Trento City MicroClimate changes

A. Codemo[a] and M. Ricci

Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy.

Abstract

The "Trento City MicroClimate Changes Research Project" is a master dissertation that seeks to define urban strategies capable of mitigating the urban heat island (UHI) of Trento. The aim of the dissertation is the reuse of existing spaces and surfaces of the city to regenerate them and make them more comfortable. The project uses climatological data to set the basis of an urban planning based on the knowledge of vulnerabilities and opportunities related to the UHI effect. The mitigation process is based on the green infrastructure approach, since it reaches several ecosystem services related to ecology, social life and economy and it has the highest cost-benefit ratio. Moreover, the proposed solutions involve strategies that make cities resilient to climate change effects. The project also seeks to define how to implement such strategies in the urban planning. In fact, the definition of guidelines for a mitigation plan at the urban scale, providing the devices and defining the actors involved, is completed by zooming in on a pilot neighbourhood to test the efficiency of the mitigation devices in the urban environment like roads, open spaces and buildings. UHI mitigation is an opportunity to rethink the city in its structure, in order to develop it into a more sustainable manner by increasing environmental and social quality parameters for its inhabitants. The project defines a clear vision and common goals for the future of Trento, which are necessary to implement the tactics and to trace a framework through which future transformations of the city can be evaluated.

Keywords: resilience, green infrastructure, mitigation, urban planning, urban heat island

INTRODUCTION

The urban heat island (UHI) effect is one of the main microclimatic phenomena threatening our cities: it consists of higher values of surface air temperature occurring in the urban areas as compared to the surrounding rural ones (Petralli et al., 2006). This phenomenon is mainly due to the thermal and radiative properties of urban surfaces and the three-dimensional characteristics of the urban fabric, but it is also a consequence of human activities, such as transportation or heating and cooling systems elements (Oke, 1973; Stewart and Oke, 2012; Akbari et al., 2009).

Actions need to be taken in order to mitigate the effects of UHI since it is affecting human health and leading to many cases of morbidity and mortality, especially for frail people, such as children and the elderly. Moreover, the intensity of the phenomenon is rising, due to the increasing number of people living in urban areas and global warming (EEA, 2016). The objective of the paper is to understand how to use climatological data to set the basis for a more comfortable environment and how to take advantage of these actions to improve urban quality.

In this paper, we will report the case proposed as a master dissertation for the Italian alpine city of Trento and describe how the structure of a city can be reconsidered and its blue and green infrastructure (BGI) enhanced in order to design more comfortable areas. At present, BGI research is not well integrated with urban design and planning and this contributes to the lack of guidance on how best to implement it. Our approach consisted of an individualisation of the working areas (climatological data), followed by the determination of the mitigation strategies to be adopted (urban strategies) and finally bringing together the afore-mentioned steps for the execution (implementation).

[a]E-mail: codemo.anna@gmail.com

CLIMATOLOGICAL DATA

Figure 1. (a) Mapping of local climate zones; (b) mapping of heat-related risk; (c) mapping of existent blue and green infrastructure.

As reported in the analysis of urban-rural temperature difference in the city of Trento in Giovannini et al. (2011) the maximum diurnal intensity of the UHI is typically around 3°C, but in certain conditions it can be higher than 6°C. Usually it has higher values during the night owing to the morphology and topography. The aim of the first phase of the process is to spatially represent climatic processes and use them as a starting point for the outline of the mitigation plan.

More specifically, the process which has been developed consists of 3 steps which lead to 3 different objectives: (1) description of the urban structure related to climate; (2) identification of the areas with priority of intervention; (3) identification of the existing opportunities of mitigation in the urban environment.

1. The city is described in terms of its constituent neighbourhood types using local climate zones (LCZs), which is considered an appropriate classification method (Bechtel et al., 2015), provided by Oke and Stewart (Oke, 1973; Stewart and Oke, 2012), that identifies different urban landscapes related to the effect they produce in the urban temperature (Figure 1a). They are defined by the type of surface (terrain roughness class, pervious surface fraction, albedo, surface admittance), morphology (aspect ratio, height) and human activities (traffic and heating). Since each city is characterized by different microclimates, it is relevant to understand which bidimensional and tridimensional properties are involved in the energy exchanges.
2. Neighbourhoods are prioritized by the level of the heat-related risk, calculated with the method which consists of a combination between normalization of exposure (density of population (inhabitants km^{-2})), natural risk (temperature (°C)) and vulnerability (elderly density – aged over 65 – and children – under 5 (inhabitants km^{-2})). The result shows three principal areas that may have a high risk level, so they are considered the ones with priority of intervention (Figure 1b).
3. Finally, the mapping of the existent green infrastructure (Figure 1c) gives an idea of the structure already present in the urban environment that mitigates the UHI (Spirn, 2013; Petralli et al., 2006; Angrilli, 2002). Moreover, since it has a significant role in the economic, ecological and social aspects of urban life (Gómez-Baggethun and Barton, 2013), the BGI can be strengthened and developed to create more comfortable urban areas.

URBAN STRATEGIES

The project seeks to develop blue and green infrastructure (BGI) since it involves many ecosystem services (Gómez-Baggethun and Barton, 2013; Zardo et al., 2014) and the strategies adopted to mitigate the UHI effect with the BGI approach also help the city attain

sustainable resilience and climate change adaptation (Petralli et al., 2014). BGI is economically convenient and it mitigates the UHI effects thanks to evapotranspiration and to the creation of shadows (Akbari et al., 2009). Moreover, it contributes to air quality improvement, CO_2 sequestration and flood protection (Petralli et al., 2014; Akbari et al., 2009).

The recommended solutions tend to improve the quality of the physical environment, with the creation of more attractive, liveable open spaces and more efficient buildings and transportation systems. The combination between climate adaptation strategies (definition of adaptation objectives, overview of mitigation policies and plans, limitation of soil growth and use, reduction of building emissions, energy efficiency) with urban strategies (referred to new paradigms considered necessary to regenerate cities and related to the waste cycle) led to the definition of guidelines and pilot actions to rethink spaces.

Mitigation of UHI can be attained through the reduction of stored and incidence heat, the reduction of anthropogenic flux and vulnerabilities, in order to create more comfortable spaces, reduce air temperature and increase awareness on such issues. The proposed strategies refer to the guidelines suggested by the European Commission (EEA, 2016) and to the projects of the main European and international cities that are investing in the adaptation of climate change, such as Copenhagen, Rotterdam and New York and can be summarised in the development of green spaces, the increase of shaded areas, slow mobility, energy efficiency, processes of collaboration and participation. These actions refer to two climate processes: the superficial and the canopy layer ones, which means that they are related to the two-dimensional and three-dimensional properties of the built environment (Oke, 1988).

On the other hand, community building, education, reuse of abandoned spaces, new entrepreneurship are the main resources that can act as drivers to re-design spaces that can be regenerated to become more attractive and more sustainable (Ricci, 2012). Strategies of urban crowdsourcing, transitory uses, recovery, access to knowledge, involvement in decisions, keeping and sharing networks are the devices used to reactivate underused spaces. Five main types of spaces are examined to understand how they can be re-evaluated and regenerated and to promote a better design of underused and oversized spaces: they are abandoned spaces, big impervious areas, roads, buildings and unmanaged pervious surfaces.

The result of these two types of strategies led to the creation of a toolbox, with principal actions that can be taken to mitigate UHI. Moreover, since the solutions proposed refer to the BGI approach for innovative urban planning and consist of an integration between the nature based systems and urban components, the approach proves to be more efficient and optimized. The synergy between urban components and ecosystem services reveals the multi-functional nature of the elements and the interactions between different functions (IUCN, 2012).

The toolbox is divided in two main parts: the first one is a list of materials to use, based on the properties related to climate such as perviousness, albedo, shadow production (Dessì et al., 2016) and the second one is the type of actions that can be taken by private or public parties to find spaces where to apply those materials (Figure 2). It is a general instrument that can be adopted by different cities, in different urban areas and contexts and it contributes to creating attractive and comfortable urban spaces and reducing air temperature. It is considered a guideline for the creation of a robust system for the design of flexible and adaptive spaces. In other words, it contributes to create a resilient and less vulnerable system, with a significant contribution in the quality and efficiency of economic, social, ecological and environmental aspects. The toolbox seeks to set the guidelines for a mitigation plan bearing in mind the climate risks existing in some urban areas and ensure a proper assessment of the potential of an existing urban environment.

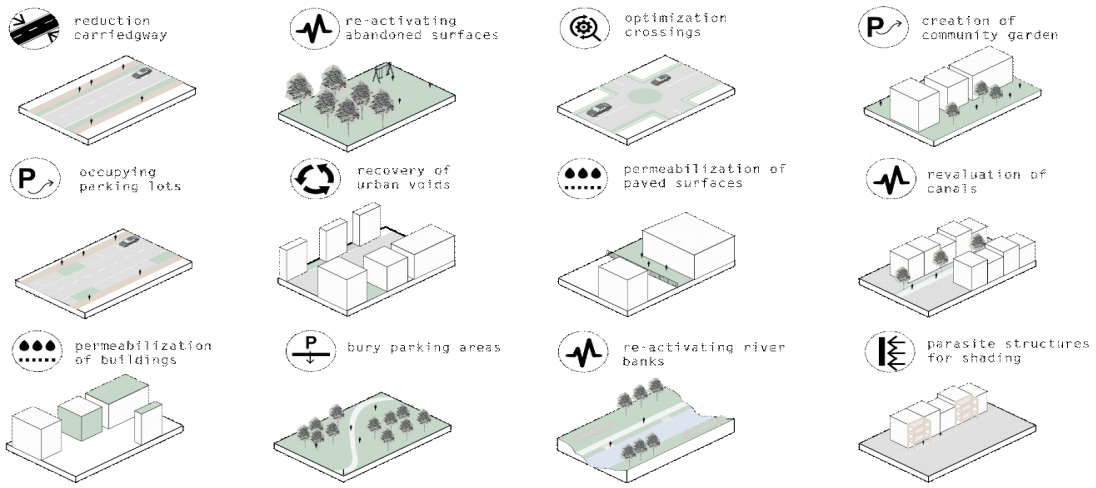

Figure 2. Toolbox: type of actions to obtain space for increasing BGI.

IMPLEMENTATION

The above-mentioned strategies are necessary to create a variety of safe areas around the town in the case of extreme heat. Additionally, they contribute to creating a greener town, i.e., a less vulnerable and more resilient town which is the main issue in the long term.

A clear and well-defined vision is necessary to implement those strategies. The vision of the future of Trento is based on four scenarios: an attractive, flexible, liveable and efficient city. Indeed, to ensure a sustainable urban development one cannot do without considering the natural environment and its impact on the economy, health and quality of life (Figure 3).

The final outcome is a strategic document with guidelines to design and manage blue and green infrastructure in the urban and peri-urban areas of the alpine city.

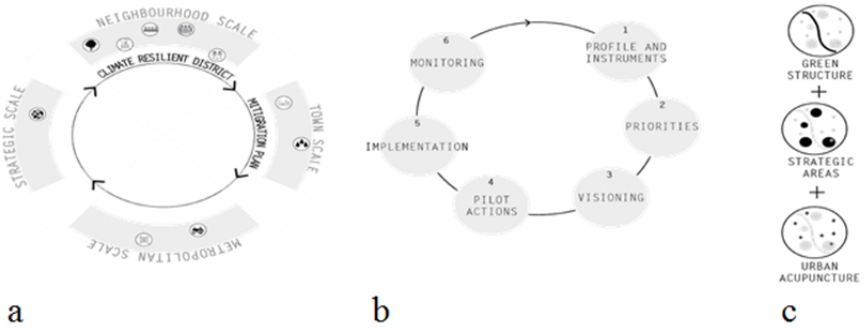

Figure 3. (a) Multiscale structure of the plan; (b) time phases of the plan; (c) multilevel structure of the plan.

The implementation is based on a multiscale and multilevel approach. Such approach represents an operative scheme based on different devices working separately and at different scales but with a common objective and vision so as to be both flexible and variable (Gausa, 2009). In the light of the above, the proposed actions imply an urban planning and ecosystem management guaranteeing and regulating the supply of ecosystem services. The identified structure consists of a climate lecture of the existing urban environment taking into account both the natural and artificial elements which is the area where the strategies are to be applied.

The approach is multiscale since it examines the urban and neighbourhood levels, but it can also be extended to the regional and the national level (Gausa, 2012).

The instrument adopted for the urban scale is the mitigation plan: it is not considered

a regulative device, it is a participation device involving both the local authorities and citizens. It explains how to apply tactics and which actions can be taken to reach the mitigation objectives. It is conceived as a dynamic and innovative plan, containing different types of actions and multiple types of instruments to implement those actions. It envisages the participation of individuals as well as public-private partnerships and new types of financing programs as per the documents published by the European Commission. It is flexible since it involves actions related to urban design, sharing opportunities, governance and maintenance and it consists of actions referring to various time phases: analysis, design and monitoring instruments. In other words, it is conceived as a circular device that can be used during any of the project phases (EEA, 2012).

On the other hand, the neighbourhood scale is conceived as a test area, where it is possible to understand urban issues and needs with the aim of developing a climate proof district. This scale allows for a better fine-tuning of the mitigation strategies.

The use of an integrated approach may appear too complex since it involves various sectors and characters but it often turns out to be more efficient and convenient in the long term. As it is multilevel, the plan can be dynamic. Indeed, it comprises three urban devices which can be overlaid, developed and/or changed without threatening the others. Each device is composed of multiple pilot projects that give the strategies and tactics described above a shape or an image and together they construct a vision for the city of Trento of the future.

The afore-mentioned urban devices have been identified since they relate to different urban structures and tackle the UHI issue in different ways: strategic areas, green structure and acupuncture. This new structure allows for decision-making processes and urban interaction both from a structural and conceptual point of view. In other words, they work separately and follow different rules, but combined they work as a unique device capable of reducing the UHI effects. The strategic areas are the high rated heat-related risk areas and they can be rethought in their structures and in their main components to be climate adapted: streets, parking lots, shape of buildings are some of the elements that can be reorganized and redeveloped in a more sustainable way.

The potential green structure is an area along the Adige River that thanks to the reuse of the abandoned spaces can take advantage of the cold stream of the river and become the green and blue lung of the town, with an increase in the environmental, social and economic benefits.

Finally, acupuncture is a system of cold spots that cool down small areas: they represent safe and liveable spaces even during extreme heat waves. They can be temporary or permanent interventions and they are often installations with recycled materials.

To conclude, as outlined above, these instruments all concur to the definition of the vision of the city, which refers to a nature based system of open spaces. It is important to keep in mind that the future city will face challenges such as a growing population, adaptation to climate changes, new integrated systems between energy and transportation and a strong BGI will support resilience of the town.

CONCLUSIONS

Green spaces in cities play a fundamental role in environment defence, but they also contribute to the improvement of microclimate, life quality of the inhabitants and the building of a community spirit. It is difficult to imagine that the proposed vision for Trento can be implemented in the entire urban fabric, but with a correct vision and valid and ambitious targets, considering a collaboration between stakeholders and the use of European financing programs, we can reach objectives that have always been considered unattainable. Mitigating UHI is necessary if we are to protect human and health in Trento, so investing in an urban device which also brings other benefits is indeed convenient.

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