Living Lab for Urban Nature

Masterplan and Environmental Baseline Report

March 2023

Preface

Urban air and noise pollution are two major factors impacting the quality of life of city dwellers and causing significant harm both to our health and to the environment. A growing number of cities are considering strategic urban greening projects as a high impact economic solution to reduce noise and traffic vibrations and improve ambient air quality.

How can cities leverage vegetation and green infrastructure to act as a barrier to these pollutants, creating a more inclusive urban environment and regenerating cities into healthier, more climate resilient hubs?

To test the associated benefits of green spaces, Arup's Climate and Sustainability experts have teamed up with the Copenhagen Municipality, Aarhus University, the local public school, Lundehus, housing associations and local businesses to design a community-centric Living Lab for Urban Nature.

Located in Emdrupvej, a street between Copenhagen's Bispebjerg and Østerbro districts, the living laboratory will investigate how nature can combat pollution by measuring pollution at street level and testing creative nature-based solutions with potential to improve urban spaces such as green roofs, flowerbeds, vertical rain gardens and wooden urban furniture designed from reused building elements.

Through its learnings, the Living Lab will partner with cities to evaluate the strategic use of plants in the urban environment for reducing pollution, improving residents' health and supporting the creation of green neighbourhoods – ultimately enhancing a city's resilience.

Please contact us to find out more about how we plan, design and shape sustainable and resilient cities though our deep demonstration projects.

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Introduction to the Living Lab for Urban Nature

Introduction to the Living Lab for Urban Nature

Urban vegetation is a scalable solution that provides a suite of positive outcomes for cities – ecological, social, and economic – all essential in the context of climate resilience and adaptation. To better regulate pollution and mitigate climate risks, we need to think about which types of plants can be planted where to bring most benefit within the urban fabric. For example, adding large trees to street canyons – streets with buildings on both sides – may reduce vibration and noise waves, while low vegetation or green roofs close to busy streets can improve air quality by increasing deposition.

The purpose of the Living Lab for Urban Nature is to explore the social and environmental effects of urban nature, and this report is the first step on the way to creating a physical living lab to measure how plants help cities combat traffic-generated pollution. The report sets out to create a set of baseline measurements for the further examinations of the benefits of green spaces in urban areas. This baseline study is created with a range of methodologies including review of existing knowledge, a questionnaire, an observation study and environmental monitoring, to provide a comprehensive baseline. This ultimately conditions us in performing a deeper analysis of the potential of urban nature following the project – all to improve the lives of city dwellers and support a more sustainable future. Finally, the report presents a suggestion for a masterplan for the Living Lab for Urban Nature, consisting of a visualization, a concept diagram, and a plan drawing, serving as inspiration for the future work in the next project phases.

This Living Lab for Urban Nature methodology takes immediate and significant action to limit biodiversity loss at a local district level in cities. With a living lab for urban nature, a pilot site for testing different urban nature solutions in the urban space will be established with the aim of investigating how the development of urban nature creates beautiful green urban spaces, improves biodiversity and promotes local identity and social engagement. This is most closely aligned with SDG 3 Good Health and Well-being, SDG 9 Industry, Innovation and infrastructure, SDG 13 Climate Action and SDG 15 Life on Land.

We hope that this work will inspire other cities around the world to move forward and establish test methodologies for turning dedicated streets into living laboratories for creative community solutions to promote planting flora, supporting biodiversity, improved circularity and hereby improve quality of life. These strategies contribute directly to more climate and energy-efficient uses for cities' pavements and roads and improved connection to "ecosystem services" for citizens globally.

Urban nature is getting more and more attention

A massive 30% reduction in air pollution could be achieved by 'greening up' city streets, according to research published in the UK, Denmark and Holland. Smaller road trees, vertical rain gardens, bushes and other greenery growing in the urban canyons are delivering measurable ecosystem services including cleaner air and noise/vibration reduction at the roadside, where most citizens are exposed to the highest pollution levels.

Researchers have found that, because pollution cannot easily escape street canyons, 'green walls' made up of plants such as moss, grass and climbing ivy provide a better opportunity to act as an air pollution filter than previously thought.

The Living Lab for Urban Nature is perfectly aligned with Arup's vision of "Finding a Better Way" in the sense that it is very much related to how we design our future excellent cities to be able to improve healthy and liveable neighbourhoods.

By establishing a Living Lab for Urban Nature, the project team anticipate obtaining valuable knowledge on the effectiveness of urban nature as a low-cost instrument to mitigate various negative environmental effects (vibration, noise and air pollution), while at the same time improving the mental wellbeing and quality of life for local citizens. This knowledge is not only valuable to Arup, but also to policy makers and urban planners in public entities such as municipalities.

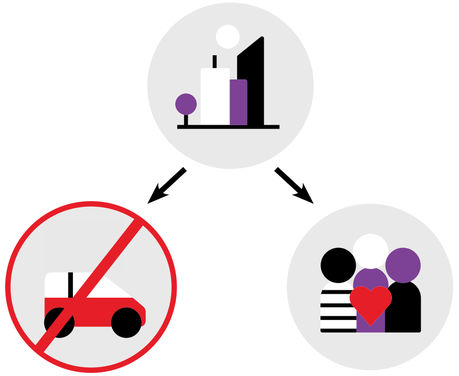


Figure 1
Urban nature's dual effect; environmental and social.

Project phases

The creation of the Living Lab for Urban Nature is made up of several phases, each with its own purpose. This report relates to the first phase, focused on baselining and masterplanning.

The following phases are yet to be funded and planned further.

Document structure

This report documents the first project phase of the Living Lab for Urban Nature. The document is divided into seven chapters.

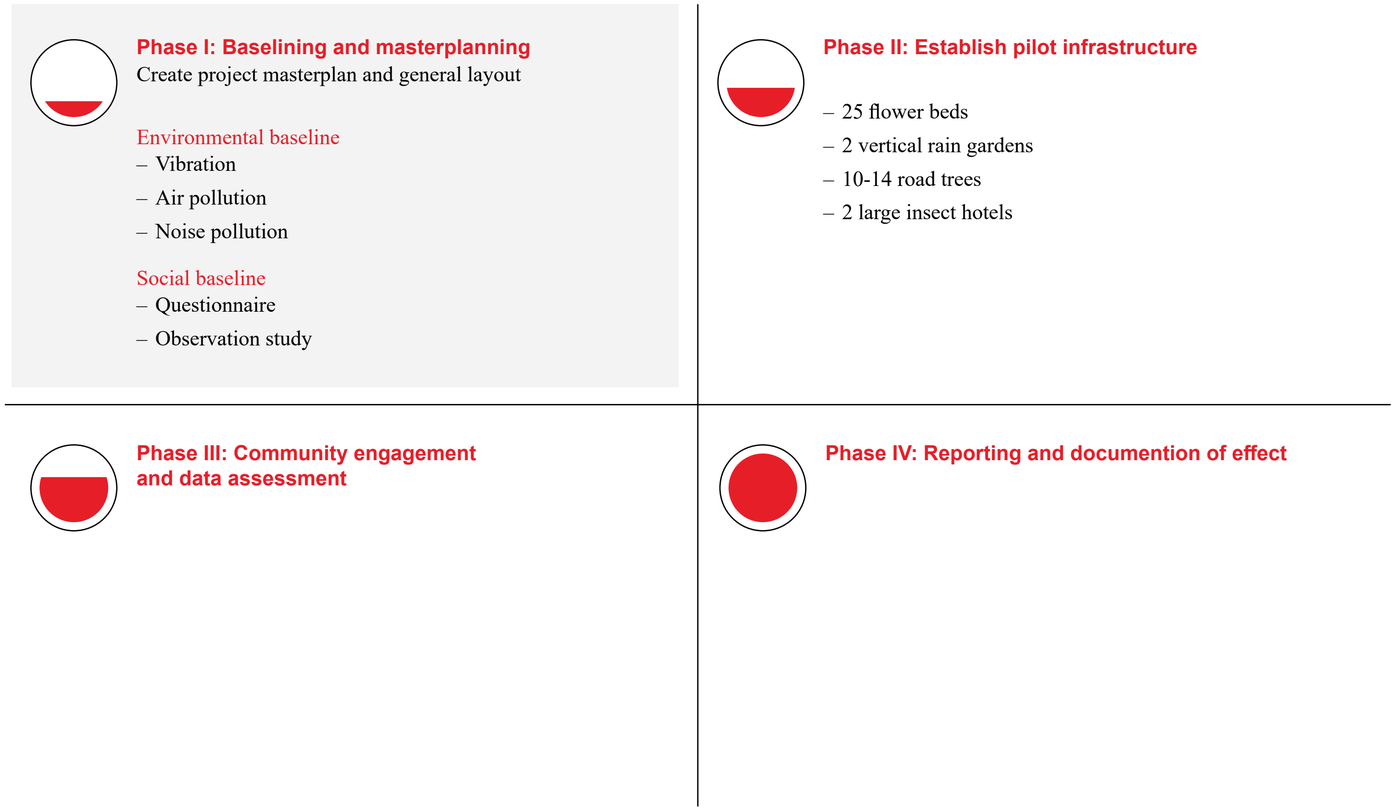
The first chapter sets the scene with a description of the project's physical surroundings and characteristics.

In the second part of the report, the methodologies for the different types of studies are outlined. As we have set out to explore the effect of urban nature implementations on both the physical environment and the people living in it, the first project phase (the baselining phase) covers three types of studies: a questionnaire, an observation study, and monitoring of the environmental issues.

Following the run-through of the methodology, the findings of the different baseline studies are presented in chapters 3, 4 and 5.

Chapter 6 then presents the masterplan, illustrating the vision, and giving inspiration to the future work and project phases.

Finally, the results are summarised in chapter 7.



1.3 Setting the scene: The physical surroundings and its characteristics

The Living Lab for Urban Nature is located on a stretch of road on Emdrupvej (“Emdrup Road”), in the Emdrup neighborhood in the northern part of Copenhagen.

Presently the street does not have a lot of vegetation, making it ideal for testing different urban nature solutions. Each side of the road is equipped with sidewalks and bike paths, as is customary for most streets in cities in Denmark.

Thus, bicycles account for a large part of the total traffic moving through the area. Car traffic is also present, and the selected stretch of Emdrupvej acts as a corridor between two heavily car-trafficked roads (Tuborgvej and Lyngbyvej).

In terms of its building mass, the selected stretch of road on Emdrupvej between Tuborgvej and Lyngbyvej is quite diverse. Along the entire south side of the road, three-story social housing units dominate the field of vision, whereas on the north side, privately owned large villas constitute most of the building mass.

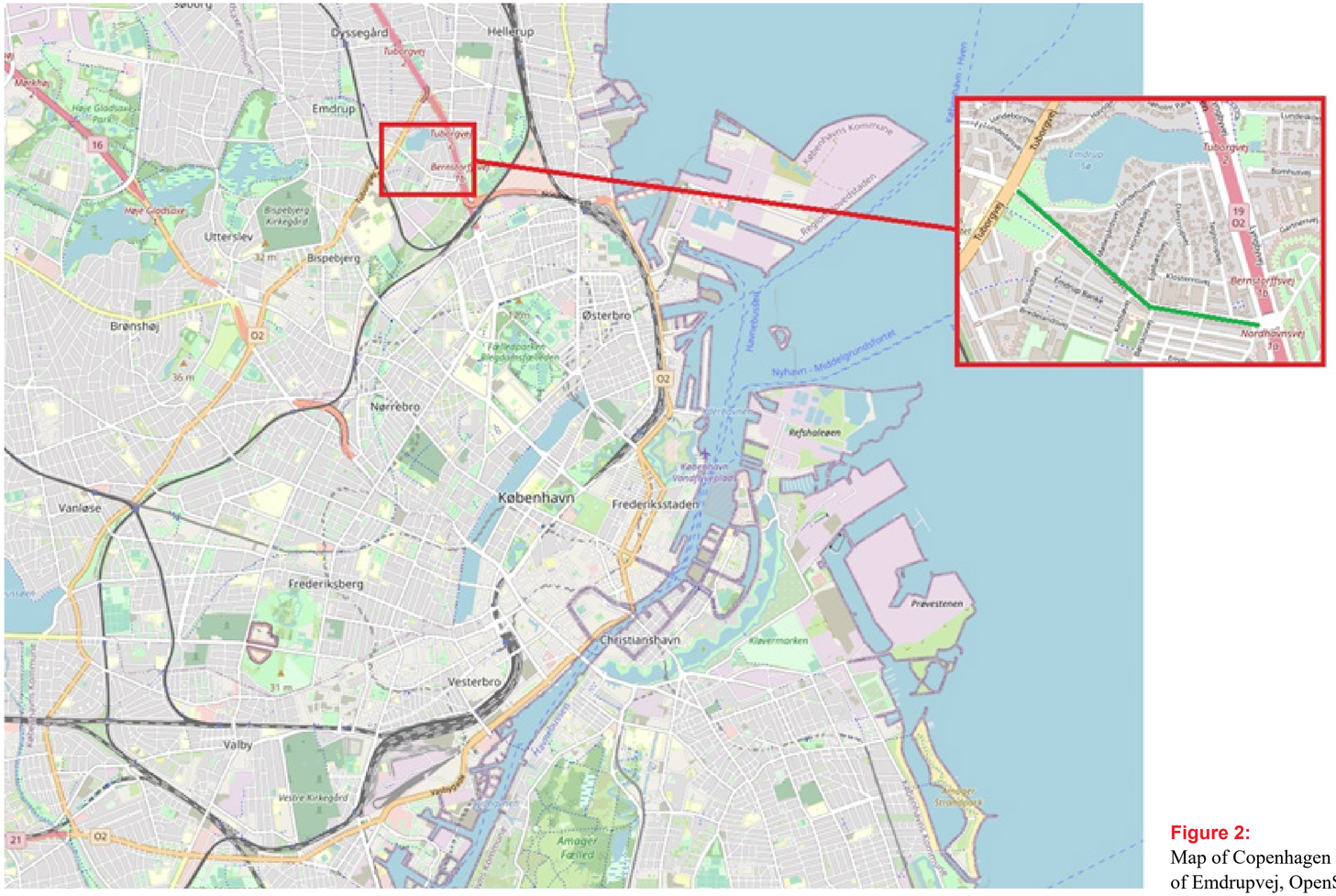


Figure 2:
Map of Copenhagen and location of Emdrupvej, OpenStreetMap.

Figure 3
Emdrupvej, Google streetview.

The diversity in building mass reflects the demographic diversity in the area; people living in large villas in the Danish capital are relatively well-off in terms of income, while the opposite can be said about the majority of people living in social housing. According to the City of Copenhagen, the area is not classified as a low-income area, however it is located in between two such, as shown on the map (Figure 4).

The implementation of urban nature solutions is unlikely to have an effect on the demographics of the area, however it is our hope is that the implementation of different urban nature solutions in the urban space on the stretch will help strengthen the social cohesion of the area across different demographic groups, as the physical area already acts as an arena where people from different walks of life can meet.

Figure 4
Surrounding low-income areas (green markings) and the stretch Emdrupvej between Tuborgvej and Lyngbyvej acting as a corridor (red marking).

Methodology

Methodology

Several methods have been in use to determine the environmental and social baselines for the study and to create a masterplan in the first phase of the Living Lab for Urban Nature.

The specific methods have been selected because they complement each other in a way that they, in combination, draw a comprehensive picture of the status of the stretch Emdrupvej between Tuborgvej and Lyngbyvej. Also, it enables and qualifies us to create a proposal for a masterplan for the area (see section 6).

The idea is that after the implementations/changes to the area have been made in the phase two of the Living Lab for Urban Nature, the studies will be repeated to evaluate the effect of the implementations.

Questionnaire

As part of the monitoring of the social baseline, a survey was carried out in the form of a questionnaire. This provided information on the local citizens' current perception of the area, level of engagement in the community, normal use of the urban space, and wishes and suggestions for the future, as well as some demographic insights.

The questionnaire was distributed physically at a meeting in the local "Vejlaug" (a specific type of homeowner's association) and online. The questionnaire, including the questions in Danish with English translation and answer options, can be found in the appendices of this report.

Observation study

Another core component of the social baselining was a pedestrian activity observation study, designed to uncover the current use of the space. The pedestrian activity categories were based on input from the questionnaire, as well as being predefined based on other similar activity observation studies.

The study was carried out during the same period as the pilot noise monitoring and traffic count and was performed by standing on the corner of Emdrupvej and Horserødvej, recording the movements and activities of pedestrians moving through or dwelling in the area. Thus, the area of the activity observation study did not cover the entire stretch of Emdrupvej between Lyngbyvej and Tuborgvej, but a shorter stretch in the middle of Emdrupvej (numbers 51-61, see map, figure 5).

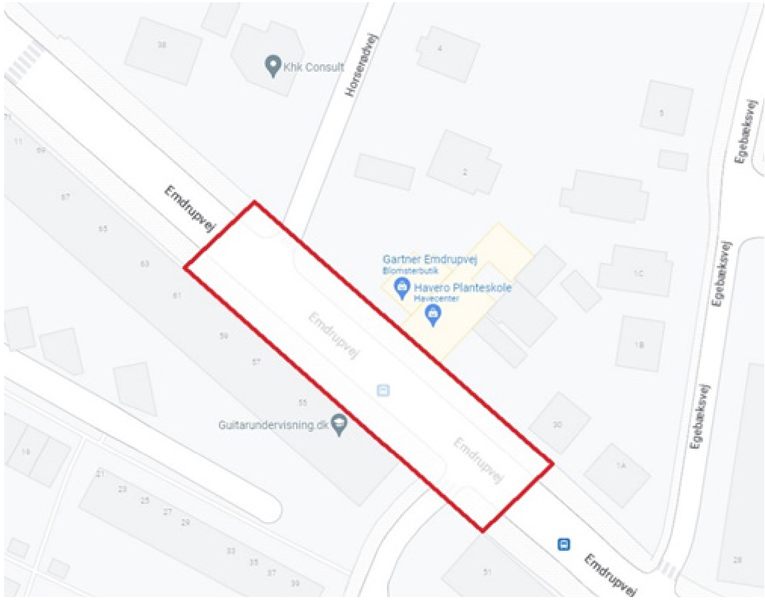


Figure 5
Activity observation study area, Google Earth.

Environmental baselining

The environmental baselining aspect of the study consisted of a multitude of different data types. Some data has been collected by Arup during the first phase of the Living Lab for Urban Nature, and this has been supplemented with other available data from various sources. In the table below, an overview of the different types of data forming the baseline is presented.

Masterplan

Next, the knowledge derived using the different methods mentioned above was considered in the development of a proposal for a masterplan. Consequently, the masterplan illustrates the overall vision for the area, by providing visual renderings of a section of the stretch Emdrupvej between Tuborgvej and Lyngbyvej.

Besides using the masterplan as a blueprint for potential urban nature installations and other changes to the physical environment to be carried out in the next phases of the project, it is also ideal for communication and dissemination purposes.

Data source	Data description	Data source	Data description
Arup Noise Baseline	Manual noise monitoring on the corner of Emdrupvej and Horserødvej (approx. on the middle of the Living Lab stretch). Measurements carried out at 1.5 meters height to meet the standard of similar studies by the authorities. Monitoring period: Regular weekday during morning rush hour (7-9 a.m.) and afternoon rush hour (3-5 p.m.). Pilot monitoring carried out the week before, simultaneously with observation study. Equipment: Sauter SU130 sound meter. Equipment preset to fast response time of 125ms. 1-2 data entries per second.	”Støj-Danmarkskortet” (”The Noise Map of Denmark”), Environmental Protection Agency, Ministry of Environment of Denmark.	Noise data for larger roads, city streets, railways, airport, industry. Calculated for two heights: 1.5 and 4 meters. Last update from 2017. https://miljoegis.mim.dk/spatialmap?profile=noise https://mst.dk/luft-stoej/stoej/stoejgraenser/graensevaerdier-vejtrafik/
Google Air View	Open data collected 5. November 2018 to 1. March 2020, by means of a Google Street View car. PM0.1, NO2, BC https://www.opendata.dk/city-of-copenhagen/airview https://insights.sustainability.google/labs/airquality	”KK støjkort” (City of Copenhagen Noise Map)	Noise data for roads in Copenhagen. Measured in two heights: 1.5 and 4 meters. Last update from 2017. https://kbhkort.kk.dk/spatialmap?selectorgroups=overskrift_kort%20overskrift_omkommunen%20overskrift_erhverv%20overskrift_borger%20miljoe%20overskrift_brugbyen&mapext=722764.4%206173462.2%20726700.4%206175798.2&layers=theme-startkort%20theme-miljoe-vejstoej_2017_1_5m&mapheight=735&mapwidth=1235&-label=&ignorefavorite=true&profile=ekstern
City of Copenhagen air quality monitoring stations	Live and historical data on five different locations in Copenhagen. PM2.5, NO2, PM10, UFP, BC https://erluftensund.kk.dk/	Meteorological data	https://www.dmi.dk/kontakt/frie-data/ http://research.dmi.dk/home/
“Luften på din vej 2.0” (” The air on your street”), DCE – Danish Center for Environment and Energy (Aarhus University)	Calculated/modelled air quality data for the whole of Denmark. Last update from 2019. PM2.5, PM10, NO2, BC http://lpdv.spatialsuite.dk/spatialmap	Vibration	Limit values for low frequency noise, infrasound and vibrations can be found at: https://www2.mst.dk/Udgiv/publikationer/1997/87-7810-830-6/pdf/87-7810-830-6.pdf https://eng.mst.dk/air-noise-waste/noise/recommended-noise-limits/noise-zones/low-frequency-noise-infrasound-and-vibrations-zone/

Questionnaire analysis

Questionnaire analysis

The distributed questionnaire generated 71 responses from local citizens. To uncover their attitude towards the current space and the ‘amount of nature’ within it, we asked them whether they think there is enough nature on the stretch of road Emdrupvej between Tuborgvej and Lyngbyvej. Not to our surprise, 73% answered no to this question, while 14% answered yes and 13% said they did not know. Besides giving a clear indication of the respondents’ thoughts on the area’s current state, this result also indicates their wish to further green the area, hence underlining the potential for creating improvements to the physical surroundings in the next phases of the Living Lab for Urban Nature project.

When asked about how often they visit the location, the vast majority of respondents responded that they frequent the area every day or at least 2-3 times a week (Figure 7). The finding that such a large proportion of respondents visit the location so often once again highlights the need for improvements. As shown in Figure 8, the respondents’ dwell time is generally limited to just passing through, and one might argue that it would be a waste of resources to green an area if the space is not really used for anything else than transit.

However, one might also argue that the minimal dwell time could be seen as a symptom of the space being uninviting to dwell in, once again supporting our overall idea of the importance of a green and inviting urban space.

Do you think there is enough nature on the stretch of road Emdrupvej between Tuborgvej and Lyngbyvej?

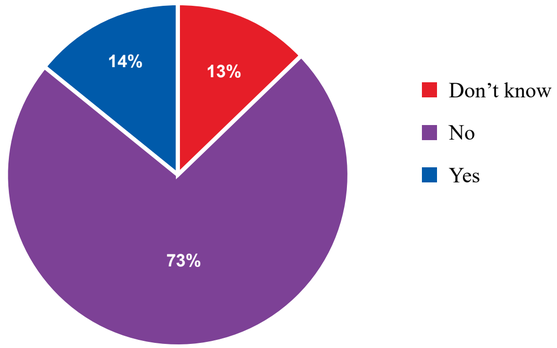


Figure 6
Respondents’ attitude toward the current degree of urban nature.

How often are you located on the stretch Edmrupvej between Tuborgvej and Lyngbyvej?

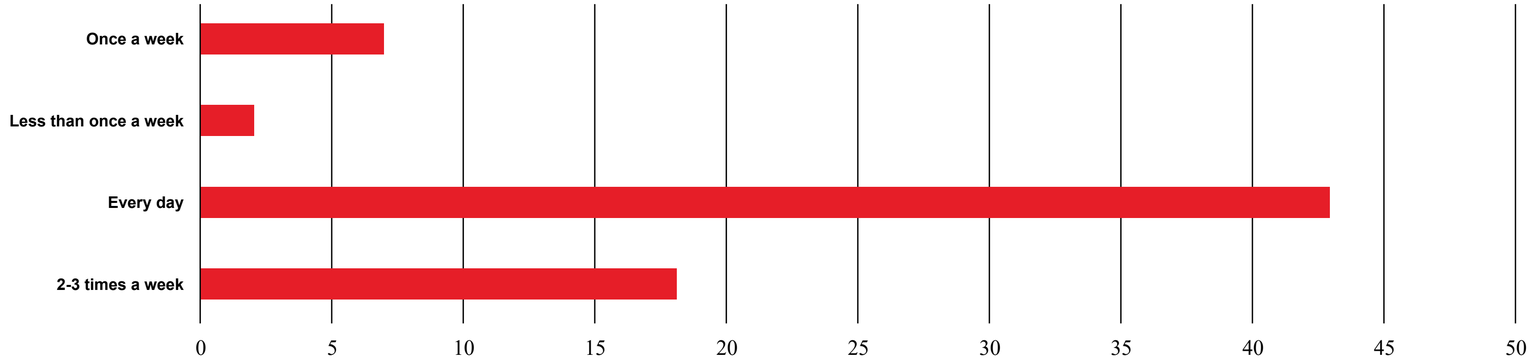


Figure 7
Respondents’ visit frequency.

For how long at a time are you typically located on the stretch of road?

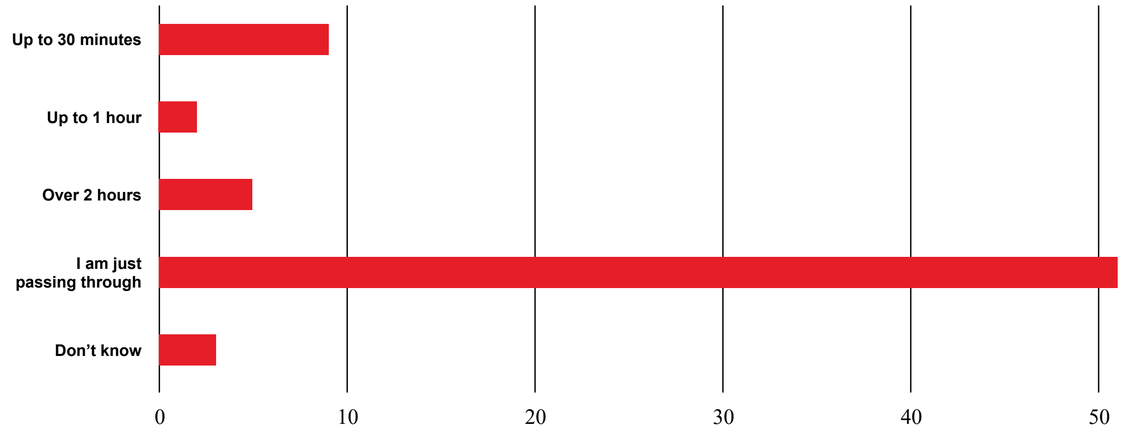


Figure 8
Respondent's dwell time.

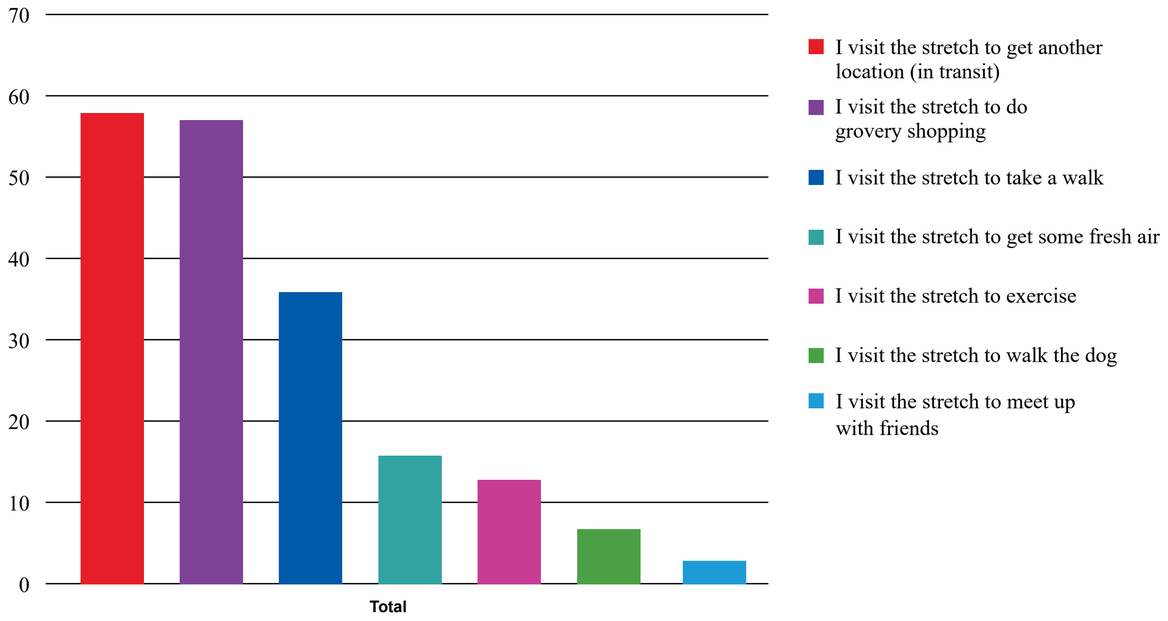


Figure 9
Respondent's use of the space.

When asked about their concrete use of the space (Figure 9), it can be said for most of the respondents that they use the space on several different occasions, but that most of the answers somehow are transit-related activities (or at least related to movement through the area, and not spending time staying in the area). The two highest scoring answers – to get to another location and to do grocery shopping – are very much related to the realm of everyday life and routines. However, the questionnaire also gives a clear indication that people actually do visit the stretch as part of their leisure activities and not just on their way to another location; even though (as per the above) they do not stop and spend more time in the area than necessary. This again hints at a need for improvements to the urban space that make it more inviting to spend time in.

Observation study analysis

Observation study analysis

The observation study was carried out at the same time as the pilot noise monitoring, during the morning and afternoon rush hours. The footfall on the street consisted of 70 people in the morning, and 127 people in the afternoon, totaling observations on 197 people and their activities in the study area.

The most significant finding from the observation study is that 100% of the people moving through the area was exactly that; moving through, meaning that no one used the space to dwell. Of course, depending on what the individual was doing during their walk, and their perceived age, the speed with which they would move through the area varied, but it is remarkable to note that no single person observed paused in the area to take a break. This observation hints at a large potential for improving the physical features of the space, making it more inviting for people to stop and dwell for a while.

The only people dwelling in the area were people waiting on the bus on either side of the street, constituting 10-11% of the observed individuals.

This finding is very much in line with the self-reported use of the space uncovered in the questionnaire, see Figures 8 and 9 above.

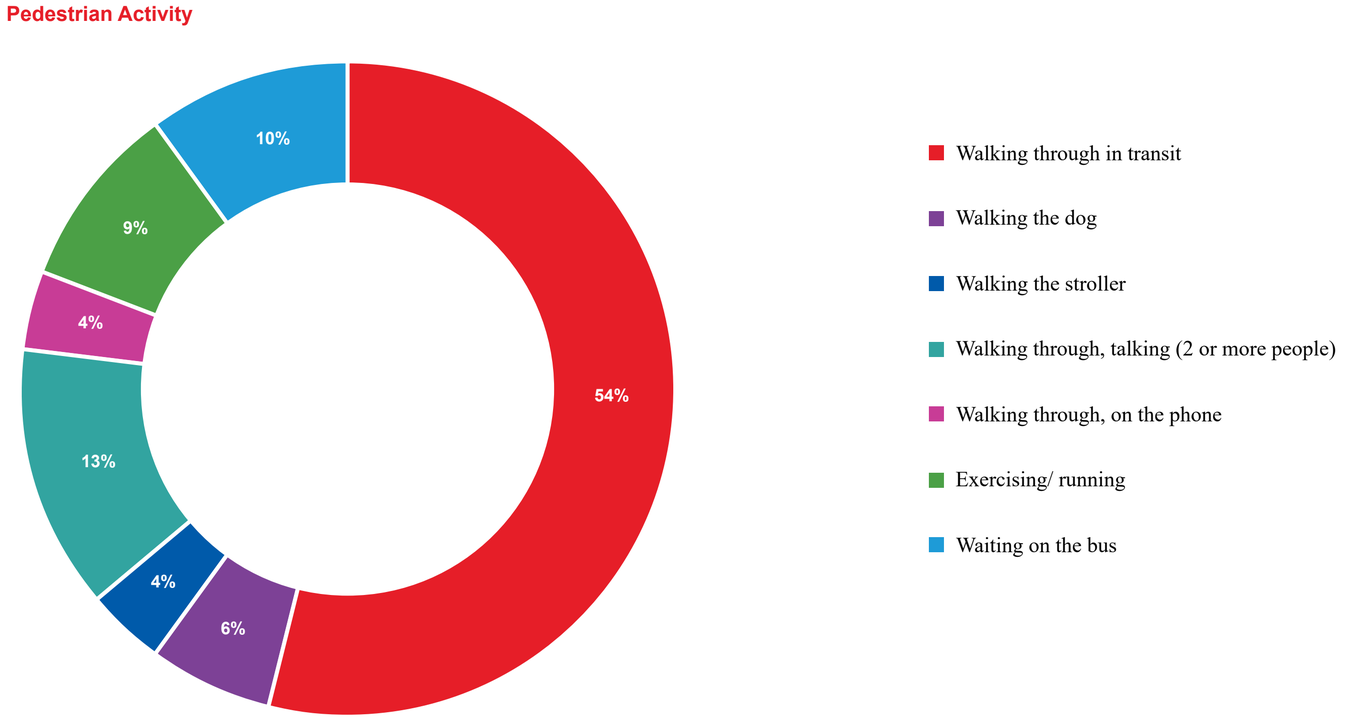


Figure 10
Observed activities of pedestrians in the area.

Environmental baselining analysis

Environmental baselining analysis

Air quality and noise pollution is recognized as a widespread problem for the quality of life in urban areas throughout the world (1). Vehicular traffic noise is the most significant source of environmental noise pollution within urban areas (2). Road traffic noise exposure can have negative mental and physical effects and may cause disruptions in daily activities such as annoyance, cardiovascular disorders and sleep disturbances and cognitive performance (3-5). Disruption of cognitive performance causes changes in comprehension, the speed of information processing and attention (3, 4).

Traffic and noise

Simultaneously with the noise monitoring, a traffic count was carried out to explore the correlation between traffic volume and noise level. Only regular car traffic and heavy traffic (lorries) were registered, as these traffic types account for most of the traffic noise. The results are presented below.

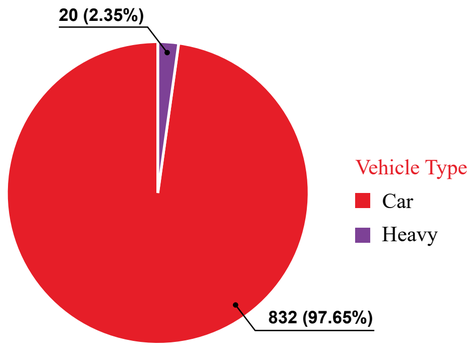
For a more comprehensive data set containing bicycles – which constitute a very large amount of the traffic in Copenhagen but are not a significant noise source – we refer to the Annual Average Daily Traffic (AADT) data collected by Copenhagen Municipality. The newest available AADT data relevant to the Living Lab for Urban Nature area is from 2021 and can be found in the appendices.

The figure below (Figure 11) shows the count and flow direction of car traffic during the morning peak (approx. 7:15-9:15 a.m.) and afternoon peak (approx. 3:00-5:30 p.m.). During the morning peak, a total of 852 vehicles drove by with the majority headed east towards Lyngbyvej. During the afternoon peak, a total of 994 vehicles were counted, with a slight majority headed west towards Tuborgvej. This change of flow direction is also supported by the AADT data. It is noted that the volume of heavy traffic accounts for less than 3% of the total motorized traffic.

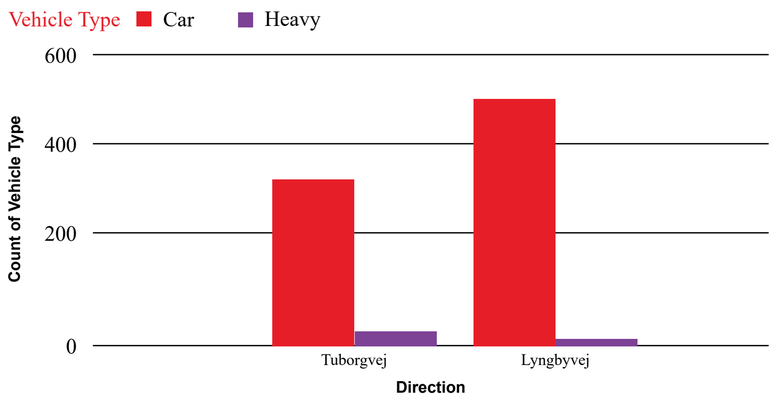
Figure 11
Traffic count and flow direction for morning and afternoon peaks

Morning

Count of vehicle type by vehicle type

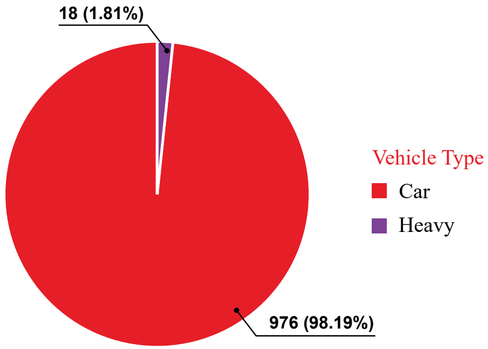


Count of vehicle type by direction and vehicle type

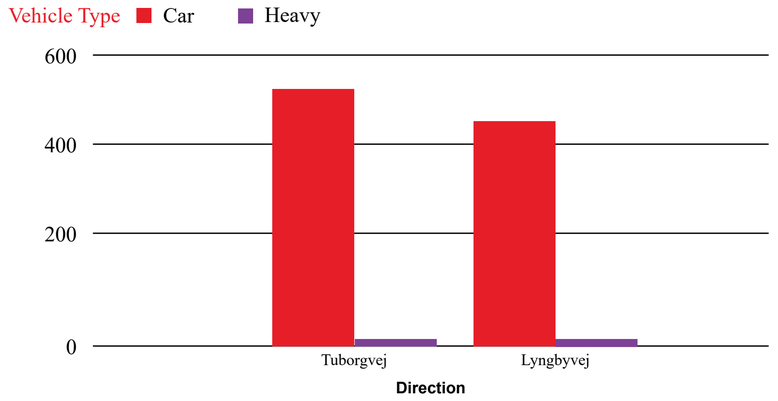


Afternoon

Count of vehicle type by vehicle type

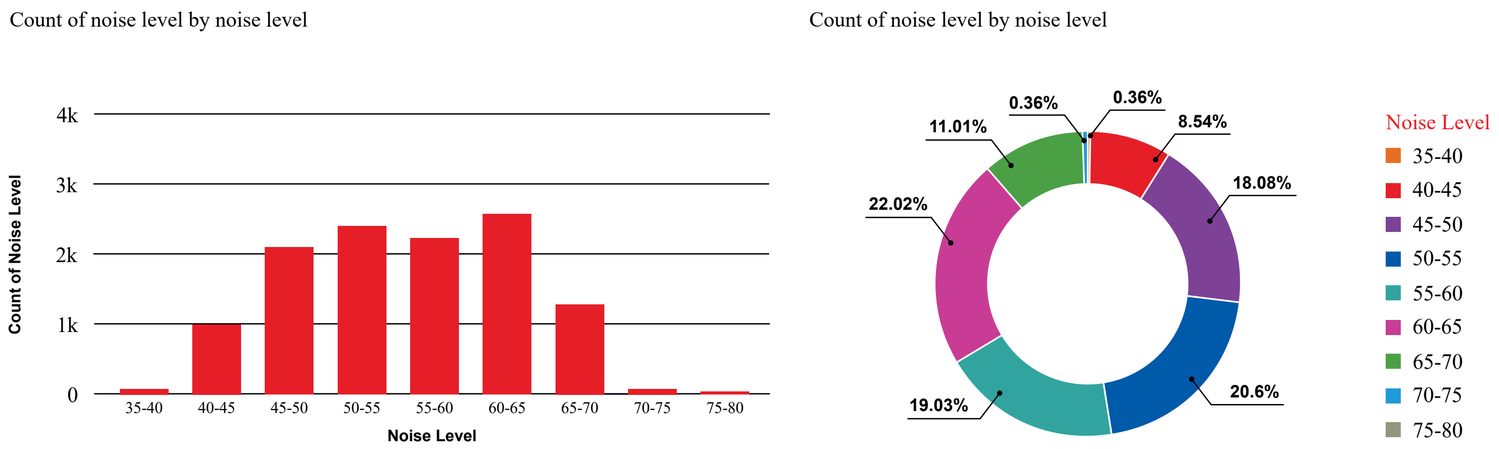


Count of vehicle type by direction and vehicle type



In relation to noise level, our monitoring indicated a rush hour noise background level of 35-40 dB as this was the lowest registered noise level during the monitoring period. The graphs below indicate that most of our data entries (in this study our monitoring device logged one or two entries per second) are in the vicinity of 45-65 dB, with a slightly larger variance in the morning than in the afternoon.

Morning



Afternoon

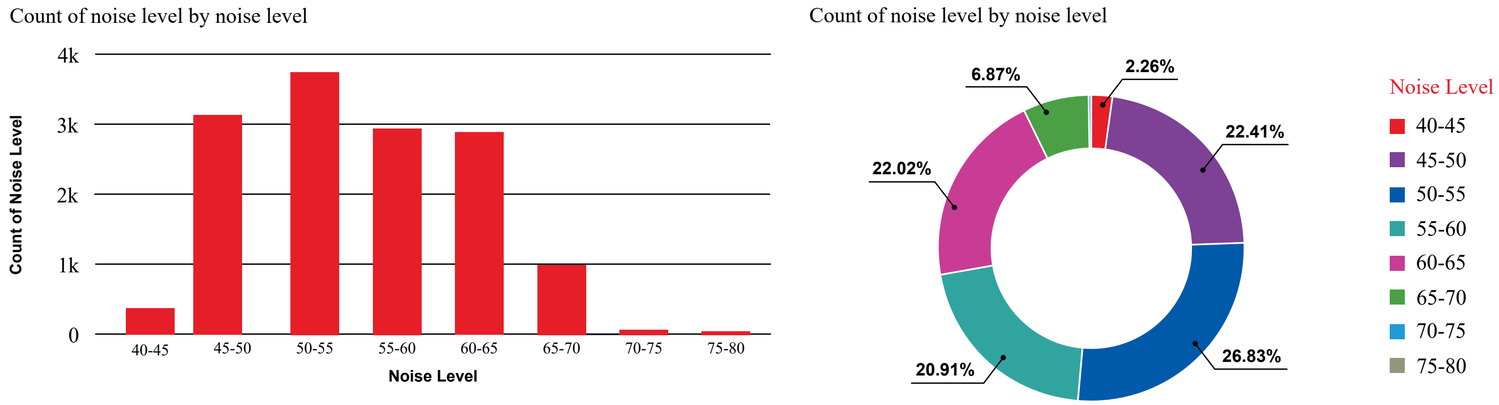
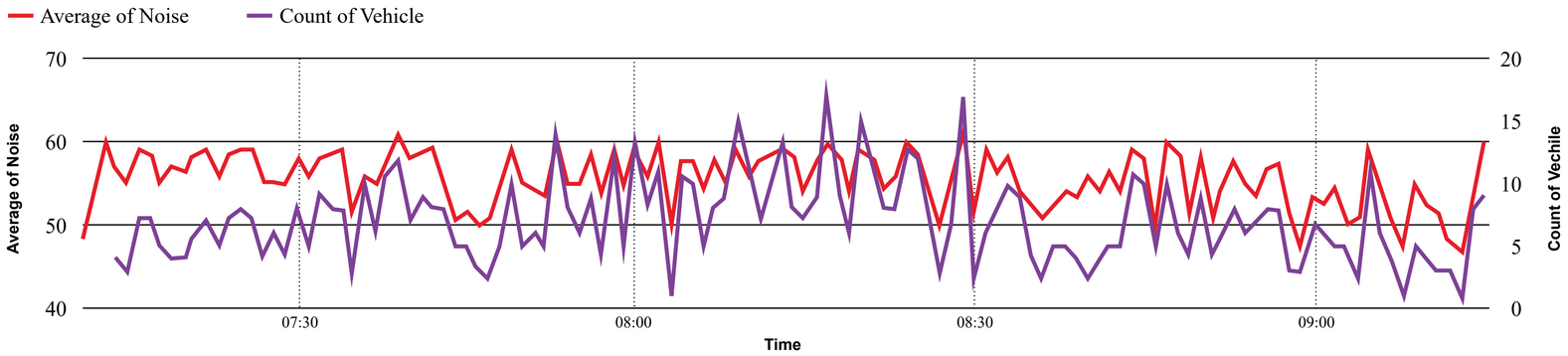


Figure 12
Count of noise level for morning and afternoon peaks

If we correlate our data from traffic counts with the noise monitoring data, it becomes evident that there is a clear causal relationship between the two, as shown on the graph below: the quantity of vehicles passing directly affects noise level.

Morning

Average of noise and count of vehicle type by time



Afternoon

Average of noise and count of vehicle type by time

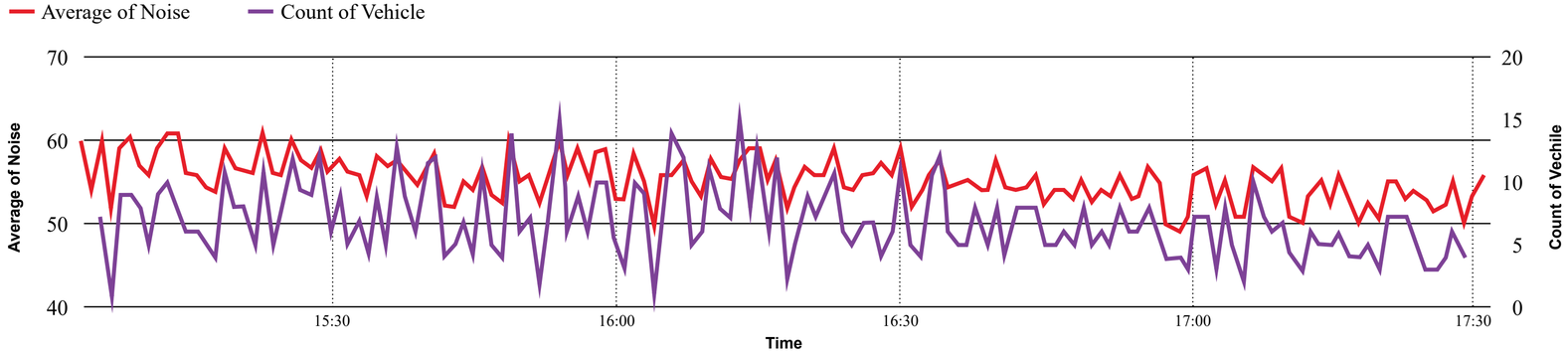
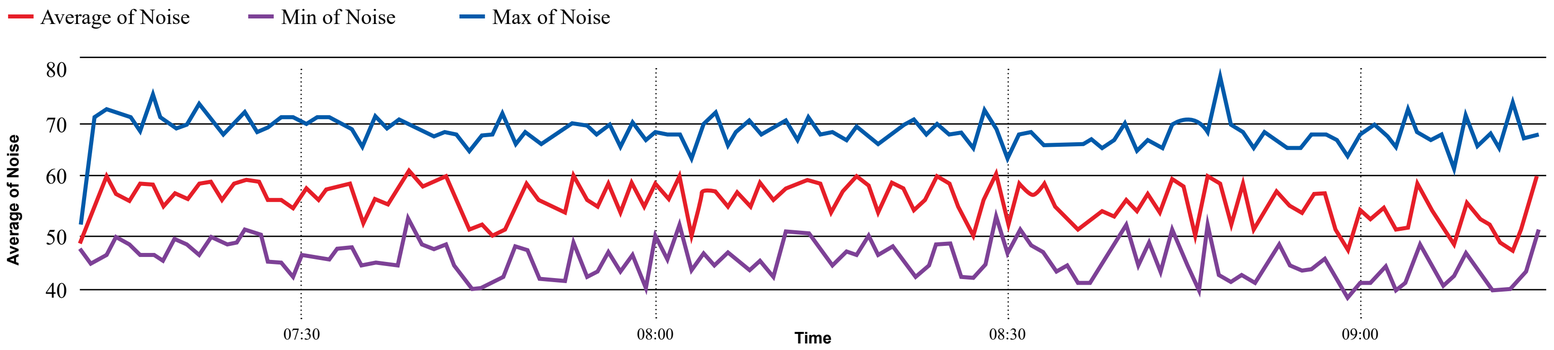


Figure 13
Traffic and noise corelation for morning and afternoon peaks

The graphs below show the highs (blue line) and lows (purple line) of the monitored noise levels for each one-minute interval. The red line indicates a calculated average, giving us a strong hint that the general noise level from traffic-generated noise is in the realm of 50-60 dB on average.

Morning

Average of noise, min of noise and max of noise by time



Afternoon

Average of noise, min of noise and max of noise by time

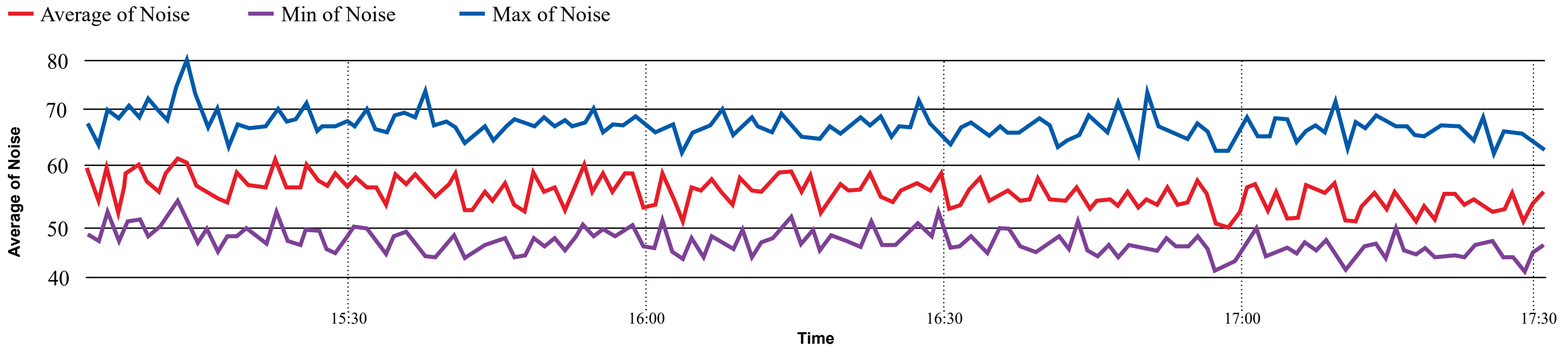


Figure 14
Noise level peaks and averages for morning and afternoon peaks

Overall, this finding is confirmed by the municipality's noise maps. The map below shows the road noise in 2017, indicating that the general level of traffic generated noise in the area on and around the stretch of Emdrupvej between Tuborgvej and Lyngbyvej is around 63-73 dB. This is higher than our calculated average but corresponds quite well to the peaks in our monitoring.

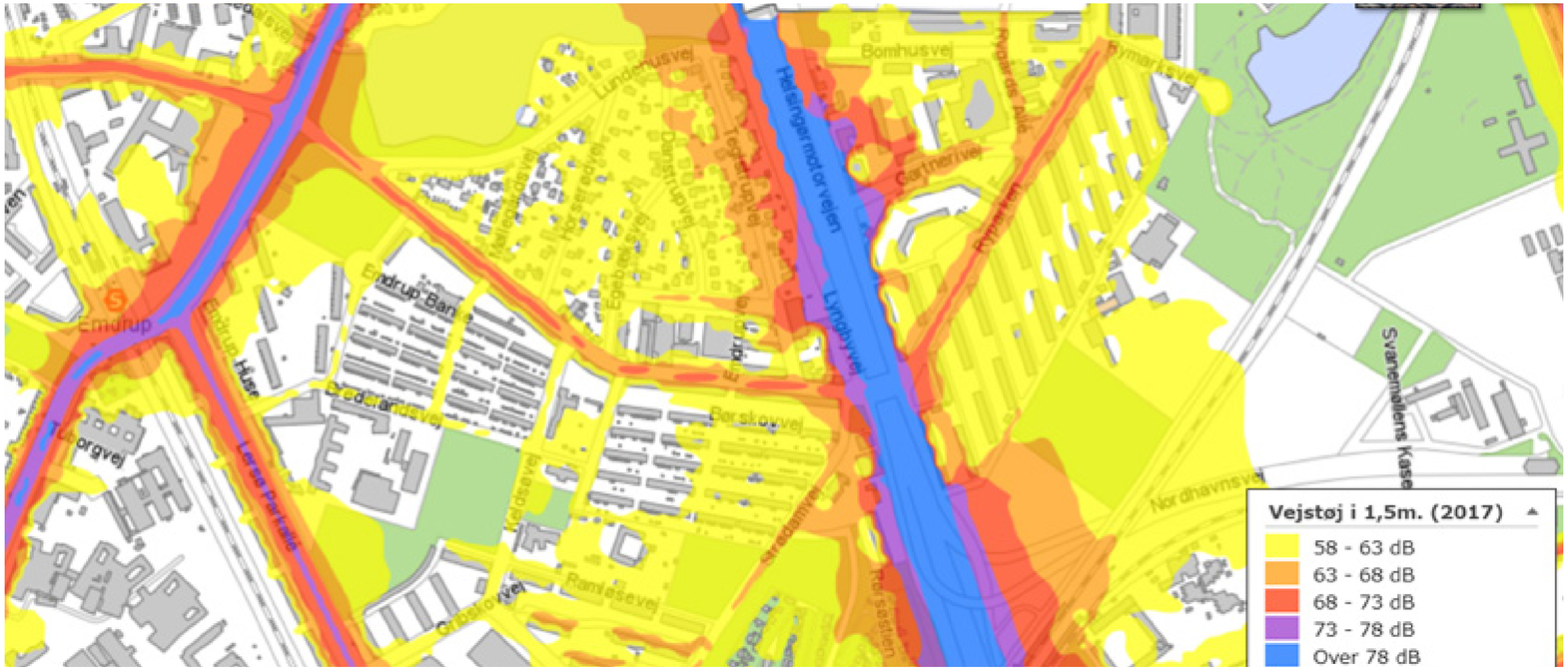


Figure 15
Noise mapping from City of Copenhagen (2017).

Vibration

Noise and vibration are considered as harmful physical agents in the environment which have adverse effects on cognitive performance.

Traffic vibration is mainly due to heavy trucks passing at relatively high speed on a road with an uneven surface profile. Interaction between wheels and road surface causes a dynamic excitation which generates waves propagating in the soil and impinging on the foundations of nearby structures.

Based on the traffic numbers in section 5.1 and considering the proportion of heavy vehicles such as trucks and buses combined with the low traffic speed and the smooth road surface (the road is paved with noise reducing asphalt), vibration from traffic is not viewed as a considerable annoyance to the local residents or business owners (based on site survey interviews dated 04.03.2023 and 05.03.2023). According to air pollution research by Professor Matthias Ketzel, vibration is rarely seen as an environmental or human health risk element in Denmark. As long as noise pollution levels do not exceed national guidelines it is, according to Ketzel, not necessary to monitor vibration levels.

Air pollution

The WHO identifies air pollution as one of the world's biggest environmental problems today, following climate change. Air pollution is associated with negative health effects, reduced biodiversity, loss of crop yields and climate change (1 & 4).

In Denmark, the number of premature deaths related to air pollution is estimated to be 3000-4000 yearly. A research area that has recently attracted significant attention is the importance of particulate contamination, especially of the so-called ultrafine particles. The ultra-fine particles have several properties relating to their size and large surface area which make them particularly dangerous, and current research suggests that very small particles post one of the most serious health problems to humans.

Air quality has improved in Denmark during the last decades due to long-term national and international initiatives reducing emissions of several types of air pollutants. Another reason for increased air quality in Denmark compared to other countries is Danish meteorological conditions: Our windy climate contributes to decreased concentrations of air pollution. Since 2017, no exceedance of the Danish limit values has been observed.

As part of the national monitoring program, air pollution data is publically available and thus enables widespread acquisition and sharing of knowledge on air pollution and present levels. According to the European Environment Agency (EEA), computer models are increasingly used for estimating air quality or forecasting changes in pollution levels. Various models are currently used across Europe. The different types of pollution baseline values for the Living Lab for Urban Nature presented below are derived from the Aarhus University

Department of Environmental Science air quality modelling calculation, which is higher in accuracy than air quality spot checks measured during a limited period. Supplementing this, the open-source data from the Google AirView project, providing pollution data on street level from 2019, can be found at https://insights.sustainability.google/labs/airquality.

The largest sources of emissions of nitrogen oxides (NO2 and NO, herein referred to together as NOx) are road transport followed by other mobile sources and combustion in energy industries. The transport sector contributes most to the emission of NO2, and the main transport sources are road transport, national navigation, railways and civil aviation.

NOx emissions have decreased significantly since 1990 due to the increasing use of catalyst cars and installation of low-NO2 burners and denitrifying units in power plants and district heating plants. The same trend applies to NO2 emissions. The map below (Figure 16) shows NO2 levels in the Living Lab for Urban Nature and area surrounding it. From the map we can clearly see that values increase with proximity to the highway (Lyngbyvej) with values around 20-25 µg/m3 on the eastern part of Emdrupvej, and 16-20 µg/m3 towards the west.

Figure 16
NO2 ug/m3 2019 for the Living Lab area, and for greater and central Copenhagen.

When it comes to particles smaller than 2.5 µg (PM2.5), the largest emission source is residential combustion plants, followed by the transport sector. For the road transport sector, exhaust emissions account for barely half of these emissions, while the remaining emissions come from tyre and brake wear and from road abrasion. The map below (Figure 17) illustrates how, once again, the concentration of pollution is higher at the end of Emdrupvej adjoining Lyngbyvej (11-11.5 PM2.5/m3), compared to further west (10.5-11 PM2.5/m3 in the area on the middle of Emdrupvej).

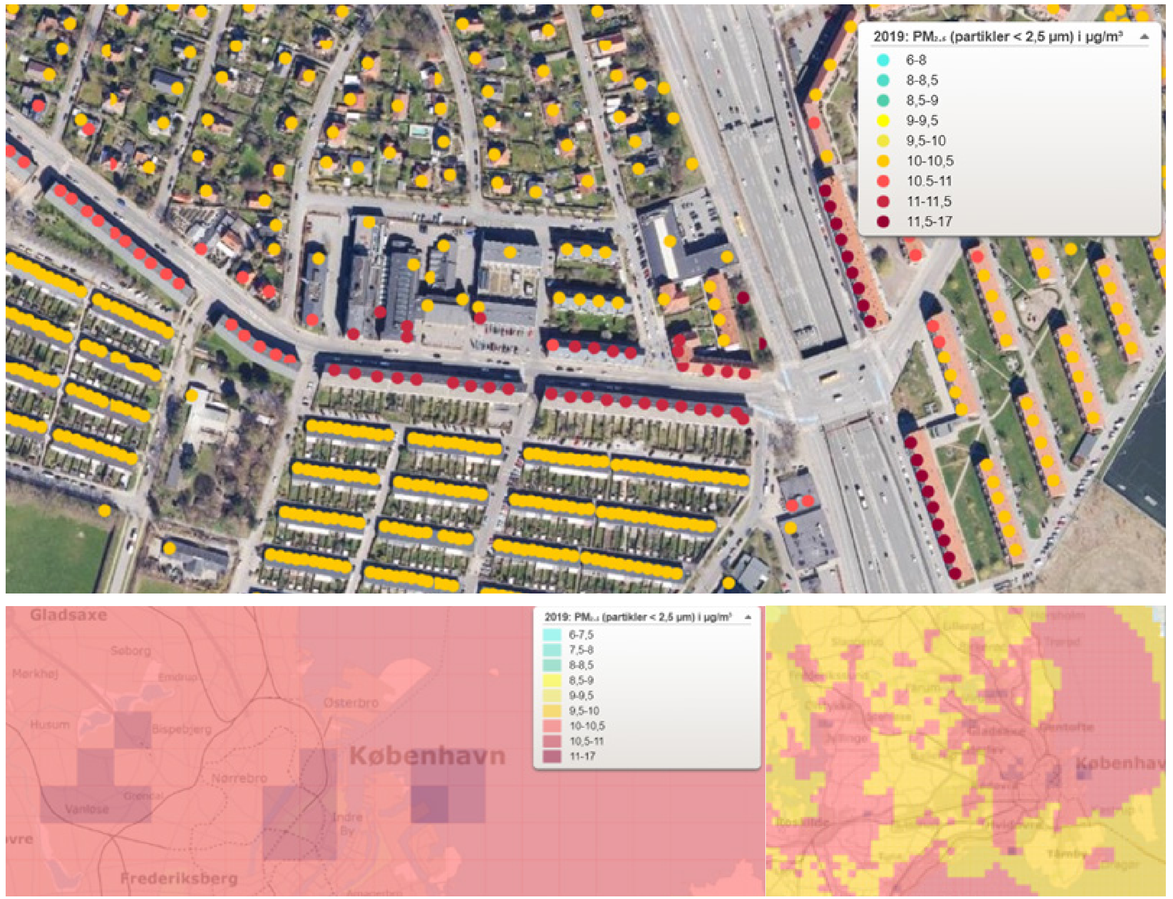


Figure 17
PM2.5 ug/m3 2019 for Living Lab area, and for greater and central Copenhagen.

Finally, the last type of pollution baselining carried out for the Living Lab for Urban Nature was the baseline for particles smaller than 10 µg (PM10.5). The same overall pattern is again apparent, with values of 18-19 PM10.5/m3 towards Lyngbyvej and 17-18 PM10.5/m3 further into the neighbourhood.

We have demonstrated the same overall picture across the different types of air pollution; that the concentration of pollution is highest in the end towards the highway (Lyngbyvej), and that the values in general are higher on Emdrupvej than in the surrounding residential neighbourhood. This underlines the potential for mitigating the air pollution via the strategic use of urban greening installations such as the ones presented in the masterplan (section 6).

Figure 18
PM10 ug/m3 2019 for Living Lab area, and for greater and central Copenhagen.

Climate and weather situation

Denmark has a typical coastal climate with mild, humid weather in winter and cool, changeable weather in summer, and average air temperatures do not vary greatly between the two seasons. However, the climate and weather in Denmark is strongly influenced by the country's proximity to both the sea and the European Continent. This means that the weather changes according to the prevailing wind direction. The westerly wind from the sea typically brings relatively homogeneous weather both summer and winter: mild in winter, cool during summer, always accompanied by clouds, often with rain or showers. With wind from east or south, the weather in Denmark tends to resemble the weather currently prevailing on the Continent: hot and sunny during summer, cold during winter. Thus, the wind direction and the season are key factors in describing Danish weather. (5)

The wind rose for Copenhagen below shows how many hours per year the wind blows from the indicated direction. The most frequent winds originates from west and southwest and would hereby avoid that the traffic pollution from the main highway (Lyngbyvejen) contributes significantly to the air pollution build up at street level on Emdrupvej. The same can be said regarding the background noise level.

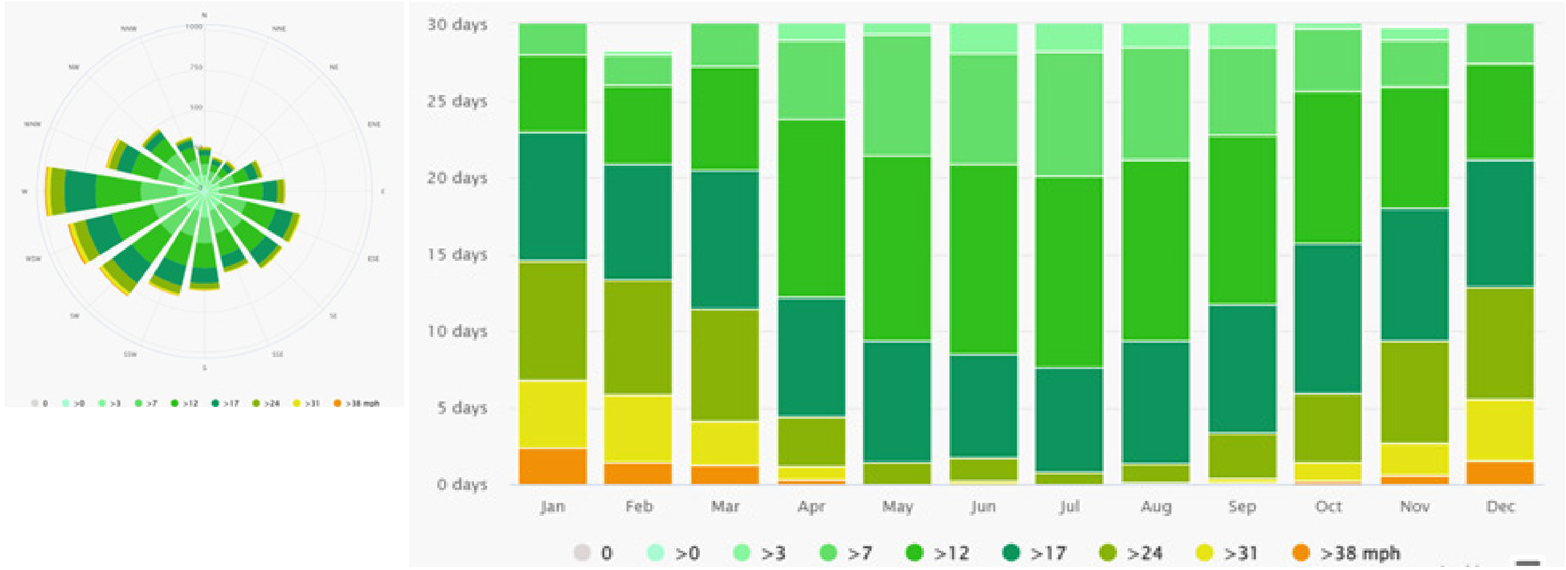


Figure 19
Wind rose illustrating the predominant wind direction in Copenhagen followed by a diagram for Copenhagen showing the days per month, during which the wind reaches a certain speed.

Masterplan

Masterplan

This section presents a suggestion for a masterplan for the Living Lab for Urban Nature, consisting of a visualization (Figure 20), a concept diagram (Figure 21), and a plan drawing (Figure 22). The Masterplan should not be viewed as a final design, as it will require much more development in the coming project phases. However, at this stage, the visualization, concept diagram and plan drawing act as a point of departure for future work, illustrating the overall vision for the Living Lab.

The purpose of the Living Lab for Urban Nature is manyfold and seeks to mitigate different types of environmental pollution as well as creating an arena for local citizens to meet; all via mindful design and purposeful installations. The visualization below serves as an inspiration for realising this, and to take the different purposes of the Living Lab into account. Thus, the dominant elements are, of course, the greening of the street using different types of urban nature installation such as road trees, self-watering planters and façade plantings. Additionally, the social elements have an important role to play, in that we can plan for social interactions when thinking carefully about how these are encouraged. In the visualisation below, you will therefore also find benches inviting citizens to dwell in the space before moving on to their final destination, that can maybe even with time become the final destination.

The concept diagram focuses on the effect of urban nature on noise pollution and illustrates how, in theory, the planting act as a noise barrier, dampening the reflection of noise.

Figure 20
Visualization of potential urban nature elements in the urban space on Emdrupvej.

Figure 21
Concept diagram of the Living Lab for Urban Nature.

Finally, the plan drawing adds a more technical perspective to the project, as the urban nature installations are shown at scale. It clearly illustrates the focus on the south side of the street, highlighting that this is where the most impactful implementations could be made, since there are more trees and bushes on the north side of the road (though in private gardens, not on the street), and more available space on the south side, making urban nature installations feasible without imposing any danger to traffic.

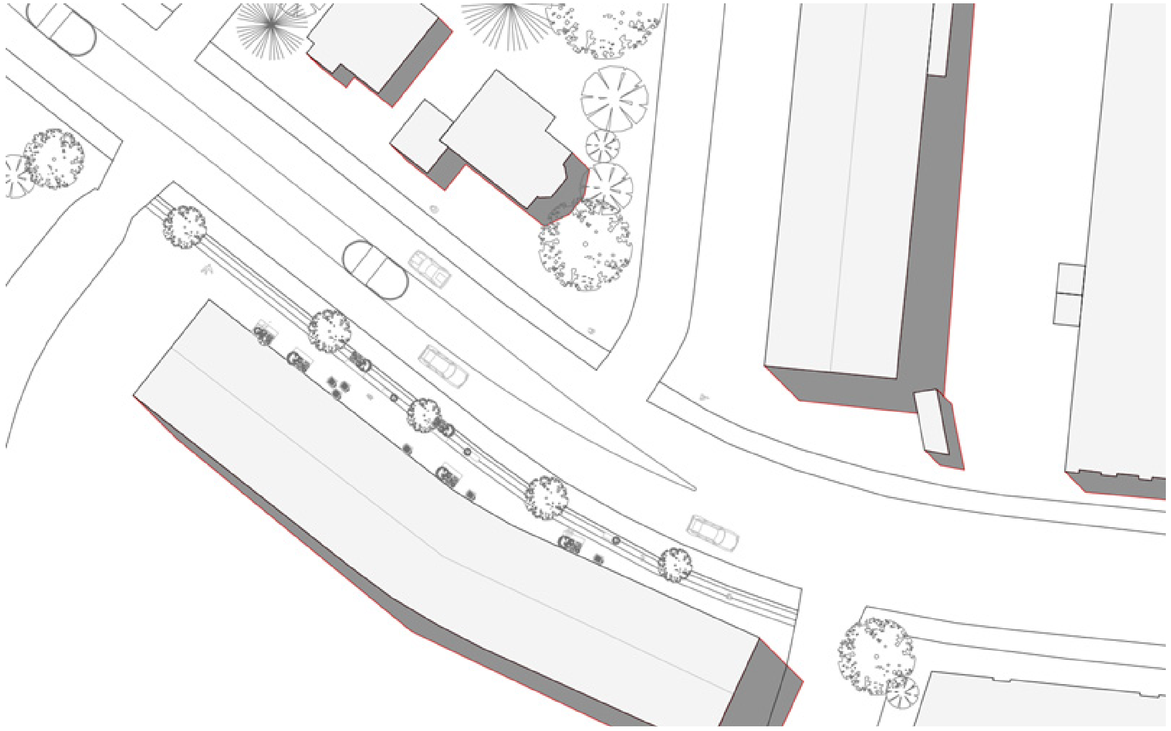


Figure 22
Plan drawing with various urban nature installations.

Conclusions

Conclusions

Urban nature provides a multitude of environmental benefits that can help mitigate some of the negative impacts of urbanization. Green spaces in urban areas can help reduce air pollution levels by filtering harmful pollutants and reducing the urban heat island effect by providing shade. Urban nature can provide a range of benefits that improve the health and well-being of urban residents and support a more sustainable future.

However, to fully realize these benefits, careful planning and management of urban green spaces are essential. This report set out to document the baselines determined in Phase 1 of the Living Lab for Urban Nature project as a first step towards a fully functional living lab, testing the effect of different urban nature implementations. By comparing the environmental conditions before and after implementations of urban nature, the vision for the Living Lab for Urban Nature is to document the effects and potential significant environmental benefits of urban nature.

Visualization of possible urban nature implementations

Reference

References

1. Carugno M, Imbrogno P, Zucchi A, Ciampichini R, Tereanu C, Sampietro G, et al. Effects of aircraft noise on annoyance, sleep disorders, and blood pressure among adult residents near the Orio al Serio International Airport (BGY), Italy. MedLav. 2018;109(4):253–63.
2. Information from the Danish Environmental Protection Agency, no. 9/1997 "Low Frequency Noise, Infrasound, and Vibrations in the Environment
3. Region Hovedstaden, Vurdering af Luft og Støj, kortlægning og virkemiddelkatelog

   Access 2. feb 2023 from https://www.regionh.dk/til-fagfolk/trafik/Analyser-og-rapporter-om-trafik/Luft-og-stoejforurening/Documents/Rapport-luft-og-støj%20Region-Hovedstaden.pdf
4. Copenhagen Municipality, Health and air pollution in Copenhagen, annual report 2019

   Access 29. Jan 2023 from https://www.kk.dk/sites/default/files/agenda/9e5708e6-8e34-4ac9-9a53-3a18ed6144bb/dc6caa3d-de0d-477c-b64e-705f671ec60e-bilag-4.pdfy
5. Cappelen, J., Denmark – DMI Historical Climate Data Collection 17682020 DMI Report 21-02 26 May 2021

   Access 4. Feb 2023 from www.dmi.dk/fileadmin/Rapporter/2021/DMIRep21-02.pdf
6. City of Copenhagen: Københavnerkortet (The Copenhagener Map), mapping of noise levels on streets in Copenhagen, measured in 1.5 meters height. https://kbhkort.kk.dk/spatialmap?selectorgroups=overskrift_kort%20overskrift_omkommunen%20overskrift_erhverv%20overskrift_borger%20miljoe%20overskrift_brugbyen&mapext=722764.4%206173462.2%20726700.4%206175798.2&layers=theme-startkort%20theme-miljoe-vejstoej_2017_1_5m&mapheight=735&mapwidth=1235&label=&ignorefavorite=true&profile=ekstern

Appendices

Annual Average Daily Traffic 2022 (AADT) (Årsdøgnstrafikdata), location 259 + location 686

Questionnaire, translation