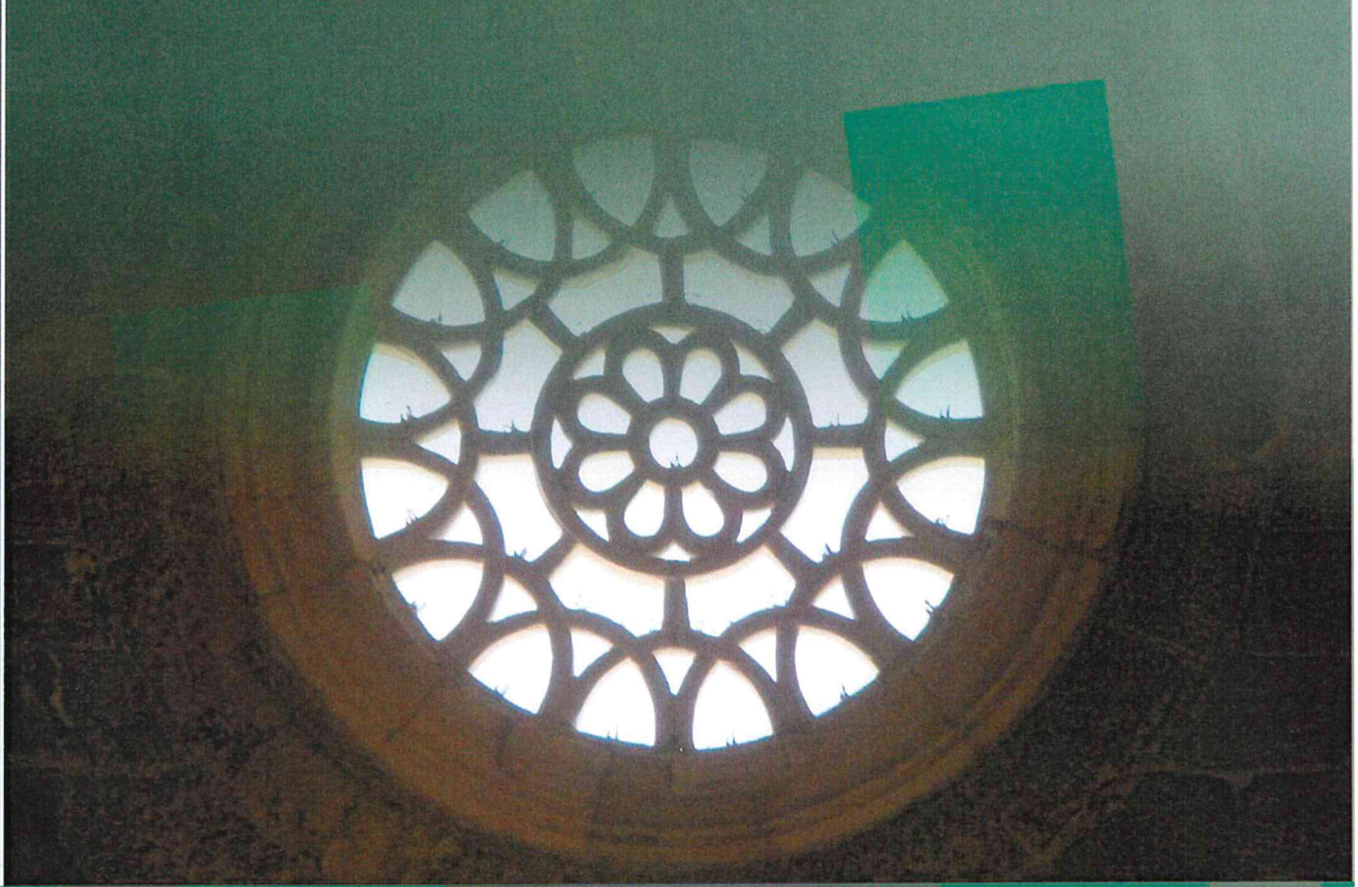
GREEN LINES BOOKSERIES ON HERITAGE STUDIES

HERITAGE 2020

Proceedings of the 7th International Conference on Heritage and Sustainable Development



Rogério Amoêda
Sérgio Lira
Cristina Pinheiro
Editors

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HERITAGE 2020

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Green Lines Bookseries on Heritage Studies

Volume 01

Series Editors

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- Safeguarding of endangered natural and cultural heritage;
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Steering Editorial Committee

Volumes in this Series

Volume 01 **HERITAGE 2020** - Proceedings of the 7th International Conference on Heritage and Sustainable Development

Rogério Amoêda, Sérgio Lira and Cristina Pinheiro (*Editors*)

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HERITAGE 2020

Proceedings of the 7th International Conference
on Heritage and Sustainable Development
8-10 July 2020, Coimbra, Portugal

Rogério Amoêda
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Foreword

HERITAGE 2020 - 7th International Conference on Heritage and Sustainable Development was not a normal Green Lines event. Due to the pandemic crisis it was not possible to gather in person all Friends, Colleagues and Authors who joined this event and the decision of keeping the conference under the format of a publication was a very hard one to take. For the first time in 12 years we did not gather in June/July. However, the spirit of Heritage conferences remains, and the series of Proceedings was not broken and that was for Green Lines and for the members of the Organising Committee the most important thing of all.

As its previous editions ***HERITAGE 2020*** aimed at maintaining a state-of-the art event regarding the relationships between forms and kinds of heritage and the framework of sustainable development concepts, namely the framework of the 2030 Agenda for Sustainable Development. The four dimensions of sustainable development (environment, economics, society and culture) were, as in previous editions, the pillars of this publication defining an approach on how to deal with the specific subject of heritage sustainability. Furthermore, beyond the traditional aspects of heritage preservation and safeguarding the relevance and significance of the sustainable development concept was to be discussed and scrutinised by some of the most eminent worldwide experts.

For a long time now, heritage is no longer considered as a mere memory or a cultural reference, or even a place or an object. As the previous editions of "Heritage" (2008, 2010, 2012, 2014, 2016 and 2018) have proven, heritage is moving towards broader and wider scenarios, where it becomes often the driven forces for commerce, business, leisure and politics. The Proceedings of the previous editions of this conference are the "living" proof of this trend.

As stated by some the Sustainable Development Goals of the 2030 Agenda, the role of cultural and social issues keep enlarging the statement where environment and economics had initially the main role. The environmentalist approach (conceiving the world as a whole ecological system) enhanced the idea of a globalised world, where different geographic dimensions of actions, both local and global, emerged as the main relationships between producers, consumers and cultural specificities of peoples, philosophies and religions. In such a global context heritage became one of the key aspects for the enlargement of sustainable development concepts. Heritage is often seen through its cultural definition and no further discussion seems to be appropriate. However, sustainable development brings heritage concepts to another dimension, as it establishes profound relationships with economics, environment, and social aspects. Nowadays, heritage preservation and safeguarding is constantly facing new and complex problems. Degradation of Heritage sites is not any more just a result of materials ageing or environmental actions. Factors such as global and local pollution, climate change, poverty, religion, tourism, commodification, ideologies and war (among others) are now in the cutting edge for the emerging of new approaches, concerns and visions about heritage. Recent events in the Middle East and other parts of the World are saddling proving the rightness of these assertions and deserve our attention.

Thus, ***HERITAGE 2020 - 7th International Conference on Heritage and Sustainable Development*** proposed a global view on how heritage is being contextualised in relation with the four dimensions of sustainable development. What is being done in terms of research, future directions, methodologies, working tools and other significant aspects of both theoretical and fieldwork approaches were the aims of this International Conference. Furthermore, heritage governance and education, as well as preservation of historic buildings and structures, cultural tourism, global warming and actions of cultural safeguarding, displaced heritage and displaced communities were brought into discussion as key factors for enlightenment of future global strategies for heritage preservation and safeguarding.

A special chapter on Jewish heritage was included in this edition, since this type of heritage (mainly architectonic) is very significant in the city of Coimbra where the conference was going to be held.

Authors submitting papers to ***Heritage 2020*** were encouraged to address one of the topics of the Conference by providing evidence on past experience and ongoing research work. As a result, ***Heritage 2020*** welcomed a significant number of papers addressing field work and case studies but also theoretical approaches on a diversity of thematic. As in the previous editions Early Stage Researchers were welcome to share the results of their research projects, namely post-graduation projects and doctoral projects, among others.

Our special word of recognition to the University of Coimbra for its willingness to host the conference. The Organising Committee also expresses its gratitude to all Members of the Scientific Committee who reviewed the papers and made suggestions that improved the quality of individual work and the over-all quality of the publication.

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Chapter 1

Heritage and Governance for Sustainability

Built environment and human behavior boosting Slow-onset disaster risk

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ABSTRACT: Air pollution concentration and heat wave intensity represent the most recurrent evidence of SLow-Onset Disaster risks that rapidly affect the population in cities. Their manifestation and concurrence depend on the context's environmental conditions and mass behavior of citizens; risk is more likely to surge during summer, a season progressively getting longer and warmer. This represents even higher risk, since heat and radiation can intensify ground-level pollution. However, these evidences are mostly experienced within the Built Environment, as some of its characteristics have proven to intensify their effect. Thus, this work concentrated on applying data driven methods and tools for identifying representative portions of the Built Environment in Italian cities (extrapolated from the city of Milan), characterized by extensive historical, cultural and architectural heritage, in which critical air pollution concentration and heat wave intensity typically arises. In this analysis, urban canyon and piazzale were identified as morphologies displaying high exposure and vulnerability; also, construction and behavioral customs are considered.

KEYWORDS: Air Pollution, Urban Heat Island, Built Environment, Slow-Onset Disaster.

1. INTRODUCTION

Nowadays, people have suffered, recognized, and/or acknowledged 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. A great share of this health deterioration issues can be linked to the environmental characteristics of these people's surrounding environments – Jackson et al. (2010); WHO (2014); Lee & Kim (2016) which have shared some evidence – and most of them can be strongly connected with the marked trend of *increasing temperatures* and *air pollution* – representative Slow-onset disasters (SLODs) according to UNFCCC (2012).

SLODs are easy to note, and predict, but are harder to mitigate. The arousal frequency of SLODs' evidence is larger in urbanized context (EPA, 2008), and these evidences can be worsened given the inherent properties of the Built Environment (BE). Thus, it is appropriate to understand which of the BE features and citizens eventual behaviors could further contribute to the impacts on inhabitant's health conditions.

In the European context, significant research work has been shared on the progression of critical SLODs (i.e. *increasing temperatures* and *air pollution*), providing a notion on where these

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disasters are more prone to take place or to have a larger effect. For instance, WHO (2019) reported an analysis of *air pollution* based on the annual mean average of PM2.5 data readings of 2016, for which Italy stands out as one of the most critical areas of Central Europe; in particular the regions of Piemonte, Lombardia and Veneto were reported as the most polluted regions, and even worse conditions have been shown for the municipality of Milan. Then, studying *increasing temperatures*, D. Guha-Sapir (2016) analyzed disaster databases and reported that between 1986 and 2016 there was a widely spread concentration of registered events reporting extreme temperature in Central and Eastern Europe; also, the European Environment Agency (2020) exposed a common trend in annual temperature increase of 0.3-0.35 °C between 1960 and 2018 for the same areas.

Therefore, in northern Italy converge considerable *increasing temperatures*, decay of air quality and *air pollution* increase, rendering this territory a useful case study given the intense hazards. Which combined with citizens' habitation preference and displacement habits have increased population density (United Nations, 2014), thus the exposure, escalating risk levels.

1.1 *Background*

The assessment of Slow-Onset Disaster risk is twofold. It shall be directed towards mitigating the frequency and intensity of their evidence, but also diminish and abate the growing trends in the long term. The United Nations have endorsed the world-wide desire to hold back the extreme climate change scenario, closely linked to SLODs, and its effects on world population by instituting the Sustainable Development Goals (SDGs); in particular goals *3. Good health and wellbeing, 11. Sustainable cities and communities* and *13. Climate action* (United Nations, 2015). These conjoint efforts are not new, they began at the Conference of Earth Summit (United Nations, 1992), however no clear evidence of slowing down or stopping climate change process has been reported, neither have their effects on inhabitants. Jackson et al. (2010); WHO (2014); Lee & Kim (2016) are just few of the vast scientific literature that have recorded evidence on SLODs affecting human health.

1.1.1 *Affected population*

When the impact of SLOD is evaluated, some demographic categories might be more disadvantaged than other, which could be referred as Social Vulnerability. They have been identified according to their age (i.e. youngsters and elders) and those having frail health. That is, toddlers frequently subjected to certain hazards might generate permanent damage, that would be severe for them at older age (De Prado Bert et al. 2018). Elders, under the same condition could result in an increase on the city's mortality (Devlin et al. 2003; Cakmak et al. 2007). Moreover, for those suffering from respiratory issues (e.g. asthma, allergies) and irregular blood pressure have a larger probability of falling ill (Delfino et al. 2010).

Youngsters and elders seem to be more frequently affected by heat strokes (complications of body functioning perceived when core body temperature rises above 40.6°C, see Yeo (2004)). In addition to youngsters and elders, those with frail health have a significantly reduced thermal regulation capacity (Barrow & Clark, 1998). Lower socio-economic groups are more frequently exposed to pollutants (households placed closer to pollutant sources); while elders, toddlers and people with frail health are more vulnerable (European Environment Agency, 2019).

People avoiding activities that require intense body work are discouraged; while occupying or transiting trafficked and unshaded areas, lacking green areas and/or water bodies, is unwise.

1.1.2 *Prone BE to SLODs*

Studies have been conducted to show how the built surfaces and the intense anthropogenic activities are the main causes of *increasing temperatures* and *air pollution*. Large constructed volumes modify solar energy influx and wind-flow (thus, air, water and particles transport) (Arnfield, 2003; Ghiaus et al. 2006; Salvati et al. 2017). Moreover, constructed surfaces tend to have larger absorption coefficients and lower albedo compared to organic surfaces. All these together stimulate the heat and pollutant entrapment within cities, or the street canyon, contributing to the temperature increase and pollution concentration.

And considering that in 2018, 55% of the world's population was living on highly urbanized areas, that this ratio is projected to grow to 68% by 2050 (United Nations, 2018), and that built heritage is hardly intervened or modified, the urban fabric and SLODs links were needed to be studied to identify the Physical Vulnerability.

According to the findings reported by Stewart & Oke (2012); Paolini et al. (2014); Jamei et al. (2016); Fuladlu et al. (2018); Colaninno & Morello (2019) the following built environmental factors are the most relevant affecting the intensity of SLOD (physical vulnerability):

- urban fabric materials, density and geometry;
- greenery location, coverage and density;
- water bodies location and coverage; and,
- degradation of the vegetation, water bodies ecosystem and urban fabric.

a) Urban Heat island

Urban Heat Island (UHI) is the heat accumulation phenomenon in urban spaces, higher sensed air temperature compared to rural spaces, that develops due to surface materials and human activity (EPA 2008).

Mitigating strategies for alleviating the UHI are mainly related to the larger integration of green areas and water bodies; together with the construction, installation and reconversion of built surfaces as low albedo materials. In fact, Trees can naturally provide cooling shade, reducing the need for air conditioning (Reeve & Kingston, 2014) and helping to remarkably moderate the urban air temperature (Doick & Hutchings, 2013). Also, water bodies (e.g., lakes, rivers) may provide temperature mitigation through their greater specific heat capacity compared to other physical objects (Manteghi et al. 2015; Wu & Zhang, 2019).

b) Air pollution

Considering that 91% of world's population, urban and rural, live in places with low air quality (WHO, 2018), that these conditions are degraded in urban spaces and that most of the world's population would soon be located in cities, handling strategies should be a priority.

Pollutants produced by the human activity have a great impact on the health of the European population. Within this context, PM, NO2 and ground-level O3 are among the most dangerous pollutants for human health (WHO, 2016). Vegetation acts as filters for pollutants, it consumes gases (e.g. COx, NOx, O3 and SOx) and cleans the air from fine particulates trapping them on leaves and bark (FAO, 2016).

As a matter of fact, the restoration of trees remains among the most effective and accessible strategies for climate change mitigation (Friedlingstein et al. 2019).

2. METHODOLOGY

To perform an analysis of great detail, it is necessary to reduce the scale of the area studied, diminishing the weight and limitations of robust assumptions. Thus, a process of downscaling is carried out to understand the specific way citizens are being affected by this type of disasters, and in particular how to gradually decrease the intensity and severity of their evidences.

A replicable process has been structured in order to steer the analysis, on a specific city, towards the most critical regions and present BE archetypes that result in worsened risk due to their higher exposure and vulnerability. A summary of the process is presented in Fig. 1.

The process starts by acknowledging delineated city divisions, and comparing these divisions based on their demographics, built density and environmental conditions. This enables to proceed with a strategic intervention on city districts. Then, after identifying the conditions of exposure (density) and vulnerability (both physical and social), a risky neighborhood can be delineated based on data collection and analysis, and crowding sources (building/space function).

Finally, these areas can be subjected to a characterization process to identify their specific features, which construct the SLOD sensitive BE typologies.

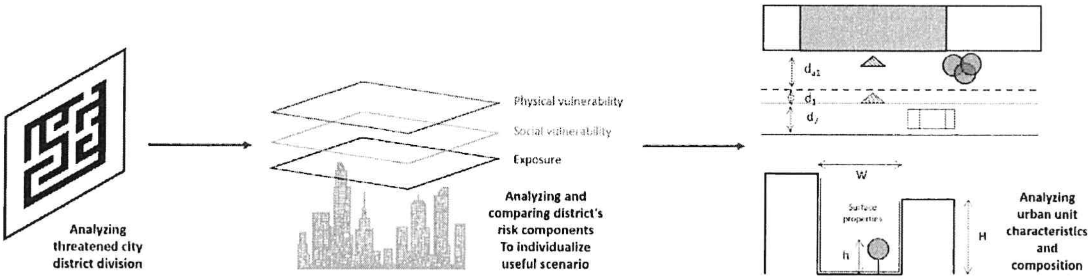

Fig. 1. SLODs risk assessment process starting from the city level scale

2.2 *Exposure and data availability-based downscaling*

The process started at the country level, assessing the degree of exposure of a region or a city (e.g. inhabitants [#People] or population density [#People/m^2]); data was obtained from open-source national demographics institutions' databases (in the case of Italy, ISTAT (2020) records were used). This would lead to informed and calculated decisions on where to assess and plan ahead impactful mitigation strategies, either by country region or cities. In this work, a city was preferred.

Then, the city was divided into Local Identity Units, or in Italian Nuclei di Identità Locali (NIL). For every NIL delineated, the number of people registered as residents within these districts was plotted using heatmaps, superimposed by plotting as dots the coordinates of buildings that their function represents a sort of crowding source (e.g. public administration buildings, supermarkets, churches, cinemas, theaters, post offices, hospitals, schools and universities). This information was obtained from Comune di Milano (2020) and processed with GIS and Python geospatial tools.

Moreover, in order to evaluate the hazard component of risk, environmental and air quality data shall be available, an additional analysis was done by plotting the location of the weather and air quality stations from which records are used to construct the municipality's databases (ARPA Lombardia, 2020).

This gives a broad knowledge in which city districts are potentially more exposed to SLODs risk; and also, in which ones is possible to further monitor the hazard intensity by means of processing temperature and pollutants concentration historical trend.

2.3 *Vulnerability analysis*

Therefore, to be certain of diminishing the rapid development of SLODs, and considering the existence of sufficient people's exposure, it is convenient to understand where these hazards can be more impactful, based on social vulnerability (allocated to peoples susceptibility to *increasing temperatures* and *air pollution*) and physical vulnerability (designated for those BE features that boost temperature perception and pollution exposure).

2.3.1 *Social vulnerability recognition*

To reduce the risk on the susceptible population (reducing social vulnerability), the first step concerns the demographic analysis of old and young population in the city. This analysis highlights where within the urban area susceptible categories are more present; by means of a heatmap comparing the number of >65 and <18-year-old registered residents.

Moreover, regarding the crowding sources, as some building functions might attract younger, older or fragile health population, the location of schools, care homes and hospitals/clinics were superimposed to the density maps created beforehand.

2.3.2 *Physical vulnerability identification*

As a rather large-scale analysis is still ongoing, the conditions of the districts compared only on the following factors:

- building footprint area coverage [m^2/m^2] and building volume density [m^3/m^3] compared to the whole district area and volume (providing insights on ease of wind flow); and,
- the estimation of Land Use Land Coverage (LULC) of greenery (determining the potential benefits of green areas).

Other factors of the urban fabric (i.e. surface materials, albedo, traffic, water body area), were not sufficiently available on the accessed database; hence, these were not used for comparison at this scale.

2.4 *Neighborhood scale selection and potential Hazard severity*

The neighborhood scale is selected based on the previous step, prioritizing the exposure, the physical and social vulnerability, and also giving a considerable weight to the proximity to data collection sources of the district and neighborhood.

Then, a smaller sector is individuated by securing an area with diverse urban space unit typologies (e.g. urban canyon, piazza, Piazzale), crowding building sources, diverse built density and presence of green areas or items.

The last step concerns evaluating more in detail the composition of the BE determining the most influential parameters that could further escalate the SLODs risk. Mainly, these elements are linked to the physical vulnerability of the specific space.

3. RESULTS AND DISCUSSIONS

3.1 *Analysis for downscaling*

Recalling that in Europe, northern Italy is one of the regions at higher risk of suffering conjointly the most critical SLODs. A preliminary comparison has been made on the densest regions in terms of number of people inhabiting them, and the cities with the largest population. This provides the degree of risk exposure that the region and city have.

Fig. 2 shows the differences amongst Italian regions, exposing that the Lombardy region presents the highest number of inhabitants. This led to investigate the cities held within this region. In fact, the Lombardy region presents approx. 40% more inhabitants than the second most populous region in Italy: Lazio.

3.1.1 *Selection of an endangered city for the assessment*

Meanwhile Fig. 3 reveals how the *Pianura Padana* holds the major and densest cities, such as Milano, Brescia and Bergamo. However, Milano displays the highest population (> 3 million), as it holds in great number national and international services, which attract floes of city users from the whole nation and from abroad (e.g. industry, universities, healthcare). Also, as mentioned in §1, Milan displays favorable conditions for both *increasing temperatures* and *air pollutions* SLODs; hence, it was selected as the main core of this work investigation.

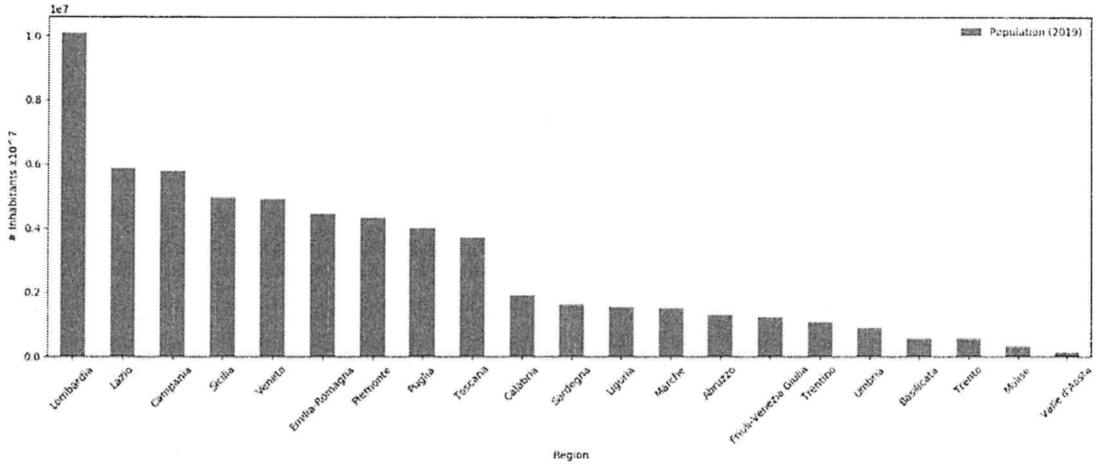

Fig. 2. Total population in Italy by regions (ISTAT 2020)

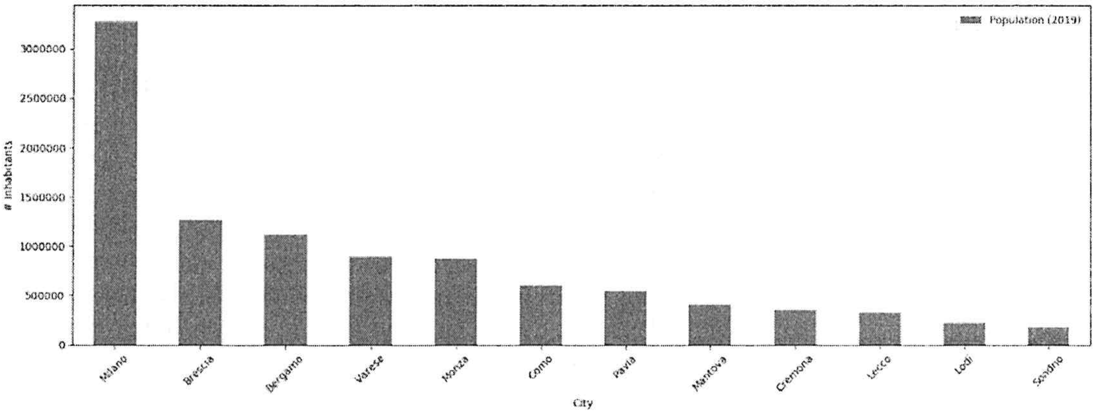

Fig. 3. Total population in the region of lombardy by city (ISTAT 2020)

3.1.2 *District selection*

After having identified the city under the highest risk hazard and exposure of SLODs, a comparable analysis has been done to analyze the city itself, starting by dividing the city on its NILs (Comune di Milano, 2019a) and reporting their main features.

The first analysis was done on understanding the availability of data sources (i.e. weather and air quality stations) spread around the city, as this can be used in further analysis for validating the existence and recurrence of risk hazard, and the monitoring of its evolution.

Fig. 4 displays how this data sources are more concentrated towards the North-east of the city; thus, the NILs (or districts) found in the proximity of these sensor data sources are: *Parco Lambro - Cimiano, Niguarda - Cà Granda, Città Studi, Guastalla, Buenos Aires - Venezia, Brera, Duomo, Stadera, Selinunte, Isola and Navigli*. Nevertheless, it shall be highlighted that for the city center (i.e. NIL *Duomo*), where evidence from the old town is more present, less monitoring stations were found (2 air quality stations placed at the edge and no weather stations).

For all NILs, but in particular for the previously mentioned districts, exposure and vulnerability were screened, and their results are presented in the following sections. However, the level of exposure was studied in parallel with the degree of social vulnerability.

a) Exposure and Social vulnerability analysis

This was done by mapping the population density dividing the citizens in the main 2 groups of susceptible population groups. Thus, the number of elder people (>65-year-old) and youngsters (<18-year-old) per NIL were plotted and compared.

Moreover, this data was combined with the location of crowding source buildings, to understand as well which of the district has perhaps a larger probability of people of finding a large concentration of citizens, not only because of the amount of people living in that area, but also the amount of people visiting that area.

The demographic and geospatial data have been retrieved form the Comune di Milano open data website (Comune di Milano, 2020), and has been processed and plotted in Fig. 5 using GIS and geospatial Python tools.

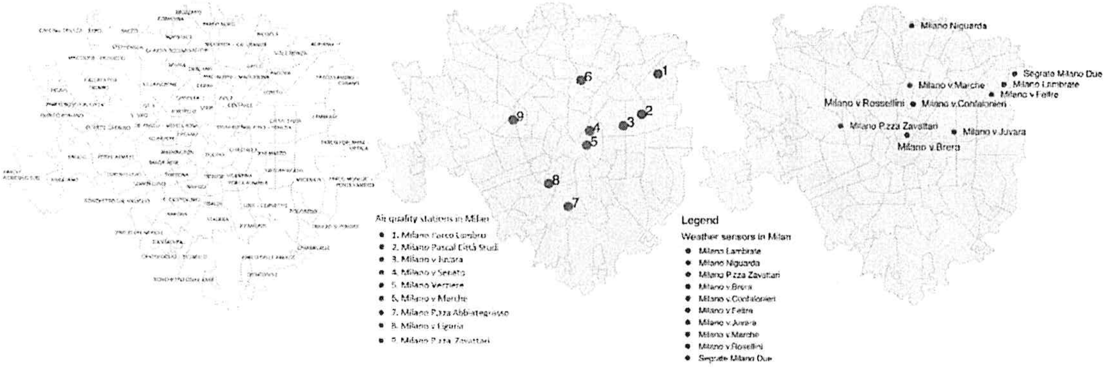

Fig. 4. Milan's NILs divison and open source data base records source locations spread within the city (ARPA Lombardia 2020)

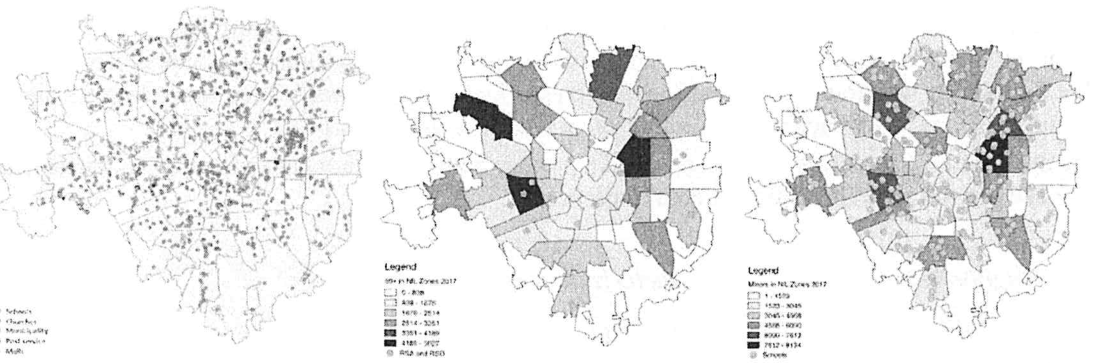

Fig. 5. Location of potential crowding source buildings immersed in the city of Milan, combined with the diversified population density distribution (Comune di Milano, 2020). From left to right: main crowding buildings, elders distribution + homecares, and youngsters + schools

This analysis evidences a rather big concentration of elders living on the districts of *Buenos Aires – Venezia* and *Bande Nere;* followed by *Niguarda Ca'Granda* and *Gallaratese*. A third group is represented by NILs *Città Studi, Loreto, Padova, Lodi-Corvetto, Villapizzone and Baggio.* Similar to the values obtained for elders, districts in the North-East area of Milano are the one presenting a higher concentration of youngsters. The *Buenos Aires* and *Venezia* represent the NIL which contains the most of young citizens.

For the elders, *Residenza sanitaria assistenziale* (RSA) e *Residenze Sanitarie per Disabili* (RSD) (Comune di Milano, 2019 b) can be considered as the most critical crowding source focal points; while for the young, the *schools* were identified as potential meeting points. This information can be considered partially complete as data on private entities are not available and they seem to be randomly spread around the citry area.

Areas reported holding a concentration of youngsters, correspond to those with various schools. For instance, both *Buenos Aires – Venezia* and *Città Studi* have 22 and 25 schools respectively; in particular, *Città Studi* shows the highest concentration of *public services – education – school premises*.

b) Physical vulnerability analysis

Further analysis to compare the city districts were performed, the built surfaces and volumes were examined. Total amount of green and built areas, and also the total built volume on districts were compared and plotted on Fig. 6.

Buenos Aires – Venezia and *Duomo* areas, which can be considered hosting most of the city's-built heritage, are reported as the densest in terms of built area and volume; and also, having the scarcest green area coverage. 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. Meanwhile, *Buenos Aires – Venezia, Duomo, Brera* and *Città Studi* maintained their above average density condition.

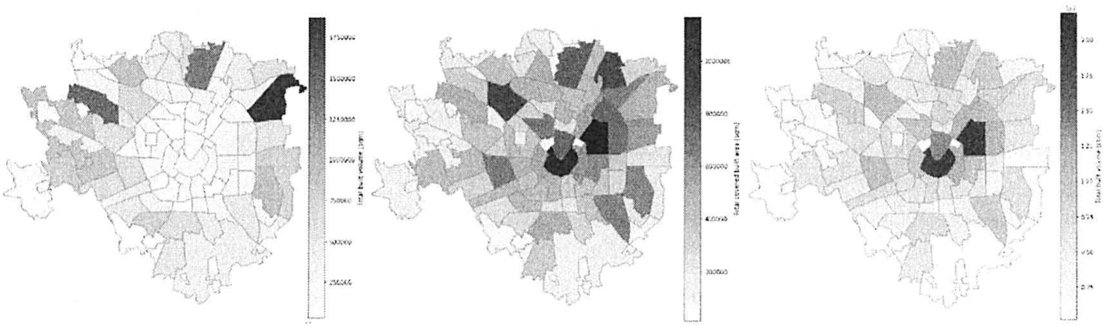

Fig. 6. Diversified population density distribution and the location of potential crowding source buildings immersed in the city of Milan (Comune di Milano, 2020)

Regarding the total greenery area coverage, the outskirts of the municipality has larger values, in particular *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.*

The analysis on the amount of area covered by water bodies was not carried out, as the database assessed did not provide sufficient data to process.

3.2 *Neighborhood analysis and characterization*

From the results gathered in §3.1, and the refined summary presented in Table 1, *Città Studi* was found to an interesting district to study. It 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 and 2 universities are hosted (one of which hosted in historical and protected buildings); 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.

3.2.1 *BE influential elements description*

Having all these features, it is possible to find within the NIL of *Città Studi* a variety of BE units that favor or diminish SLODs risk, by modifying the physical vulnerability that surrounds the single citizen or the family unit; that is, in a much smaller scale.

For that reason, a similar smaller neighborhood scale area was delineated. This was selected based on crowding, weather and pollution data sources on the proximity. The delineated area is shown in Fig. 7, and for this smaller area a survey was carried out on the physical vulnerability and most influential parameters, as described on §2.3.2 & §2.4; identifying as critical:

- *Crowding sources proximity* – understanding the proximity (distance) and the type of crowding sources (e.g. schools, hospitals, homecare) for estimating the number of people, and susceptible people in the nearabout. If possible, understanding the moments of occupation peak could be of great use.

- *Density and geometry* – in particular canyon's Height-Width ratio (H/W) and canyons orientation favoring (or not) wind and solar radiation access.
- *Greenery and tree coverage* – identification of tree and greenery location, typology, shape, crown/canopy, lush and species. In particular to determine their pollution capture and solar shading potential.

Table 1. Ranking of neighborhoods in Milan where meteorological and air quality stations are located

Neighborhood	Elder [%]*	Young [%]*	Green area [%]**	Built area [%]**	Volume ratio***	School count
Parco Lambro - Cimiano	28.4%	14.2%	37.6%	9.3%	0.30	20
Niguarda - Cà Granda	27.1%	14.7%	31.8%	18.0%	0.46	23
Città Studi	25.3%	13.6%	15.4%	31.4%	0.52	25
Guastalla	24.7%	15.3%	13.8%	39.1%	0.53	41
Buenos Aires - Venezia	23.1%	14.8%	6.8%	40.6%	0.97	22
Brera	23.0%	16.4%	9.1%	45.6%	0.64	21
Duomo	22.2%	16.1%	8.5%	48.4%	1.00	20
Stadera	22.2%	16.2%	19.3%	15.7%	0.31	22
Selinunte	21.2%	17.5%	11.5%	30.1%	0.21	5
Isola	20.1%	14.0%	11.3%	35.2%	0.33	15
Navigli	19.8%	14.7%	9.9%	30.0%	0.25	7

* Portion of the total population on the NILs' selection.
** Portion of the total area of the NILs' selection.
*** Normalized on the maximum value reported from NILs' selection.

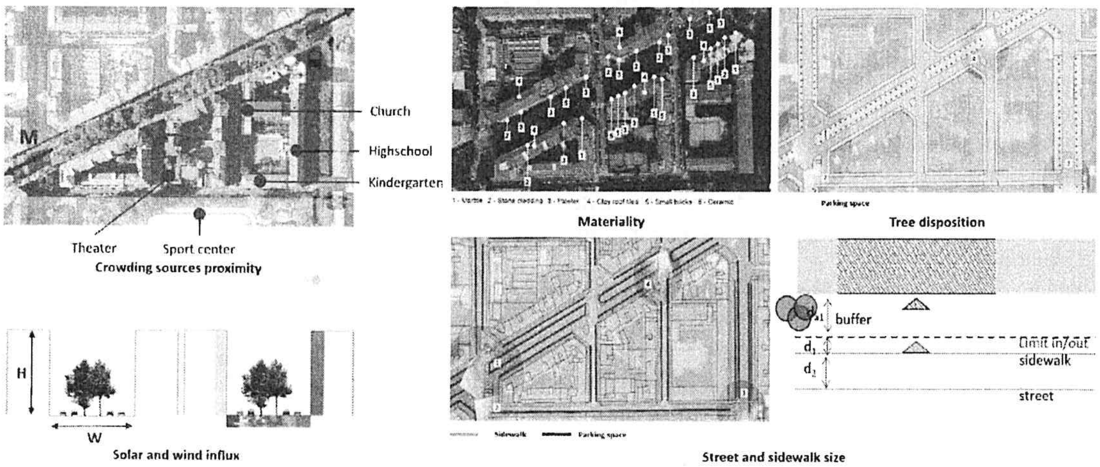

Fig. 7. SLODs risk assessment process overview at the neighborhood and urban unit scale

- *Street and sidewalk size* – related to the disposition of sidewalks, their "degree of occupation" (e.g. parking, urban furniture), and the traffic intensity. These parameters could also include the presence of protecting barriers (acoustic and pollution) between the street and the sidewalk. This is mostly related to cultural population behaviour, preferences or simply habits (e.g. walking, biking, or automobile culture).
- *Construction technology and materiality* – identifying the materials that compose the facades of the buildings facing the street to characterize their albedo coefficient, heat capacity, roughness and porosity. These allow surface temperature, wind flow and outdoor comfort analysis (when coupled with reliable environmental conditions data).
- *Building interface* – describing in detail the buildings entrance size (in particular those of crowding), identifying buffer areas. The way the access is designed reduces the flux of people entering, increasing the lead time, thus the exposure.

4. CONCLUSIONS

The presented work represents the methods and tools for identifying representative portions of the BE in cities typically characterized by an high architectural heritage, while applying the process into an Italian city as an example, in which critical *air pollution* concentration and high UHI intensity typically arise.

The specific analysis has been carried out following a structured methodology on the city of Milan, to identify specific zones containing risky BE units that can be extrapolated to any other city and identified as a potential risk area (given the probability of the hazard to manifest).
To identify the specific BE units, the most critical parameters have been listed as: *proximity of crowding sources; built environment density and geometry; street and sidewalk size; greenery and tree coverage; construction technology and materiality; and, building interface.*

In the case of Milan, built heritage has been identified as a potential risk are in terms of SLODs, having large constructed density and low green areas (physical vulnerability); but also, these areas do not host permanently such a large number of citizens, neither susceptible population (i.e. elders and youngsters). However, its exposure and social vulnerability fluctuates as they are main tourist attractions; thus, monitoring stations shall be inserted to gather sufficient data.

Lastly, the characteristics of the sidewalk and street were linked with the social and cultural preferences, or habits, of the population held within the city; therefore, the analysis the SLODs risk assessment shall consider this to acknowledge how much these repetitive activities can boost the risk physical vulnerability and the risk exposure.

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