 4.12. Changes occurring between 2012 and 2017 for land cover type category Commercial and recreational



In general and considering all the cities analysed, the increase of potential quiet urban areas is due to the increase of residential areas primarily, counting for a net increase of 1,5 % and then, the net increase of both green and blue areas and commercial and recreational areas both of 0,2%.

Considering that the increase of potential quiet areas has occurred mainly in areas classified as residential, one may suppose that the quality of environmental noise at city level has increased because residential areas are spaces where people live and work. The increase also in quiet green and blue areas, which are primarily areas located in the outer circle of the city, can also indicate an improvement in the quality of environment in cities' surroundings, where people look for relief from environmental stress. Both provide a positive net balance considering the 15 cities, which could be somehow related to an improvement of the quality of life of the inhabitants due to an increase of available potential quiet areas. Nevertheless, the analysis case by case would give a better overview of the situation at local scale.

4.4 Conclusions

As already stated before, further investigations are needed to determine whether the results obtained are due to factors such as the use of different traffic noise modelling methodologies between 2012 and 2017 and the different urban delineations between reporting years. Therefore gain/loss of quiet areas may not be strictly related to a real increase/decrease of noise, but some conclusions could be pointed out.

The surface of potential quiet areas is higher than potential noisy urban areas in half of the 15 cities analysed, although those areas are fragmented mainly by the road network in the core city but also in the surroundings.

Three main groups of cities emerge from the combined analysis of the reclassified land uses :

- cities with a high share of green and blue areas (above 75%) and most of residential areas located in potential quiet zones
- cities with most of green and blue areas and residential areas located in potential quiet zones but the share of the green and blue areas is lower (between 17 and 65%)
- cities where most of the residential areas are located in noisy neighourhoods

If the same analysis is done without including the agricultural areas in the category green and blue (areas normally not publicly accessible to the general population), 5 groups of cities can be distinguished : cities where marine areas are very important, cities where there is a high percentage of river areas, cities where green urban areas (referring to urban parks and not to forest areas) are predominantly found, cities having nearly all potential quiet areas classified as forest having as well the highest percentage of potential quiet areas, and finally a mixed group having characteristics from all the above groups.

Changes between 2012 and 2017 show that in those cities where there have been an increase of potential quiet urban areas, this increase occurred mainly in areas categorised as green and blue; while in cities where there have been a decrease of potential quiet surface, this decrease occurred both in areas categorised as green and blue and residential.

Considering the percentage of change of the total city areas, residential areas count for a net increase of 1,5% in potential quiet urban areas while the net increase for green and blue areas as well as for commercial and recreational areas is of 0,2%. With this figures, it is important to highlight that area of total change is very small compared to the total area of no change per city (quiet in 2012 and 2017, and noisy in 2012 and 2017), meaning that changes in noise exposure situation are directly linked to urban developments and traffic management which has a longer period than the 5 years reporting cycle of the END.

5 Analysis of accessibility

As already highlighted before, not solely the availability of potential quiet urban areas inside the city is important, as we need to determine where those areas are located, their surroundings and how they are accessible by the population.

This section then, describes a methodology for assessing the access to quiet urban areas by the population living in European cities. The main objective is to measure how residents of a city can easily reach the quiet areas in their neighbourhood. We determine an area of easy walking distance –10 minutes' walking time – around these quiet areas and then calculate the population inside this area. If the acces point is reached in 10 minutes' walking time we consider that the total area is accessible. We calculate the population-weighted median surface of quiet green & blue urban areas by agglomeration that can be reached within 10 minutes' walking time. Following recently published indicators (EC, 2018.

A walk to the park?) we used the travel distance of 10 minutes'. We used the median value rather than the arithmetic average because it is useful as an estimator of central tendency.

5.1 Data and methodology

5.1.1 Data

The following datasets are used in the analysis:

1. Agglomeration delineation from Environmental Noise Directive.
2. Noise contour maps 2017. Agglomeration all $L_{den,}$ or the geometric union of all the noise sources L_{den} >= 55 dB.
3. Corine Land Cover (CLC) 2018, Version 20b2 datasets.
4. Population distribution inside urban areas. GHS population grid, derived from EUROSTAT census data (2011) and ESM 2016. The data is published at 100m in LAEA ETRS89 (EPSG:3035).
5. Road network derived from Open street maps (OSM) dataset.

The most relevant data for calculate quiet areas inside urban areas ($\geq$ 55dB L_{den}) is data from noise contour maps 2017 available for agglomerations. The best data for doing the analysis is the data delivered considering all noise sources in an agglomeration (*agglomeration all*). This data is provided on voluntary basis, and it is designed to contain information for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area. When this data was not delivered by the country we selected the agglomerations with data available for all the sources (road, railways, air, industry, and also for the major sources) when exists for these agglomerations. The final selection of the agglomerations and the different noise sources used in the analysis are listed in Table 5.1.

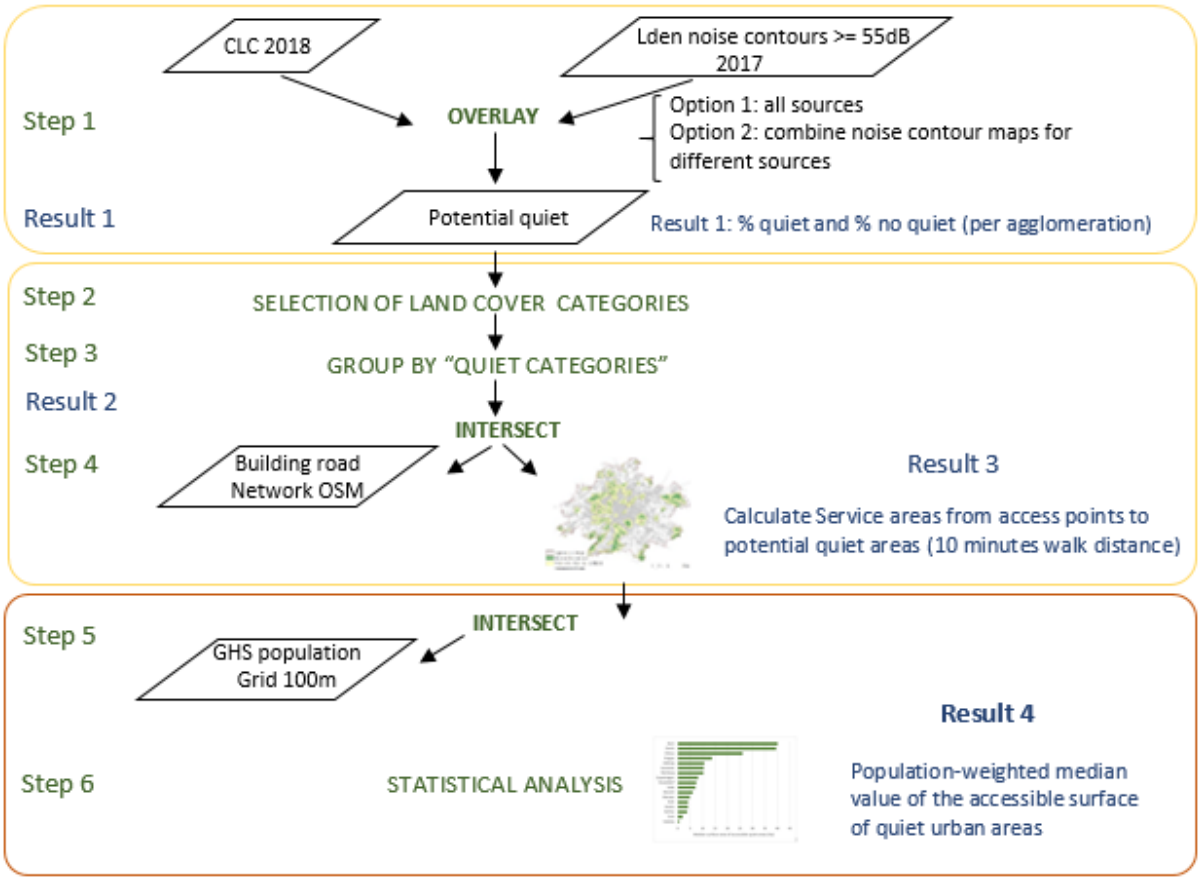
Table 5.1. Final selection of agglomerations included in the analysis, specifying the noise sources used per each agglomeration

Country	Agglomeration	Agglomeration road	Agglomeration	Agglomeration Air	Agglomeration	Agglomeration all	Major road	Major railways	Major airports
Bulgaria	Sofia					■			
Switzerland	Bern	■	■				■	■	■
Switzerland	Zurich	■	■				■	■	■
Switzerland	Lausanne	■	■				■	■	■
Czech Republic	Prague					■			
Germany	Hamburg	■	■	■	■		■	■	■
Germany	Munich	■	■	■	■		■	■	■
Germany	Cologne	■	■	■	■		■	■	■
Germany	Dusseldorf	■	■	■	■		■	■	■
Denmark	Copenhagen	■	■				■	■	■
Denmark	Aalborg	■	■				■	■	■
Denmark	Aarhus	■	■				■	■	■
Ireland	Dublin	■	■	■	■		■	■	■
Ireland	Cork	■	■	■	■		■	■	■
Lithuania	Vilnius	■	■	■	■		■	■	
Malta	Valletta	■		■	■		■		
Poland	Warsaw	■	■	■	■		■	■	■

5.1.2 Methodology

The methodology for identifying the accessibilty of potential quiet urban areas is described in Figure 5.1.

Figure 5.1. Methodology followed for the calculation of population accessibility to quiet urban areas in a walking time distance of 10 minutes.



This methodology uses, for reasons of temporary scale (noise contour maps from 2017), Corine Land Cover 2018 (see 4.2.1 for detailed specifications) but can be applied to Urban Atlas 2018 when it will be published by the end of 2019.

Population distribution inside urban areas comes from the Global Human Settlement Layer (GHSL) project supported by European Commission, Joint Research Center and Directorate-General for Regional and Urban Policy. This spatial raster dataset depicts the distribution and density of residential population, expressed as the number of people per cell (100m). Resident population from censuses for year 2011 provided by Eurostat were disaggregated from source zones to grid cells. Is derived from EUROSTAT census data (2011) and ESM 2016 (European Settlement Map).

Road network is derived from Open Street Map (OSM). OSM is a collaborative project to create a free editable map of the world. We decided to use OSM for creating the road network because contains all the features needed to create a road network which is the base of the calculation of service areas. We selected all those OSM road segments that intersect with the agglomerations involved in the analysis.

Calculation of quiet areas from noise contour maps 2017:

It is clear that not all CLC categories can be considered quiet areas despite being outside the noise contour maps of more than 55 decibels. This is the case, for example, of Mineral extraction sites (131) or Construction sites (133). The reclassification of the categories of CLC in categories green and blue requires taking a series of decisions. We have decided to make two different classifications of green and blue blue areas and forests. After the analysis we examine results for every classification.

Building road network:

The first step to delimitate accessibility areas in ArcGIS is building a network dataset on which the service area analysis will be performed. The network dataset needs at least one time-based and one distance-based cost attribute.

For computing travel time per segment is required to determine a walking speed. After checking the literature on that issue (see Table 5.2), different walking speeds were considered. We decided using the average walking speed for slower pedestrians – 1.1 m/s because this value is expected to accommodate at least 85% of pedestrian population (Tarawneh, 2001).

Table 5.2. Walking speed literature review

Walking pace (min/km)	Walking speed (m/s)	Region	Comments	Reference
11 to 13	1.25 to 1.47	USA	Comfortable walking speeds of adults aged 20-79 yr. from 4.5 to 5.3 km/h, and maximum speeds, sometimes called exercise walking or health walking speed, range from 6.3 to 9.2 km/h	Cho et al., 2011
12	1.34		Average free walking speed	Daamen and Hoogendoorn
12	1.39	EU	A walk to the park? Assessing access to green areas in Europe's cities	Poelman
12 to 15	1.34 and 1.11	Jordan	The average and 15th percentile pedestrian speeds in Jordan, respectively	Tarawneh, 2001
12 to 15	1.39 to 1.11	Spain	http://mobilitat.gencat.cat/ca/serveis/mitjans_de_transport/a_peu/	Generalitat de Catalunya
13	1.25		The 15th-percentile walking speed for younger pedestrians (ages 14 to 64)	Knoblauch et al., 1996
13	1.32	Germany	Average for pedestrians	Weidmann, 1993
14	1.22	USA	Manual on uniform traffic control devices for streets and highways. Federal Highway Administration (FHWA), US Department of Transportation, Washington, DC (1988)	(FHWA, 1988)
15	1.11	Spain	Assuming average walking speed of four kilometres per hour for pregnant women	Dadvand et al. 2012
17	0.97		For older pedestrians (age 65 and over)	Knoblauch et al. 1997
17	0.99	Germany	Tourists	Weidman 1992
17 to 18	0.91 to 0.99	USA	Recommended to be used for traffic signal timing	Dewar (1992)

Travel time is calculated as follows:
Travel time (minutes) = segment length (m) / speed (m/s) * 60 (s/min)

Tr_time_Slw = [Shape_Length] /(1.1*60)

This analysis requires building a road network that contains the necessary attributes to enable selection of streets accessible to pedestrians by walking 10 minutes. For developping this step, spatial analysis tools from ESRI ArcGIS and scrips using Python were implemented.

Creation of service areas around potential quiet areas:

In this step, we create service areas of 10 minutes' walking time around quiet areas. First of all, we calculate the points of access to the quiet areas from the network. Then, we calculate the service area from each point of access and finally, we create one service area for every quiet area by dissolving the polygons by quiet area code.

Figure 5.2. Example of service areas around green and blue quiet areas in Prague. Green and blue includes: green urban areas, forests, rivers, estuaries and sea.

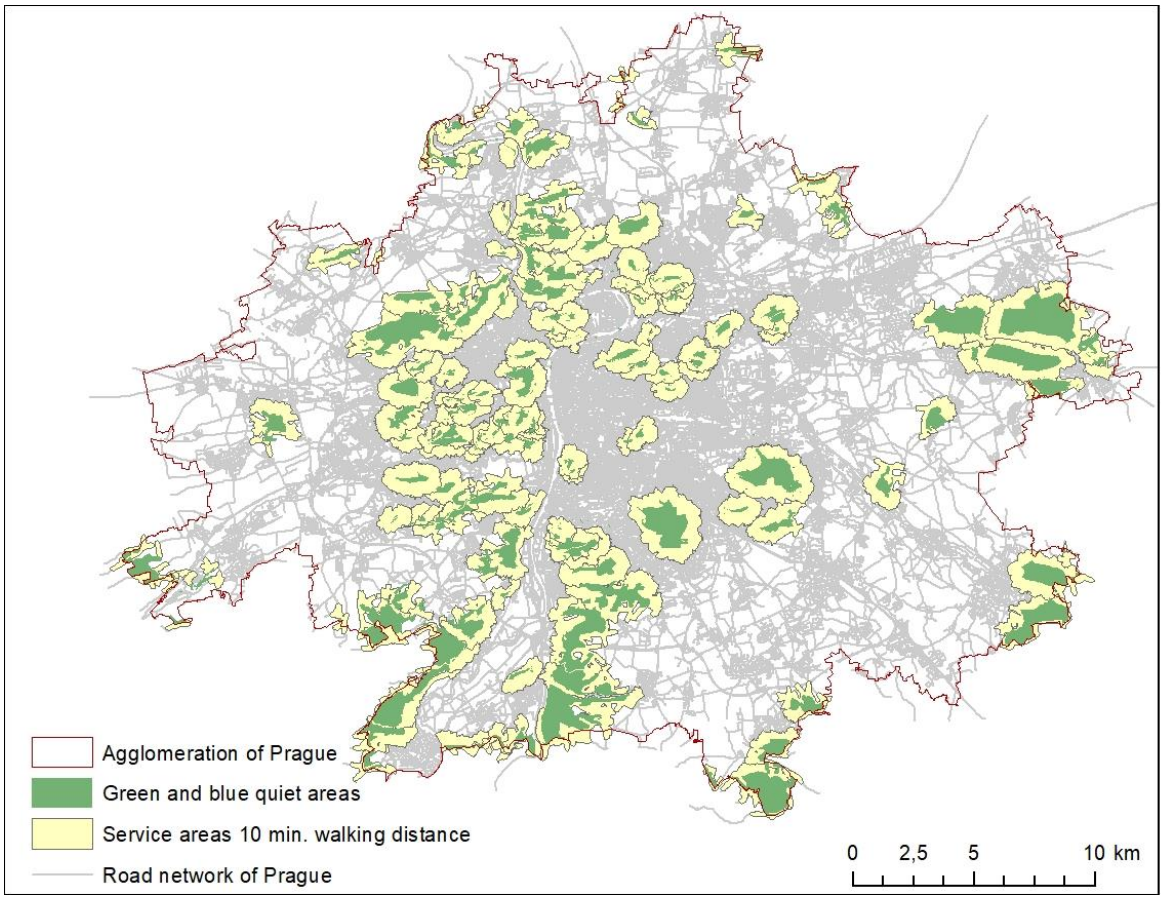
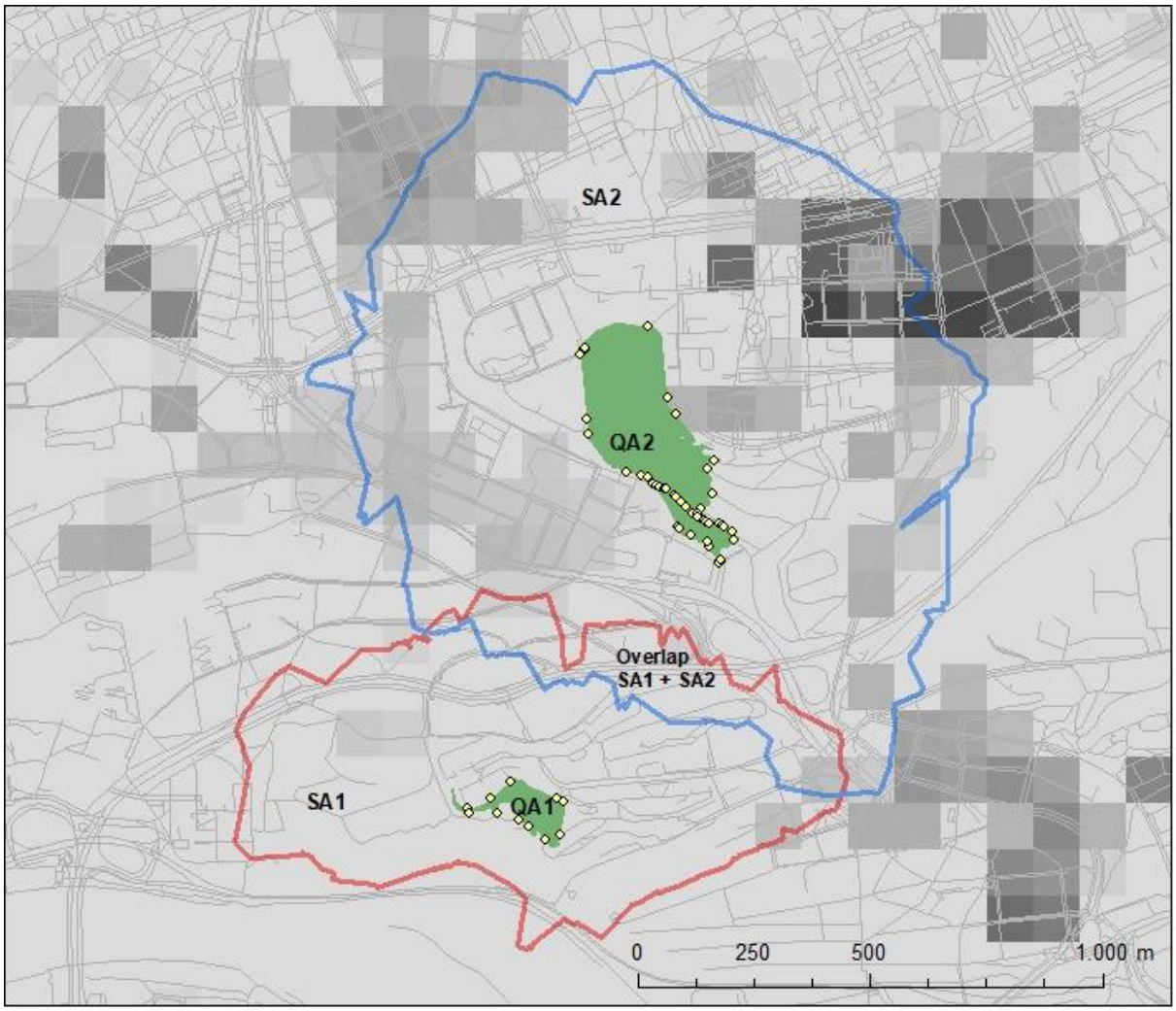


Figure 5.3. Example of population accessibility to two quiet areas (QA1 and QA2) in Prague. Service areas in red and blue and access points to quiet areas in yellow. Population layer in grey cells.



Example of population accessibility to two quiet areas (QA1 and QA2) :
Blue and red service areas delineates accessibility to one quiet area and the overlap area delineates the 10 minutes walking area with population access to the two quiet areas. Grey cells represent population layer. Points in yellow are the access points to the quiet areas from the road network (grey lines). Residents in SA1 (1462) have access to 1,3 ha of quiet area (QA1) and residents in SA2 (12,658) have acces to 7,7 ha of quiet area (QA2). Residents in the overlap area SA1+SA2 (335) have access to 9 ha of quiet areas (QA1+QA2). Table 5.3 contains the calculation of the population weighted median of the example (Figure 5.3) considering only population in service areas red and blue. In this example the result is 7.08 (ha). The calculation of this value at agglomeration level uses the total population, inside and outside service areas for the final result.

Table 5.3. Calculation of population-weighted median value of the accessible surface of quiet urban areas (green and blue) for the service areas blue and red (considering only residents in SA1 and SA2)

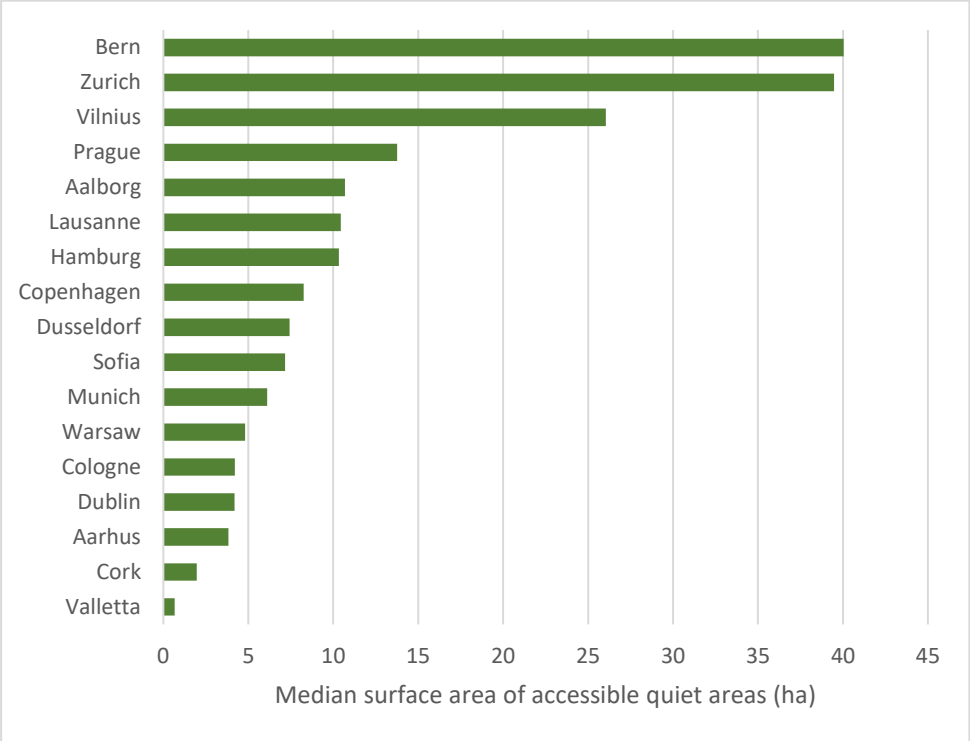
Service area	Population	QA Accessible (ha)	Population weighted median (ha)
SA1	1462	1.3	0.13
SA2	12658	7.7	6.74
SA1 SA2 (overlap)	335	9	0.21
Total	14455		7.08

Next step is the calculation of population-weighted median value of the accessible surface of quiet urban areas (green and blue), and the share of population that has no green urban areas in its neighbourhood. R-Studio was used to calculate statistics on population.

5.2 Results

There is substantial diversity in the accessible potential green quiet areas, ranging from 0,7 ha in Valletta to 40 ha in Bern. There is still little evidence on the differential health benefits associated with the characteristics of green space (size, composition, structure) as highlighted by WHO (2016). In this report we have considered potential quiet areas patches with a minimum size of 1 ha, following most of the practices found in the literature and reported by Member States (section 3). Therefore, Valletta would be the only city where the median accessible area falls below this threshold. On the other side, Bern and Zurich outstand as the cities with a larger median surface (about 40 ha) followed by Vilnius (27 ha).

Figure 5.4. Access to quiet areas in selected European cities. Access is measured as a population-weighted median area of quiet areas that could be reached within 10 minutes walking time. Sources: END (2017), Corine Land Cover.



However, there are other factors to be considered in order to understand the accessibility to quiet areas. As reflected in Figure 5.5., most of the population in all analysed cities does not have a quiet

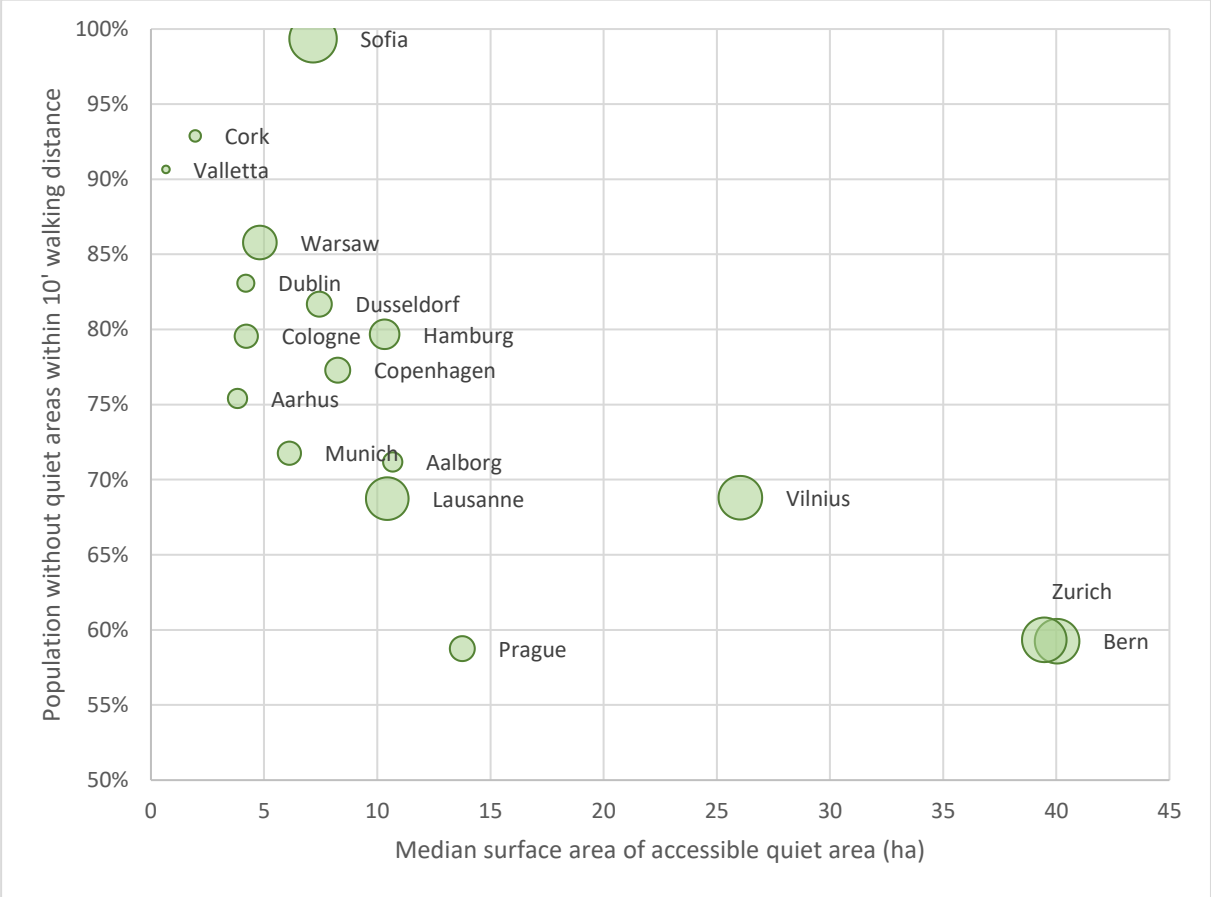
area nearby (vertical axis). Moreover, cities with similar median surface of nearby quiet area may have different percentage of population without access. This is the case of Lausanne and Hamburg. Both cities have a median surface close to 10 ha. However, 80% of population in Hamburg lacks a nearby quiet area, while in Lausanne this figure goes down to 68% of the population.

Sofia is the most extreme case, while the median area is like most cities (7 ha), only 1 % of the population has a quiet area nearby. This is explained by the fact that almost all quiet areas concentrate on the periphery of the city, resulting in a high share of quiet areas, but accessible to few people.

The case of Valletta reflects how physiografy and local conditions restricts the availability of quiet areas. This is a typical compact Mediterranean costal city. Traffic noise and the pattern of streets does not allow for green quiet areas inside the core city, and they are only available on the periphery. Human activity along the coastal line also makes difficult to integrate part of the beaches and sea as a quiet area.

These results highlight that although the size of quiet areas is important to ensure a good accessibility (r^2 = 0,52), its accessibility is modulated by its pattern of distribution. In many cases, larger quiet areas are found on the periphery of the city, resulting in a large percentage of the population lacking access or, in best cases, access only to small quiet areas. A similar conclusion could be extracted on the importance of the percentage of quiet areas in the city (size of the bubbles in Figure 5.5) in providing good accessibility (r^2 = 0,49). Cities with higher accessibility have more than 10% of share of quiet areas in total land area, indicating that quiet areas are becoming more ubiquotious in the city. Cities below 10% of quiet areas show a higher variability in terms of accessibility, having a higher impact the distribution of patches of quiet areas.

Figure 5.5. Proximity of quiet areas, population without quiet areas nearby and share of quiet areas in the total land area



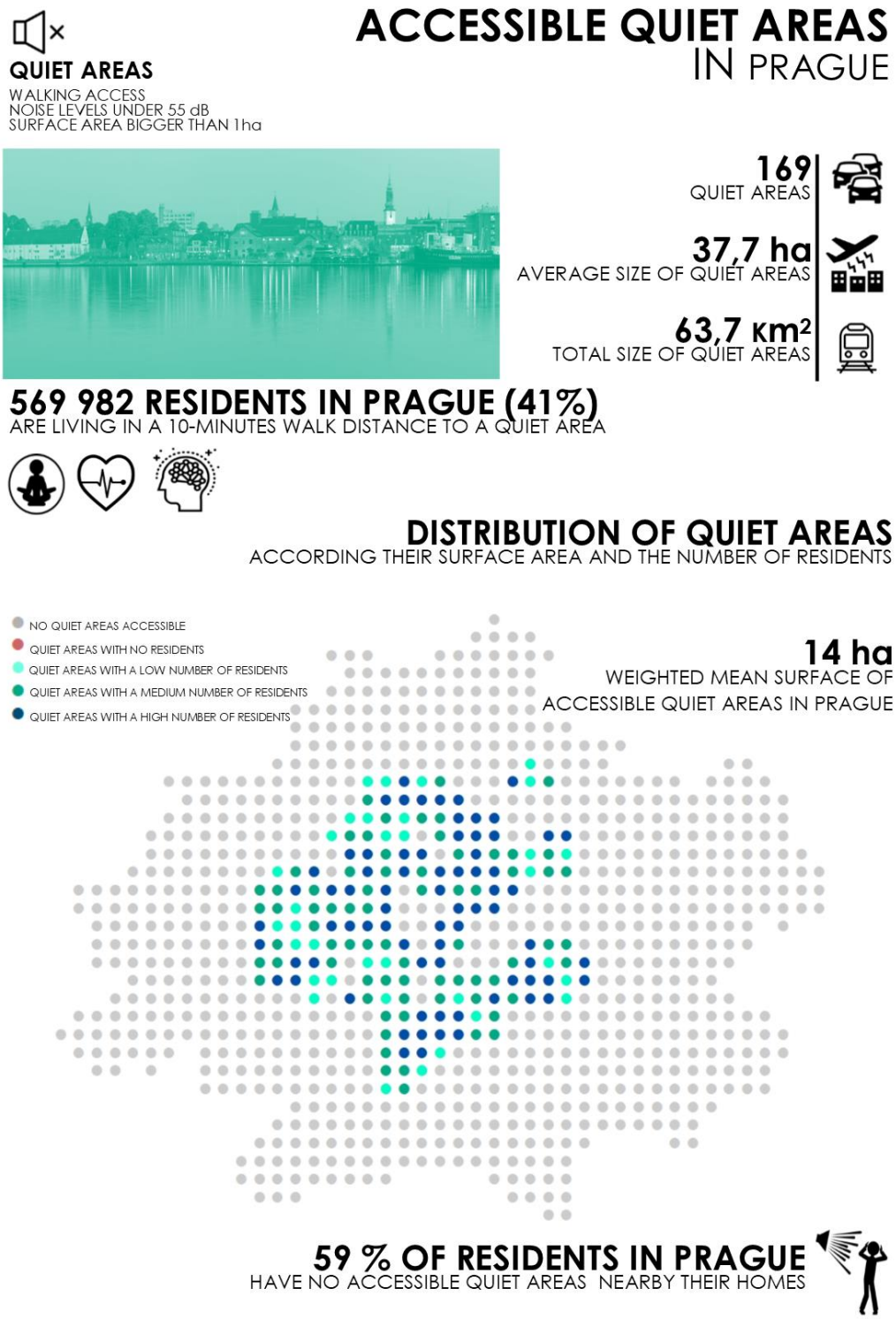
5.3 Conclusions

Accessibility to potential green quiet areas has a large variability betweeen european cities and could be described as a combination of factors :

- Local conditions and history determine to a large extent availability, size and distribution of green quiet areas. For example compact coastal Mediterranean cities tend to have smaller green areas inside the city. In those cases, traffic management is almost the only option to have quiet neighbourhoods in the city center since there are few opportunities for new park developments.
- Percentage of green areas is important. But alone does not ensure good accessibility. There are cases with high share and low accessibility because most of the green areas are concentrated on the periphery (e.g. Sofia).
- Median accessible area needs to be considered together with the percentage of people without quiet areas nearby. In fact, all the analysed cities have at least 55% of the population without quiet areas nearby.

6 How to represent the results obtained

Below is an example of how to present the results in graphic form for dissemination. It is a visual representation of information analysed and provides a quick overview of quiet areas status at agglomeration level.



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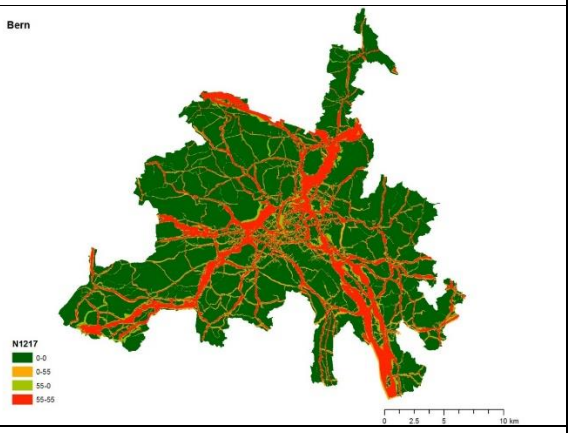
Annex 1
Changes of quiet areas

Legend	CH Bern
0-0 No change (potentially quiet) (2012-2017) 0-55 Quiet to No quiet (2012 – 2017) 55-0 No quiet to Quiet (2012 – 2017) 55-55 No change (potentially no quiet) (2012 – 2017)	
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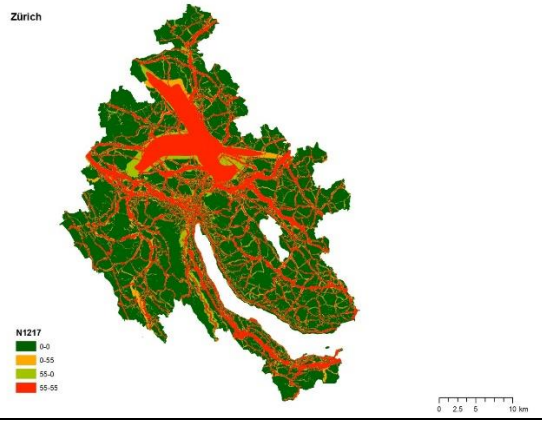
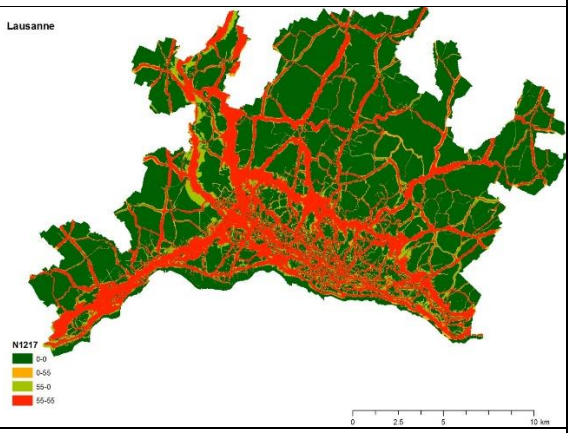
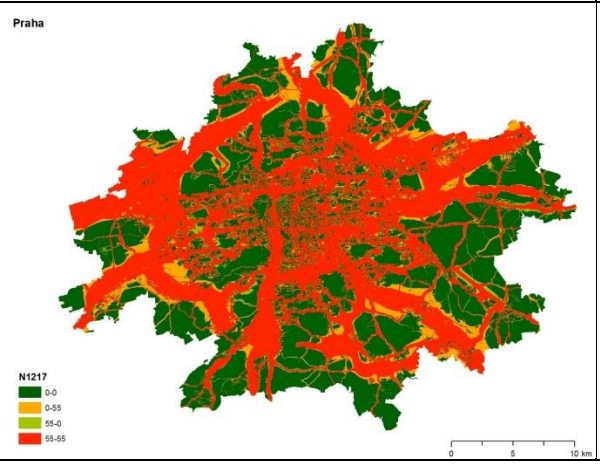
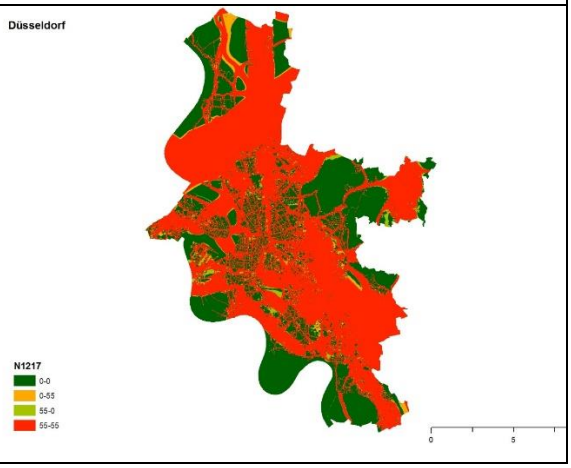
	
CZ Prague	DE Dusseldorf
	

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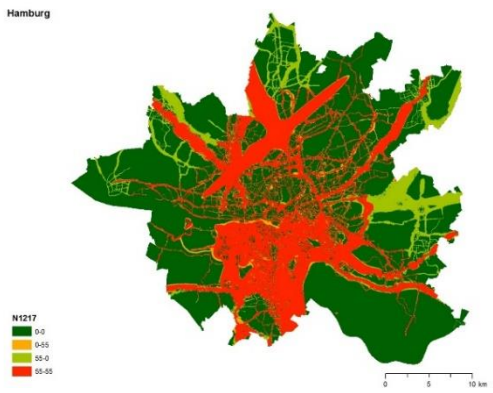	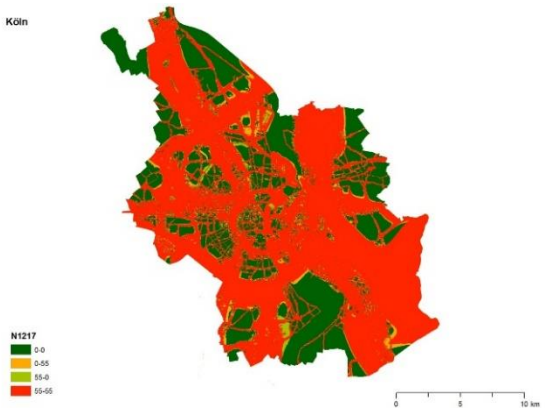
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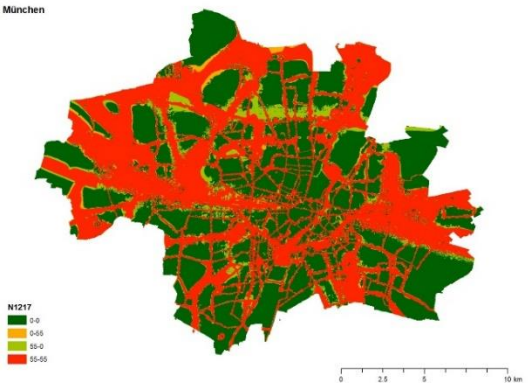
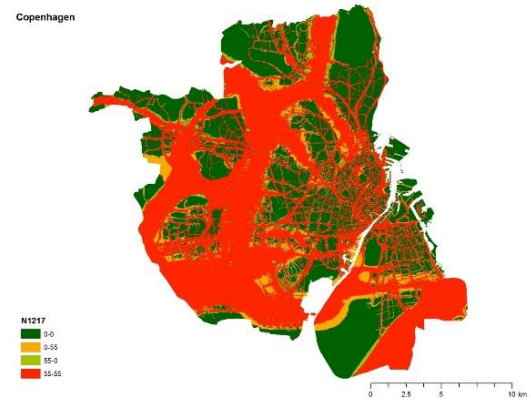
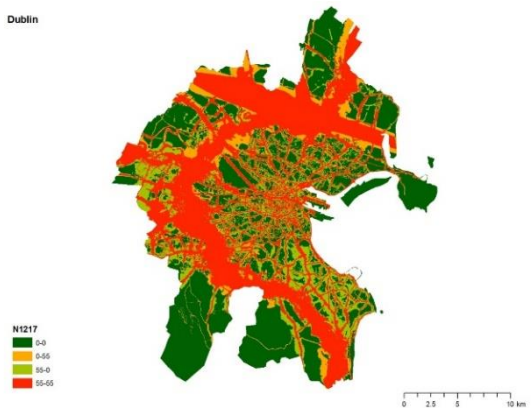
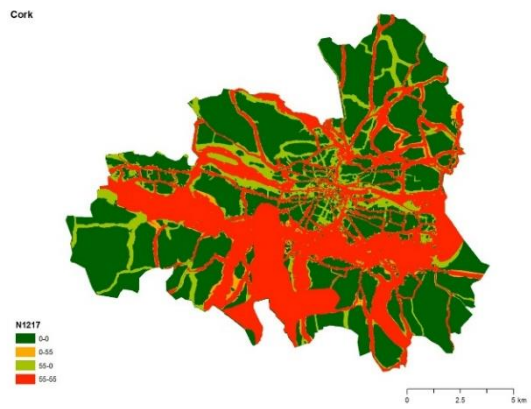
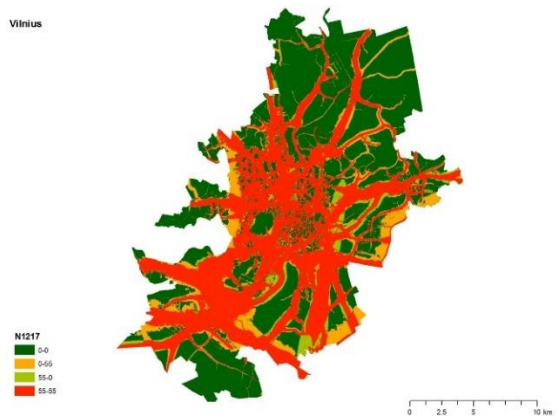
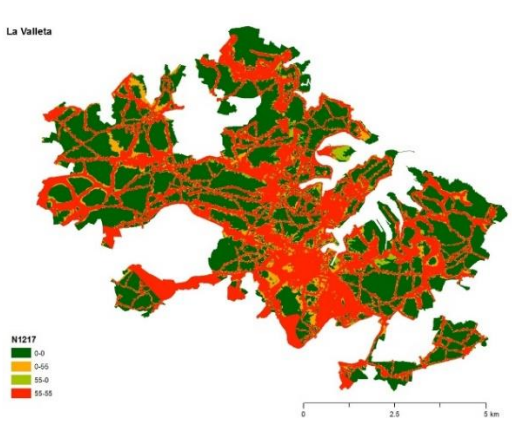
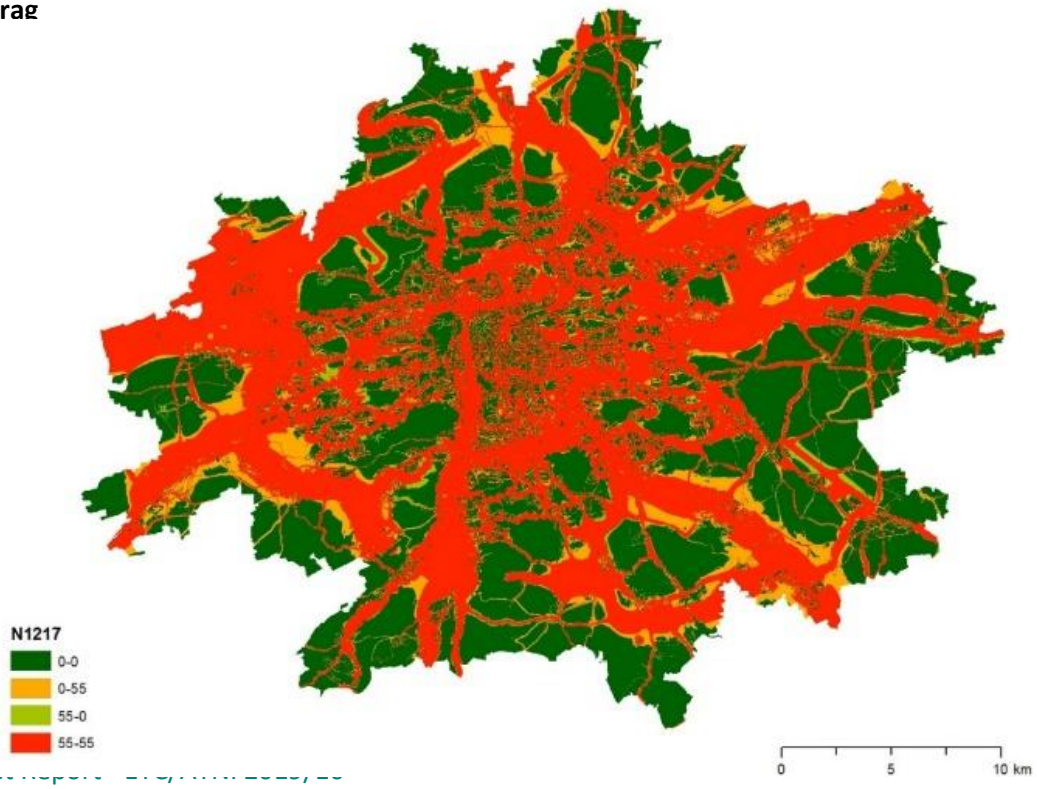
	
DK Aarhus	DK Copenhagen
	

IE Dublin	IE Cork
	
LT Vilnius	**MT La Valletta**
	

Example of Prague agglomeration at a bigger scale.

Prag

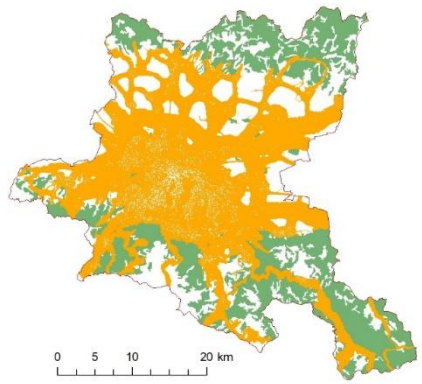
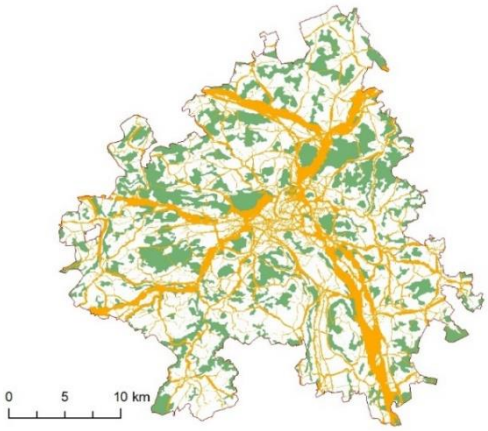


Annex 2
Corine land cover categories reclassified to quiet areas categories

Corine land cover 2018 description	Reclass	Description
111: Continuous urban fabric	1	Residential
112: Discontinuous urban fabric	1	Residential
121: Industrial or commercial units	3	Commercial - recreational
142: Sport and leisure facilities	3	Commercial - recreational
141: Green urban areas	4	Green & blue
211: Non-irrigated arable land	4	Green & blue*
212: Permanently irrigated land	4	Green & blue*
213: Rice fields	4	Green & blue*
221: Vineyards	4	Green & blue*
222: Fruit trees and berry plantations	4	Green & blue*
223: Olive groves	4	Green & blue*
231: Pastures	4	Green & blue*
241: Annual crops associated with permanent crops	4	Green & blue*
242: Complex cultivation patterns	4	Green & blue*
243: Land principally occupied by agriculture, with significant areas of natural vegetation	4	Green & blue*
244: Agro-forestry areas	4	Green & blue*
311: Broad-leaved forest	4	Green & blue
312: Coniferous forest	4	Green & blue
313: Mixed forest	4	Green & blue
321: Natural grasslands	4	Green & blue
322: Moors and heathland	4	Green & blue
323: Sclerophyllous vegetation	4	Green & blue
324: Transitional woodland-shrub	4	Green & blue
331: Beaches, dunes, sands	4	Green & blue
332: Bare rocks	4	Green & blue
333: Sparsely vegetated areas	4	Green & blue
334: Burnt areas	4	Green & blue
335: Glaciers and perpetual snow	4	Green & blue
411: Inland marshes	4	Green & blue
412: Peat bogs	4	Green & blue
421: Salt marshes	4	Green & blue
422: Salines	4	Green & blue
423: Intertidal flats	4	Green & blue
511: Water courses	4	Green & blue
512: Water bodies	4	Green & blue
521: Coastal lagoons	4	Green & blue
522: Estuaries	4	Green & blue
523: Sea and ocean	4	Green & blue
122: Road and rail networks and associated land	5	Other
123: Port areas	5	Other
124: Airports	5	Other
131: Mineral extraction sites	5	Other
132: Dump sites	5	Other
133: Construction sites	5	Other

* Agricultural classes were excluded in the accessibility analysis.

Annex 3
Areas equal or above 55 dB and green quiet areas.

BG Sofia	CH Bern
	
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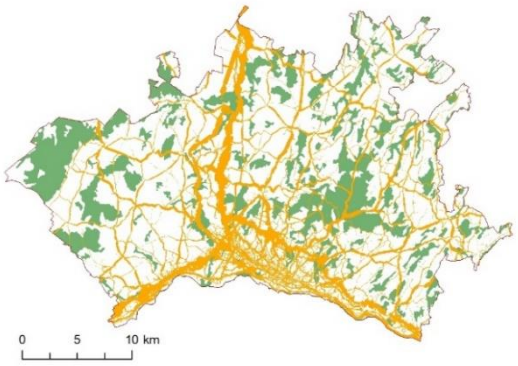
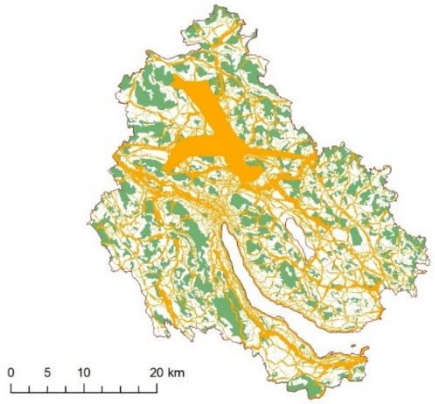
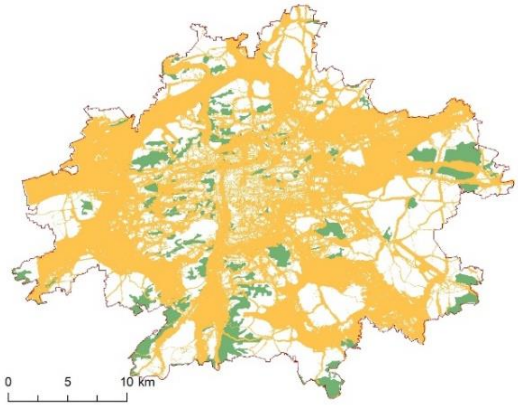
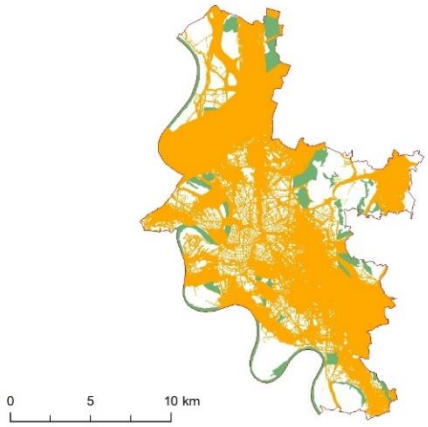
	
CZ Prague	**DE Dusseldorf**
	

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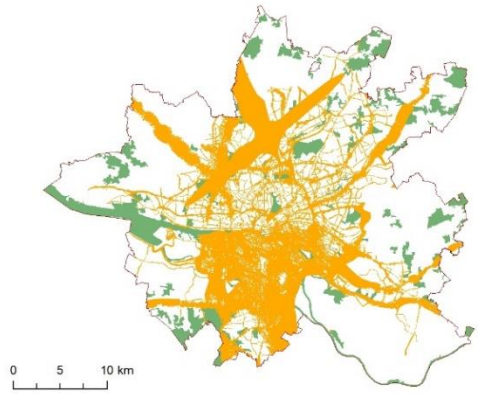	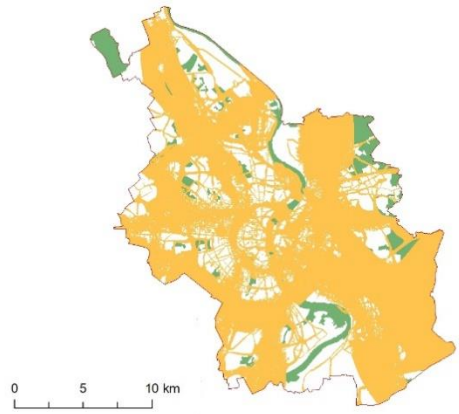
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	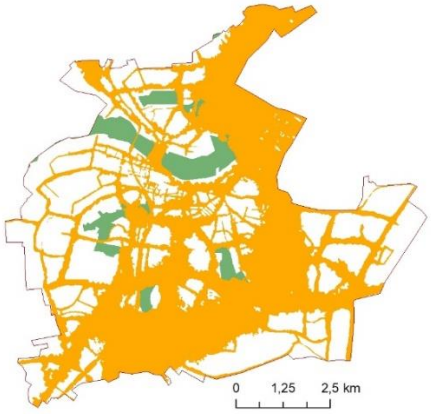
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	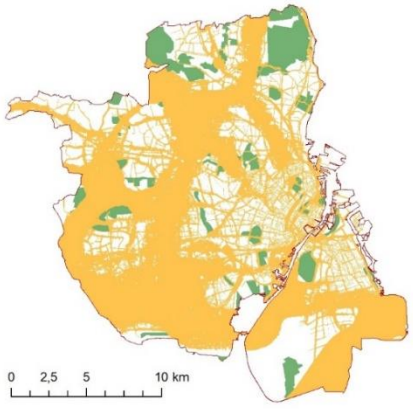

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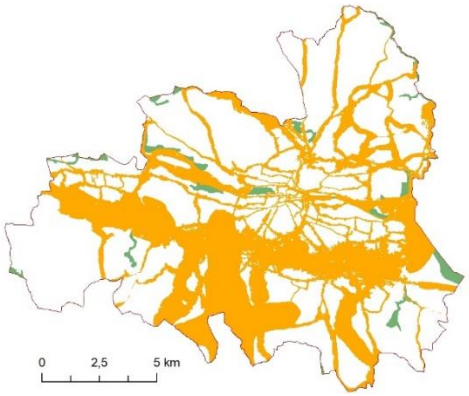
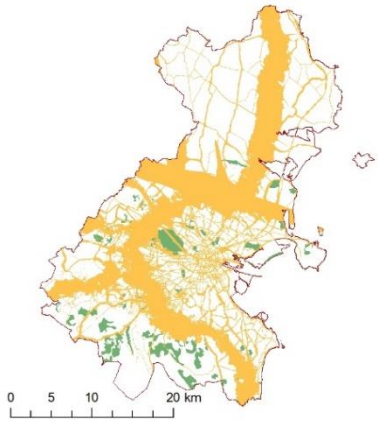
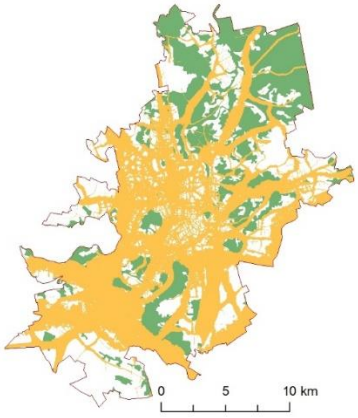
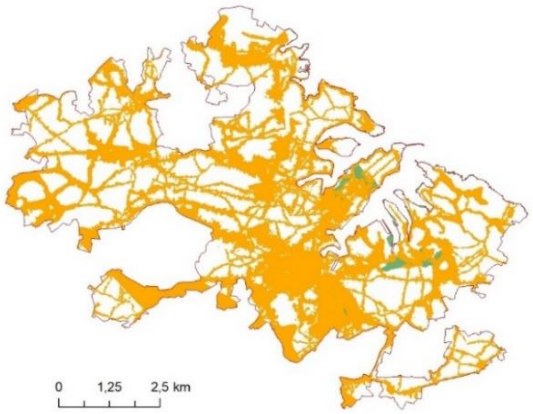
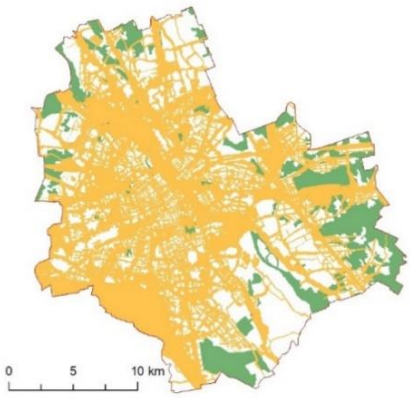
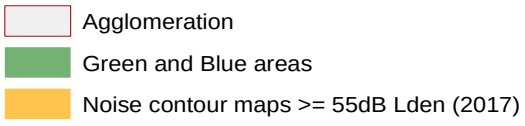
	
LT Vilnius	MT La Valletta
	
L Warsaw	Legend
	

European Topic Centre on Air pollution,
transport, noise and industrial pollution
c/o NILU – Norwegian Institute for Air Research
P.O. Box 100, NO-2027 Kjeller, Norway
Tel.: +47 63 89 80 00
Email: etc.atni@nilu.no
Web : https://www.eionet.europa.eu/etc/etc-atni

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transport, noise and industrial pollution