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Land Use, Mobility and Environment

This Special Issue of TeMA - Journal of Land Use, Mobility and Environment, collects twenty-seven contributes of international researchers and technicians in form of scenarios, insights, reasoning and research on the relations between the City and the impacts of Covid-19 pandemic, questioning about the development of a new vision and a general rethinking of the structure and urban organization.

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Special Issue

Covid -19 vs City -20

scenarios, insights, reasoning and research

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COVID-19 vs CITY-20
SCENARIOS, INSIGHTS, REASONING AND RESEARCH

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The cover image is a photo collage of some cities during the Covid-19 pandemic quarantine (March 2020)

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Take advantage of the black swan to improve the urban environment

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Abstract

The outbreak of the Covid-19 virus for all humanity is a typical example of the birth of the black swan, a metaphor that indicates an unpredictable crisis event, because its very low probability. Statistics and probability theory teache that any deterministic hypothesis of forecasting this type of event is a chimera. More concretely, it is necessary to pay attention to the robustness of the socio-ecosystem, with respect to any crisis advent, not the pursuit of the specific black swan, which, by the way, takes different forms: from financial perfect storms to pandemics, to the unpredictable effects of climate change etc.. The paper refers to the health risk investigating the process of Urban Heat Island (UHI) which is a cause of health risk and of the increase in air pollution hazard. At the moment, there is a debate about the link between air pollution and Covid-19 diffusion, but, in any case, the precautionary principle pushes to take the opportunity of the crisis for a more sustainable city in terms air quality and citizen wellness. This paper presents a simple method to spatially classify areas of the city with different UHI-air pollution hazard, according to their morphology and land use. The possible employment of a such approach for planning has been discussed, to potentially pursue mitigation of the whole supply chain of urban climate-pollution-virus diffusion.

Keywords

Covid-19; Post-lockdown planning; Food self-sufficiency; Mobility; Climate change.

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1. Introduction

About half the world's population (over 3 billion people) lives in urban areas, and this number might rise to over 6 billion by 2050. Urban growth will be greatest in Africa and Asia, followed by Latin America and Oceania (Urbanet, 2020). This growth will not only result in more megacities (cities of more than 10 million people, increasingly concentrated in Asia) but also in more medium-sized cities, especially in Africa.
These were the forecasts, before the advent of the black swan, in the form of the pandemic coronavirus Covid-19 (hence forth Covid). The pandemic has undermined the belief of the triumph of the city (Glaeser, 2011) because under the carpet of the splendor of the civilization of encounter and economic development a lot of dust has been accumulated: actually 1 billion people live in slum-like conditions, and, with the world wide population predicted to expand to 9 billion by 2030, this number could reach 2 billion.
In developed countries, on the other hand, cities (above all Italian art cities) have become attractors for relatively affluent people and for tourists (Koolhaas, 2020) which are heavy city negatives, immediately from the social point of view, but also from a robustness point of view, because mono-functional postcard cities are very fragile. In fact, news of these days indicates the budgetary difficulties of Florence, caused by the lack of revenue from tourism. Urban environments can strongly affect human health and their correct planning and management increases systems resilience leading to more robust, reactive and even anti-fragile cities. The coronavirus Covid epidemic is the dramatic signal of overcoming and setting an era: the Enlightenment and mechanistic Modernity (Leone et al., 2018). Following Taleb's (2012) definition of Modernity, it is not the post-medieval historical period, but the era in which mankind predominated over the environment, a definition very close to that of Franco Cardini (2019) according to which the engine of Modernity is the "cancellation of the sense of limit". The consequence is the great fragility of modern systems, for example: megalopolis with suburbs affected by chronic social malaise and always on the brink of social explosion; on the other hand, food safety is threatened by industrial agriculture, dependent on chemistry, genetics and very few varieties of seeds and plant species, which today are even being attempted to patent.
The debate is not new, recalling the criticism of Sassen (2015) who identifies precisely in the global metropolis the place of the emptying of social rights.
This Modernity at the end of the cycle is under the illusion of controlling everything, but, in this way, it accumulates fragility (or entropy, see Leone et al., 2018) with the systematic smoothing of the factors of small stress, which instead have the function of "vaccine" for individuals and society (Taleb, 2012). On the other hand, it is useless to disappoint oneself and large crises and black swans call for a clever solution: the strengthening exercise brought on by smaller crises (precursor signals) and their dynamic function of developing "vaccine" and serendipity. Indeed, we have to learn from smaller crises and mistakes (Taleb, 2012).
Consequently, a second Modernity is required to mitigate all the distortions that the last phase of Modernity has introduced. One of these, among the most important in the urban field, is the care for the environment of and in the city, with a new role for the town planning: no longer a project aimed at "magnificent and progressive fates" (e.g. the over sizing of urban plans), but the empathetic effort in understanding and preventing the pathologies of urban living systems (Beck, 2013). This new season, however, is not a complete change of paradigm; on the contrary, its roots are in the origins of Enlightenment town planning, which arose also from the epidemics of the nineteenth century (Astengo, 1970; Benevolo, 1998).
Since change always brings conflicts, opposed by consolidated powers and their "allies" (Leone et al., 2018), such as the pessimism that generates fear of change and laziness. The crisis is an opportunity to overcome these problems by looking at the best tradition of the past.
Hence, rather than thinking about the virus as an architect of the future, it is necessary to use it as a lever to build a better future and, to do this, the environmental protection and management of urban systems is fundamental. The paper discusses the current Covid related environmental issues providing recommendations

for more effective actions that would address the urban planning towards a comprehensive sustainability of future cities. Section 2 presents a brief resume of the links between Covid and urban environmental issue, in particular, air pollution and urban heat island. Section 3, proposes a simple UHI assessment method for an exemplificative case in Bari city, Southern Italy. Finally, section 4 and 5 accounts the outlined discussion and conclusive remarks, respectively.

2. Covid and urban environment

The eruption of the environmental issue in urban planning means resuming, in a contemporary key, the urban hygienist tradition, because protecting the environment also means taking care of health, with the best care there is: the prevention of pathologies, firstly environmental and territorial. In fact, the hygiene requirements of the second Modernity consist above all in environmental care.

Regarding the presence and spread of Covid, it cannot yet be definitively said that air pollution favors the spread of the virus, but more than one scientific paper confirms the high probability of this hypothesis, especially for ammonia and fine-dust pollution. Xiao et al. (2020) investigated whether exposure to fine particulate matter ($PM_{2,5}$) increases the risk of Covid deaths in the United States. The results of this paper suggest that long-term exposure to air pollution increases hazard, i.e. the probability to experiencing the most severe Covid outcomes. These findings align with the known relationship between $PM_{2,5}$ exposure and many of the cardiovascular and respiratory co-morbidities patient (Rydin et al, 2012; Watty et al., 2015). This can be a contributory cause of the dramatically increase of deaths by Covid, because air pollution offers pre-conditions for both the development of respiratory related diseases and the complications and co-morbidities (Murgante et al., 2020). Similar results come from other researches: a position paper from various Italian universities (Setti et al., 2020) shows the strong correlation between the number of infected people and the average of exceeding the PM_{10} limits. The authors attribute this result both to the carrier effect of the atmospheric particulate matter and to its substrate action that keeps the virus in the air viable for a long time. These same authors cite previous studies, therefore more consolidated in the data, relating to avian influenza, in which the number of infected people is related exponentially to the concentrations of fine-dust.

Furthermore, Lu et al. (2019) report a similar situation in the case of a measles epidemic. Further confirmation comes from the recent Becchetti et al. (2020) study, which also assessed the effect of the lockdown in Italy. The study finds a very significant statistical association between pollution, contagions and severity of Covid outcomes, for which the quality of air is a strong predictor of contagion and mortality.

These studies are largely sufficient to demonstrate the importance of the link between air pollution and the risk of contagion, at least on the basis of the precautionary principle.

Furthermore, the "simple" fight against air pollution is already a duty of the town planner, given the numerous diseases that this entails (Rydin et al., 2012; Watty et al., 2015). The role of the planner is very important because planning can prevent or at least minimize the health crisis, through urban design and management, while the doctor is the last bulwark, with the disease arrived.

The analysis carried out in this paper is based on risk assessment, i.e. the careful examination of what, from atmospheric point of view, could cause hazard to people. A hazard is something that can cause harm, while a risk is the chance, high or low, that any hazard will actually cause somebody harm (Tiboni, 2002). In this case, the hazard factor is the urban heat island (UHI), which is a risk for the health of citizens, favors pollution and, likely, is a facilitator of contagion from viruses (Leone, 2019). Consequently, the management of the urban heat island problem becomes a powerful solution tool for all these problems. Furthermore, UHI is itself a pollution factor, because it triggers the chemical reactions that lead to the formation of ozone, one of the main atmospheric pollutants in the city, along with fine dusts and NO_2. Fig. 1 shows the conceptual scheme adopted in this paper.

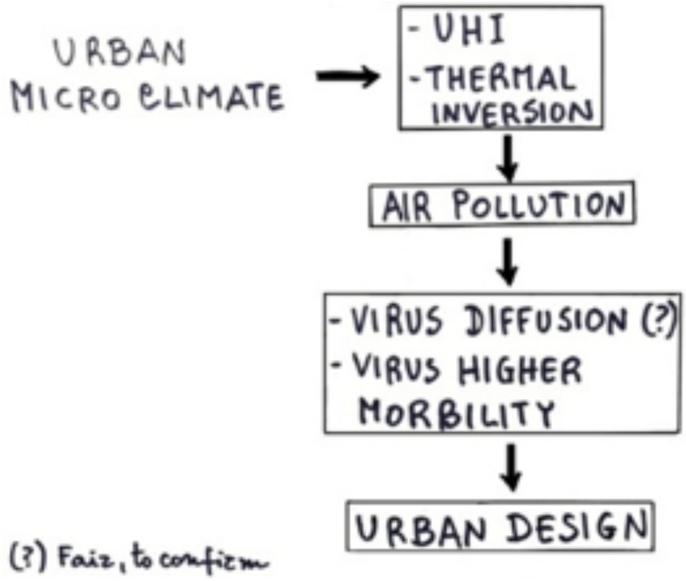


Fig.1 Urban microclimate and hazards.

The Urban Heat Island

The fundamental impact of the city on the atmosphere consists in the phenomenon of the urban heat island, i.e. the significantly higher temperature of the city, compared to the surrounding countryside (Gerundo et al., 2014). This phenomenon influences other processes, such as inversion of vertical thermal profile and even the amount of rainfall during the most intense events, as Zhang et al. (2018) demonstrated in the event of the Harvey hurricane, passing over the city of Houston, Texas.

The UHI is an intrinsic phenomenon of the city, which, especially for built environment materials and geometry, captures the incident solar radiation and retains the anthropogenic heat emitted by vehicles and conditioned buildings, to release it at night (Akbari & Rose, 2001). These processes are very variable, so urban microclimate is highly differentiated and understanding this variability is fundamental for the design and regeneration of the city that is comfortable for its inhabitants, which adapts best to climate change and to the risk of damage to health. UHI is a process that has occurred since long, before the global climate change and has a greater entity, see the example of Paris in Fig. 2: the phenomenon began in the early 1900s, with the great urbanization of the time. Furthermore, the figure shows that UHI is more sensitive to the minimum (night) temperatures.

The size of the city (in terms of inhabitants number, *P*) is the first trigger factor for a synthetic estimate of the phenomenon, Oke's (1981) model suggests of the maximum UHI ($\Delta T_{(u-r)max}$):

$$\Delta T(u-r)\max = 2{,}01\ \times \log_{10} P - 4{,}06 \qquad [°C]$$

UHI has two effects on citizens' health: direct, because it alters the conditions of climatic well-being, which is already a mortality factor for weak subjects (Fig.3a); indirect, because it influences atmospheric stability and, therefore, the tendency to accumulate gaseous pollutants and fine dust (Fig.3b, Parry et al., 2012).

As regards air pollution, the following morphological factors of the city are very important:

- size of the urban canyons (Fig.4);
- height and slenderness of the buildings (horizontal section exposed to the wind), which determine the roughness of the urban surface, or its resistance to the motion of the air. The roughness index z_0 is the height at which the vertical profile of the wind extrapolates the speed to zero; it is defined by the following relationship (Erell et al., 2011, modified):

$$z_0 = \frac{H \times a}{2\,(A - A_P)} \qquad [1]$$

being H (m) the buildings' mean height (m), a (m^2) buildings' slenderness, A (m^2) the area of the sector examined, A_P (m^2) the area occupied by the buildings.

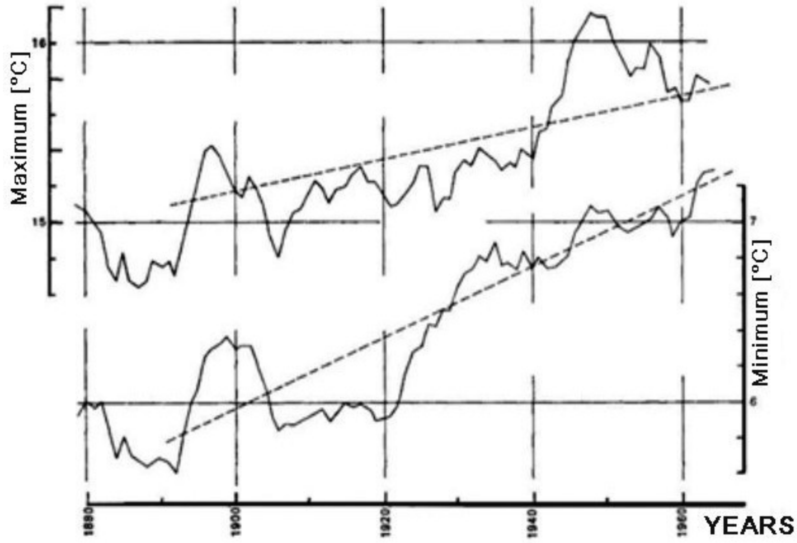
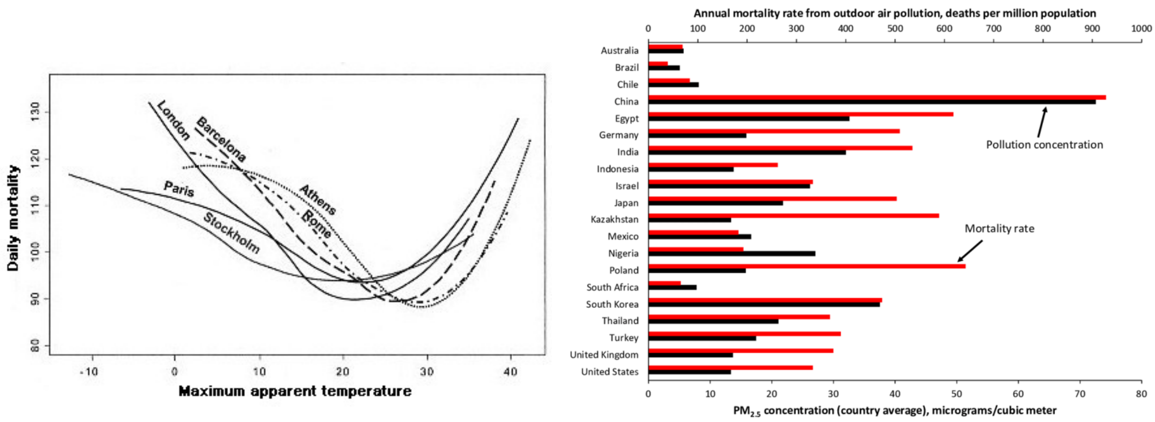


Fig.2 Average annual temperatures in Paris.



(a) (b)

Fig.3 (a) Mortality of weak subjects and thermal comfort (after Bargagli and Michelozzi, 2011); (b) Mortality and $PM_{2,5}$ concentration worldwide (after Parry et al., 2017).

From the point of view of atmospheric vulnerability, urban geometry has a double and synergistic action: i) the roughness z_0 makes the atmosphere more stable, reducing turbulence and wind speed, especially at night, just when the UHI is greater (Fig.5); ii) at night, it is released the energy stored during the day, so the thermal inversion is triggered, being the soil "warmer" and the air above it "colder".

It is well known that thermal inversion is the situation of greatest hazard (i.e. intrinsic vulnerability) of the atmosphere (Leone, 2019). The best indicator of this process is the vertical thermal gradient $\Gamma = \Delta T / \Delta z$ (°C/100 m) which is normally negative, because the temperature decreases with altitude. The more the gradient is negative, the less vulnerable is the atmosphere, because the pollutant particles introduced into the air are pushed upwards and dispersed. On the contrary, if Γ reverses and becomes positive (or close to zero), the vulnerability is maximum (Leone, 2019).

Figure 4 shows a scheme of the urban-rural gradient, with the urban positive gradient due to UHI ($\Delta T_{(u-r)}$), whose quantification can be obtained from the following relationship, coming from the reworking of the data provided by Landsberg (1981):

$$\Gamma = 1{,}49 \times \Delta T(u-r) - 1{,}94 \qquad [°C/100\ m]$$

Since a $\Delta T_{(u-r)}$=1,3°C is sufficient to generate thermal inversion (Γ>0), this equation shows that almost always the UHI generates a strong vulnerability to pollution of the atmosphere.

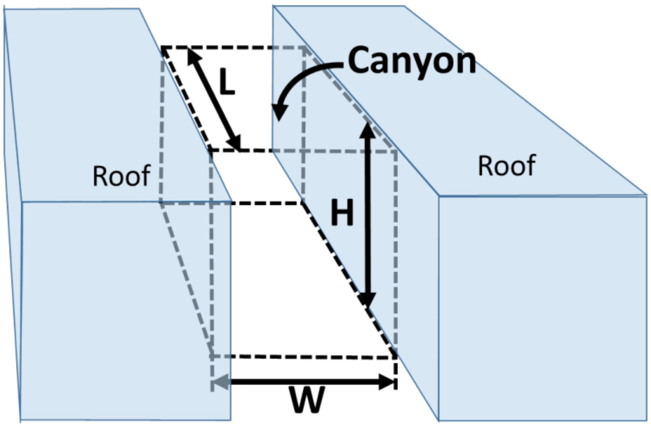


Fig.4 Building morphologies influencing UHI.

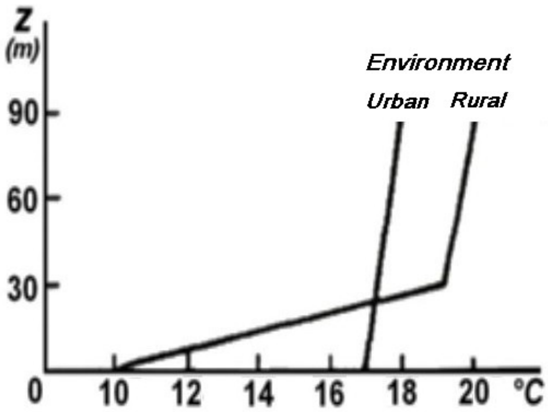


Fig.5 Vertical thermal profiles of urban and rural environments

Urban heat island, city planning and management

In addition to the effect on atmosphere vulnerability, the benefits of reducing UHI include decreasing energy demand and CO_2 emissions, reducing photochemical reactions that produce ozone on the ground. These advantages increase if urban greening is used as a control system of UHI, with all the further advantages that green brings to urban environment and people (i.e. ecosystem services, see Pelorosso et al. 2017a). Therefore, reducing the urban heat island is a fundamental, multifunctional, element of sustainability of the urban project and urban regeneration.

The city is a complex system and its climate is not an exception, as shown by the analysis carried out so far, from which it is observed that the "microclimate in the city" is more important than the "microclimate of the city", because urban different morphologies, physical, geometric and coverage characteristics (buildings materials, vegetation presence, wind exposition etc.) influence all weather-climatic parameters. Interactions and feedbacks among these parameters generate very different micro-zones that it is necessary to identify, to increase sustainability, in the specific case pursued in terms of urban well-being, less energy consumption and lower emission of climate-altering gases (Alexander et al., 2015).

3. A proposal of UHI assessment

A powerful tool to manage UHI is first of all its quantitative estimate, which can be obtained through the Oke model (1981), which considers the geometry, the more significant process, as it is defined in Figure 3:

$$\Delta Tu - r\ (max) = 7{,}45\ +\ 9{,}14 \times log10(H/W) \quad [2]$$

This model has been tested with good results for European and North American cities (Oke, 1984; Nakata-Osaki et al., 2018). It is widely used in literature (Roth, 2012; Nakata & Souza, 2013; Chokhachian et al., 2020) because it is based on easily available data and allows an immediate, general urban analysis. In fact, this model allows setting a zoning of the city for different degrees of hazard of the UHI, thanks to the GIS technology. In a second phase, stressed the "hot zones", it is possible a more detailed analysis, to carry the urban design.
An exemplificative application of this analysis is presented in study case, in particular nineteenth-century central district of the Bari city, South Italy. Figure 6 shows the Digital Surface Models (DSM, made by the Puglia region in 2006), coming from the LiDAR system, in which pulses of light travel to the ground allow to evaluate buildings height. The data of Figure 5 has been used to calculate UHI of the streets in the district by equation.
The results of Figure 7 were considered as the first screening on UHI, street by street, from minor to major. Later, a more detailed energy balance of the canyon has been applied to some of these streets, following the approach of the CAT model (Canyon Air Temperature, see Kaplan et al., 2016). In this way, the night UHI was estimated and the results were inserted in the well-being diagram of Olgyay & Olgyay (2015) for some significant days between June 15th to September 15th 2018 (Fig. 8).

Fig.6 Bari downtown DSM analysis

Fig.7 Downtown UHI distribution following Oke's model

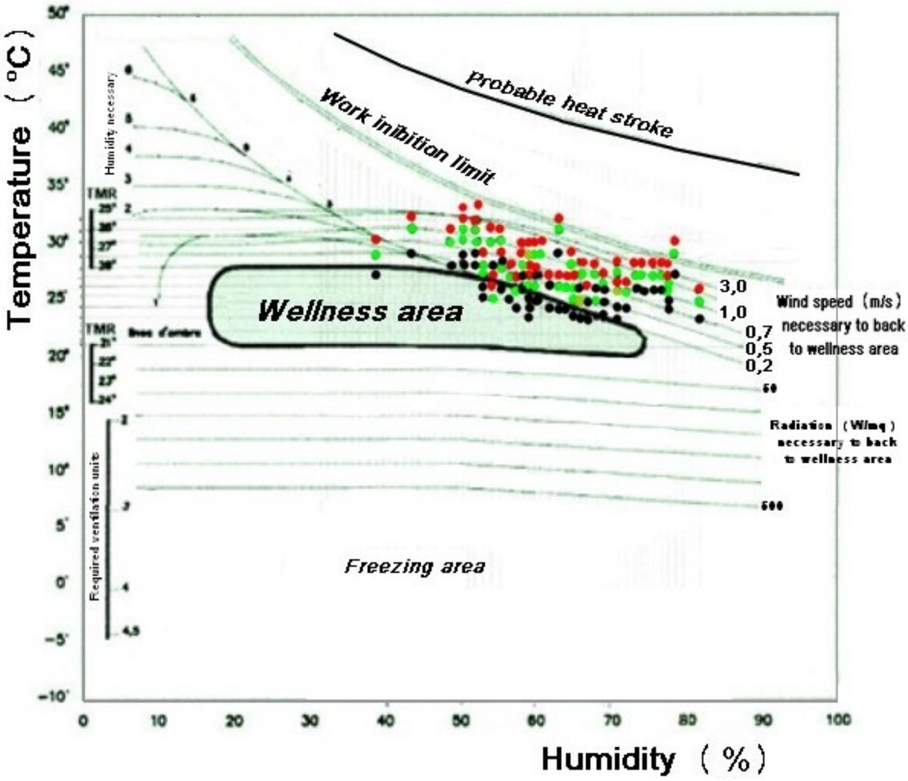


Fig.8 Evaluation of dis-comfort due to nocturnal UHI. The black points refer to the temperature and humidity recorded by the station of Bari, available from the weather archive www.ilmeteo.it; the green points relate to the minimum temperature surplus ("cooler streets"); the red points relate to the maximum temperature surplus (warmer streets).

4. Discussion

This paper aims to demonstrate how to prevent urban environmental issues related to the health status of citizen; specifically, it regards the UHI phenomenon, whose relevance is evident from Figure 8: for all the investigated period, UHI generates un-sustainable "tropical nights" for the whole period examined. The same figure shows the importance of the wind, that can be sufficient to bring weather back to the wellness area, but, unfortunately, summer atmospheric calm during the night is frequent and urban geometry itself is a wind attenuation factor, as shown in equation 1.

In consequence, UHI is a relevant issue which will tend to increase the impacts on life quality in future cities. The opportunity to control this process effectively arises from Covid crisis, going in the direction of Taleb's postulate: rather than to chase the unpredictable black swan, it is necessary to improve sustainability, in order to absorb any future crisis.

In the specific case, the prevention of the UHI occurs through the art of designing wellness in the built environment and, furthermore, favoring adaptation to weather and climatic conditions. This aim has been pursued by distinguishing the different parts of the city, according to UHI productions factors, interpreted in a fine grain, street by street, with a sort of "precision urban planning".

The results expressed by Figures 6 and 7 are useful for various urban sustainability strategies. In fact, acting with the aim of reducing the UHI means, too:

- to counteract air pollution and virus spreading morbidity, an action which can, therefore, be an aid to the territorial medicine;
- to set the consequent health plans in case of occurrence of pollution beyond the law limits;
- to adapt the city to climate change also in the immediate term by supporting civil protection plans aimed to prevent the consequences of summer heat waves.

Understanding the hazardous areas forth phenomenon allows setting regeneration, whose outcome can be quantitatively assessed in terms of environmental sustainability and adaptation to climate change. For example, Stewart and Oke (2012) distinguished the local microclimate zones for universally describing neighborhood morphology and thermal climate: each zone is defined on the basis of parameters which impact on the thermal properties, such as green land cover, street canyons geometry, building materials, waste heat management and so forth.

In addition to the care for building materials (reflectance, emissivity, green roofs etc.), there are many other aspects of the sustainable urban project that can be supported by the results shown in Figures 6 and 7. Certainly, the most important outcome consists in the push for the widespread increase of green systems, which are the main mitigation factor of the UHI (Skelhorn et al., 2014).

For these objectives, parks are important, see also Figure 6, where it is evident the role of green areas. But also single and small widespread green areas can play an important role, especially in the compact city, where spaces are limited. For example, scientific literature demonstrates the importance of pocket parks and residual green areas in mitigating the UHI (Lu et al., 2019).

In this latter case, the example of the city of Bari is significant: downtown, practically, have not spaces for green regeneration, but the urban checkerboard structure leaves many spaces between the curtains of the buildings (Figure 5). Historically, these spaces were gardens, which disappeared about 60 years ago, to create warehouses. This tradition can be restored through greening the courtyard (e.g. grass cover and trees) and the technique of green roofs, a component of urban regeneration that can bring microclimatic improvements if opportunely irrigated (Pelorosso et al., 2017b; Pelorosso et al., 2018a; Pelorosso et al., 2018b; Leone et al., 2020).

Furthermore, the quantitative assessment of the UHI can allows Strategic Environmental Assessment (SEA) of regeneration plan to be improved. Indeed, too often the SEA paths neglect the measurable effects of the plan choices (Conticelli & Tondelli, 2013). Finally, spatial indexes of UHI as those proposed in this paper can be employed in innovative performance-based planning approaches based on climate and urban morphological factors (He et al., 2019; Pelorosso, 2020).

The environmental issue and the chain climate change-air pollution-virus diffusion risk is the strategic opportunity to fully address these problems and change the outdated beliefs and paradigms. The metropolis was thought to mean the future of quality, because its essence lies in making available goods, services, flow capacities and relationships, impossible for smaller realities (Glaeser, 2011). It is true, but Covid has showed metropolis' fragility, it is there that the virus has found vitality: in the way of living, moving, consuming and producing. It does not seem a coincidence that Milan's and New York's areas, the most Modernity paradigmatic cities in their respective countries, have been the most affected by Covid that seems to impersonate the barbaric people that attacked the heart of the Empire.

Regarding another Modernity's fragility factor, the global climate change, the online journalist Rob Wijnberg (2020) finds the following four similarities between the Covid pandemic and the climate crisis, considering, in any case, that the climatic emergency is worse than the Covid, because, beyond a certain threshold, it is irreversible and because there is no "vaccine" that allows people to continue living as always:

- the problem is mostly invisible and its invisibility is the problem.
- the problem is global: globalization is "the abolition of distance" and therefore promotes contagion; as well as the world shares a single atmosphere. Hence, concepts like "here" and "there" are misleading;
- the problem affects everyone, everyone can catch the virus, but it also discriminates the weakest people: elderly, people of color, immigrants, low-educated adults, people on lower incomes, people in developing countries, refugees, etc.;
- the climate crisis requires an equally fundamental restructuring of society.

Aiming to problem solving, the authors of this paper add a fifth similarity:

- solution to the above problems often coincide: the presence of open spaces for walking and cycling and the greenery of cities more accessible for the inhabitants are the same recipe, both for adaptation to climate change and for the fight against UHI, air pollution and Covid contagion.

5. Conclusion

Given their unpredictability, to mitigate the effect of black swans, it is necessary the construction of robust systems acting before they present themselves, so that, at that moment, the system can react and perhaps take advantage of the crisis to acquire new resilience.

The weak point in the application of this reasoning consists in the timing, because building robust systems means acting in a non-emergency situation, when the path is more difficult, and people don't believe in change. Politicians and decision-makers, even when sensitive and open to new strategic visions, know that acting in a non-emergency situation is rarely convenient in electoral terms. The advantage of the crisis is an opportunity also because it may give strength to the more advanced visions. Then, the strategy must be twofold: an immediate tactic, to mitigate the specific effects of the black swan, and a wide-ranging one, aimed at increasing new and more advanced balances.

The link between urban climate-pollution-virus diffusion discussed in this paper offers a concrete example in this sense. The positive feedback that connects all these processes makes it an unmissable opportunity for an authentic sustainable and fair city regeneration.

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Image Sources

Fig.1: Elaboration by authors;

Fig.2: Landsberg, 1981;

Fig.3a: Bargagli & Michelozzi, 2011;

Fig.3b: Parry et al., 2017;

Fig.4: Elaboration by authors;

Fig.5: Elaboration by authors;

Fig.6: Elaboration by authors;

Fig.7: Elaboration by authors;

Fig.8: Elaboration by authors.

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