With the contribution of
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LIFE MONZA
Methodologies for Noise Low Emission Zones introduction and management

Noise Low Emission Zone implementation in urban planning: results of monitoring activities in pilot area of LIFE MONZA project

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First OBJECTIVE OF LIFE MONZA

The main objective of LIFE MONZA - Methodologies fOr Noise low emission Zones introduction And management - is to **introduce an easy-replicable method**, and related guidelines, for the **identification and the management of the Noise Low Emission Zone**, an urban area subject to traffic restrictions, whose **impacts and benefits regarding noise issues** will taken into account, analyzed and tested in the pilot area of the city of Monza, located in Northern Italy

The project started in September 2016 and will finish in June 2020

Beneficiaries: ISPRA, University of Florence, VIE.en.ro.se Ingegneria, Monza Municipality

SCOPE of the project

Low Emission Zones are urban areas subject to road traffic restrictions, primarily introduced in order to ensure compliance with the air pollutants limit values, set by the European Directive on ambient air quality (2008/50/EC).

LEZ implementation is the most common measure adopted in EU, considering road traffic planning and the impacts on air quality improvement are widely analyzed, whereas the effects and benefits concerning the noise have not been addressed in a comprehensive manner.

The definition, the criteria for analysis and the management methods of a **Noise Low Emission Zone** are not yet clearly expressed and shared.

LIFE MONZA project addresses these issues. The results of the project activities will increase knowledge about LEZ environmental effects, giving the opportunities to evaluate its adoption in the framework of noise action plans.

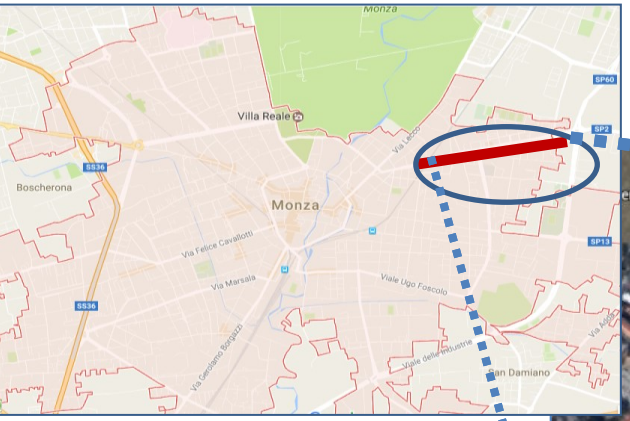
Further OBJECTIVES of LIFE MONZA

The second objective regards specific ***top-down measures***, infrastructural interventions adopted by the municipality and able to turn up the urban area in a permanent Noise LEZ

The third objective is to **reduce the average noise levels** in the pilot area of Libertà district, with positive complementary effects also on the **air quality** and benefits on the **quality of life of the inhabitants**

The fourth objective is to encourage an active involvement of the people, in the definition of a more sustainable lifestyle (***bottom-up measures***)

PILOT AREA in Monza Municipality



Libertà district is identified as a **hotspot in the Noise Action Plan of the city of Monza**.

Noise strategic map of the city of Monza, dated 2017, highlights that in a range of 30 m from the Viale Libertà almost the 100% of the receivers is exposed to levels higher than 65 dB(A) during the day and 55 dB(A) during the night.

TOP-DOWN MEASURES: infrastructural interventions for NLEZ establishment

- **traffic management** (access restrictions to the transit of heavy vehicles; the speed vehicles reduction);

- **road paving substitution with a new dense-graded low-noise paving, on Viale Libertà** (based on results of Leopoldo project);

- **road design with lanes-width reduction and pedestrian crossings introduction**

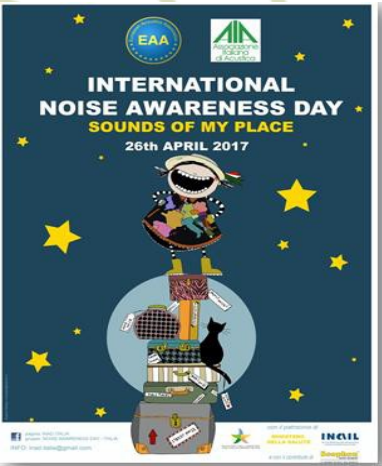
Dense graded at optimized weaving, mixtures of bituminous conglomerate with granulometric characteristics, which guarantees results of 3-4 dB in term of acoustic abatement and an efficiency period of about five years from the laying. The works to lay the new low-noise asphalt has started on Monday 17th September 2018 and finished on Saturday 22th , 2018.

BOTTOM UP MEASURES

People habits and voluntary actions implemented by the citizens can produce positive effects on the achievement of the environmental targets in the urban area where they live.

In order to encourage the local community involvement and to strengthen the dialogue between citizens and public bodies, many activities are carrying out, as:

- **meetings in primary and high schools to raise awareness about noise effects**;
- **ideas contest for students** for Noise LEZ picture and logo;
- ***pedibus*** service for schoolchildren;
- **questionnaires** on perceptions of specific noise impacts; on the quality of life, air quality and social aspects



MONITORING ACTIVITIES and methods tested in pilot area

Monitoring activities in pilot area regarding noise, air quality and the wellbeing conditions of the citizens, tested before and after the Noise LEZ implementation, in order to discuss and to evaluate the main effects of Noise LEZ introduction in urban planning and in the lifestyle of the inhabitants.

Noise Monitoring	• **Class I instrumentation** • **Smart low-cost sensors**
Air Quality Monitoring	• **EU Directive requirements** • **Passive sampling**
Wellbeing Quality of life	• **Survey**

NOISE MONITORING in pilot area

Monitoring activities are carrying out referring to the **standard methods, using sound level meters of Class I precision**, and also by developing and using a **smart low-cost monitoring system**. Some counter-traffic units were put in place to monitor road traffic flows.

About the standard method, the ante-operam monitoring was carried out between Monday 20 and Monday 27 November 2017, the post-operam monitoring was carried out between Monday 21 and Monday 28 January 2019. the SNMS works continuously since June 2017.

A **prototype system for smart monitoring activity of noise** has been designed and implemented, in order to be used as a continuous monitoring unit in the ex ante and ex post scenarios; 10 monitoring stations have been installed in the pilot area of Libertà district (June 2017) and they are continuously working.
After the end of LIFE MONZA project, the prototype will be given for free to Municipality of Monza that will take care of using it for monitoring activities in the three years after the project end.

Smart low-cost noise monitoring systems experiences and procedures

SNMS has been developed, based on the outcomes of the state of the art analysis

DREAMsys
Smart monitoring networks – Ghent University
SENSEable Pisa
LIFE DYNAMAP
Barcellona Noise Monitoring network
Low-cost monitoring systems based on smartphone devices – Regional Environmental Agency of Piedmont
Participatory monitoring projects

Smart low cost noise monitoring systems	
main characteristics arising from analyzed projects	
Short /long term noise measurement	long term noise measurement
Embedded pc monitoring system /Units with microcontroller and digital signal processor	Embedded pc monitoring system
Type of microphones	MEMS microphones ¼ - inch condenser low cost microphone
Time basis acquisition	Different values. In most frequent cases =1 sec;
Acoustic dynamic range	70 dB
Acoustic Measure range	Different ranges. 30 (40)-100 (110) dB(A)
Acoustic frequency range	20 Hz-20 kHz
Floor noise value	30-35 dB(A)
Tolerance	LAeq ±2 dB(A)
Acoustic indicators	In all cases studies: L_{Aeq}, L_{A10}, L_{A50}, L_{A90}; In some cases studies: $L_{A01;}$ L_{Ceq}, M_{60}, M_{70}, N_{cn}
Spectral data	1/3 octave
Calibration	Periodic calibration
additional characteristics	
weatherproof	Applied in all case studies
connectivity	Wifi/3G/4G
possibility of audio recording	Applied in some case studies
other properties	Extensible with temperature/humidity sensors, air pollution monitoring sensors, GPS logging etc; battery for energy storage.
Size of PCB assembly	10mm < x < 10 mm
Shape of PCB	Optimized to avoid diffraction effects
pilot area of implementation	
Urban/Suburban	Urban and sub-urban areas
Territorial scales	Different dimensions, from medium to large scale; (most frequent dimension in urban area: ≈1,00 km^2)
Number of stations	Different situations. For areas of medium spatial dimensions, in most cases, from 5 to 20 units

Smart low-cost noise monitoring system – LIFE MONZA

acoustic parameters: overall A-weighted continuous equivalent sound pressure level, LAeq,1s and continuous equivalent sound pressure level, Leq,1s, as 1/3 octave band spectrum data;

timing for data recording: data acquired with a time basis of 1 second in order to permit the recognition of unusual events in the analysis phase;

timing for data transmission: data will be sent every hour;

data transmission network: the data will be transmitted through the 3G cellular telephonic network;

power supply: small solar panel (30cm x 20cm) and battery for energy storage or direct connection to electricity network;

sensors location: on streetlight or on façade, height 4 m above the ground level

sensor type: ¼ or ½ inch low-cost microphone with removable rain protection;

floor noise < 35 dB(A);

requency response at nominal frequencies of 1/3 octave within the class I specs ± 1dB.

Smart low-cost noise monitoring system – LIFE MONZA

Two **types of microphones** have been used:

for **sensors placed on poles** that use solar panel energy, in order to obtain high performances of energy efficiency, digital MEMS microphones, adapted onto a ½ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator;
for **sensors placed on façades** that use power supply connection, electret microphones have been used. For reasons related to shielding for electromagnetic compatibility they have been adapted onto a ¼ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.

LAeq,1s values which were lower than 35 dB and higher than 80 dB are automatically excluded as associated with exceptional events, which are not possible to recognize in real time, only in post-processing phase.

Smart Noise Monitoring System on site calibration procedure

The low-cost sensors challenge consists in maintaining network performance during long term periods of outdoor operation.
A preliminary check procedure and an on-site, long-term site verification procedure have been carried on.

Referring to the **long-term on-site**, the following time-stability verifications, four-months based, have been performed:
- 1 kHz calibration check: a calibration check at the frequency 1 kHz, by using a sound pressure class I calibrator;

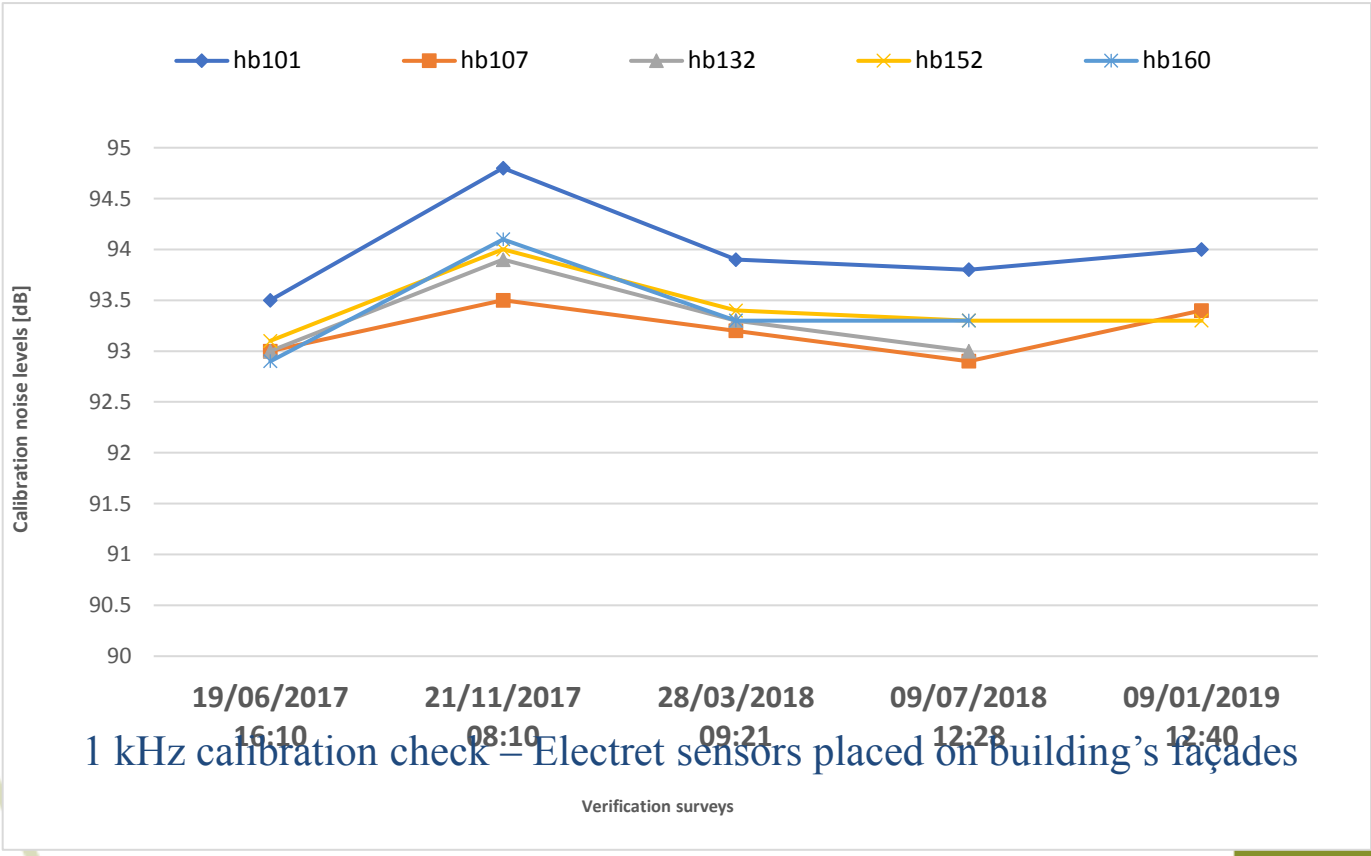
- broad band check: a comparison between the LAeq,30s obtained from the low-cost sensors and a class I equipment both subjected to the same broad band noise signal (e.g. pink noise produced by an electroacoustic equipment) in the range 45/105 dBA;

- measurements to determine free field correction in order to evaluate the correction necessary to move from the sensor position to a similar free field position, i.e. at least 1m from the pole for pole installations and 1m from the façade surface for façade installations.

Results of Smart Noise Monitoring System on site calibration procedure

Results obtained according to the application of the 1 kHz calibration check procedures are reported. For each SNMS a check procedure by using a class I, mono-frequency (1000 Hz) calibrator has been carried out during the on-site verifications.

Regarding the sensors placed on building's façades, the calibration noise levels turn out to be constant and generally between 93 dB and 94 dB.

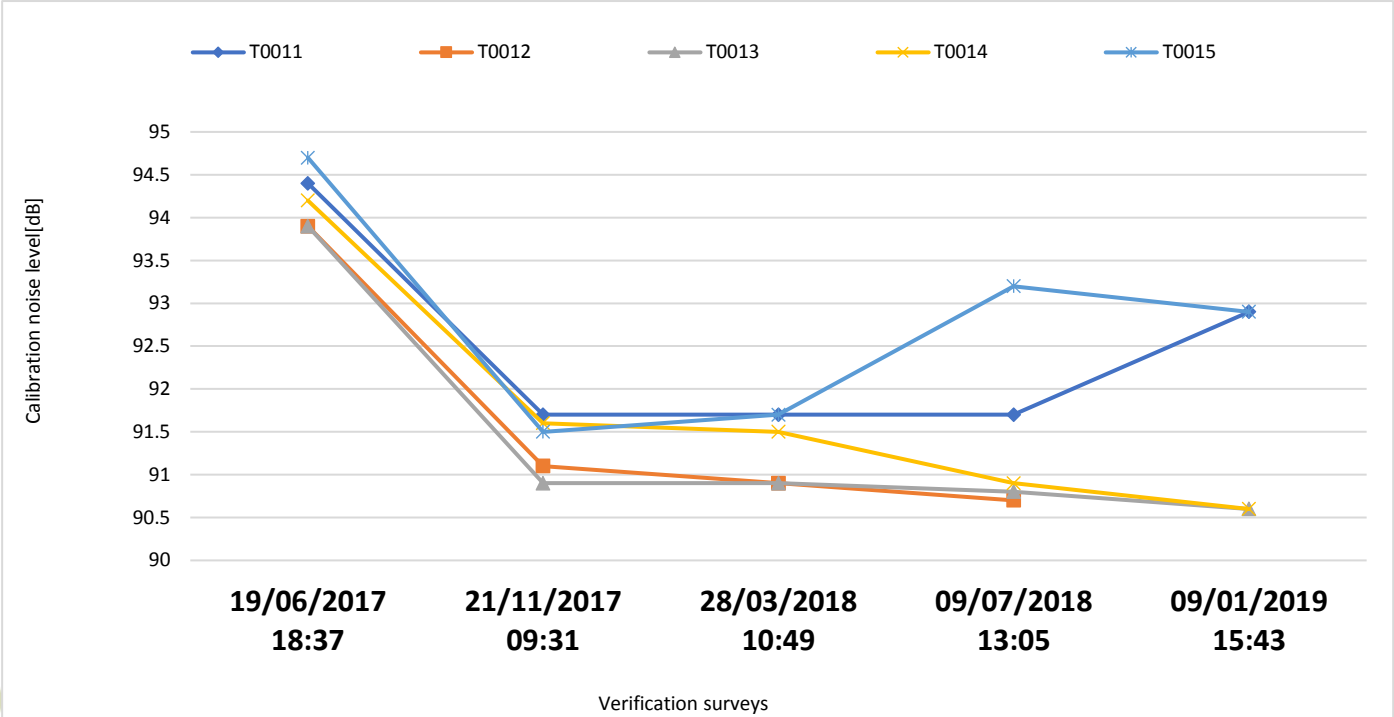


1 kHz calibration check – Electret sensors placed on building's façades

Smart low-cost noise monitoring system – LIFE MONZA

Results of Smart Noise Monitoring System on site calibration procedure

Regarding the sensors placed on poles it could be noted a reduction up to 3 dB of the calibration noise levels from the first to the second survey and, subsequently, a stabilization of the calibration values. Smart sensors T0011 and T0015 have been replaced before the calibration check



1 kHz calibration check – MEMs sensors placed on poles

Comparison of noise levels in ante and post operam scenarios

Analysis of the results obtained for Lday, Levening and Lnight by the low-cost sensors and class I systems

November 2017: differences in day and evening periods are due to the activities happened nearby of the entrance of Civic Centre, where the sensor is located and they have been not taken into account.
January 2019; about 3 dB between the sound pressure levels recorded by low-cost sensor and class I systems in all periods analysed (Day, Evening and Night time). Difference is due to the different position of the microphones.

	Period	Lday (06-20) [dB]	Levening (20-22) [dB]	Lnight (22-06) [dB]
Class I Instrumentation	Nov-17	59.5	58.8	56.5
Sensor HC101	Nov-17	64.6*	62.5*	59.2
	Difference	5.1	3.7	2.7
Class I Instrumentation	Jan-19	57.5	53.7	50.3
Sensor HC101	Jan-19	60.4	57.0	53.0
	Difference	2.9	3.3	2.7

Concerning the first results of ante and post operam measurement, using standard method: in the Evening and Night periods, there are 5-6 dB of reduction, due to the passages of only light vehicles and the conditions of the traffic, which is is fluid (low-noise laying mainly works on the rolling noise); during the Day there are 2 dB of difference, due to light traffic and different traffic conditions (stop and go).

Source: R. Bellomini, S. Luzzi, C. Bartalucci, F. Borchi, M. Carfagni, S. Curcuruto, R. Silvaggio; E. Mazzocchi, C.N. Casati. First results of activities carried out in the pilot area of LIFE MONZA project, Internoise 2019, 16-139 June 2019, Madrid.

AIR QUALITY Monitoring activities tested in pilot area

Four measurement campaigns were performed before the NLEZ implementation in Viale Libertà (inside the NLEZ, using a mobile laboratory) and at a fixed site, belonging to the regional air quality network, in the urban area of Monza (outside the NLEZ).

Measurements lasts 3 weeks during each seasons from spring 2017 to winter 2017/2018 and will be repeated during 2019/2020 with the same schedule.

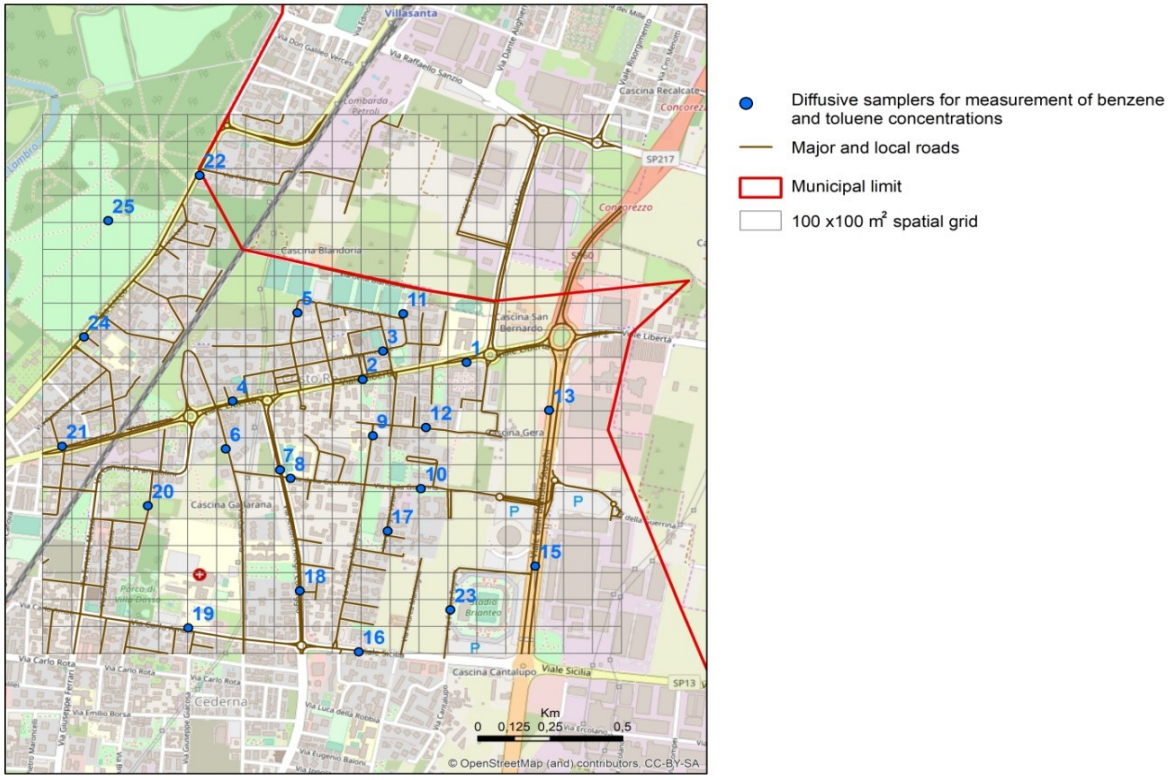
Hourly (SO2, CO, NO2, NOX, O3, benzene and toluene) and daily (mass concentration of PM10 and PM2.5) averages were measured using the respective European reference methods.

The data collected showed a marked seasonality for NO2, benzene, PM10, PM2.5 and Black Carbon, with much higher concentrations in the colder months of the campaign. The NO2 and PM10 concentrations measured within and outside the NLEZ, before implementation, fall within the range of the regional variability, typically found at urban traffic stations of the Milan agglomeration.

AIR QUALITY Monitoring activities tested in pilot area

In order to compare the spatial variability of traffic related air pollutant before and after the NLEZ implementation, toluene and benzene land use regression models in a 4 km2 around the NLEZ, will be developed. Benzene and toluene, as traffic sources indicators, were measured at 25 locations , using diffusive sampling technique within and outside the noise LEZ, in winter and summer (14 days each) before the noise LEZ implementation. Benzene mean concentration ranging between 0.20 (urban background, inside a park) and 0.83 µg/m³ (Viale Libertà), whereas in winter the range was 0.94 - 1.67 µg/m³. Air quality monitoring is carried out by Lombardia Enviromental Protection Agency.

Pilot area: diffusive samplers for measurement of benzene and toluene concentrations



SURVEY ON THE PERCEPTION OF LIVING CONDITIONS, NOISE, AIR QUALITY AND QUALITY OF LIFE IN PILOT AREA

In order to study **the effects of the actions foreseen by LIFE MONZA on the local social system**, a **diachronic survey** was designed and launched on the **social perception of living conditions, noise and air quality** in the Libertà district of Monza.

The first survey, already carried out, aimed at defining the ex-ante situation, the second, started in April 2019, aimed at defining the conditions detectable after the implementation of the infrastructural interventions and other measures foreseen by the project, in order to evaluate the changes occurred.

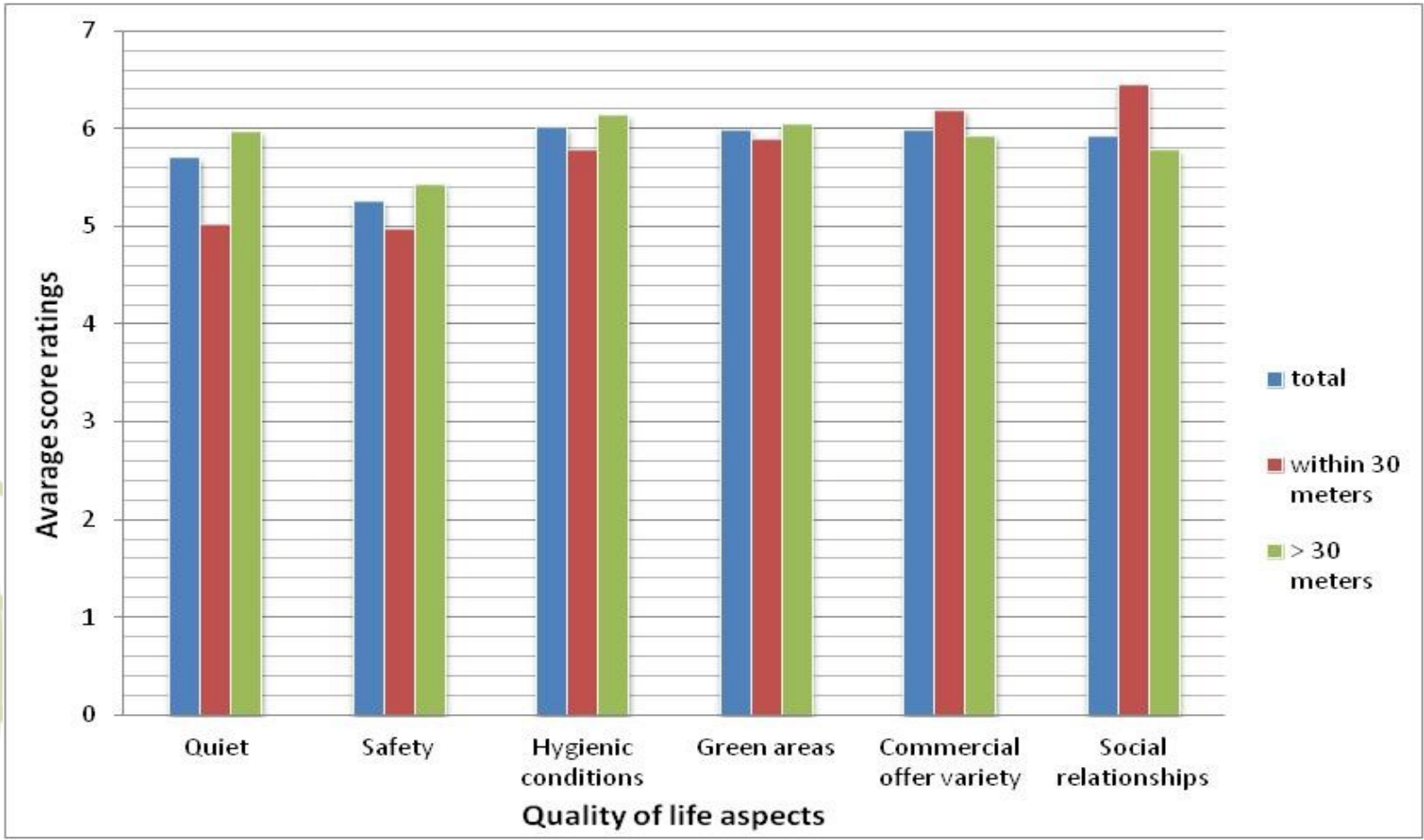
Concerning the **identification of the sample**, both for the pre and post test, a random sampling strategy stratified by **gender** (M / F), age (18-35 / 36-60 /> 60) and **positioning with respect to Viale Libertà** (≤30 meters/>30 meters) has been adopted.

Despite the limited number of responses, all types required in the sampling plan are represented and a certain proportionality between the different types has been respected. **Subjects living within 30 meters from Viale Libertà responded more consistently (97%** of the original sample, whereas for those residing over 30 meters, the coverage stops at 24%).

SURVEY ON THE PERCEPTION OF LIVING CONDITIONS, NOISE, AIR QUALITY AND QUALITY OF LIFE IN PILOT AREA

Results of the first survey (177 subjects; 31% of cases provided by the sample project), can provide some evaluating aspects. About noise, which seems to be perceived as a prevailing problem with respect to air quality, road traffic is identified as one of the main causes (91% of respondents).

the average score ratings on the quality of life in the neighborhood (total, for residents within and over 30 meters from Viale Libertà).



conclusion

Positive preliminary results, due to both top-down and bottom-up measures implementation can be found, especially concerning noise impact.

The completion of all monitoring campaigns and surveys even in post-operam phase will allow a completed and more detailed evaluation of the project actions.

Thank you for your kind attention

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