WP 2 – BE and SLOD: SoA, Risks and human behavior

T.2.1 - SoA-based definition and characterization of BE as network of buildings, infrastructures, connecting space in reference to SLOD occurrence and users' typologies

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Abstract

The air pollution and the heat wave represent the main SLODs that affect medium and large cities. Their combination is very common during the summer season. Heat and sunshine are two 'ingredients' that can intensify ground-level pollution by mixing with nitrous oxide gases (from sources like car exhausts) to create ozone, a pollutant. The aim of this report is to identify, starting from the findings of the Deliverable D2.1.1, a representative the Built Environment (BE) area of the City of Milan in which the air pollution and heat wave typically arises over the year due to multiple factors. The selected area is composed by different urban archetypes (the urban canyon and piazzale) connected each other in a complex system prone to produce negative effects on the population through amplification of the consequences of the exposure to the SLODs mentioned above. The report represents a preliminary description of a selected portion of the city that will be further analyzed by means of measurements and simulation tools to observe and verify how the structure of the BE can affect the perception of the two analyzed SLODs.

Keywords

Slow-Onset Disasters, Built Environment; Pollution; Urban Heat Island; Climate change, demographic analyses, BE characterization, case study investigation

Approvals

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Revision versions

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Summary

1. Introduction

Nowadays people have suffered, identified/recognized, or acknowledge the fact that being exposed to certain conditions for rather long periods, and or short periods of large frequencies generates a deterioration of their health. The arousal of SLOD evidence is bigger in urbanized context, and this evidence can be escalated given the inherent properties of the built environment. Thus, following the deductions made in Deliverable D2.1.1 certain convergence of features and eventualities could be predicted or identified to avoid harming the city's inhabitants.

In the European context, research work has been shared on the progression of the labelled critical SLODs (*increasing temperatures* and *air quality and pollution*), providing a notion on where these disasters are more prone to take place.

For instance, analyzing *air quality and pollution* from the annual mean average of PM2.5 in Figure 16 of DeliverableD2.1.1, Italy stands out as one of the most critical areas for Central Europe; in particular the regions of Piemonte, Lombardia and Veneto, even worse conditions have been drawn for the municipality of Milan. On the other hand, when studying the *increasing temperatures*: in Figure 9 of DeliverableD2.1.1, there is a widely spread of concentration of registered extreme temperature events between 1986 and 2015 in Central and Eastern Europe; also, Figure 1 displays a common trend in annual temperature increase of 0.3-0.35 °C between 1960 and 2018 for the same areas.

Thus, in northern Italy converge both considerable *increasing temperatures* and decay of *air quality and pollution* increase, rendering the country a useful case study to assess due to high *Hazard*. Which combined with large population density (Figure 2)., increases the risk of impacting a larger number of people.

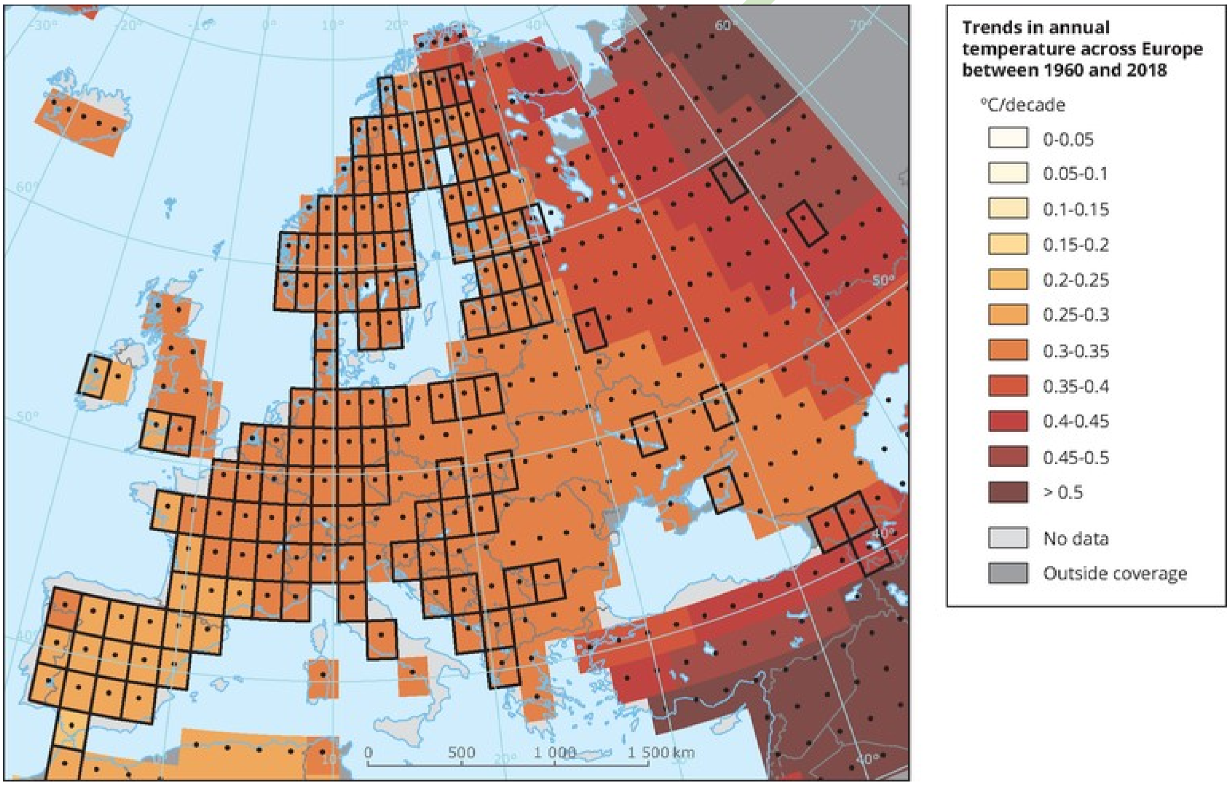


Figure 1 - Trends in annual temperatures across Europe between 1960 and 2018 (extracted from European Environment Agency)

The analysis of the exposition to Slow-Onset Disaster is twofold. When the impact of SLOD is evaluated, some demographic categories might be more disadvantaged than other, referred as the susceptibility of the population in D2.1.1. Therefore, to be certain of diminishing the rapid development of SLODs in these population categories (reducing *vulnerability*), the first step concerns the demographic analysis of old and

underage population in Milano. This analysis highlights the urban area where demographic categories are more present in the municipality.
The second step concerns determining the availability and analyzing the historical series related to air quality and environmental data. This information has been retrieved from the open data shared by the *Agenzia Regionale per la Protezione Ambientale* (ARPA).
Additionally, the Land Use Land Coverage (LULC) has been estimated to determine the potential benefits of greenery and estimate the density of the zones composing the built environment.
These analyses have been presented by dividing the built environment at the level of the *Nuclei di Identità Locali* (NIL). The results have guided the selection of a narrower area to assess, in which later on the features mentioned on D2.1.1 and §2.4 would be extracted and studied.
The presented deliverable presents in §3 the description of the case study highlighting how the selected and delimited BE is representative of areas in which the SLODs introduced and analyzed in the D1.1.1. affect human health by contributing to increase the mortality.

2. Italian context analysis

Recalling that northern Italy, is amongst Europe, one of the regions which is at higher risk of suffering conjointly the most critical SLODs. The *Pianura Padana* holds within major cities as Milano, Brescia and Bergamo. Glancing at the regional population, the Lombardy region presents he higher number of inhabitants (Figure 2).
This is a peculiar condition that lead at investigating mainly the cities belonging to this Italian region. Indeed, the Lombardy region presents approx. 40% more inhabitants than the second most populous region in Italy: Lazio.

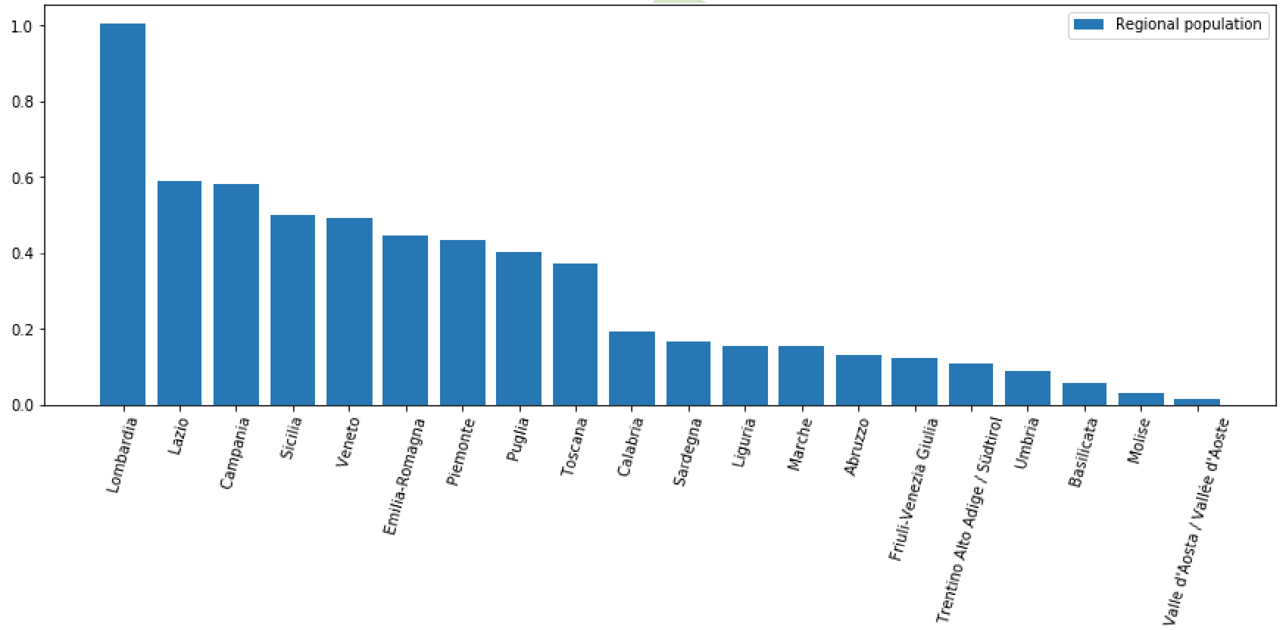


Figure 2: Total population by regions (data source: ISTAT, 1 Gen 2019) (ISTAT 2020).

Among the *Capoluoghi di Provincia* in Lombardia, Milan represents an exceptional case. Its population is ~6.5 times higher the other cities (it doubles Torino with ~1.3 Million inhabitants) given that it holds, in great number, national and international services attracting floes of city users from the whole nation and from abroad (e.g. industry, universities, healthcare). Also, as mentioned before, Milan displays favorable conditions for both assessed SLODs.

2.1 Demography maps

Vulnerable population has been located, according to the city's *Nuclei di Identità Locali* zonification. The demography data have been retrieved form the Comune di Milano open data website (Comune di Milano 2020).

This becomes the first layer of the matrix (i.e. crowdedness) to understand the severity of SLOD risks, as susceptible individuals belong to the *vulnerability* factor of the definition relationship for evaluating risk as a function of exposure, vulnerability and hazard.

As mentioned before, elder people fall into the category of susceptible to SLOD population. This, given the lower capacity of achieving an effective thermoregulation of their body; resulting in significant and dangerous dehydration during summer, while low metabolic heat production during winter (see D2.1.1 for more details). Also, their bodies have already been exposed to considerable amount of pollutants, or their lungs are not capable of assimilating such contaminated air and provide sufficient oxygen for their body organs.

Thus, the number of elder people (defined as >65) per NIL has been plotted and compared in Figure 3. Showing a rather big concentration on the *Buenos Aires – Venezia* and *Bande Nere;* followed by *Niguarda Ca'Granda* and *Gallaratese*. A third group is represented by NIL *CItta Studi, Loreto, Padova, Lodi-Corvetto, Villapizzone and Baggio.*

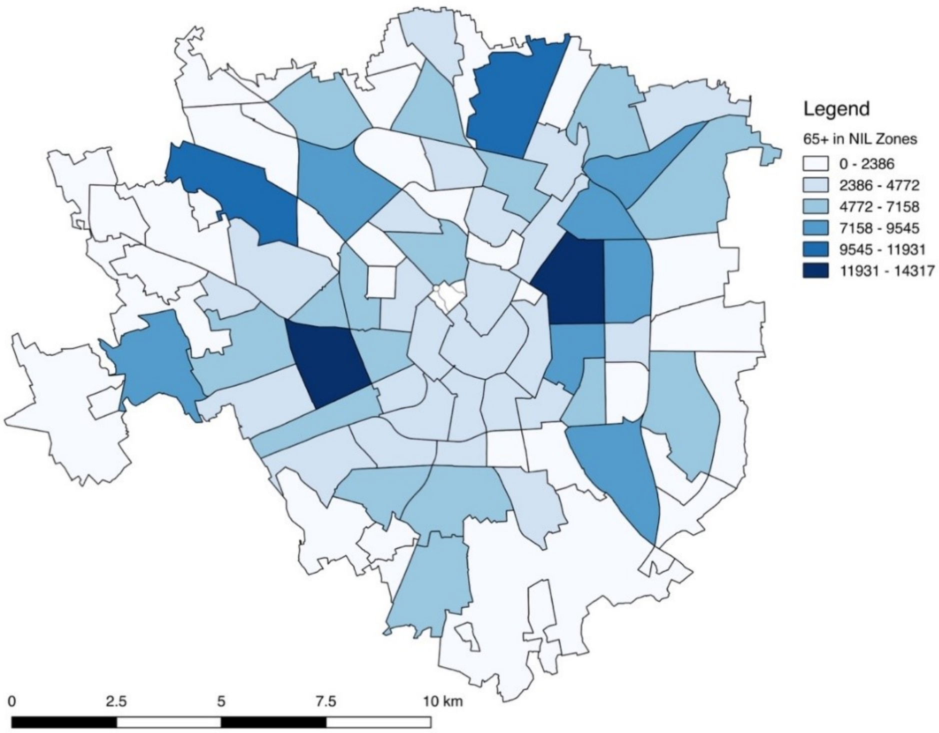


Figure 3 - Number of over 65 citizens in the Nuclei di Identità Locale (NIL) in Milano (2017).

The same risks suffer the children or underage. Their bodies are still developing, and their organs can be severely damaged if affected at this stage. Hence, the quantity of new born citizens located within the NIL has been compared in **Errore. L'origine riferimento non è stata trovata.**. Similar to the values obtained for elders, NILs in the North-East area of Milano are the one presenting an higher concentration of newborns. The *Buenos Aires* and *Venezia* represent the NIL which contains the most of young citizens.

Figure 4 - Number of new born citizens in Nuclei di Identità Locale (NIL) in Milano (2017).

2.2 Mapping crowding source buildings/institutions

The potential crowding source focal points for elders and youngsters have been identified and plotted on a map for the Milan municipality Figure 5. These are not meant only for the identification of risk areas based on the rough probability of having considerable quantity of people present. But they could help inferring also the probability of having a certain number of people which fall into the category of susceptible to critical SLODs (*increasing temperatures* and *air quality and pollution* as defined in D2.1.1).

For the elders, *Residenza sanitaria assistenziale* (RSA) e *Residenze Sanitarie per Disabili* (RSD) (Comune di Milano 2019) can be considered as the most critical crowding source focal points; while for the young, the *schools* were identified as potential meeting points. These were plotted in top of the density maps, to establish probable locations of larger risk according to their proximity (Figure 6 and Figure 7). This information can be incomplete as data on the locations of this building types are mostly available for public schools and entities.

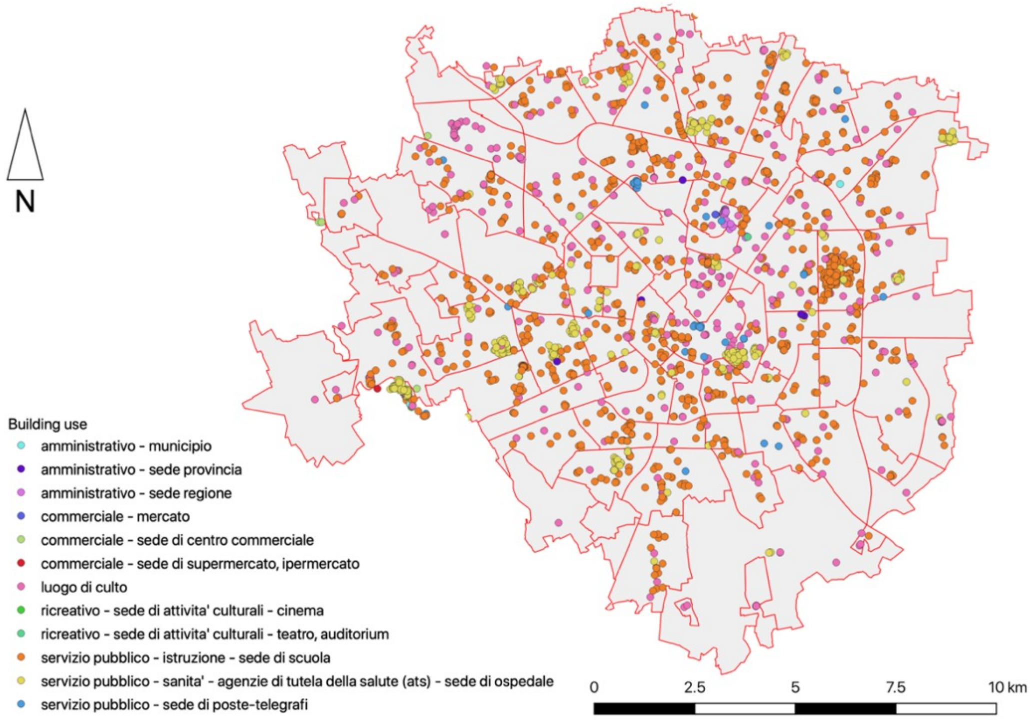


Figure 5: Building use (data source: Database Topografico Regionale - DBTR) (Regione Lombardia 2019).

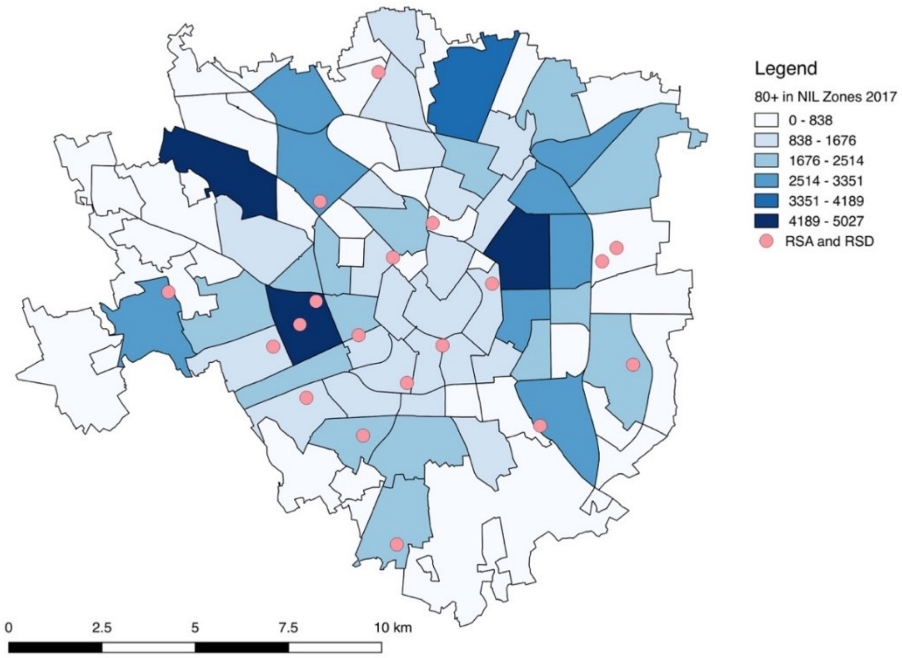


Figure 6 - Number of over 80 citizens in Nuclei di Identità Locale (NIL) in Milano and location of open RSA e RSD promoted by Regione Lombardia (2017).

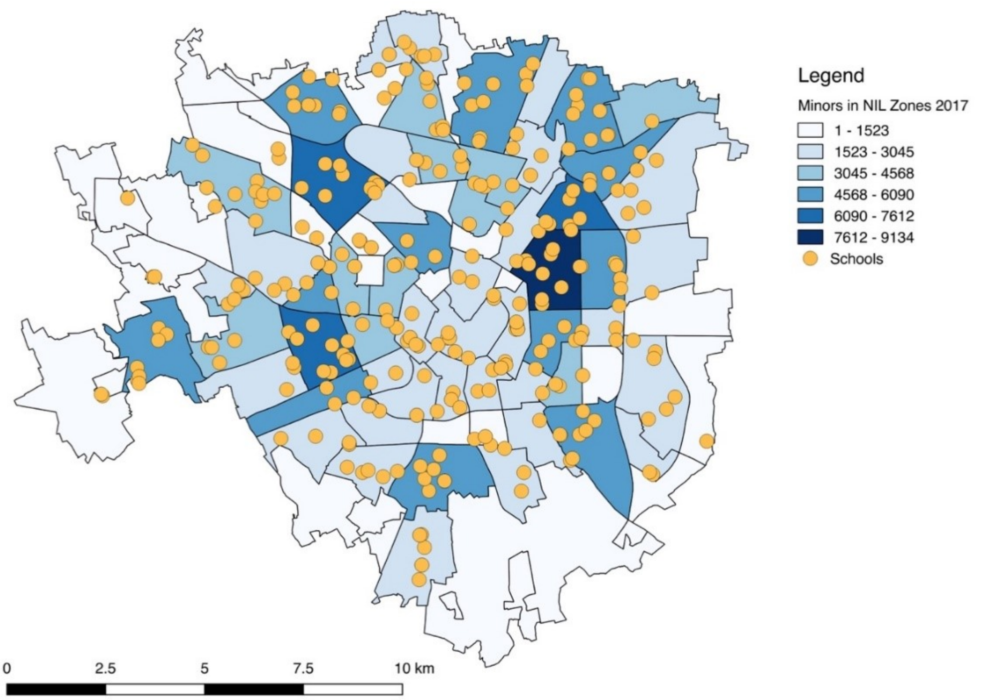


Figure 7: Number of minors in Nuclei di Identità Locale (NIL) in Milano and location of public schools (2017).

The areas reported as holding rather large numbers of youngsters, correspond to those displaying numerous school locations. For instance, both *Buenos Aires – Venezia* and *Città Studi* have a considerable amount of schools as well embed; in particular in Figure 7, *Città Studi* shows the highest concentration of *public services – education – school premises*.

2.3 Mapping environmental conditions data source

As the SLOD risk analysis requires the information coming from the recognized involved actors (*population, environmental conditions,* and *built environment characteristics*), and from these, the most variable is the environmental conditions of the analyzed context (even when they are considered at a certain degree periodic) it is key to map where the data is coming from.
Moreover, the conditions surveyed, have proven to vary significantly from site to another (See D2.1.1), thus, the information recorded of a site is relevant for a certain area of influence of the micro-climate in which this surveying system is immersed.
Furthermore, the surveying systems commissioned for retrieving and gathering useful data are commonly scarce (or not sufficient to cover the built environment unit). Thus, in order to perform an accurate SLODs risk assessment it is necessary to find the convergence of severity of built environment, susceptibility of population and harshness of environmental conditions; this last, depends entirely on the availability of reliable data.
Therefore, the location of air quality and weather-stations across the built area has been laid down in Figure 8 and Figure 9. And also, to evaluate to what extent the stations are equipped, the number and type of sensors held by each have been identified and condensed in Table 1.
Within Italy, the entity *Agenzia Regionale per la Protezione dell' Ambiente* collects and stores information on parameters affecting the environment. Hence, from this entity for the region of Lombardy, opensource data was obtained to analyze the environmental conditions that would shape the degree of severity of the SLODs risk in the city of Milan.

a. Location of the weather and air quality stations

In Milano there are 9 air quality stations, equipped with 63 sensors (see Table 1) detecting the air quality according to the following parameters:

- Ammoniaca
- Arsenico"
- Benzene"
- Benzo(a)pirene
- Biossido di Azoto
- Biossido di Zolfo
- BlackCarbon
- Cadmio
- Monossido di Carbonio
- Nikel
- Ossidi di Azoto
- Ozono
- Particelle sospese PM2.5
- Particolato Totale Sospeso
- Piombo
- PM10 (SM2005)

These monitoring stations have been mainly placed in the North-east side of the city, in both low-dense (e.g. station 1 and 8 in Figure 8) and high dense meso-scale environments (e.g. station 2, 3, 4 and 5 in Figure 8).

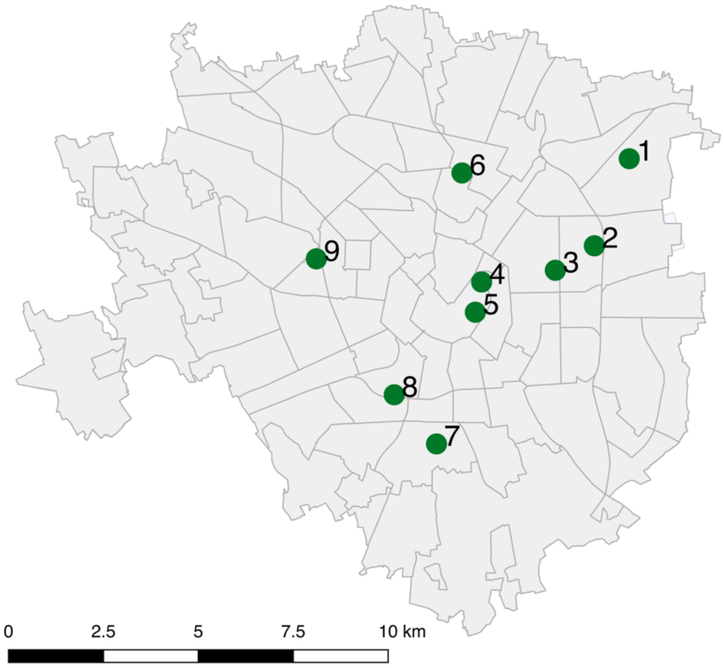


Figure 8: Map of the location of ARPA's air quality stations in Milano.

Table 1:Air quality parameters measured for each air quality station.

Map id	Station	Sensor code	Type of sensor
1	*Milano - Parco Lambro*		
		5722	Ozono
		5550	Biossido di Azoto
		6340	Ossidi di Azoto
2	*Milano - Pascal Città Studi*		
		17126	Benzene
		20020	Ammoniaca
		10282	Ozono
		12629	Benzo(a)pirene
		10278	Ossidi di Azoto
		12626	Cadmio
		12627	Piombo
		20004	BlackCarbon
		12624	Nikel
		12625	Arsenico
		10273	PM10 (SM2005)
		10283	Particelle sospese PM2.5
		10279	Biossido di Azoto
		10280	Biossido di Zolfo
3	*Milano - via Juvara*		
		5713	Ozono
		6637	Particolato Totale Sospeso
		5505	Biossido di Azoto
		6905	PM10 (SM2005)
		5625	Biossido di Zolfo
		10269	Ammoniaca
		9874	Particelle sospese PM2.5
		6312	Ossidi di Azoto
		12639	Cadmio
		17122	Particelle sospese PM2.5

Map id	Station	Sensor code	Type of sensor
		12641	Benzo(a)pirene
		12638	Arsenico
		6354	Ossidi di Azoto
		20005	BlackCarbon
		5834	Monossido di Carbonio
		5551	Biossido di Azoto
		10320	PM10 (SM2005)
		12637	Nikel
		12640	Piombo
		6057	Benzene
5	*Milano - Verziere*		
		6956	PM10 (SM2005)
		5725	Ozono
		5838	Monossido di Carbonio
		5531	Biossido di Azoto
		6366	Ossidi di Azoto
		5647	Biossido di Zolfo
6	*Milano - viale Marche*		
		5827	Monossido di Carbonio
		17127	Benzene
		5651	Biossido di Zolfo
		6328	Ossidi di Azoto
		6641	Particolato Totale Sospeso
		5504	Biossido di Azoto
7	*Milano - P.zza Abbiategrasso*		
		5552	Biossido di Azoto
		5637	Biossido di Zolfo
		6344	Ossidi di Azoto
8	*Milano - viale Liguria*		
		5542	Biossido di Azoto
		6639	Particolato Totale Sospeso

Map id	Station	Sensor code	Type of sensor
		5823	Monossido di Carbonio
		6320	Ossidi di Azoto
		5628	Biossido di Zolfo
9	*Milano - P.zza Zavattari*		
		6062	Benzene
		5650	Biossido di Zolfo
		6372	Ossidi di Azoto
		6651	Particolato Totale Sospeso
		5506	Biossido di Azoto
		5841	Monossido di Carbonio

Meanwhile, for monitoring the meteorological condition of the site, 10 stations have been found. All of them placed on the northern part of the city, but mostly on the east side. Their sensors have been listed in Figure 10, finding that they measure mostly air temperature, relative humidity and wind speed.

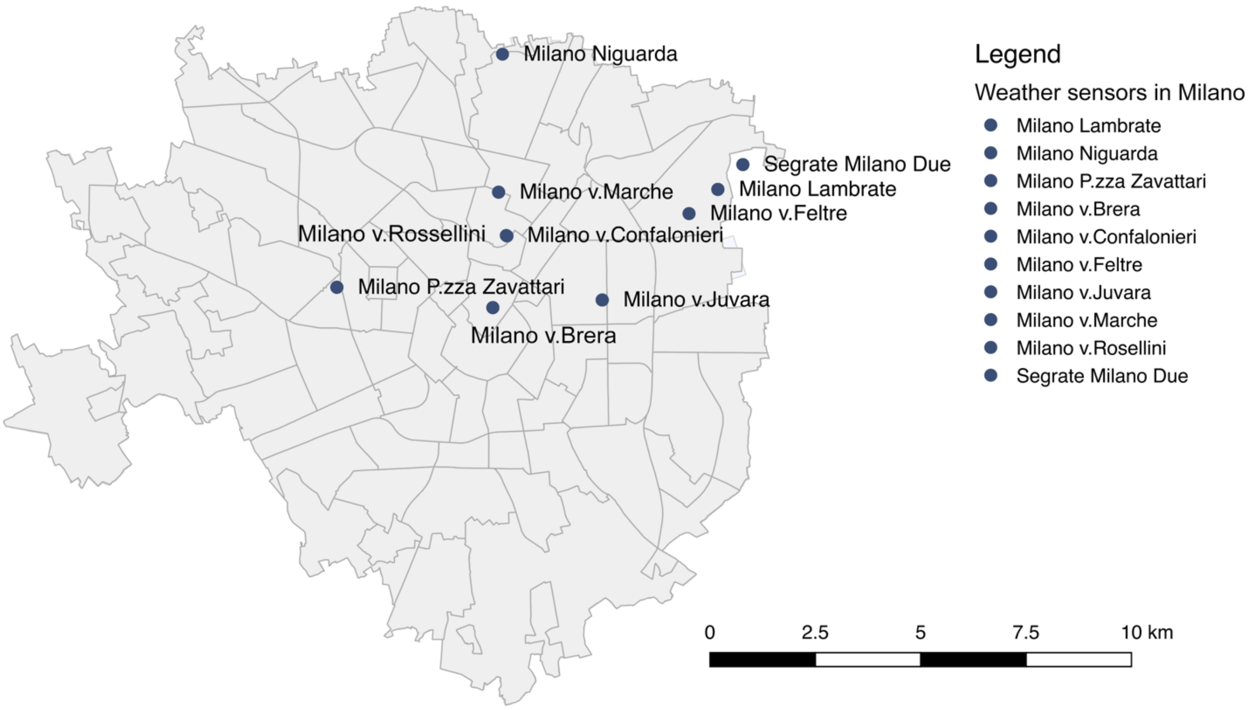


Figure 9: Location of ARPA's weather stations' in Milan.

Milano Lambrate	2006	Precipitazione	mm	100	Milano Lambrate	45.4968	9.25752
	2001	Temperatura	°C	100	Milano Lambrate	45.4968	9.25752
	2002	Umidità Relativa	%	100	Milano Lambrate	45.4968	9.25752
	2008	Radiazione Globale	W/m²	100	Milano Lambrate	45.4968	9.25752
	14391	Velocità Vento	m/s	100	Milano Lambrate	45.4968	9.25752
	14390	Direzione Vento	°	100	Milano Lambrate	45.4968	9.25752
Milano Niguarda	3118	Livello Idrometrico	cm	1425	Milano Niguarda	45.5258	9.19222
Milano P.zza Zavattari	5920	Temperatura	°C	503	Milano P.zza Zavattari	45.4761	9.14179
	19005	Velocità Vento	m/s	503	Milano P.zza Zavattari	45.4761	9.14179
	19006	Direzione Vento	°	503	Milano P.zza Zavattari	45.4761	9.14179
	6185	Umidità Relativa	%	503	Milano P.zza Zavattari	45.4761	9.14179
	9341	Precipitazione	mm	503	Milano P.zza Zavattari	45.4761	9.14179
Milano v.Brera	19008	Velocità Vento	m/s	620	Milano v.Brera	45.4717	9.18911
	19374	Radiazione Globale	W/m²	620	Milano v.Brera	45.4717	9.18911
	5897	Temperatura	°C	620	Milano v.Brera	45.4717	9.18911
	19373	Precipitazione	mm	620	Milano v.Brera	45.4717	9.18911
	19009	Direzione Vento	°	620	Milano v.Brera	45.4717	9.18911
	6174	Umidità Relativa	%	620	Milano v.Brera	45.4717	9.18911
Milano v.Confalonieri	8149	Precipitazione	mm	890	Milano v.Confalonieri	45.4871	9.19323
Milano v.Feltre	8125	Livello Idrometrico	cm	869	Milano v.Feltre	45.4916	9.24874
	8162	Temperatura	°C	869	Milano v.Feltre	45.4916	9.24874
Milano v.Juvara	19244	Direzione Vento	°	502	Milano v.Juvara	45.4732	9.22232
	5908	Precipitazione	mm	502	Milano v.Juvara	45.4732	9.22232
	19243	Velocità Vento	m/s	502	Milano v.Juvara	45.4732	9.22232
	5909	Temperatura	°C	502	Milano v.Juvara	45.4732	9.22232
	6179	Umidità Relativa	%	502	Milano v.Juvara	45.4732	9.22232
	6458	Radiazione Globale	W/m²	502	Milano v.Juvara	45.4732	9.22232
Milano v.Marche	6597	Umidità Relativa	%	501	Milano v.Marche	45.4963	9.19093
	19020	Velocità Vento	m/s	501	Milano v.Marche	45.4963	9.19093
	5911	Temperatura	°C	501	Milano v.Marche	45.4963	9.19093
	19021	Direzione Vento	°	501	Milano v.Marche	45.4963	9.19093
Milano v.Rosellini	14121	Precipitazione	mm	1327	Milano v.Rosellini	45.487	9.19347
Segrate Milano Due	2064	Umidità Relativa	%	104	Segrate Milano Due	45.5021	9.26513
	2065	Precipitazione	mm	104	Segrate Milano Due	45.5021	9.26513
	2063	Temperatura	°C	104	Segrate Milano Due	45.5021	9.26513

Figure 10: ARPA's weather stations data type in Milan, together with the sensor ID and coordinates.

The most equipped stations happened to be within the NILs *Buenos Aires – Venezia* and *Città Studi.*

2.4 Mapping built environment features

The built environment features would determine both the severity of the *Physical vulnerability* and the intensity of the *Hazard* linked to the SLODs risk occurrence on the hosted inhabitants.

These features shall be measured appropriately according to the dimension scale of the area in which the analysis is performed. That is, there are certain parameters that would easily be more sensible to estimate the risk therefore the following categories have been established (Figure 21 in D2.1.1):

- **District:** Mainly related to LULC.
  - Urban fabric (built surface area and volume).
  - Streets.
  - Greenery (green area coverage).
  - Water bodies.
- **Canyon / Piazza:**
  - Density and geometry (e.g. height [h], width [w], aspect ratio [h/w], volume, orientation).
  - Greenery and trees presence and coverage.
  - Street and sidewalk size (i.e. width [w]).
- **Building**
  - Type of roofing.
  - Façade geometry.
  - Access (interface with pedestrians).
- **Surfaces**
  - Materials (mainly related to albedo).

Some of these have been assessed progressively in the following chapters, gradually as the scale of the analysis area is narrowed down. This scaling down analysis led as well to the delineation of a small area that would serve as a study case for a rather human-scale analysis. Thus, the remaining parameters are meant to be tackled in the following Work Packages of the project (D2.2.1 and D2.2.2).

Regarding LULC, dividing the city into zones by their NIL, the total greenery area coverage has been compared in Figure 11, while the density of the built environment has been described in Figure 12. Moreover, to define the volumetric density of the built elements Figure 13 is presented, the last could serve as an insight of the actual wind flow within the built environment and solar radiation influx.

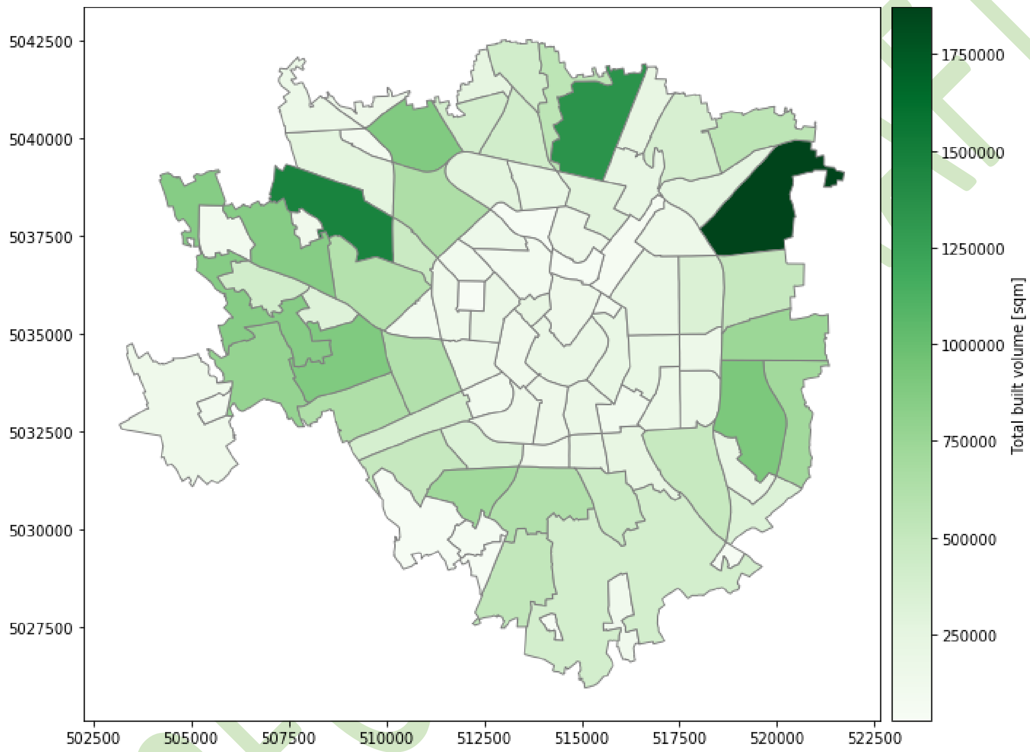


Figure 11: Total green areas coverage per Nucleo di Identità Locale.

It is clear how in the outskirts of the municipality, larger greenery areas identified, in particular the one for *Parco-Lambro – Cimiano* and *Gallaratese.* Most of the areas in which more vulnerable population was found, such as *Buenos Aires – Venezia* and *Bande Nere* were found scarce for the presence of greenery, ad exception of *Gallaratese and Niguarda Ca'Granda.*

Then, *Buenos Aires – Venezia* and *Duomo* areas are reported as the densest in terms of built area and volume. It Is interesting to note the shift in area to volume density of certain areas, such as Viale Monza in which the built surface area is considerable, but the built volumes are rather average-low. These areas, although dense favor wind flux decreasing the severity of the built environment (see §5 in D2.1.1). Meanwhile, *Buenos Aires – Venezia, Duomo, Brera* and *Città Studi* maintained their above average density condition.

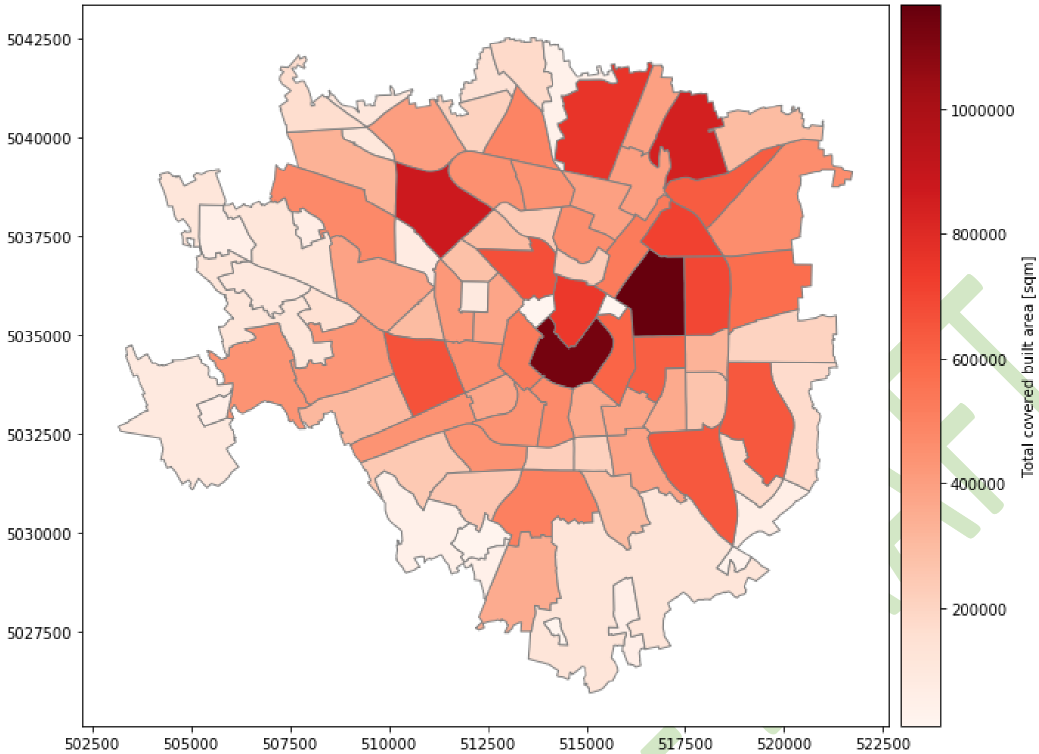


Figure 12: Total built area (Superficie Coperta - SC) in the Nuclei di Identità Locale.

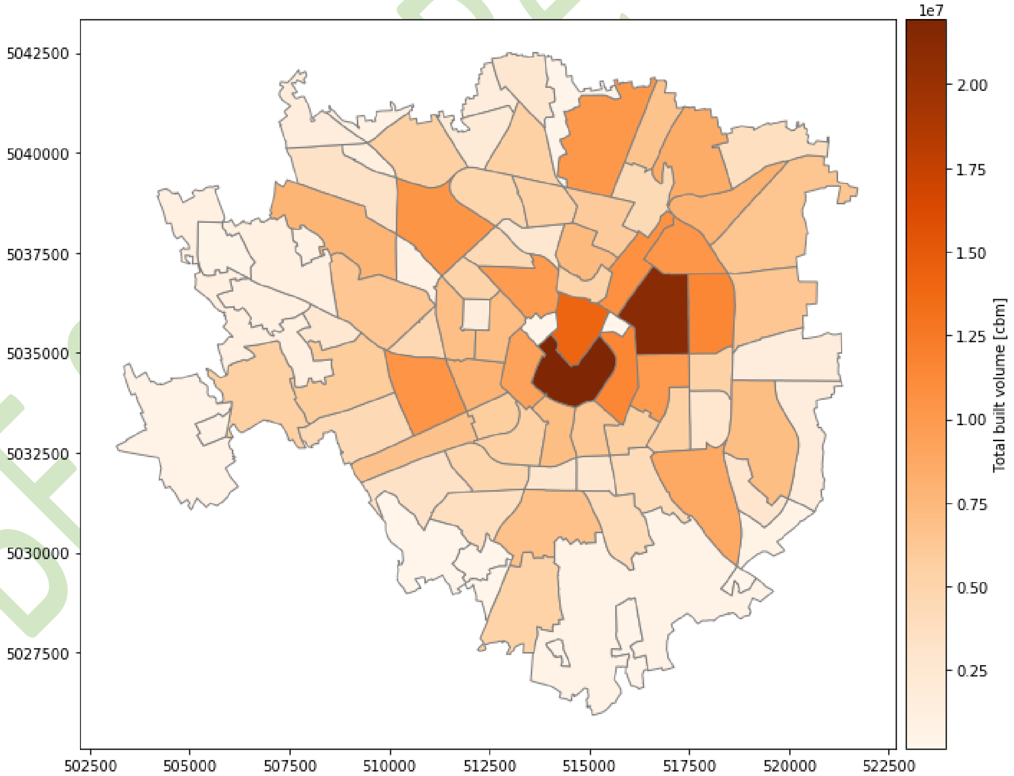


Figure 13: Total built volume in the Nuclei di Identità Locale.

2.5 Analyzing and comparing site-specific conditions from data sources

A testing procedure was carried out to demonstrate how different the readings from one station to another can be according to the context surrounding the sensor. The values used in the comparison correspond to 2016, where all the sensors had sufficient and reliable data stored in the servers accessed. In fact, 2019 values are unreliable.

For example, taking stations from the NIL *Parco-lambro, Citta Studi* and *Buenos Aires – Venezia,* that allow to compare respectively low density and green areas to dense and rather "grey" areas; the cumulative difference function (Figure 14) computed every hour (P*arco-Lambro – Citta Studi*) goes above 2000 μg/m^3 in the first month (January), for an average larger than 3 μg/m^3 every hour. Moreover, the maximum single registered μg/m^3 difference peaked 76; and the 1 quartile of the hourly collected differences data are reported above 7.1 μg/m^3.

In addition, when comparing air temperature (Figure 15) to expose the evidence of Urban Heat Island (UHI), the yearly mean air temperature values for the denser area (*Juvara*) is 1 °C higher than the other (*Parco-Lambro*). Also, the maximum difference encountered was 8.1 °C higher for the more urban condition, and half of the hourly data fall between 0.6 and 8.1 °C.

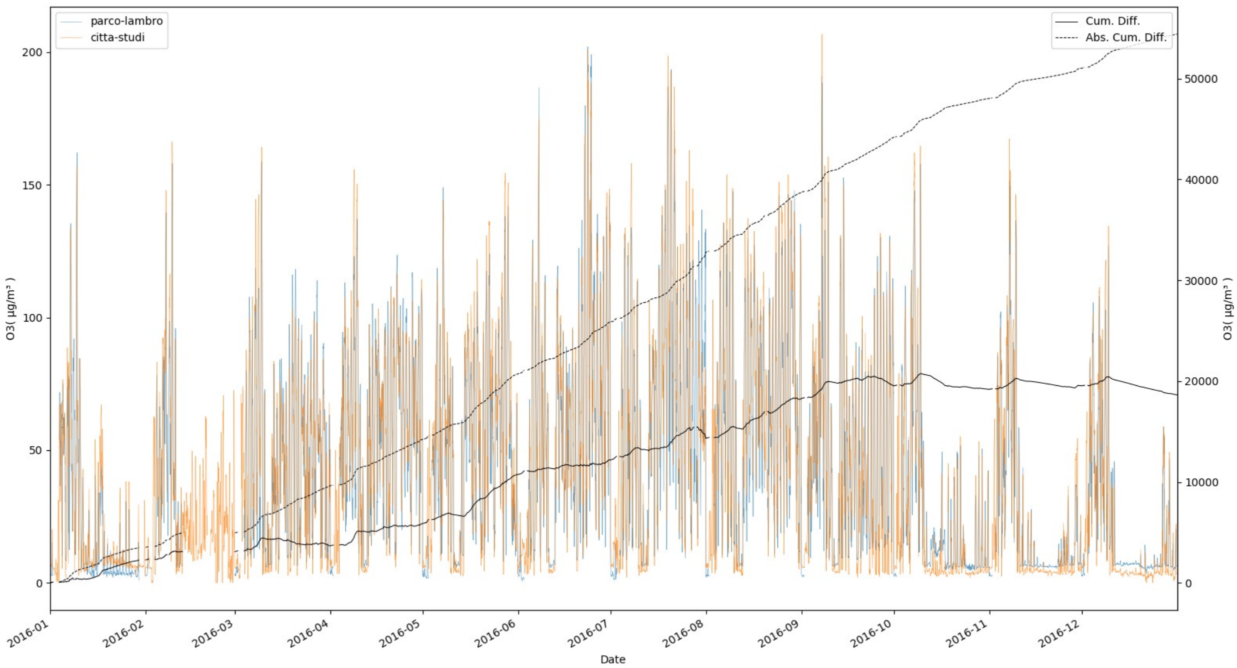


Figure 14: Ozone concentration comparison between Parco Lambro (large greenery coverage) and Città Studi (low greenery coverage)

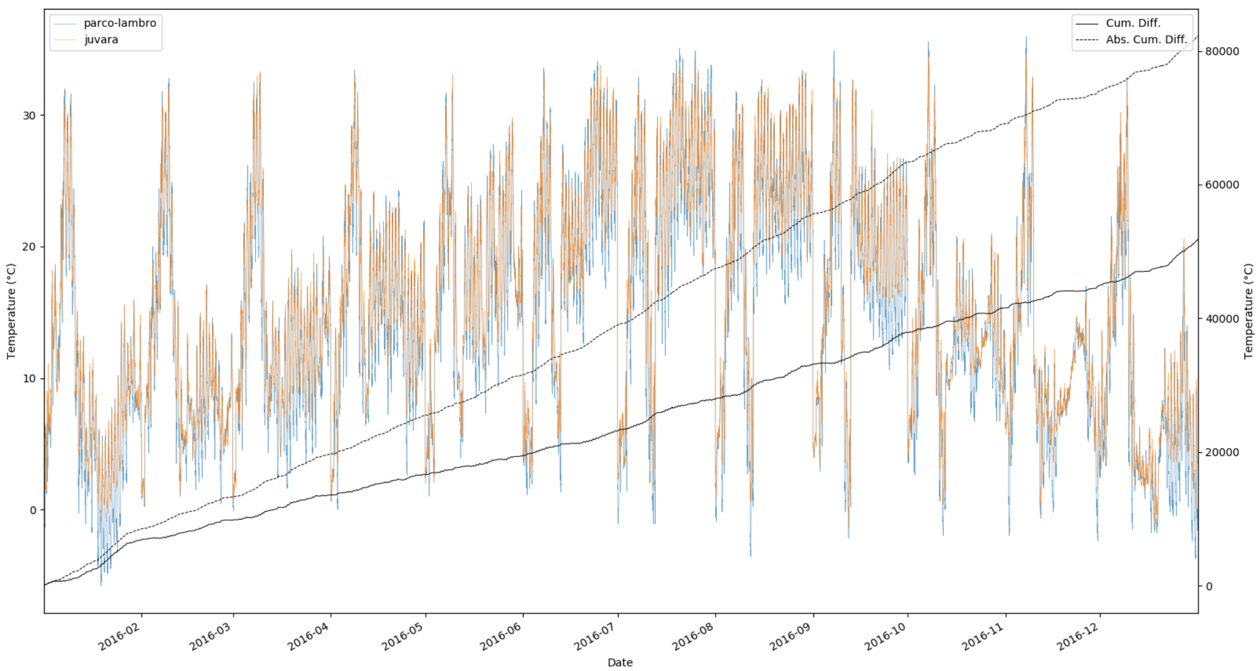


Figure 15: Air temperature comparison between Parco Lambro (large greenery coverage) and Juvara (low greenery coverage)

These corroborates the trend of higher air temperature and pollution concentration in denser areas with lower greenery coverage; and also, the trend of lower pollutant absorption/dilution capacity. Actually, the station in P*arco-Lambro* displayed 10% less frequency of reported readings above the suggested healthy limits of O_3 concentration in the air (Figure 12 D2.1.1) and 10% more of air temperatures above 26°C (typical buildings' HVAC cooling set point (EN-ISO-7730 2005) when compared to *Citta Studi* and *Juvara* respectively. Eventually, data concerning the demography and geometric characteristic of the neighborhoods in the city of Milan, have been collected and ranked in Table 2 allowing to select the most significant areas of the city on which to accomplish further analyses.

Table 2: Ranking of neighbourhoods in Milan where meteo stations and AQ sensors are located.

Neighborhood	Tot inhab.	Tot A [m²]	65_ratio	Minori_ratio	Green [m²]	SC [m2]	Volume [m³]	Schools
Parco Lambro - Cimiano	19546	4971970	28,4%	14,2%	1871305	464428	6500108	20
Niguarda - Cà Granda	36795	4251282	27,1%	14,7%	1350501	763687	10173958	23
Città Studi	36232	2207487	25,3%	13,6%	339461	693885	11507446	25
Guastalla	15050	1548021	24,7%	15,3%	213601	604518	11555550	41
Buenos Aires - Venezia	61891	2877542	23,1%	14,8%	195787	1167669	21239789	22
Brera	18199	1637395	23,0%	16,4%	148339	746217	14056048	21
Duomo	16882	2341704	22,2%	16,1%	199811	1132538	21936364	20
Stadera	30100	3232237	22,2%	16,2%	625291	508502	6850990	22
Selinunte	26576	984926	21,2%	17,5%	113070	296239	4652911	5
Isola	22896	1322966	20,1%	14,0%	149915	465252	7345541	15
Navigli	17122	1483928	19,8%	14,7%	147594	445102	5517992	7

For ranking the neighborhoods, corresponding to the NIL, only those containing at least one meteorological station or one AQ station have been selected. Moreover, for carrying out further analyses, the following parameters have been considered:

- *65+_ratio*, calculated as the ratio between the number of inhabitants aged 65 years or more and the total inhabitants (*Total*)
- *Minor_ratio*, namely the ratio between the number of under-aged inhabitants over the total inhabitants (*Total*);
- *Green* is a parameters indicating the total surface of green areas per neighbor;
- *SC (Superficie Coperta)* is the built surface in the neighborhood;
- *Volume* is the total built volume in the neighbor;
- *Schools* is the total number of schools (nurseries, primaries, middle and high schools).

These parameters inform on the characteristics of the neighborhoods and allow to choose the most suitable area on which to implement the further analyses. Figure 16 represents the parameters above mentioned, ranked according to the number of the *65+_ratio.* The Città Studi neighborhood has been chosen as case study area since is one of the most representative of the considered parameters. The Parco Lambro and Niguarda neighborhood have not been considered since they present a Green parameter to high to be reliable, since it could deeply affect the next investigations on the effects of the heat island and air pollution on the BE. Moreover, the next step of the research concerns the investigation of the micro-scale BE related to the effects SLOD agents on the population. This analysis will be done thanks to the employment of portable sensors recording, pollution, climate data and the geographic positioning. For increase precision and accuracy, a Real-time kinematic correction will be used: a technology freely available in Città study neighborhood. This is a further reason why the Città Studi neighborhood has been chosen.

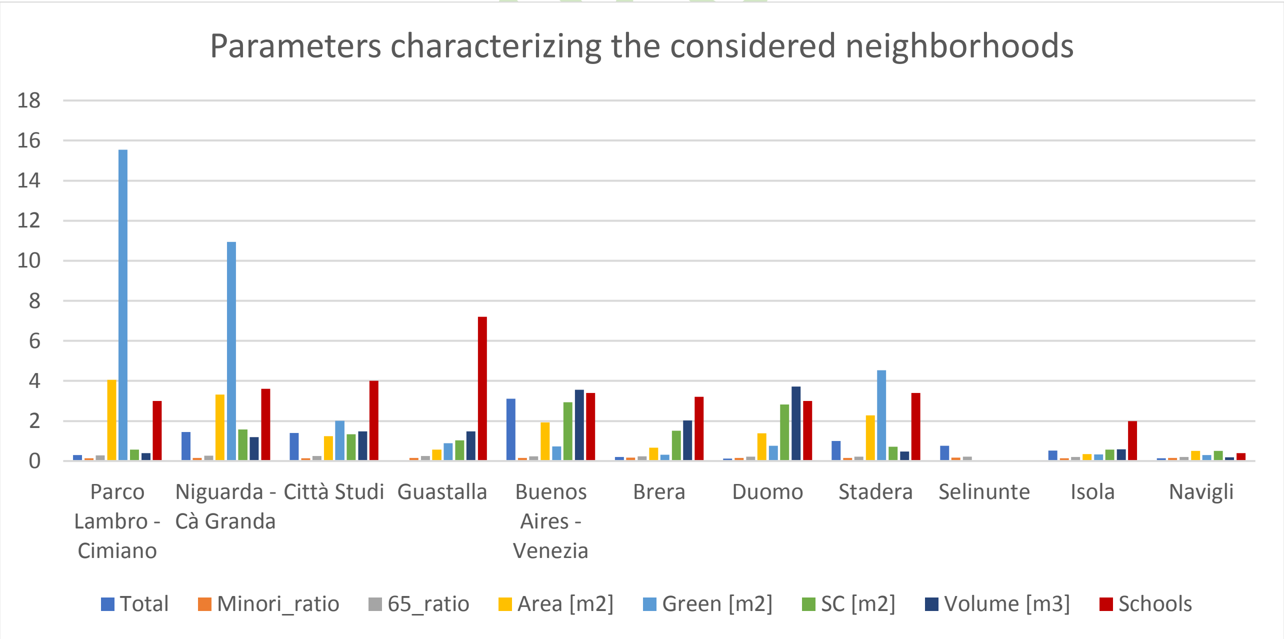


Figure 16: Features of the considered neighborhoods.

3. Case study selection and description

The selected case study is located in the North-Est area of Milano city in the so called Città Study – Lambrate district. The area is represented by a high population density with heterogeneous infrastructure and built environment typologies.

In particular, the NIL area of *Città Studi* represents a rather distinct area, in which: an average concentration of susceptible population can be found; 2 RSA RSD are located near the boundary limits; a considerable number of schools are hosted; 1 reliable data source for monitoring air quality is within the boundary limits (*Milano - Pascal Città Studi*) and one more adjacent was found for supervising both air quality and weather fluctuations (*Milano - via Juvara*); rather low greenery area coverage (a minimum amount is desired to test its convenience) and fairly high built surface area and volume coverage.

3.1 Insights data and delimitation of the case-study

This NIL delimited area has nearly 30% of its total plan area dedicated for the construction of building units, while 15.4% has been used for greenery space (mainly the area allocated for grass, bushes and other greenery types). That is, nearly half of the space (55%) is currently, allocated for infrastructures, streets, sidewalks, parking etc. (Table 3).
The neighborhood was born around the universities (Politecnico di Milano and Università degli Studi di Milano) and later important public buildings were added such as the Institute of Cancer and the National Institute of Neurology Besta. The neighborhood is served by two stops of the underground (Piola and Lambrate) and is located 600 m far from a regional railway connection represented by Lambrate station. Several green areas surround the area, starting from P.za Leonardo da Vinci, to Giuriati sport facilities and piscina Ponzio swimming pool.
has been done for understanding better the disposition of the areas, its features and also for identifying criticalities of the built environment. It includes the location of different buildings that represent crowding sources, the location of the relevant data sources (weather and air quality monitoring stations) and the classification of the existing public facilities (e.g. universities, hospitals, schools, health).

Table 3: Nucleo di Identità Locale Città Studi key LULC data.

Data	Values	Percentage
Total surface area	2,207,487 m^2	
Total Built area	694,201 m^2	29.4 %
Total built volume	11,507,445 m^3	
Total green surface	339,461 m^2	15.4 %

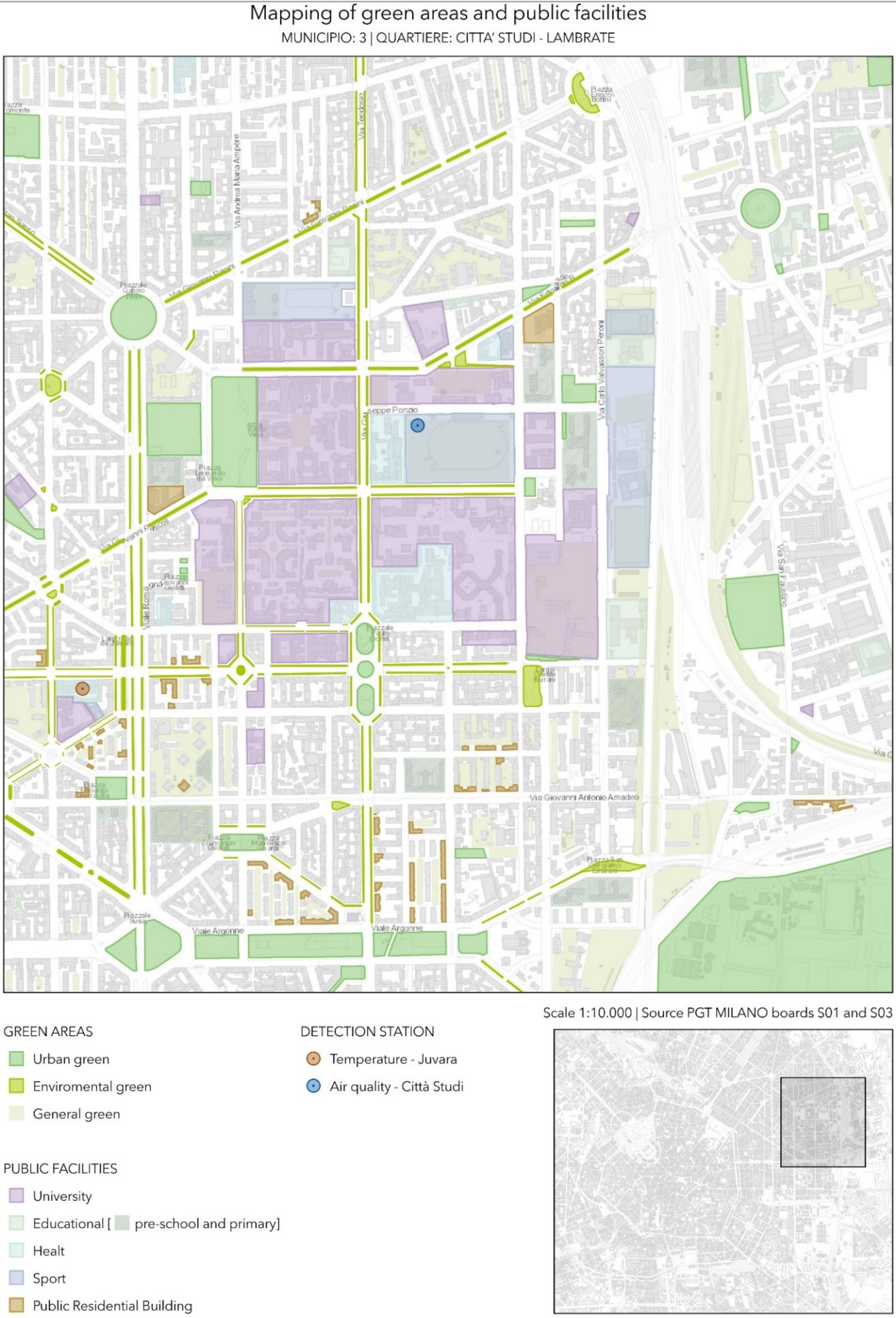


Figure 17: Urban analysis of the Lambrate - Città Studi area. The red triangle represents the selected case study area.

Table 4: Key demography data for NIL Città Studi in 2017.

Variable	Value	Percentage
Men	16754	46,2%
Women	19478	53,8%
Total	36232	100,0%
Underaged	4935	13,6%
Foreigners	5303	14,6%
Families	18322	50,6%
One-person families	8513	23,5%
Lone over 80	1606	4,4%
Newborn	248	0,7%
Deaths	389	1,1%
Emigrates	1331	3,7%
Immigrates	865	2,4%
80 plus	3318	9,2%
65 plus	9171	25,3%
Infant schools (number)	7	
Primary schools (number)	8	
Middle schools (number)	5	

Therefore, it is reasonable to infer that the selected NIL is an active neighborhood, frequented during the day by thousands of people (from all age ranges); and from the demographic data gathered from ISTAT (2020) and summarized in Table 4, the NIL *Città Studi* holds a diverse population, with large susceptible groups. For instance, ~39% of the residents of this area are either over 65 or under 18; from which ~9 % are over 80 years old.

3.2 Description of the specific Built environment area for the SLOD risk analysis

To achieve a much-detailed analysis on the parameters of the built environment, and in specific, of the way the built elements are designed and constructed, a reduced, but representative, area has been selected for the future analysis (see demarcated in Figure 18). The specific analyzed plot is located in the Città Studi area and includes different urban built environment types (such as *Piazzale type (a), urban canyon (a) and (c)* from the archetypes defined in D2.1.1), holds potential crowding points, a nearby waterbody and embed greenery. Figure 18 presents a perspective view of the plot, with nearby focal crowding points that contribute to the population flow within the canyons.

Figure 18: Aerial view of the case study area. (Extracted from: Google Earth)

In addition, as presented for the intermediate scale (i.e. NIL *Città Studi*), the demographic characteristics of the delineated plot have been collected and age-related information has been represented in Table 5. This time, more granular data has been reported. For this region, ~31% of the residents' population is over 65 years-old, and 2.5% are toddlers; hence 1/3 of the residents fall within the age-related susceptible group when dealing with *personal physical vulnerability*.

Table 5: Key demographic data of the case study area

Variable	Value	Percentage
Age 10 - 14 Years-old	12	3.0%
Age 15 - 19 Years-old	18	4.6%
Age 20 - 24 Years-old	10	2.5%
Age 25 - 29 Years-old	16	4.1%
Age 30 - 34 Years-old	21	5.3%
Age 35 - 39 Years-old	35	8.9%
Age 40 - 44 Years-old	35	8.9%
Age 45 - 49 Years-old	28	7.1%
Age 5 - 9 Years-old	19	4.8%
Age 50 - 54 Years-old	26	6.6%
Age 55 - 59 Years-old	20	5.1%
Age 60 - 64 Years-old	23	5.8%
Age 65 - 69 Years-old	29	7.3%
Age 70 - 74 Years-old	38	9.6%
Age < 5 Years-old	10	2.5%
Age > 74 Years-old	55	13.9%
Female	230	58.2%
Italian	371	93.9%
Male	165	41.8%
Total residents	395	100.0%

This narrowed area is characterized as well by busy roads that run between a variety of canyons composed by multi-story buildings of diverse façade materials. The dense urbanized area represents a perfect case study to analyze the effects of the islands of heat and concentration of pollutants that are worsen in the presence of certain materials used in flooring and buildings' surfaces. Also, the case study offers the opportunity to analyze roads with different orientations and different types of buildings that characterize the road sections.

This study is also fundamental for assessing the risks on the most vulnerable categories, for example children and the elderly (given the presence of health and educational facilities), when immersed in a heterogeneity of canyons. It allows to study wider and busier avenues, but also with tree-lined stretches and compare them with narrower streets, but without any presence of green areas. These parameters are hereby further described:

a. Block description and building functions

The narrowed area is mainly composed of residential buildings, quipped with commercial services on the ground floor, as shown throughout Figure 19, Figure 20 and Figure 21.. However, there are buildings with the potential to evoque crowding, such as *daycare* (Figure 19)*, theater* (Figure 20)*, church, kindergarten and High-school* (Figure 21).
These building types, by nature, frequently summon a considerable amount of people during particular hour ranges which might coincide with problematic SLODs conditions. These eventualities shall be identified while gathering more granular and localized data..

Figure 19: Western area block description and functions held

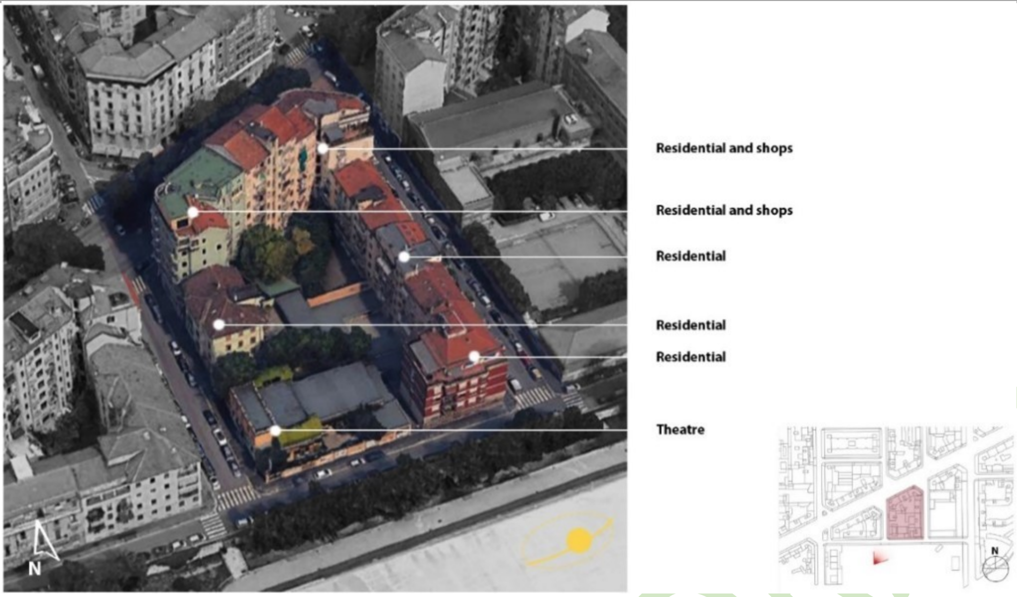


Figure 20: Central area block description and functions held

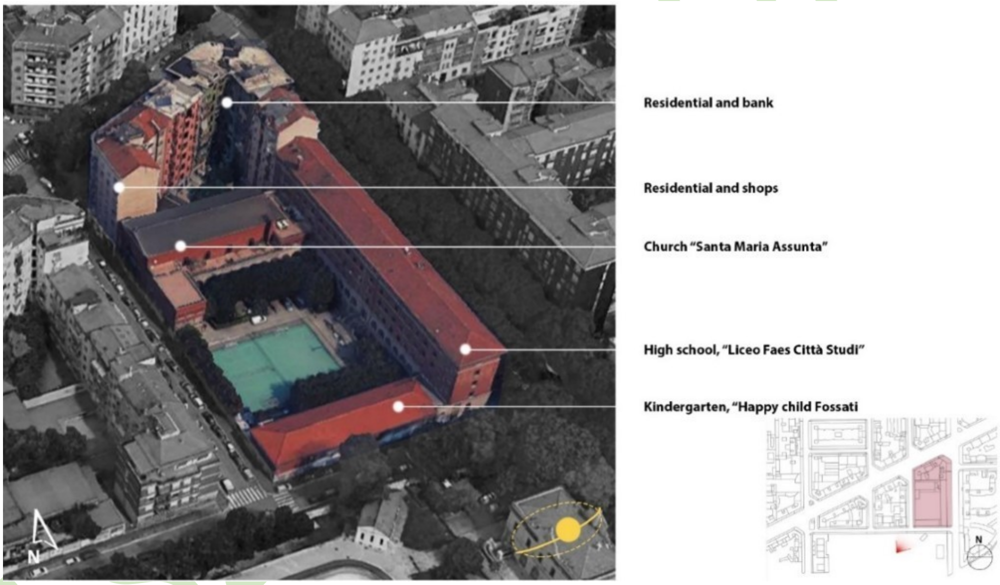


Figure 21: Eastern area block description and functions held

3.3 Description of the potential SLODs' hazard and physical vulnerability of the specific Built environment area

The *hazard* and *physical vulnerability* components of the risk assessment are closely related for SLODs. The *hazard* can be greatly diminished by low *vulnerability*, resulting in a much lower risk.

a. Density and geometry

For example, in terms of *Increasing temperatures* the *physical vulnerability* can be low when the affected population is located under the shadow (no direct radiation) and the surrounding surfaces have a rather low temperature. Thus, it is important to understand the behavior of the shadows, or the potential shadow tan an element inserted in the area might provide. That is the case for Figure 22, where the shadow analysis has been performed at different hours of the day in winter season.

The shadows projected by the built environment are closely related with the building, or block, density, geometry (aspect ratio) and orientation. Specially as the sun altitude and position varies during the day and along the year.

b. Street and sidewalk size

People would rather walk by shaded paths during summer, but sunny ones during winter. This choice is limited by the disposition of sidewalks, and their "degree of occupation". That is, the real possibility of a person to use a sidewalk given the objects (either temporarily or permanent) located on them. To deal with that, it is possible to estimate the areas allocated for parking, or the information on occupation permits given by the municipality. Occasionally, this occupation is the result of certain population behavior, preferences or simply habits; in the case study there is a settled trend of using most of the sidewalk, or available space (besides the frequently transited portions of the street) for parking automobiles.

Figure 23 maps the spaces destinated to pedestrians for their displacements within the narrowed area of interest, and the available parking lots. One can note that these are always located along and very close to the pedestrian paths, ad exception of the street on the eastern boundary of the zone (Numbered as 3 in Figure 23), which has arranged a buffer zone in between resembling D2.1.1 *urban canyon* type (b). Differently for zone numbered as 1 or 4 in Figure 23, which would resemble D2.1.1 *piazza and piazzale* type (a) instead, by having a considerable wide area within the two street lanes.

Solar shadows study

Figure 22: Winter shadow analysis at 10:30, 15:00 and 18:00.

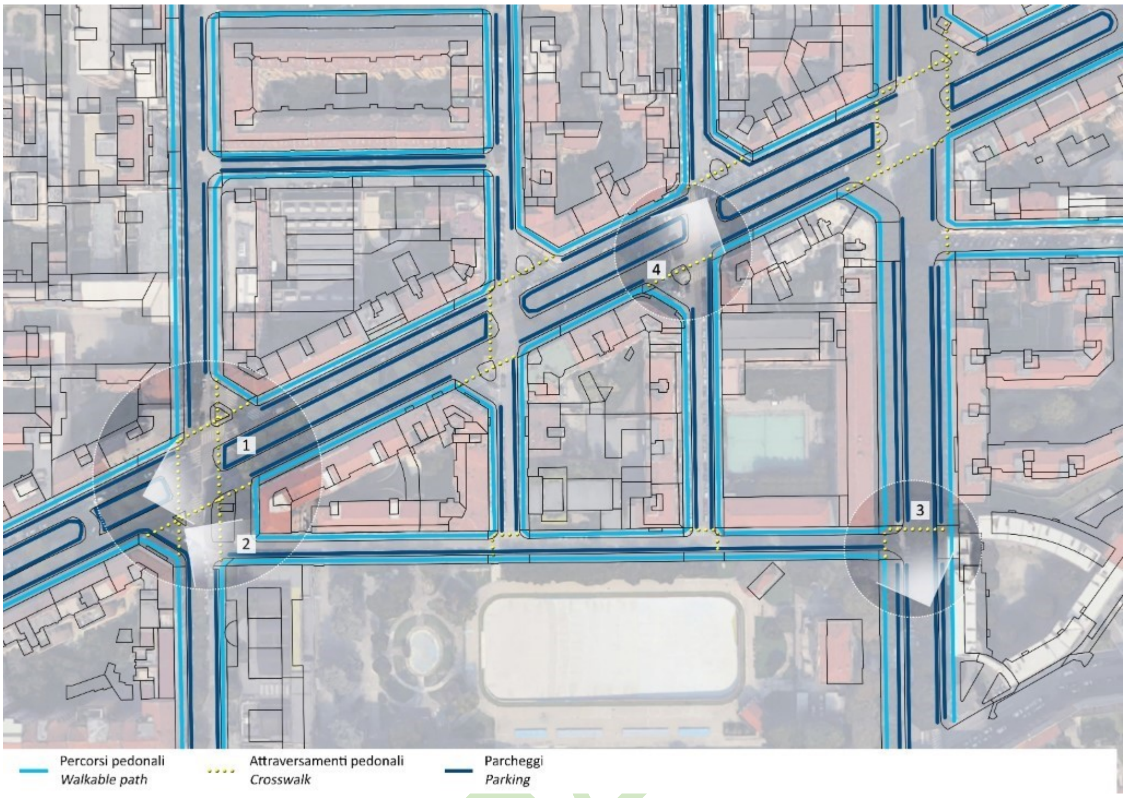


Figure 23: Classification of pedestrian destinated space and identification of available space for automobile parking.

In addition, it is rather peculiar to find a double line parking on the side of the street, which can only be possible if a rather invasive parking is performed by citizens, as shown in Figure 24; this type of arrangement can only affect negatively the pedestrian with a lower available space and shorter proximity to a source of pollution (automobile). Nevertheless, this type of automobile parking disposition can only be acknowledged with in-situ measurements and is rather complex to account for it in analysis which consider larger scales.

c. Greenery and tree coverage

Considering that the built environment has mainly been designed following a rather car-centered approach (Trancik 1986), thus reduced space for people, it is key to understand how the remaining space has been thought to be conditioned for pedestrians.

Pedestrian and drivers prefer to walk in and park their cars under a casted shadow, which if not casted by a building will more certainly be preferred to be casted by lush trees. Databases normally include a description of the area covered by green infrastructure, but it is fairly ambiguous when mapping trees in the city (valid, given their continuous changes). However, the presence of trees can affect significantly the SLODs risk as defined in D2.1.1; thus, these were mapped for the case-study in Figure 25. In addition, in-situ reconnaissance enables the identification of tree typology, shape, crown/canopy and lush (Figure 26).

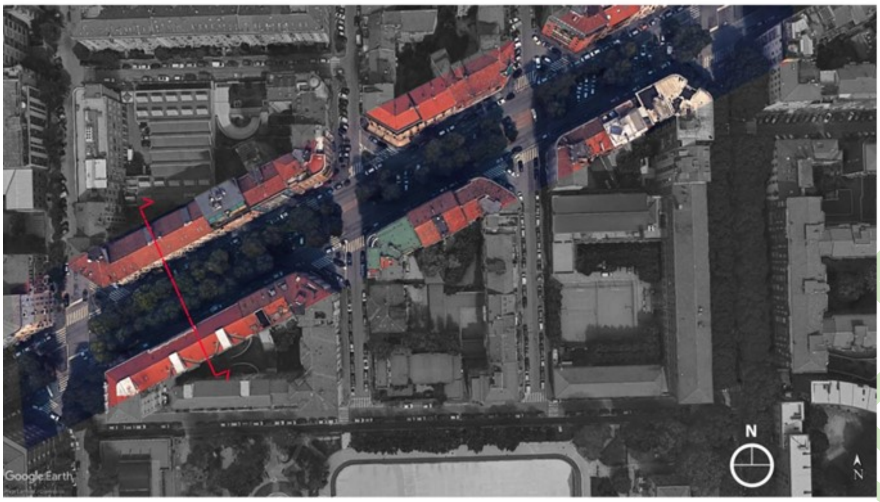
Figure 24: Parking space use within the delimited area.

With this information, it is possible to identify the typology of the *piazza-piazzale* and the *urban canyon*. For instance, in Figure 23 and Figure 25 the spaces labelled as 2, 3 and 4 can be classified as follows:

- *Space labelled #2*
    - *Piazza and Piazzale* type (c).
    - Average/high h/w ratio.
    - Barely any tree is present on the sidewalk.
    - Depending on the albedo and the irradiance, risk severity 2 or 3.
    - SLOD related, *increasing temperatures* perceived as critical heat island.
- *Space labelled #3*
    - *Canyon* type (b).
    - Average h/w (high w and h).
    - Trees are present.
    - Risk severity 2.
    - SLOD related, *air quality and pollution* depending on traffic intensity.
- *Space labelled #4*
    - *Piazza and Piazzale* type (a).
    - Low h/w ratio.
    - Trees are present on the streets.
    - Risk severity 2.
    - SLOD related, *air quality and pollution* depending on traffic intensity, *increasing temperatures* perceived as critical heat island.

Figure 25: Identification and mapping of existing trees within the case-study area.

Figure 26: Identification of the tree type, location and crown size for the main roads of the delimited area



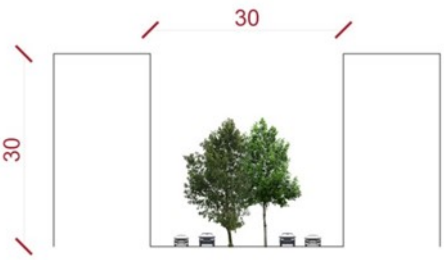


Figure 27: Via G. Pacini location and section description

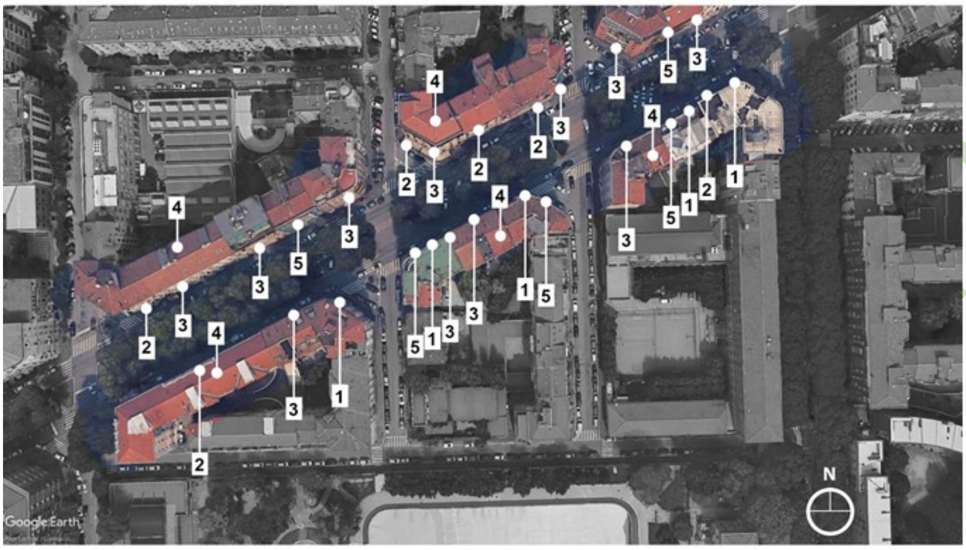
A more definitive classification and SLODs severity allocation can only be performed after surveying all required parameters (see §2.4), and in particular, estimating the built surfaces albedo and the potential captured irradiance.

d. Built environment (BE) space description

Therefore, following the same approach presented in D2.1.1 §5, the building and pavement surfaces were mapped in every major street within the narrowed case-study area (spaces 2, 3 and 4) and analyzed in detail. In order to better study the effects of the *increasing temperatures*, it was considered appropriate to specify the materials that characterize the facades of the buildings facing the street and taking these into account to select their average albedo coefficient (from literature) during the analysis with specific software.
Retrieving all this information from the built environment it is possible to perform irradiation, surface temperature, wind flow and outdoor comfort analysis (when coupled with reliable environmental conditions data). Hereby, only preliminary potential irradiation analysis is presented.

Via Giovanni Pacini (h/w = 0.9)
This avenue is one of the largest of those analyzed. The road consists of 4 lanes interspersed with a double tree-lined avenue under which there are parking lots (Figure 27). The orientation of the road is North-East to South-West. In total, the road section is approximately 30 meters wide and the buildings on its sides are roughly 30 meters high. Being one of the main courses, this is the busiest road amongst the delimited area.

There is no buffer space between the street and the pedestrians, that is, the tree lanes were preferred to be located on the middle of the avenue, limiting the greenery advantages of pollutant absorption and the casting of shadows during higher solar altitude periods (mainly summer).
The materials found for every façade were grouped in 6 macro-categories and mapped in Figure 28, while a panoramic view of the space has been included in Figure 29 for a clearer understanding of the studied BE.



LEGEND:
1 - Marble
2 - Stone cladding
3 - Plaster
4 - Clay roof tiles
5 - Small bricks
6 - Ceramic

Figure 28: Schematic representation of building materials along the road for via G. Pacini.

Figure 29: On-site pictures taken along via G. Pacini.

Analysis of solar radiations in the urban canyon

After defining the properties of the materials, this can be included into the open-source radiation calculation components of Rhino's plug-in Ladybug and Honeybee based on ray-tracing analysis run on Radiance engine

(Ward, G. and Shakespeare 1998), to compute the potential irradiance falling on the inner surfaces composing the canyon (Figure 30).

This values are indicative of the probable increment on thermal sensation that a person can feel due to the direct solar radiation (Arens et al. 2015), and of the reasonable surface temperature gradient of the surfaces stricken by larger beam solar radiation (Radhi et al. 2014).

The irradiance analysis was performed in 3 different times of the day; displaying the solar radiation intensity (kWh/m^2) for June 21st on the specific hour range 8:00 – 9:00, 12:00 – 13:00 and 18:00 – 19:00. Showing that in case of high air temperatures, the Northern sidewalk is less advised to be used by pedestrians, and also that the apartments belonging to that façade are in larger risk of suffering overheating.

All these analyses were performed as well for *Via G. Ponzio*, *Via Oorcagna, Via Fratelli Fossati* and *Via Zanoia.*

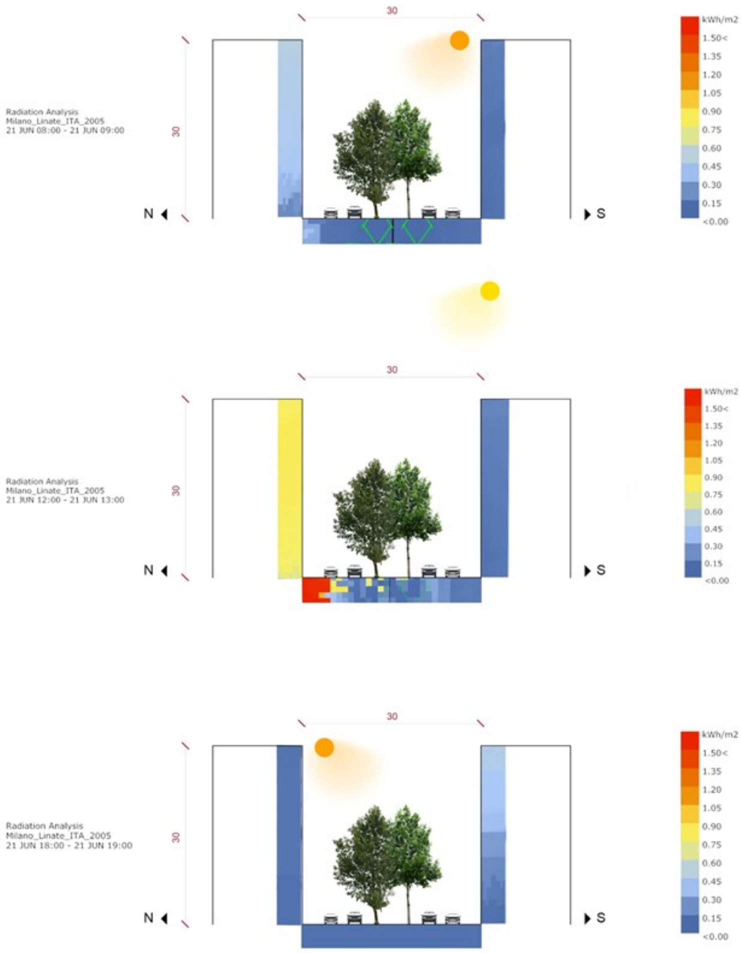


Figure 30: Via Giovanni Pacini section analysis for the irradiation intensity exposure during June 21st.

Via G. Ponzio (h/w = 0.9)

Likewise, *Via G. Ponzio* is a comparatively large road. In terms of geometry, it is fairly similar to *Via Pacini*: their width is approximately the same, around 30 meters. The traffic is also high on this road and there are lots of trees along the way but placed differently. One more significant difference is the orientation, in fact this road runs North to South (Figure 31).

This time there is a buffer space between the street and the pedestrians, tree lanes were preferred to be located between the sidewalk and the avenue, profiting from the greenery advantages of pollutant absorption and the casting of shadows during summer.

The materials found for every façade were allocated according to the previously defined macro-categories and mapped in Figure 32, which can be recognized from the panoramic view included in Figure 33.

Figure 31: Location and section description of via G. Ponzio.

LEGEND:
1 - Marble
2 - Stone cladding
3 - Plaster
4 - Clay roof tiles
5 - Small bricks
6 - Ceramic

Figure 32: Schematic representation of building materials along via G. Ponzio.

Figure 33: On-site photos taken along via G. Ponzio.

Analysis of solar radiations in the urban canyon

Analyzing the same timeframe and the same date, results on the irradiation intensity on the inner surfaces of the canyon are presented in Figure 34.
Although this street is differently oriented and seasonality of the leaves was not considered, it shows how the *increasing temperatures* risk would shift from the pedestrians onto the car drivers by the relocation of greenery. Specially as on the times of the day in which the sun should be rather perpendicular, it affects the most both sides of the façade materials. Thus, only apartments on that facade should be careful to avoid extreme thermal stress.

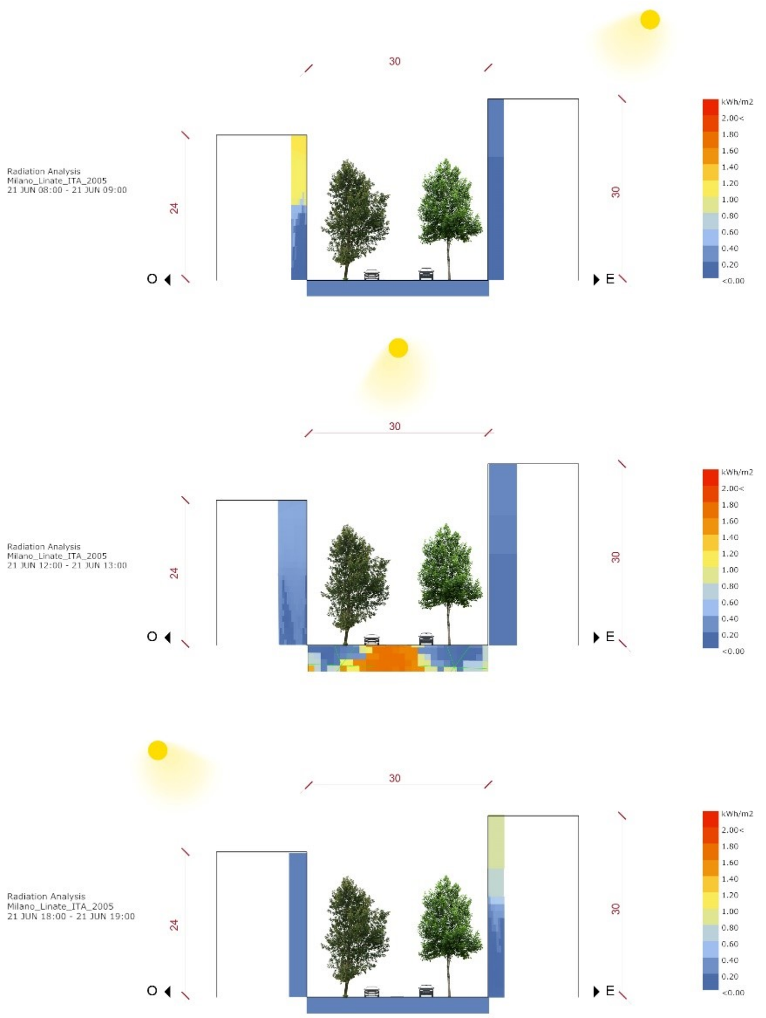


Figure 34: Via G. Ponzio section analysis for the irradiation intensity exposure during June 21st.

Via Orcagna (h/w = 0.1.33)

Via Orcagna is one of the secondary roads of the lot. In fact, this road does not present the classic trees of the typical wide street of Milan. The orientation is North-South, the width is approximately 13.5 meters and along the two sides of the street there are normally full of parked cars, and the traffic intensity along this corridor is lower (Figure 35).

On this street there are no trees neither a buffer space between the street and the pedestrians, so there is no trace of an evident strategy for pollutant absorption and casting of shadows (Figure 37).

The materials found for every façade were allocated according to the previously defined macro-categories and mapped in Figure 36, which can be recognized from the panoramic view included in Figure 37.

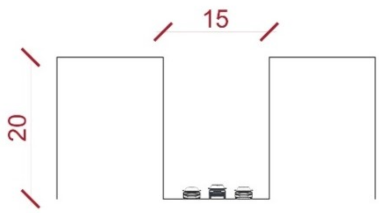


Figure 35: Location and section description of via Orcagna

Analysis of solar radiations in the urban canyon

For the same timeframe and date, results on the irradiation intensity on the inner surfaces of the canyon are presented in Figure 38.
Similar to *Via G. Ponzio*, it shows that for the *increasing temperatures* risk is worst during mid-day but this time for both pedestrians and car drivers. Meanwhile for the façades, on the times of the day in which the sun should be rather perpendicular, it affects the most both sides of the façade materials.

LEGEND:
1 - Marble
2 - Stone cladding
3 - Plaster
4 - Clay roof tiles
5 - Small bricks
6 - Ceramic

Figure 36: Schematic representation of building materials along via Orcagna.

Figure 37: On-site photos taken along via Orcagna.

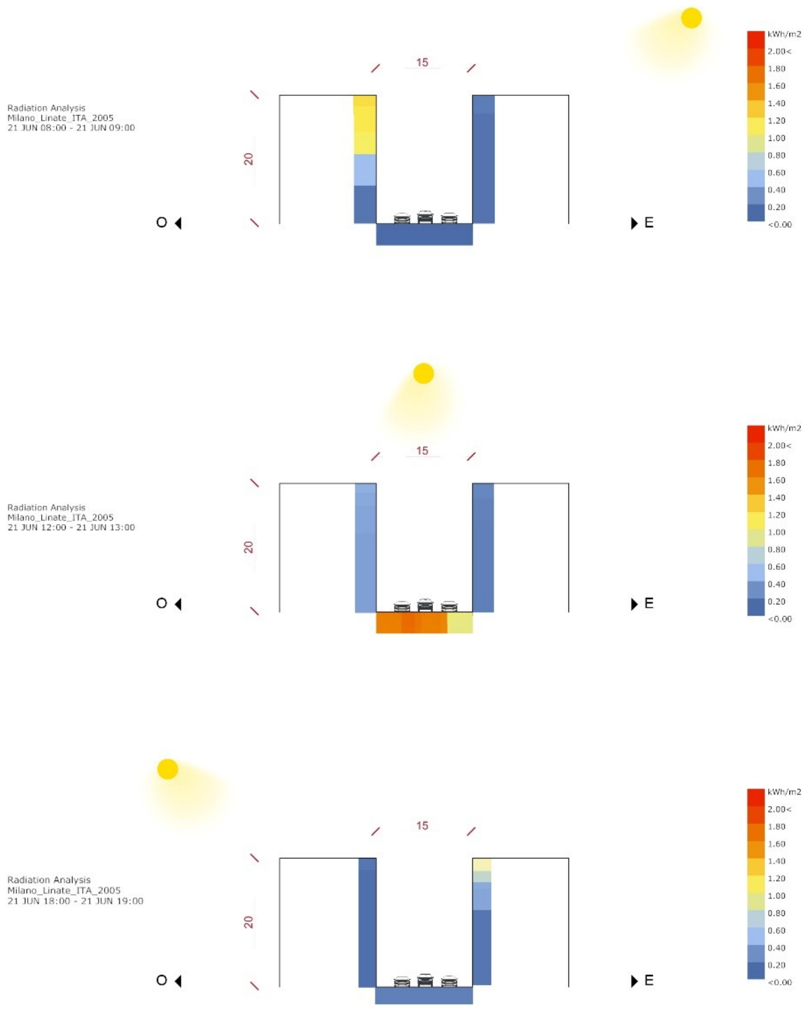


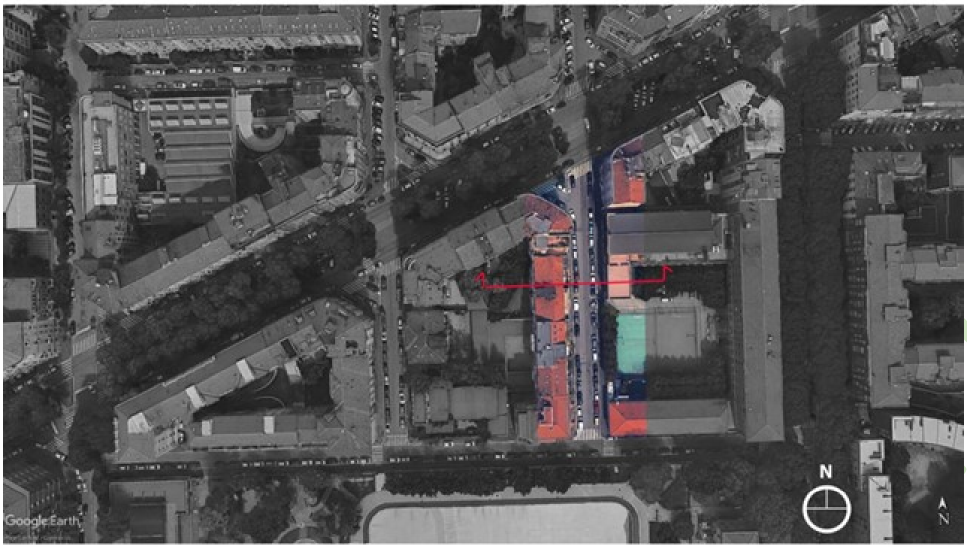
Figure 38: Via Orcagna section analysis for the irradiation intensity exposure during June 21st.

Via Fratelli Fossati (h/w = 1)

Fossati road is another secondary road of the area. Once again, no trees are present. The orientation is North-South, the same as *Orcagna* and *G. Ponzio* road, the width is close to 13 meters and along the two sides of the street there are sidewalks and parking lots (Figure 39).

On this street neither trees nor a buffer space between the street and the pedestrians are present, so there is no trace of pollutant absorption/dilution nor of casting of shadows.

The building façades were allocated according to the materials found and the previously defined macro-categories, these were mapped in Figure 40, which can be recognized from the panoramic view included in Figure 41.



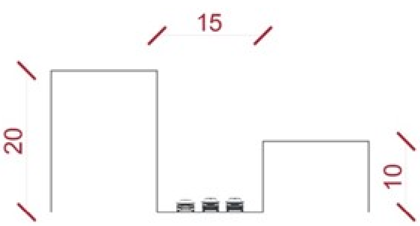
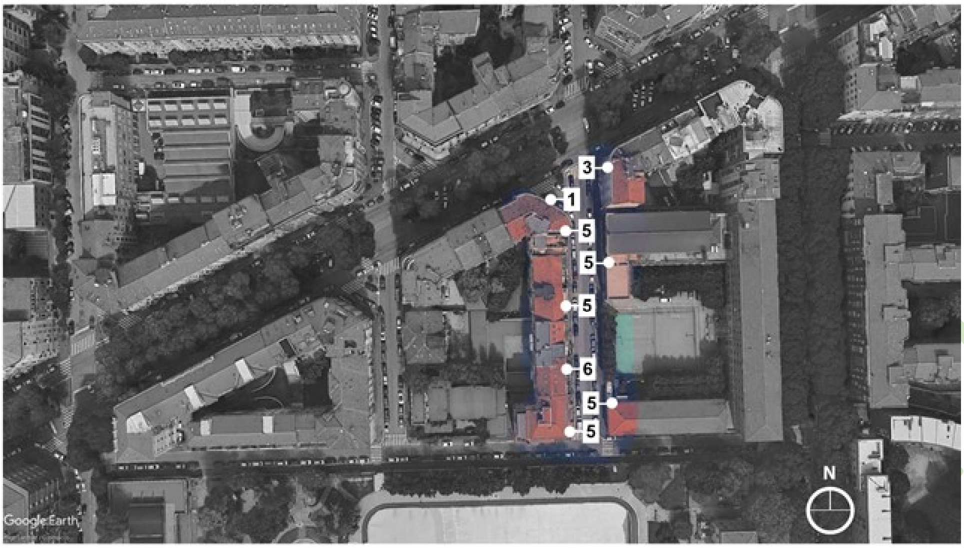


Figure 39: Location and section description of via Fratelli Fossati

Analysis of solar radiations in the urban canyon

For the same hours and date, results on the irradiation intensity on the inner surfaces of the canyon are presented in Figure 42.
Similar to *Via Orcagna*, it shows that for the *increasing temperatures* risk is worst during mid-day but this time for both pedestrians and car drivers. Meanwhile for the façades, on the times of the day in which the sun should be rather perpendicular, it affects mostly the west façade materials as the building on the east side does not provide any major shadow (i.e. lower building height).



LEGEND:
1 - Marble
2 - Stone cladding
3 - Plaster
4 - Clay roof tiles
5 - Small bricks
6 - Ceramic

Figure 40: Schematic representation of building materials along via Fratelli Fossati.

Figure 41: On-site photos taken along via Fratelli Fossati.

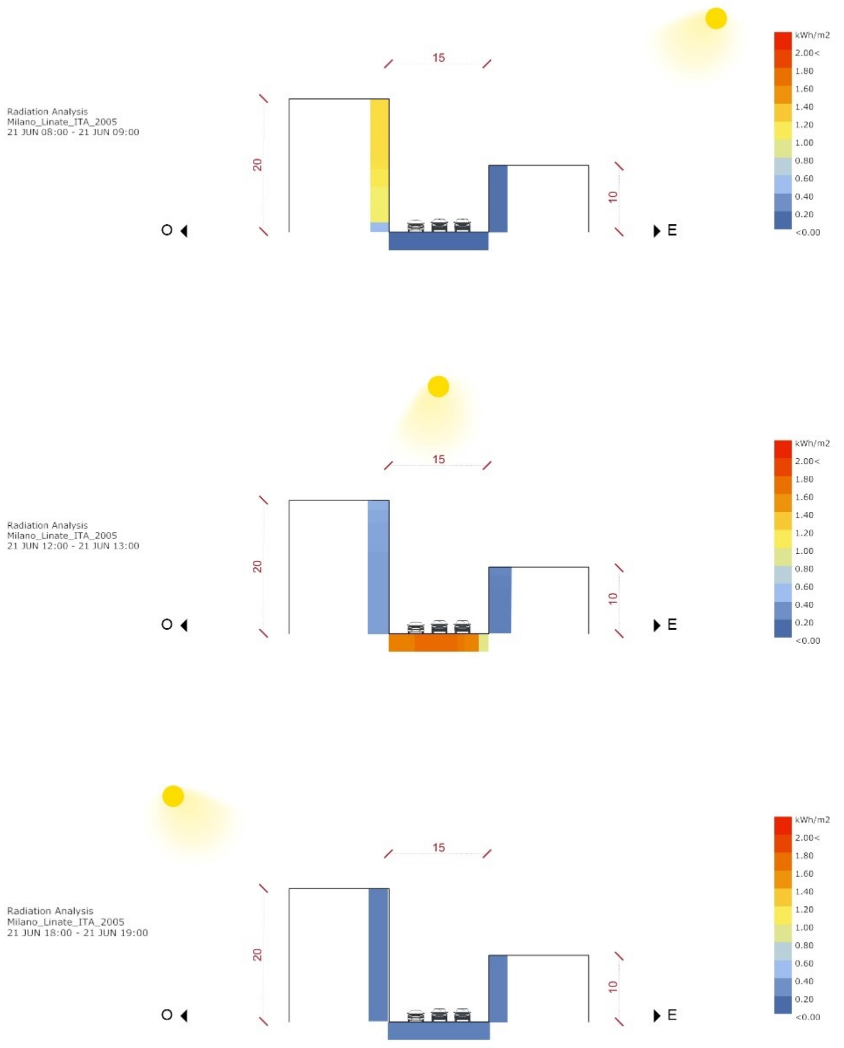


Figure 42: Via Fratelli Fossati section analysis for the irradiation intensity exposure during June 21st.

Via Zanoia (h/w = 0.79)

This avenue is the third secondary street in the studied lot. The road has buildings on one side and on the other side there is a fence wall. The orientation of the road is East - West. In total, the road section is 12 meters wide. Since it is a secondary road, the traffic intensity is low, and the southern street side is used as parking.

Once again, this street lacks trees and buffer spaces between the street and the pedestrians, there is no trace of pollutant absorption/dilution nor of casting of shadows. However, beyond the fence there is a small park which contributes to deal with the air pollution ().

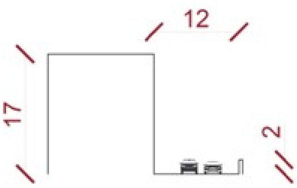


Figure 43: Location and section description of via Zanoia

The building façades of the northern section side were allocated according to the materials found and the defined macro-categories. These were mapped in Figure 44, which can be recognized from the panoramic view included in Figure 45.

Analysis of solar radiations in the urban canyon

For the same hours and date, the irradiation intensity on the inner surfaces of the canyon have been mapped and presented in Figure 46.
Similar to Via Fratelli Fossati, for the *increasing temperatures* SLOD risk is worst during mid-day for both pedestrians and car drivers. And for the façades, again during mid-day the sun (probably the warmest moment of the day) the south oriented façade materials reports high irradiance intensity as the 2 meter wall does not provide any significant shadow.
In the worst-case scenario for this section, the risk severity is high cause no shades are present, surface temperatures (under high irradiance) would probably be high and low greenery coverage is present. Nevertheless, being a secondary road, it must be verified the presence of a crowding source that boost the pedestrian flow through this corridor.

LEGEND:
1 - Marble
2 - Stone cladding
3 - Plaster
4 - Clay roof tiles
5 - Small bricks

Figure 44: schematic representation of building materials along via Zanoia.

Figure 45: On site photos taken along Zanoia road.

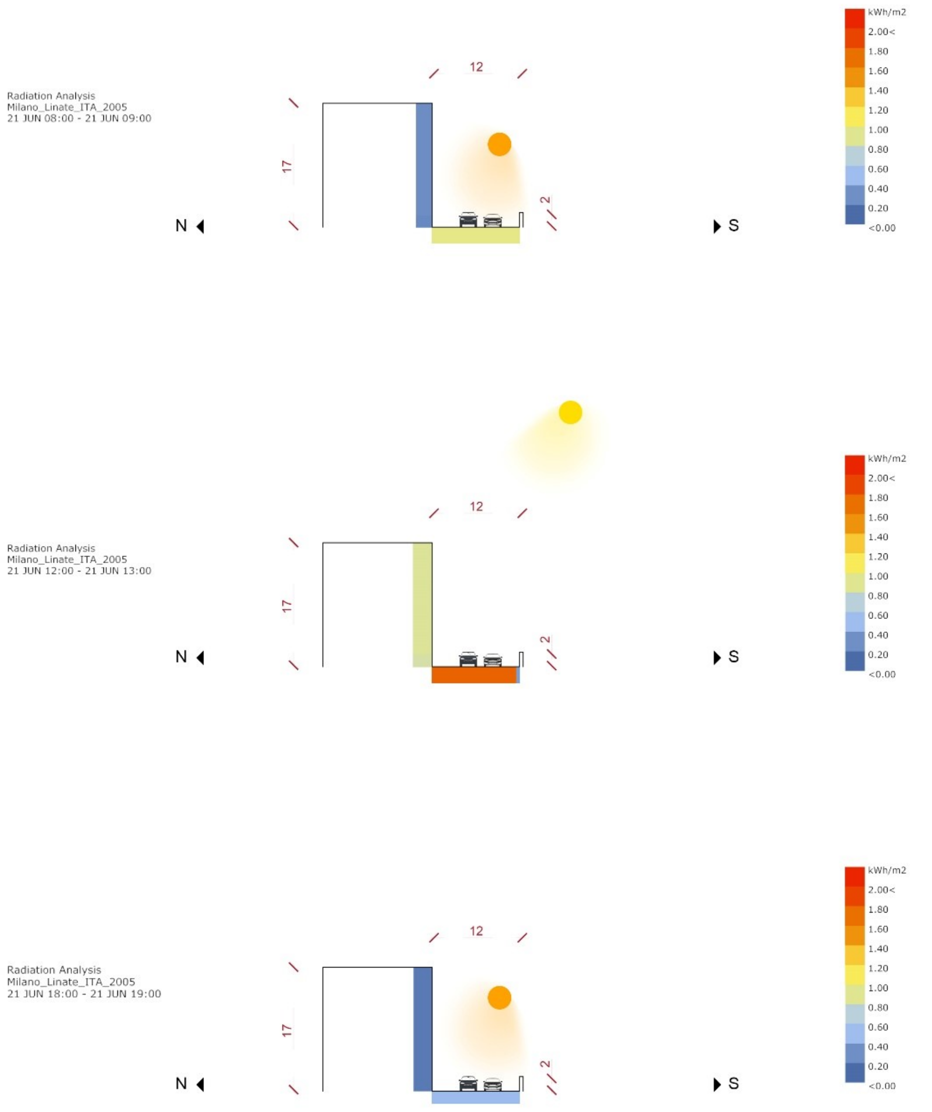


Figure 46: Via Zanoia section analysis for the irradiation intensity exposure during June 21st

To conclude, Table 6 has been produced, summarizing the data collected on the macroscale of the BE, these data allows to identify representative case studies that are dispersed within the city.

Table 6 – Summary of the outdoor areas scrutinized, comprising both areal and linear, including their main characteristics and physical vulnerability severity.

Road	h/w	Trees presence	Albedo	BE type	Severity
Via Giovanni Pacini	0.9	On the Piazzale	0.5 – 0.7 (avg.)	Piazza and Piazzale (a)	3
Via G. Ponzio	~1	Between sidewalk and street	0.5 – 0.7 (avg.)	Canyon (b)	2
Via Orcagna	1.33	No trees	0.5 – 0.7 (avg.)	Canyon (c)	3
Via Fratelli Fossati	1	No trees	0.5 – 0.7 (avg.)	Canyon (a)	2
Via Zanoia	0.79	On the Piazzale (non on sidewalk)	0.5 – 0.7 (avg.)	Piazza and Piazzale (c)	2 or 3 (Radiation dependent)

e. Building typology and built environment interface

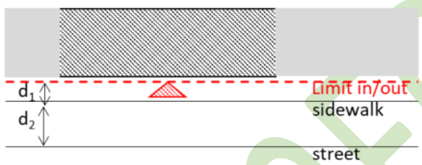
Going in depth with the characterization of the built environment to which the city's population is exposed, or with which it interacts, a much granular analysis can be performed, at the scale of building and its surroundings.

This is meant to delineate the areas in front of the buildings (in particular those representing a focal point for people crowding) which spurs, to a certain extent, the time for access. Hence, this will be critical for understanding if, additionally to attract a significant number of people (even worse if they fall into the susceptible population category), the way the access is designed reduces the flux of people entering, increasing the lead time, thus the *exposure*.

This is planned to be evaluate when assessing an even smaller scale, determining the size and type of access to these buildings. Considering the width of a buffer (d_{a1}, if any), the sidewalk (d_1), street (d_2) and the presence or not of a park in front. This was done for a collection of school building geometry archetypes in Table 7.

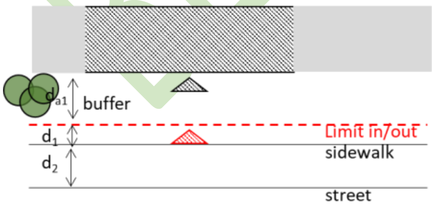
Table 7: Characterization of entries of crowding type Schools, for the most common building geometry archetypes in Milan

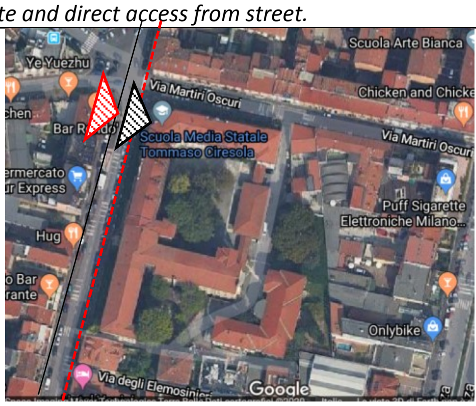
Type (a)



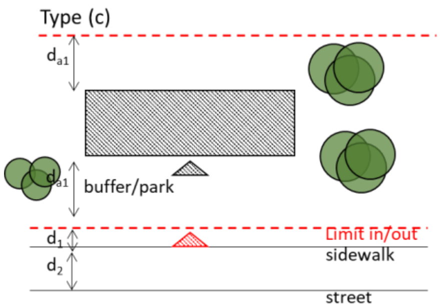
Type a. Building in urban block with medium/low crowding rate and direct access from street.

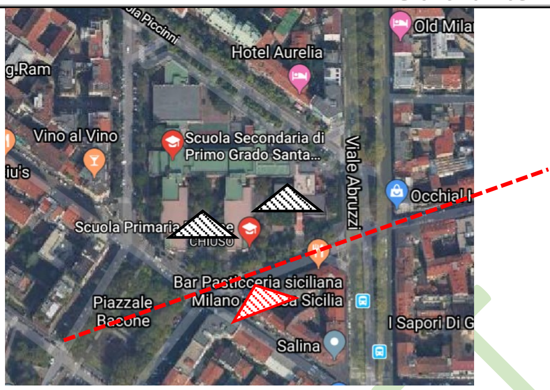
Type (b)



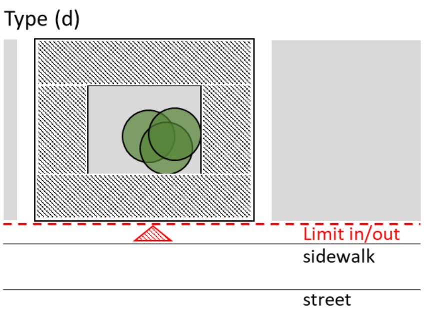


Type b. Building in urban block with medium/low crowding rate and indirect access from buffer space.

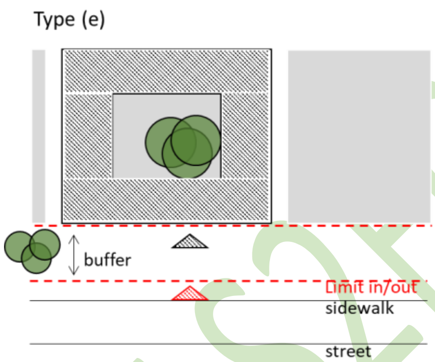




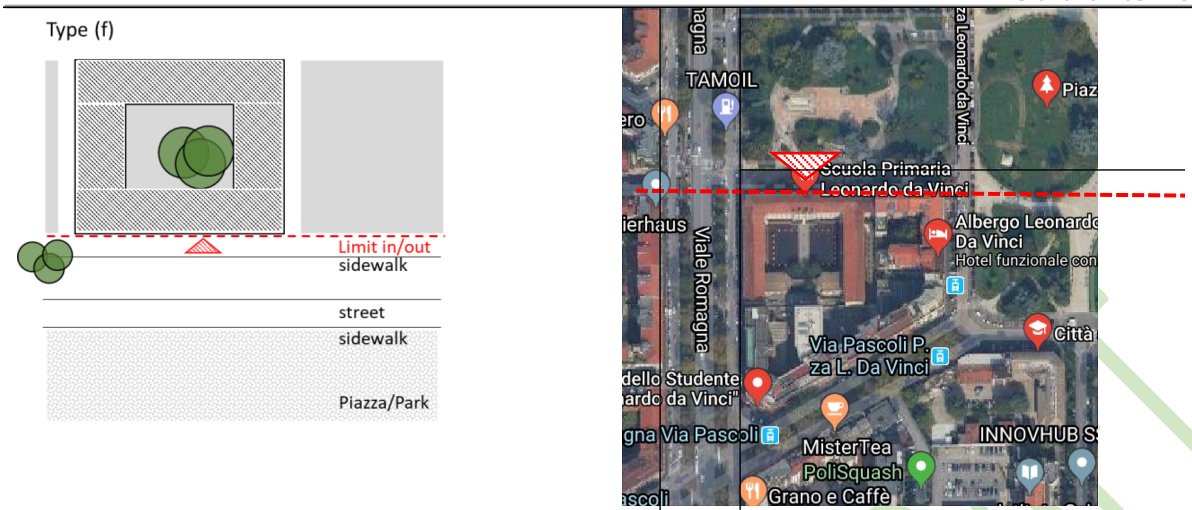
Type c. Single building (or cluster of buildings) in urban park. Medium/small size building with medium/low occupancy rate.



Type d. Block with courtyard and direct access to the building from the street. Building with high occupancy rate.



Type e. Block and indirect access to the building from buffer space. Building with high occupancy rate and high traffic street front.



Type f. Block and direct access to the building (no buffer space). Building with access facing the public square/urban park with high occupancy rate and high traffic street side.

Those access points identified as more critical, correspond to the allocated categories (a) and (d), in which no buffer exists and there is none, or insignificant, greenery in front to assimilate the pollution coming from the street in front. For these cases, the size of the access shall be reviewed so the entry flux can be eased, and less population is left outside exposed for longer periods. Moreover, the presence of greenery in an inside courtyard favors the wellness of the building users.

4. Conclusions

The present document, starting from the findings of the Deliverable 2.1.1, introduces by means of several multi-scale analysis and characterization of the city of Milan what will be further studied during the project's Task 2.2 activity. The area for data collection and specific SLOD risk evaluation has been selected considering the listed key factors which affect negatively or positive the air pollution and the heat entrapment within the built environment.

As mentioned in §3, this narrowed delineated area is appropriate for carrying out dedicated analysis, which performed at larger scales would be just extremely complex. This delineated area is expected to comprehend:

- An average concentration of susceptible population (both elder and young).
- Reliable data from nearby sources for downloading and monitoring air quality and environmental conditions (Milano - Pascal Città Studi and Milano - via Juvara).
- Sufficient greenery area coverage to verify its convenience.
- Fairly dense in terms of built surface area and volume coverage.

In this area, BE with severity risk 2 and 3 (see §3.3 and §5 in D2.1.1) have been identified, together with the criticalities of zones with smaller features which can affect negative or positively the SLODs risk assessed. In particular *Piazza and Piazzale* (a) and (c), *urban canyon* (a), (b) and (c) have been identified.

The information mapped, together with the analysis of the falling irradiation provides a guidance for recognizing the BE spaces where it is worthy to concentrate most of the following data analysis and surveying work. In particular to enable ton studying the convergence of adverse parameters (BE features) and variables (crowding and environmental conditions). In general:

- Greatly solar exposed canyons were found within the area, with high surface albedo and low greenery area coverage.
- Narrow canyons were found with high surface albedo and scarce greenery, low shading potential during high solar altitude and also, low heat sink and pollutant dilution due to high volume density (decreased wind velocity).
- Wide avenues with large greenery coverage area were found, but not serving the pedestrians for air quality or shading provision.
- Wide avenues with proper greenery coverage for both shading and air quality management.
- Crowding source buildings were found within the delineated area which could potentially attract both elder and young population, and in particular of critical type (d) for building access interface.

5. References

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