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Urban Heat Island (UHI) risk maps as innovative tool for urban regeneration strategies. The case of Parma

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Abstract. For the purposes of regeneration of the consolidated city it is increasingly important to have the knowledge of the micro-scale distribution of the vulnerability of the population to the consequences of climate change and increasing urbanization. The work to be presented starts with the creation of maps of the risk classification induced by the heat islands in the city of Parma, and aims to investigate which are the most effective strategies that a Public Administration can adopt. The maps that have been created allow to assess the risk for the fragile population at the level of the single building. They relate the climatic datum of thermal variation with the population residing within each building, and verify the causal relationship with the soil sealing and with the morphology of the urban fabric. The results of the study can help to identify the thermal hot spot, receivers of specific mitigation actions. The risk map is itself a tool to develop multilevel actions, designed according to the peculiarities of the sites, where the possible adaptive solutions are compared with the physical and morphological characteristics of the places. The positive function of green infrastructures (contrast of overheating, flood mitigation, creation of places and services with a recreational function) is acquired by research and urban planning practice. It is equally well known the difficulty faced by Local Authorities in the maintenance and increase of unbuilt public areas, fundamental for the connection of ecological networks.

1. Introduction

One of the cruxes to be faced in urban regeneration policies concerns the city's vulnerability to climate change, in the face of which territorial planning is proving to be a 'discipline' in evolution, without consolidated certainties.

In a context of ongoing changes, cities take on a dual role: they are a place of accumulation and production of climate-alteration negative externalities, but at the same time they can be the privileged place for experimenting with new urban planning practices to increase the resilience of the urban systems, as evidenced in many international documents [1].

The management of critical issues related to climate change, especially through emergency and civil protection plans, has probably made it possible to perceive the entity and the danger, without however fully understanding the harmful consequences in the long run, evaluable only with the quantification of the risk, starting from the identification of the areas for individual categories.

Among the main difficulties detected by scholars is the absence of linearity or proportionality between causes and effects, which causes even small-scale variations to amplify outcomes and result in major transformations, while large interventions may have small effects or not have [2][3][4]. To this is



added the difficulty inherent in human perception that tends to underestimate the slow and protracted changes over time, differently from the skill and promptness manifested in responding to rapid changes [5].

In this context, traditional urban planning models and techniques prove to be insufficient, starting from the construction of traditional knowledge frameworks.

In fact, they acquire a primary role the physical characteristics of the materials of which the city is composed, its settlement morphology, the function of urban settlements, the density and the distribution of public and private un-built spaces, orientation and width of the roads and above all the vegetation equipment and its distribution within the urban space. All factors should considerably influence the urban microclimate and the relative comfort conditions.

The amount of digital data, increasingly open, constitutes a significant patrimony of available knowledge that allows the realization of modelling simulations aimed at the analysis of urban climate vulnerability.

Starting from the physics of climate change in urban areas and its macroscopic implications, it is in fact possible to define maps of the danger of the consequent risk, especially for the weakest sections of the population. It is necessary to consider that in many urban areas, climate changes are amplifiers of previous critical points, also induced by the demographic changes taking place, not least the progressive aging of the population.

In the European reference framework, a major responsibility for mitigation and adaptation to climate change is attributed to local policies.

Although there are many international and European examples of climate maps and their use to support urban planning strategies, in Italy it is still experimentation mostly related to the drafting of Climate Adaptation Plans which, not having a mandatory nature, are currently rather rare, but they have rather high reliability guarantees thanks to the scientific technical approach set at the community level. With the innovation of the Action Plan for Sustainable Energy and Climate, which since 2015 has obliged the new underwriters to draw up an adaptation plan, the climatic datum has fully entered into the drafting of the plans themselves. However, these are collateral tools, whose addresses have difficulty in integrating with urban planning tools [6]. Furthermore, it is not to be underestimated the difficulty of urban planners in understanding the climate functioning of the city, responsible for the consequent lack of transfer in the plan processes. Recent international documents [1] invite in this regard to promote collaboration between the scientific community and public administrations of all levels, especially local, to spread knowledge and best practices on the widest scale.

Other obstacles are opposed to the construction of climate change adaptation governance through urban planning. One of these is the lack of clear, non-confrontational and hierarchically coherent institutional frameworks. The adaptation to climate change, in fact, is often downgraded in current practice to management issues (as in the case of flooding caused by overflowing of water bodies). In this way, it is not taken into due consideration the fundamental contribution that urban planning is able to provide to a strategy of adaptation to climate change [7][8].

Nevertheless, in a scenario of weak economic resources, where the Public Administrations risk to have more and more restricted possibilities to regulate the 'safeguard and use of the territory' (from the title of the new urban law of Emilia-Romagna region), the risk mapping can reveal its usefulness in urban regeneration strategies.

One of the perhaps most underrated aspects of urban policies in Italy concerns the UHI, despite many studies highlighting the need to provide information to policy makers to design policies to reduce UHIs and their negative effects [9].

Heat waves are the key climate factor for summer air temperature rise and the associated risks potentially affect human health. The most negative impacts affect the vulnerable groups of the population: the elderly, the sick and to some extent the children. The increased vulnerability of the elderly is related to particular situations of fragility, given not only by health, but also by economic conditions. In particular, mortality for populations in the European Union has been estimated to increase by 1 to 4 % for each degree increase of temperature above a (locally specific) cut-off point [10].

Urban air pollution concentrations increase in warming cities [11][12]; they may also increase during heat waves with significant consequences for mortality. This is due to the fact that high temperatures

and solar radiation stimulate the production of ozone as well as volatile organic compounds (VOCs). Under existing air pollution abatement policies 311,000 premature deaths are projected in 2030 due to ground-level ozone and fine [10].

The role that can be assumed by the Public Administrations is many-sided: supplier of resources through the provision of positive incentives, primarily allocated to the areas that prove to be most vulnerable; self-regulator for maintenance interventions and infrastructural planning on public spaces; facilitator of participatory processes for people of the city. But above all, the resulting policies can trigger the action of environmental justice, establishing priorities for action in favour of areas where the probable negative effects of climate change are associated with the presence of the most disadvantaged urban communities.

This paper shows the maps that have been created to assess the risk for the fragile population at the level of the single building in the city of Parma and proposes them as an instrument to develop multilevel actions, designed according to the peculiarities of the sites, where the possible adaptive solutions are compared with the physical and morphological characteristics of the places.

Although initially working on individual aspects, the recommended transformation strategies and practices for heat island mitigation can have positive effects and repercussions on several components of the territorial and urban system. Starting from environmental problems, the intervention recommendations, due to the characteristics of the process and the activated solutions, can in fact impact positively on different sectors.

The study that led to the achievement of the classification of the risk induced by the heat islands on the fragile segments of the population was carried out in collaboration with the Ibimet (Istituto di Biometeorologia del Consiglio Nazionale delle Ricerche) of Bologna and Florence.

2. Urban Heat Island and the impact towards the Cities. The case of Parma

2.1. The city of Parma: the soil consumption vs urban ecological network

Parma, city of about 200.000 inhabitants, as the other chief towns of the Po valley and especially in Emilia Region, has been interested in the last fifty years by an increase in the average values of the maximum summer temperatures and by an increase in the duration (in days) of heat waves [13].

The municipal territory presents one of the highest soil consumption values in Italy, although in the two-year period 2016-2017 it showed a low tendency towards the density of changes (the new consumption of soil compared to the territorial surface) and an even lower level of soil consumed per capita (0,25-1 sqm/inhabitants/year) [14].

Luckily as in the Emilia-Romagna Region cities also in Parma a virtuous ten-year planning practice has allowed the creation of a wide range of public facilities (parks, equipped green areas, neighbourhood services, social residences) that now must be managed and retrained also with regard to the new challenges posed by climate and social changes ongoing.

The urban centre of Parma is characterized by a multiplicity of green areas with very variable characteristics among them in terms of extension, vegetation cover and location. The prevailing situation is represented by areas with tree-shrub covering between 10% and 25%, where there are various tree specimens that often form small vegetated spots, located mainly along the Parma torrent, in particular in the northern section of the railway line, along the River Baganza and in city parks [15]

Particularly important sites of the ecological network in urban environment, with undoubted positive influence on microclimatic conditions, are: the confluence between the River Baganza and the River Parma, the Parco Ducale and the Cittadella, which are of primary importance for their position within the city as areas of refuge and reproduction for animal organisms that are more in confidence with humans. In particular, the Parco Ducale has an excellent ecological potential, characterized by a good autochthonous vegetation with the presence of elements of historical value, which can play a primary role as a node of ecological connection, with calming function of high summer temperatures [15].

2.2. Urban Heat Islands risk maps and urban system

The correlation between the increase in average temperatures and the high degree of imperviousness is a fact recognized by the scientific literature [16] while the behaviour of surface temperature in areas surrounding residential buildings is not well known, especially if they do not belong to urban homogeneous areas.

The evolution of digital tools has made it possible to make freely available a significant heritage of open data, allowing modelling simulations aimed at the analysis of urban climate vulnerability.

For the city of Parma, thanks to the cooperation with Ibimet – CNR, it has been possible to quantify the influence of the high degree of imperviousness of the soil on the ST (Surface Temperature) of the residential buildings.

The elaborations have correlated high-definition thermal images, detected through the Aster satellite platform (Advanced Spaceborne Thermal Emission and Reflected Radiometer) and very high-resolution (10 m.) mapping for the calculation and monitoring of soil consumption developed by ISPRA (Italian National Institute for Environmental Protection and Research), in order to investigate the causal link between day and night temperatures - detected during the days of maximum insolation of the year 2015 - and the degree of soil sealing. An additional information level has been added: the urban environment (densely built-up) and park/rural areas identified by using the current municipal urban planning instruments.

For LST estimation was used the thermal infrared (TIR) wavelength band 14 of Aster with high-spatial resolution (90 m). It was considered a general emissivity value of 0.95 because most of the roofs of residential buildings in the city of Parma are characterized by red rough bricks.

To overcome the inadequacy of Aster's spatial resolution, a Building Thermal Functional Area (BTFA) was introduced, calculated within a radius of approx. 56.42 m from the centroid of each analysed residential building. Through the study of the different parts of the municipal area, from the most densely urbanized to the rural areas and parks, during both day and night, Morabito et al. [17] showed that the characteristics related to the density of soil consumption, internal to each BTFA, can influence the thermal state of the building in an almost proportional way.

The average difference in ST in BFTAs is about 3.3 °C in urban areas during the day, and 2.2 °C in rural areas.

In general, the 98% of the analysed residential buildings with surface temperatures at night between 26 and 28 °C falls within the urbanized territory.

Whilst the 93% of the residential buildings analysed with surface temperatures of between 35 and 40 °C is within the urbanized territory.

Even only the absolute data show the influence of the UHI, but the most interesting data is the relationship between the increase in temperatures and the rate of land consumption: growth is more consistent with the approach of 60% and achieves maximum values when land consumption approaches and exceeds 80% in the BTFA [17].

The datum is even more relevant since about 70% of the residential buildings analysed fall within the urbanized area (densely built-up) and insists on a soil whose sealing rate exceeds the 60% limit.

The major socio-demographic indicator of heat exposure generally used in risk assessment studies is considered to be the geo-density of the population [18].

The comparison of remote sensing data, with the demographic and personal data sets - descriptive of the exposure of the population and of the vulnerability of the most fragile share, respectively -, offered then useful indicators in the analysis of the health risk referred to the UHI.

The age groups considered vulnerable were: children under the age of five, seniors over the age of seventy-five, people over the age of sixty-five. The latter represent 22.4% of the total population [19]

The 'spatialisation' of the resident population has obliged however to univocally unite the census data with the building ones, resorting to the retrieval of information through the factors common to the two classes of data, determining the size of the sample (a little more than a third of existing residential buildings) on which to conduct the analyses.

In the examination of risk, vulnerability is undoubtedly the most complex component since social and temporal factors have been introduced. And it is also the most dynamic parameter that requires constant updates for the monitoring.

As explained by Rota et al. [20], the vulnerability has been intended as a two-dimensional factor given by the integration of the sensitivity parameter of urban-environmental sensitivity, represented by soil consumption, referring to ISPRA's National Land Map with the 'spatialisation' of the sensitive population, considered to the above mentioned thresholds. All data have been normalized and five risk classes were obtained (very low, low, medium, high, very high).

The mapping of the city has highlighted high risk conditions in the areas of greatest population density, where the rate of land consumption approaches and exceeds the limit of 80%. Its distribution follows, overlapping, the classification of buildings according to the ST.

The statistical distribution shows some interesting features, if evaluated according to urban planning. In fact, it was found that the "medium" risk buildings, amounting to just under 48% of the analysed sample, represent the largest group. The second most populous group, however, is that of high-risk buildings, which collects an average of 36% of the real estate analysed "patrimony" of the city. Equally interesting is the statistical distribution of the risk index on the inhabitants of the city, obtained by correlating each building with the number of its inhabitants. Even with the approximations due to the partiality of the available data, it has been observed that taking into account the groups considered vulnerable in the population, more than 58% live in high-risk buildings.

2.3. Urban Heat Islands risk maps: a comparison between two districts in the outskirts of Parma

The geo-referencing of the data obtained has made evident the critical issues inherent in the neighbourhoods of the first post-World War II expansion. However, not all the consolidated city is invested in equal measure by the UHI phenomenon. Near the watercourses, in correspondence of the tree-lined parks, in the presence of a more accurate planning, one notices a certain difference also of temperatures and of UHI risk.

It is perhaps possible to measure the predictive effectiveness of the urban planning instruments also through the classification of the risk, in this case in relation to an aspect that could appear partial, as is the heat island, but which gains importance when considering the danger which subjects the most vulnerable and non-negligible, even numerically, part of the population.

By comparing two very different districts of the city for social, urban and environmental conditions, the San Leonardo and the Montanara, the first located to the north and the second to the south of the city, it is noted how the morphology of the territory has conditioned both its development and the environmental conditions in terms of different response to heat waves, even in apparently similar situations of settlement.

In San Leonardo, a district of the first industrial expansion whose evolution was conditioned by the presence of infrastructural barriers, the need to provide low-cost homes for workers led to the formation of a compact built fabric, with lots of variable land density, with peaks over 5.2 mc/sqm near the railway. The settlement morphology is very fragmented, to the residential fabric is approached the irregular fabric of the productive settlements, often equipped with large areas of sealed courtyards. But beyond the morphological typological differences of the consolidated fabric, the unitary and peculiar element is the scarcity of open spaces, coinciding with a strong consumption of soil. The equipment of the greenery is almost exclusively assigned to the rows of trees along the roads and to the condominium green, which is however rather scarce. The overlap of the risk map with the land consumption map (Figure 1) shows then vulnerable situations, considered in terms of high rates of land consumption, and the massive presence of high risk and very high risk buildings (it is perhaps not to be overlooked that the district is considered to be one of the most dangerous in terms of perceived social security).



Figure 1. Overlap of the over 65 risk map and the soil consumption map (ISPRA, 2015) in the Montanara district (on the left) and in the San Leonardo district (on the right). The high level of imperviousness (gray background) negatively affects the risk conditions. The presence of permeable areas in the Montanara district is evident. The provision of urban greenery begins to be enriched with the construction of the Peep, especially in the southern area.



Figure 2. Image of a road inside a parcelling plan inside the Montanara district and the risk UHI map.



Figure 3. Image of a road inside a parcelling plan inside the San Leonardo district and the risk UHI map.

The decision to temper the effects of urbanization, that of the sixties and seventies of the last century, dictated by the need to accommodate immigration, especially from the countryside, and based on the maximization of land rent, was implemented in Parma through popular economic housing plans (Peep), especially in the southern part of the city. The positive results are evident in the Montanara district, which combines the fact of being lapped by the two streams. The green of the river banks widens in the green spaces inside the neighbourhood, it merges with the space of the gardens. It is however interesting to observe how most of the buildings at high or very high risk is concentrated in the northern part of the district, where most of the buildings that have arisen since the 1950s are concentrated, characterized by

high building density and scarcity of areas greens. In the southern part the Peep districts are concentrated, where the allocation of public greenery acquires a prevailing dimension, and the same settlement morphology studied to favour the passage of summer breezes and break the winter winds, determine more contained risk conditions (Figure 1).

If we compare the parcelling plans of San Leonardo and Montanara, we note there are also urban blocks with the characteristics comparable by type and density of buildings, and they have different risk classes. (Figures 2, 3).

From the images of comparison between the two subdivisions a similarity occurs in the building types; there is a greater compositional order in the distribution of the quadrangular self-referenced divisions of the Montanara subdivision. But the main difference is undoubtedly given by the endowment of the green: almost absent in the San Leonardo, solved with the linear green along the streets and with the presence within the even small condominium gardens. The factors described, in addition to the proximity to the Baganza River, contribute to determining a risk class shift, moving from one situation to another.

3. The contribution of the UHI risk map for urban regeneration strategies

The participatory approach is consistent with action encouraged by the European Community, starting with the approval of the Green Paper of 2007 [21] and the White Paper on Adaptation [22], from which urban planners and decision-makers across Europe are increasingly trying to integrate UGI, ecosystem services and solutions based on nature in their urban planning processes at the local scale.

The cases at the neighbourhood scale are interesting in this context, particularly the one conducted by the city of Hamburg at the International Building exhibition (IBA) with the creation of the Wilhelmsburg District of the exhibition [23], characterized by interventions aimed at achieving a climate-neutral district, with a strategic spatial approach to growth / transformation, compatible with adaptation goals through the Top Climate Plan.

For the Municipality of Parma a sensible innovation consists in the possibility of making the cognitive part, the risk assessment for fragile subjects, and the selective use of data - therefore the planning use of data - a collective process [24].

The risk map can be periodically updated and become a progressively more reliable tool through an integration in the conferment and extraction of data from the different subjects: Public Administration, associations, stake holder, citizen.

This means to better integrate the planning tools with the climate adaptation charts, obtaining indications for the de-sealing actions prescribed by the Region Emilia Romagna and the indications of greatest suffering areas where it is appropriate to strengthen the NBS.

3.1. Imperviousness vs Nature Based Solutions and cool materials

The repercussions on the use of the city by the inhabitants can have multiple outcomes. The risk maps show first of all the caution with which it is important to face the urban regeneration strategies especially if based on the densification which, if not controlled could trigger and intensify the UHI effect. To counteract the negative effects of the built up concentration, free spaces are needed, hopefully interconnected and designed to allow the flow of the wind. In the case of Parma, it can be noted that even in the closeness of the rivers, the existence of buildings of considerable size acts as barriers to the breezes that run along the river bed contributing to the elevation of the ST.

The main strategies identified by the field literature are based on the development and continuity of the Green Infrastructure. Numerous studies have been carried out with the aim of verifying the effect of mitigation of the UHI by increasing the surface of vegetated areas within the urban context, noting how urban green can also reduce the air temperature by 5-7 ° C globally, improving microclimatic comfort [25].

It has been highlighted that the ecosystems and the green and blue infrastructures can be long-term adaptive measures to climate change, however, the extent to which they are able to do so, depends on both their quality and the context in which they are embedded. And a UHI risk map, since it highlights areas of greatest climatic distress, can suggest places where to operate first. If an NBS is not positioned correctly, it will do little to mitigate extreme events [26]. The redesign of open spaces, mainly public,

and the intervention where sealing is high, through the use of NBS must take into account a multiplicity of factors that should be the basis of planning strategies and public works. The role of self-regulator for maintenance interventions and infrastructural planning of public spaces in the Public Administration, is in this sense of primary importance because, based on the results of the risk maps, it can adequately choose site-specific interventions: integration of cool pavement and de-sealing of spaces residual in the most densely built-up areas, as in the case of San Leonardo or with targeted maintenance of the existing greenery, as in the Montanara.

It should be added, however, that the shortage of public and private financial resources and the fragmentation of properties no longer allow to proceed only through public intervention for the regeneration of the city. The approach to the widespread care of the territory through the active protection, and the participation of citizens, are like a network project that structures and innervates, together with the ecological network, the contemporary city. Furthermore, the social potentials inherent in frequentation and care should not be overlooked, as valuable elements of territorial control against petty crime, which can animate new forms of urban sociability [27].

In addition to forms of control and video surveillance, collaborative practices in public space care can contribute to lowering the perception of risk in contexts such as some areas of San Leonardo. In the Montanara district - considered among the most liveable in the city - the now historic presence of social gardens (cultivated above all by elderly people) is being flanked by spontaneous experiences of care for the green in the public space.

The proprietary fragmentation, peculiar to the city structure that has always represented a problem in tackling radical urban redevelopment interventions, can, on the contrary, facilitate small qualification operations, on the construction scale, if opportunely encouraged, but above all its knowledge and usefulness is promoted.

The UHI risk maps, appropriately simplified, can in this case help to raise awareness of the problem towards the population or particular stake holders (e.g. such as condominium administrators).

The intervention strategies for the 'resilient regeneration' of the consolidated city group together a series of operations that have their strong point in green infrastructures, but which can also be found in the use of cool materials [28].

The standards developed to measure the solar reflectance of roofing and paving materials are used by labelling organizations such as the Cool Roofs Rating Council (CRRC 2015) and the European Cool Roof Council (ECRC 2015).

The urban conversion of black roofs into green roofs is able to ensure a better management of rainwater, an improvement in air quality and an increase in urban biodiversity. However, many factors must be considered in an overall assessment of the use of cool roofs and green roofs. Their specific performances, the aging of materials used for the construction of cold roofs, the irrigation needs of green roofs, as well as the climatic differences, should be simultaneously taken into account to maximize the prospects of mitigation [29]

3.2. The Inclusive Dimension of the Governance

Given the rapid evolution of the phenomena associated with climate change, the decision-making process is in charge of proposing solutions for urban regeneration planning, through the adoption of specific assessment systems, converging towards the goal of urban system resilience.

Presently, the relationship between the policies and the planning tools needed for adaptation, has not resulted in reliable or tested frameworks, nor has it already identified an agreed upon method for the construction of knowledge frameworks related to the vulnerability, the sensitivity, the resilience and the risk levels of the urban system.

In some Italian municipalities, in response to climate change, considerable efforts have been made to develop techniques that allow a morphological analysis of the city aimed at recognizing the homogeneous areas that are more vulnerable and in which the physical transitions, of form and use, can be addressed with less cost and greater benefits, by means of guidance systems in the PAESC (Action Plan for Sustainable Energy and Climate). The transformation of brownfield sites into new urban parks and the re-greening of public spaces are examples of this response.

Systematic actions capable of affecting the project parameters [30] involve, however, a substantial engagement of financial resources by the Municipalities. Moreover, in the approval phase of the instruments, effective achievement of the objectives is not really guaranteed.

Analysing the data using multiple criteria and pairing the actions using different scales (from the general planning scale to the neighbourhood micro-scale) can determine if the resulting “urban nature” will guarantee an effectiveness that will increase the city’s resilience. This can be evaluated in terms of benefits in the different (physical or immaterial) scenarios that are differentiated based on the number of interested beneficiaries that have been interrelated with the various vulnerability, sensitivity, resilience and risk classes [31].

For the purpose of adopting multilevel actions related to adaptation themes, planning experiences focused on climate adaptation have demonstrated the importance of activating the inclusive dimension of governance models, starting from the phase of downscaling of information.

The purpose of adopting measures aimed at mitigating the effects of climate change assumes strength and relevance with specific sectors of the Municipal Administration, such as the Civil Defence, resulting in a concerted, partnership dimension, especially when applied at the smallest scale (at the scale of groups of buildings or of the neighbourhood) and for short-term responses to disasters that are perceived as direct threats to the health and safety of the resident population [32]

Particularly in those areas where the vulnerability is understood as a high ratio between the urban form and the risk of death, the use of instruments such as the “availability contract” or the “innovation partnership” can become strategic outside the scope of the PAESC and on the scale of individual context analysis (conducted with systems such as meteorological monitoring). This suggests different objectives for short and medium-range time actions, providing decision-makers with guidelines on potential beneficiary groups and elevating the priority of actions towards, for example, the elderly population.

Otherwise for short and medium-range time actions, the certification systems are one of the best places to experiment with participation policies because of the opportunity for a comparison between the needs of the inhabitants in the specific contexts, and the strategic objectives and value system of the Municipal Administration.

In such cases, the governance models limit the assessment to a well-defined area, much more circumscribed than the entire city. Furthermore, the models must be able to involve in their different phases (decision-making and implementation-management) the widest possible spectrum of subjects and stakeholders.

The assessment of recoveries in the mitigation and adaptation performances that can affect the microclimate and the regeneration based on nature and on the systems that adaptation performance can achieve in Ecosystem Solutions Based micro-regeneration interventions, becomes fundamental to the scale of the neighbourhood with private subjects, through the introduction of roof-gardens, green walls, and green on the balconies. In the context of the S. Leonardo and Montanara districts, the action can be assessed in short, medium and long range time, and brings together different approaches concerning the "strategically managed" networks of urban green spaces and natural and semi-natural ecosystems located within the confines of the two urban ecosystem. Thanks to a strategic spatial approach to transformation, these high-quality, biodiverse areas can help to make the city of Parma more sustainable and help to solve many challenges such as air pollution, noise, climate change impacts, heat waves, floods and public health problems even outside of a strategic planning dimension.

4. Conclusions

The strengthening of the resilient capacity of the cities passes through the elaboration of multi-objective strategies that see the involvement of the components of the territorial system, understood in its economic, social, administrative, political structure.

As some European experience shows the solutions can emphasize the specificity of the places and face the need of a careful deepening of the possible adaptive solutions. In fact, the solutions not only have to be differentiated with respect to the physical and morphological characteristics of the places, but they should be studied in relation to the identity, to the immaterial value of the places themselves. For instance, considering the delicacy of treatment that the historical city requires, where the morphological

characteristics are intangible and unchangeable - not to mention the problems that even the only treatment of the 'skin' of the historical building can induce.

In the cases of S. Leonardo and Montanara it's important to consider non-invasive solutions able to reconcile the needs of renewal and maintenance, which the consolidated city built after World War II requires, with the needs of the residents

The search for a new 'unstable equilibrium' to increase the cities resilience to climate change, can occur in the greater respect of the identity values in which the inhabitants recognize themselves, values whose attribution is destined to an equal 'instability', in the different future horizons

The risk map is a valid tool to develop multilevel actions to design according to the peculiarities of the places, to provide set of solutions at the neighbourhood scale, that can be integrated and synergistic.

References

- [1] CitiesIPCC 2018 *Global Research and Action Agenda on Cities and Climate Change Science*. [Online] Available at: <https://citiesipcc.org/wp-content/uploads/2018/09/Research-Agenda-Aug-10-Final-Short-version.pdf>
- [2] Gunderson L and Holling C S 2002 *Panarchy: Understanding Transformations in Human and Natural Systems* (Washington DC Island Press)
- [3] Folke C, Carpenter S, Elmqvist T, Gunderson L, Holling C S, Walker B, Bengtsson J, Berkes F and Colding J 2002 *Resilience and Sustainable Development: Building Adaptive Capacity World of Transformations* (Stockholm Edita Norstedts Tryckeri Ab)
- [4] Davoudi S 2012. Resilience: A Bridging Concept or a Dead End? *Planning Theory & Practice* **13**(2) 299-307
- [5] Walker B and Salt D 2006 *Resilience thinking: sustaining ecosystems and people in a changing world* (Washington Island Press)
- [6] Regione Emilia Romagna 2018 *Valutare la rigenerazione urbana*. (Bologna)
- [7] Mickwitz P, Aix F, Beck S, Carss D, Ferrand N, Görg, C, Jensen A, Kivimaa, P, Kuhlicke C, Kuindersma W, Mániz M, Melanen M, Monni S, Pedersen AB, Reinert H and Bommel S van 2009 *Climate Policy Integration as a Necessity for an Efficient Climate Policy* IOP Conference Series Earth and Environmental Science
- [8] Gerundo C 2018 *L'adattamento delle città ai cambiamenti climatici* (Napoli FedOAPress)
- [9] Fintikakis N, Gaitani N, Santamouris, M, Assimakopoulos D N, Fintikaki M, Albanis G, Papadimitriou K, Chryssochoides E, Katopodi K and Doumas P 2011 Bioclimatic design of open public spaces in the historic centre of Tirana, Albania *Sustainable Spaces and Society* **1**(1) 54-62
- [10] World Health Organization (WHO) 2011 *Air quality and health*, Geneva World Health Organization, Fact sheet n.313.
- [11] Stathopoulou E, Mihalakakou G, Santamouris M and Bagiorgas H 2008 On the impact of temperature on tropospheric ozone concentration levels in urban environments *Journal of Earth System Science* June 227-236
- [12] Akbari H, Cartalis C, Kolokotsa D, Muscio A, Pisello A L, Rossi F, Santamouris M, Synnefa A, Wong N H and Zinzi M 2016 Local Climate Change and Urban Heat Island Mitigation Techniques – The State of the Art *Journal of Civil Engineering and Management* January 1-16
- [13] ARPAE and Regione Emilia-Romagna, 2017. *Atlante climatico della Regione Emilia-Romagna. 1961-2015*. [Online] Available at: https://www.arpae.it/dettaglio_generale.asp?id=3811&idlivello=1591
- [14] ISPRA 2018 *Consumo di suolo, dinamiche territoriali e servizi ecosistemici*, **288**/2018
- [15] Comune di Parma 2008 *Piano Strutturale Comunale. Quadro Conoscitivo. Sistema Ambientale*
- [16] Ng E and Ren C (eds) 2015 *The Urban Climatic Map for Sustainable Urban Planning* (Oxon – New York Routledge)
- [17] Morabito M, Crisci A, Georgiadis T, Orlandini S, Munafò M Congedo L, Rota P and Zazzi M 2018 Urban Imperviousness Effects on Summer Surface Temperatures Nearby Residential Buildings in Different Urban Zones of Parma. *Remote Sensing*, **10**(26) 1-17

- [18] Morabito M, Crisci A, Gioli B, Gualtieri G, Toscano P, Di Stefano V, Orlandini S and Gensini G F 2015 Urban-hazard risk analysis: Mapping of heat-related risks in the elderly in major Italian 152 cities. *PLoS one*, **10**(5) 1-18
- [19] Berzieri L, 2019 *Il Bilancio demografico del Comune di Parma al 31 12 2018* (Parma Comune di Parma)
- [20] Rota P and Zazzi, M 2018 The contrast to the Urban Heat Island phenomenon to increase the Urban Comfort as an incentive to slow mobility. A study on the City of Parma Tira M and Pezzagno M. (eds) *Town and Infrastructure Planning for Safety and Urban Quality: Proceedings of the XXIII International Conference on Living and Walking in Cities* (LWC 2017), Brescia Italy (Taylor and Francis Group) 2018 233-240
- [21] European Community 2007 *Green Paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Region* [Online] available at: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52007DC0354>
- [22] European Community 2009 *White Paper. Adapting to climate change: Towards a European framework for action.* [Online] available at: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52009DC0147>
- [23] Scheffler N 2015 Cities Tackling climate change: the case of the international building exhibition (IBA) Hamburg. *Sustainable regeneration in urban areas, Urbact II Capitalization*
- [24] Gravante A, Rota P and Zazzi M 2018 Enhancing the Resilience of the Urban System: from Risk to Adaptive Strategies. A Study for the City of Parma in Amôeida R., Lira S, Pinheiro C, Santiago Saragoza M.J, Calvo Serrano J and Carrillo G F (Eds.) 'Heritage 2018 – International Conference Proceedings' Granada Spain 12-15 June 2018 (Edition Universidad di Granada, Granada, Spain) 481-491.
- [25] Livesley S J, McPherson E G and Calfapietra C 2016 The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale *Journal of Environmental Quality Special Session* 119-124
- [26] Kabisch N, Korn H, Stadler J and Bonn 2017 Nature-based Solutions to Climate Change Adaptation in Urban Areas *Theory and Practice of Urban Sustainability Transitions* (Springer Open)
- [27] Ash A and Thrift N 2005 *Città. Ripensare la dimensione urbana* (Bologna Il Mulino)
- [28] Ferrari C, Muscio A and Siligardi C 2016 Development of a Solar-reflective Ceramic Tile Ready for Industrialization. *ScienceDirect. Procedia Engineering* **169** 400 – 407
- [29] Kolokotsa D, Santamouris M and Zerefos S 2013 Green and cool roofs' urban heat island mitigation potential in European climates for office buildings under free floating conditions, *Solar Energy* **95** 118–130
- [30] Oke T R 2006 Towards better scientific communication in urban climate. *Theoretical and Applied Climatology*, **84** 179-190
- [31] Fattinanzi E, Mondini G (eds) 2019 L'analisi multicriteria tra valutazione e decisione (DEI tipografia del Genio Civile). [Online] Available at: <https://www.pausania.it/sulle-analisi-multicriteria-nella-rigenerazione-urbana-elementi-per-una-riflessione-di-marcello-capucci/>
- [32] Musco F and Fregolent L 2014 *Pianificazione urbanistica e clima urbano* (Padova Il poligrafico)