ACTIVATING PUBLIC SPACE
An Approach for Climate Change Mitigation

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(Eds.)

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Content

3. Practices

PREFACE

Sustainable Urban Development in the 21st Century

Thomas Auer

Urban planning is the planning of the unfinished. In this context, cities are always subject to change - an imperative of urban development, so to speak. The city is ultimately a reflection of the spirit of the times, the materialization of a society's lifestyle and values. In the 20th century, for example, our cities were shaped by industrialisation and the need for motorised individual mobility. In the same way, the tasks of our time and new technologies will also change cities. For example, the Internet and smartphones have changed our lives more than our built environment. In order to shape the future of our cities - and not just react to it - we must recognize the challenge and potential of the necessary transformation. "Plan for the future because that's where you are going to spend the rest of your life." (Mark Twain)

The tasks are likely to vary considerably from one region to another. In Europe it will be a matter of restructuring - without giving up identity - cautiously and simultaneously ambitiously. Issues such as global warming accompanied by extreme weather phenomena, changed mobility, ecological restructuring - the EU Carbon Roadmap calls for a 90% reduction in CO2 emissions from buildings by 2050 - and, above all, affordable housing in large numbers for all sections of the population, will shape the restructuring of our cities over the coming decades. Tabula Rasa is neither economically appropriate nor would it meet with acceptance. Rather, it will be necessary to build on what already exists without historicising dogmas. The frequently used argument of the "historical city ground plan" cannot be knocked out. Just because it is historical does not mean it is correct - especially since the boundary conditions have changed drastically.

There are certainly great opportunities and potentials in the upcoming reconstruction. Ultimately, it is about nothing less than the question of how we can achieve a better quality of life with reduced resource consumption. Our buildings and our cities must materialize and manifest this quality of life.

According to US studies, the so-called “Millennials” (the years 1977 - 1998) already drive about 20 % less car kilometres than the generation of the previous decade. Self-propelled cars combined with “shared rides” can reduce the demand for vehicles in conurbations by up to 80 % (Carlo Ratti, Senseable City Lab, MIT). This creates space in our cities so that public space can be used for climate adaptation. Through a combination of shading, evaporative cooling e.g. by water surfaces and/or vegetation, reflection of surfaces and other measures, we not only regulate the urban climate / outdoor comfort even during hot spells, but also create a good climate in the buildings. “Instead of a park in the city, we need a city within a park” (Bruce Mau). A reconstruction of our cities taking into account the addressed issues will only be successful and meet with acceptance if the quality of public space increases; the quality of public space will decide on success or failure. The European city will also easily accept an increased density of buildings if at the same time the public space remains or becomes liveable and lovable. Many European cities have developed positively in this respect. Particularly noteworthy are the subsidised housing projects of the City of Vienna (Vienna model) or the City of Zurich, where the population voted by a large majority of 3/4 yes votes in 2008 in favour of sustainable development in accordance with the model of the 2000-watt society. According to this model, energy consumption is to be reduced to 2000 watts per person and CO_2 emissions to one tonne per person by 2050, i.e. to approximately one tenth of today’s level. In the context of this decision, the City of Zurich is working very intensively on the issue of sustainable urban development with high-quality redensification.

INTRODUCTION

Living in a Changing Planet
Challenges and Climate Adaptation for Contemporary Cities

Federico Cinquepalmi

The critical issues that urban systems are facing nowadays, related both to internal and external challenges, are threatening cities administrators and decision makers, to a point that is the very idea of the city that seems to be in discussion. The question is, if the present-day cities are still granting a safe and comfortable place to live for their citizens, or if they are progressively evolving in deadly traps. The dangerous evolution from cities to megalopolis, and all the potential risks connected to such evolution, has being the subject of a very interesting little book published in Italy in 1971 by Roberto Vacca Professor at La Sapienza University in Rome (Vacca, 1971). In the introduction, Professor Vacca stated that:

"...It is not necessary for a few kilo-megatons of hydrogen bombs to explode for hundreds of millions of people to be killed. The same result may occur by less violent and more intricate means: that is, by virtue of the fact that vast concentrations of human beings are involved in systems that are now so complicated that they are becoming uncontrollable. This hypothesis of an apocalypse that is impersonal, haphazard and unpremeditated - is more tragic than the other".

All present global challenges broadly summarized as demographics transformations, pandemic diseases, climate change and extreme climatic events, considered within the same framework of energy/food/water supply challenges, must be evaluated taking into account the need to guarantee urban system's management and preserve citizen's quality of life. These are essentially today the terms of the discussion about environmental, cultural, infrastructural and human sustainability in our cities.

Taking into account the complexity of climate challenges, versus a progressively over-urbanized planet, we have no intention to get into the international debate around true causes, or rather contributing causes of the global climate change, and the role to be possibly attributed to human development. However, the matter of fact is that the climate of the planet is in a progressive modification and worldwide cities are seriously threatened by this phenomenon (Redman and Jones 2005).
The international scientific community estimate an increase in the average global temperature between 2 and 3 degrees during the XXI Century, which implies that Earth will experience unprecedented changes, in comparison with the past 10,000 years. In order to cope with such "climatic revolution", an extremely difficult adaptation will be required for most of the human population worldwide.
Indeed, northernmost regions of the planet will initially benefit of this rise in temperatures, especially in terms of duration of harvesting agricultural seasons. However, worsening climate would become very soon a dominant element on the entire planet, with an escalation in frequency and gravity of adverse weather events, such as heat waves, storms and floods. The increase of temperatures will cause melting of polar ice caps and glaciers, producing an extensive seal level rise with serious consequences on lowlands and coastal zones (The Royal Society, 2008).

The adaptation to planet climate changes, together with mitigation strategies, are the subject of the Intergovernmental Panel for Climate Change (IPCC) researches (IPCC, 2014). Section 8 of IPPC 2014 report is fully dedicated to the effects of climate change on urban systems, where over 50% of the entire world population lives today (Revi et al., 2014), and about 1/7 of this population stays in bad and overcrowded conditions, with inadequate basic infrastructures (IPCC, 2014, pp. 542-543). Most of urban areas are located nearby coastal areas, in condition of extreme vulnerability to extreme climatic effects. Coastal zones are the areas where the effects of climate change threaten globally the 72 largest coastal cities, for about 350 million inhabitants, potentially endangering urban services and infrastructure and in general the citizens quality of life.

Modern urban areas are mostly places with very low soil permeability, mainly for the extensive asphalt and concrete ground coverage, and with a very low percentage of vegetation. Although they cover less than 2% of the emerged land surface, urban areas consume approximatively 78% of the world's energy and are responsible for the emission of carbon dioxide and other greenhouse gases for over 60% of the total human anthropic related emission.
Getting at European level, coastlines referred to Member States are about 68.000 km, three times more than the United States and about the double of Russia. Together with the European Economic Area (EEA)[1] countries, the European Coastal development reaches 185.000 Km of length, covering an area of about 560000 km2 of coastal areas, equivalent to the 13% of emerged lands. The 2011 evaluations of EUROSTAT quantified that 41% of EU population, about 206 million of EU citizens, insist in the boundary of 50 km distance from the sea, most of them concentered in urban areas located along the seashores (EEA, 2007).
The sea level rising effect connected to climate change, is commonly considered the most evident danger threatening urban areas. Between 1900 and 2010 the global sea level increased by 1.7 ± 0.2 mm/year and, in particular, from 1993 satellites and tide indicators have showed an increase of ~ 3.4 ± 0.4 mm/year (IPCC, 2013). Another significant effect connected with climatic modifications is the anomalous high intensity tropical cyclones, that especially in the past three decades have progressively moved away from the equator, increasing coastal flooding rick for non-tropical coastal communities, mainly in the northern hemisphere.

Within such scenario, full maintenance of urban metabolisms and related services will present increasing difficulties, to be carefully evaluated in terms of social and economic costs.

European Union economic activities located less than 500 meters from the sea, have an estimated value between 500 and 1000 billion euros and consequently the potential cost for the protection of those activities form erosion and floods, has been calculated on 5.4 billion of euros per year, referring to the period 1990-2020 (EEA, 2007/2019 p. 6).

A further significant critical area is energy production and consumption, essential component of urban metabolisms and economic development. Any negative impact from climatic events on energy infrastructures, will negatively affect public services, such as emergency and healthcare, treatment of drinking and waste water, public transport and traffic management (Revi et al., 2014). More than 6700 power plants, suppling almost 15% of worldwide electricity production in 2009, are significantly exposed to the risks of flood, high tides and extreme rainfall (Wong, et al, 2014), because located within the Low-Elevation Coastal Zone (LECZ), defined as: "…the land area and the total and percentage population, by country, that is located in various low elevation coastal zone bands ranging from 1m to 20m elevation above mean sea level" (NASA, 2016).
According to an overview of the electrical supply sector, changes in temperature profiles will be the driving force behind a significant adjustment in current urban energy consumption models. Although, if on one hand in the temperate and more northern regions, the increase in winter temperature will reduce the heating energy needs, on the other hand, the potential increase in electricity demand during summer will produce peaks in electricity demand for cooling, potentially producing Brownout or Blackouts phenomena, according to 2014 IPCC report (IPCC, 2014 p. 557).

In addition, supply water and sewage management are increasingly challenged by changing climatic conditions, as well as by uncertain availability of water resources. Climate change therefore has a strong impact on water demand, supply and management. The modification of rainfall and water flowing regime, with alternation of very dry periods and flooding, as well as sea level rise producing salt/marine water intrusion in the coastal aquifers (the so-called saline wedge), would cause alterations both on agricultural production and availability of drinkable water for cities (IPCC, 2014 pp. 556- 557). If the excess of raining period could be critical for flooding, especially in highly urbanized areas surrounded by vast shanty outskirts and slums, on the other hand a very long dry period will have multiple consequences in urban areas. Droughts are heavily affecting not only the urban water supply, in terms of human consumption, but also the energy production sectors, including the lack of hydroelectric power, especially in very socially fragile regions like central Brazil or sub-Saharan Africa (IPCC, 2014 p. 558).

Furthermore, very long dry seasons could produce the forced switch-off of nuclear and fossil fuels power plants, both requiring fresh water-cooling systems. Such occurrence is getting quite frequent even in Europe in recent years (Medarac et al., 2018) , causing the dilemma of choosing between the agricultural use of water or the energy production[2].

Permanent drought conditions are among the main reasons of migrations from countryside's towards cities; currently, an estimated 150 million people are subjected to perennial drought conditions, and bearing in mind the present demographic trends and climatic scenarios, this number is expected up to a billion of migrants by 2050 (IPCC, 2014 p. 555).

However, the most dangerous effect of changing climatic conditions towards cities remain the so-called Urban Heat Island (UHI). This phenomenon, bothering almost any modern city, is defined as an area significantly warmer than the surrounding rural areas, with high density of buildings and infrastructures, with generally greater difference in temperature during night than in the day and becoming even more evident when the winds are weak or during summer. The main cause of the urban heat island effect is connected with human activities producing heat (mainly from cooling systems), but also because the soils impermeability and lack of vegetation (Solecki et al, 2005); UHI has significant impacts on human health, both in drought or with high humidity concentration, with stronger effects towards elderly and childish population (IPCC, 2014 p.556). Recurrent heat waves, both on land and sea, are growing in frequency and severity since 1980 and dramatically affects the so called Cryosphere (IPCC, 2019) as well as urban areas (Pörtner et al., 2019), producing the melting effect of glaciers and polar caps, and transforming our cities especially during summers, in lethal cement valleys.

After having identified the central role of greenhouse gases for climate change effects on the Planet, and more specifically on present urban environmental crisis, it is important to underline that the same urban areas are responsible for more than half of those greenhouse gases emissions.

In front of this "Inconvenient truth[3]", today's cities around the world, but mainly in the northern hemisphere, must carefully redefining their management objectives and development strategies, achieving a substantial reduction of their greenhouse gases emissions, considering local environmental issues. The present urban challenge is linking the climate change effects with the energy-devouring nature of postindustrial cities, taking into account that urban areas consume between 67% and 76% of global energy production, and are responsible of about three quarters of global carbon emissions. Those simple facts must force Local authorities and Governments to reconsider their development perspectives in light of environmental priorities (United Smart Cities Program, 2018).

Having an environmentally correct approach to urban planning and building management is now strongly required, together with careful policies for reducing emissions, enhancing sustainability and best available technologies for energy and building management. This same approach, in line with all UN Sustainable Development Goals[4], but in particular with goal 11) "Sustainable Cities and Communities", will be able to grant a better quality of life for urban inhabitants, and in the long run, to the entire Planet.

Notes

[1] The European Economic Area (EEA), established in 1992, is an international agreement which enables the extension of the European Union's single market to non-EU member parties, and links the EU member states with three European Free Trade Association (EFTA) states (Iceland, Liechtenstein and Norway).

[2] The EU energy sector requires significant quantities of water for its operation and water-related problems have highlighted the inadequacy of electricity generation in power systems of some EU member states during the hot summer of 2018. Reactors of nuclear power plants in France, Finland, Germany and Sweden have been shut down, because high water temperatures (reduction of cooling efficiency) and in order to avoid rivers overheating. Similar problems occurred in the thermoelectric plants in Italy, located nearby freshwater collection points.

[3] An Inconvenient Truth is a 2006 American documentary film about former United States Vice President Al Gore's campaign to educate people about global warming. For wide-reaching efforts to draw the world's attention on global warming - which is centerpieced in the film - Al Gore, along with the Intergovernmental Panel on Climate Change (IPCC), won the 2007 Nobel Peace Prize.

[4] The Sustainable Development Goals (SDGs) are the 17 global goals designed by the United Nations General Assembly in 2015 to be a "blueprint to achieve a better and more sustainable future for all". The SDGs are intended to be achieved by the year 2030, as part of UN Resolution 70/1, the 2030 Agenda. The Sustainable Development Goals are: 1) No Poverty; 2) Zero Hunger; 3) Good Health and Well-being; 4) Quality Education; 5) Gender Equality; 6) Clean Water and Sanitation; 7) Affordable and Clean Energy; 8) Decent Work and Economic Growth; 9) Industry, Innovation, and Infrastructure; 10) Reducing Inequality; 11) Sustainable Cities and Communities; 12) Responsible Consumption and Production; 13) Climate Action; 14) Life Below Water; 15) Life On Land; 16) Peace, Justice, and Strong Institutions; 17) Partnerships for the Goals. UN General Assembly, Transforming our World: the 2030 Agenda for Sustainable Development (A/RES/70/1), New York, 2015, p. 18.

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1. ESSAYS

Mapping Public Space
Activating Outdoor Climate Control

Alessandra Battisti

Abstract
This essay explores the phenomenon of the city mapping of the environmentally sustainable and resilient data and parameters relating to outdoor space in the urban area, adopting the complexity typical of an interdisciplinary perspective as an epistemological tool for a renewed exchange of knowledge between urban geography and climatic surveys within the area of studies of the architecture of intermediate spaces. The purpose is to analyze and explore the information/energy/microclimate/public spaces/buildings exchanges in contemporary urban basins and particularly in the historic and consolidated city. The path in this sense is structured around different lines of research dedicated to geography and to urban studies, cartography, analysis of the microclimate, and the performance of materials and components, until the planning of new scenarios is achieved. It starts from the assumption that the legibility and comprehension of the data of the urban space is an open question not only for academic studies, but also for all those whose daily experience is defined by typically urban spatiality, practices, and rhythms. In this sense, the notion of city mapping is rapidly gaining ground in the literature on architectural sustainability, and, with it, frameworks for assessing and configuring scenarios have developed that represent an effective way to integrate the issues related to microclimate and to resilience into the process of designing the city's intermediate spaces.
The purpose of this essay is not, however, to explain only the importance of collecting and mapping data in research operations on outdoor urban space, but, to a certain de-

gree, it aims to offer a critical vantage point on the assumption of study parameters and on the definition of possible future planning scenarios. Deeply understanding the meaning of collecting data means knowing how to choose the parameters that then determine the solutions to be tried out in the various contexts, taking due account of the setting's tangible and intangible components, long-standing performance demands, and demands for services for society at large, articulated for specific needs.
Intermediate urban space, especially in historic and/or consolidated fabrics, is in fact a complex architectural/spatial situation with many different faces that it is important to identify. It is precisely this complexity that makes the research so interesting on how this situation structures the possible configurations of the planning scenario – configurations that are environmentally sustainable and resilient to the climate changes taking place.
What relevant aspects of mapping, then, are highlighted in the most recent research? And what is their most innovative function that may be gleaned from the literature and from sectoral policies? In other words, how is the urban basin represented, and with what intent in terms of planning is it represented in that manner in the studies on environmental sustainability and resilience?

Keywords
Smart City, Climate Design, Well-Being, Outdoor Space, IoT

Introduction

The preponderant presence of digital technologies within cities represents today a demand for guidance for design, so as to comprehend a setting in continuous technological, cultural, social, economic, and environmental transformation, and to define the content of a different man/nature approach that is destined to offer, instant by instant, models of individual and collective existence considered to be the "best applicable". It is a process that takes place almost imperceptibly, fluidly, providing the impression of a new natural order of the things of human nature, set within a data-driven society in which every manifestation of the

real finds itself subjected to a series of operations, with a view to taking the right direction from time to time, while following carefully defined criteria (Hosni, Vulpiani, 2017). This is an extension of a "systematic planning", or science of classification of relations between people and nature, between built elements and relations, and the science of relations, that is destined to be applied to all spheres of human life and, in particular, in the designing of public space. We are in fact witnessing a proliferation of innovative research and action programmes grappling constantly with big data, a term defined in long-ago 2001 by the company Gartner as high-volume, high-speed, and high-variety information assets that require new forms of processing and elaboration of the information, allowing us to improve decisions, intuit discoveries, and optimize processes (Duncan, 2015). This definition places the process of elaborating and aggregating data on a large scale – and performing their algorithmic extraction – at the centre of every planning method. In recent years, we have seen the latter operation applied more and more frequently within the planning actions grappling with context conditions of great complexity, from the regeneration of urban and peri-urban areas to meeting the demand for public services and collective equipment; from the problem of finding the resources for a new quality of living to defining non-authoritarian and non-bureaucratic paths of collective decision-making to safeguard natural capital.
In this way, a dynamic between real and virtual was established, in which design is placed in a continuous tension that subverts the constrictions and conventions of chronological succession. This tension is suitable for avoiding any form of inertia and for pursuing a design strategy capable of recognizing and adapting by following that selective and evolutionary trait typical of natural systems, and of reorganizing the nexus binding together technology systems, flows of resources, and organization of spaces and functions, understood as elements interconnected with one another and in close relation with the set of social and environmental components. In other words, there is a dialectic interrelationship, by virtue of which the current architectural creation acts and retroacts, modifying the

meaning and function of space in real time (Bucchi, 2010). By some, this process is experienced as a techno-scientific fantasy, an economic and anthropological axiom that presumes to build an infallible and indefinably dynamic governance of human affairs. The French philosopher Eric Sadin labels this process a "life industry", in which, in an IoT perspective, each individual gesture generates a flow of data not only linked to communication and consumption, but also connected with emotions and sensations – "the most promising sector in the new economy destined to cannibalize all the others". It remains, however, problematic how good use may be made of this knowledge in a historical and cultural context in which information easily degenerates into superstition: "Today, we are experiencing a change of state in digital technologies. They no longer have the purpose of allowing us to easily manipulate information but claim to reveal the reality of the phenomena beyond appearances. Today, computational systems have a disturbing vocation: to enunciate the truth. Technology is attributed prerogatives of a new kind, such as that of illuminating, with its own light, the course of our lives", Sadin was to write (Sadin, 2019).

Proving the French philosopher's statements, digital maps are everywhere today, and immediately transforming communication between inhabitant and city, expanding the horizon of exploitation to the point that at times the inhabitant is disoriented by it, and is lost in it. Indeed, after having recognized and identified the borrowings of various origins constituting the individual tesserae of these virtual mosaics that open on computer screens and smartphones and are fixtures of urban life on various scales, we end up immersing ourselves in a new city – the expression of technology – about which, theoretically and practically, almost everything can be known; but there is often no true interpretative key for understanding and intuiting its functions and deeper meanings closely linked to the identity of the places that make it possible to anticipate the future, and thus to design. "Thanks to the growing quantities of data produced by cities, often consisting of tracking data (which is to say data relating to specific points of the physical space)", assert Picon and Ratti in a recent essay suggestively titled *Mapping the Future of Cities: Cartography, Urban Experience, and Subjectivity*, “it is now possible to map all the types of phenomena, from environmental parameters like pollution levels to the state of vehicular traffic” (Picon & Ratti, 2019). This process is translated into an immersion in a shared, living image with fluid boundaries, in which it is difficult – and at times even irrelevant – to establish with certainty the line of demarcation separating the datum on real conditions from the conditions imagined in the future, and from the work of memory: we are dealing with the real/virtual unity that requires continuous work of recovery and interpolation, almost a sort of architectural hypertextuality.

A disciplinary approach

Rapid urbanization, climate change, sustainable development, the depletion of resources, the ubiquity of the Internet and of mobile phones: all are challenges to which the technological culture of design is called upon to respond, by guiding policies of adaptation and resilience to climate change towards a vision capable of holding together the various choices of government and control. This is done within a dynamic framework of analysis and scenarios, to be introduced into the planning and transformation of the intermediate spaces, that might allow their forms and uses to be changed (Betsill & Bulkeley, 2006; Biesbroek, Swart, and Van der Knaap, 2009).

In this perspective, the use and effects of urban digital tools may be assessed on different levels. The growing availability of spatial data offers broad opportunities for urban planning. Planning resilience and permitting positive planning results requires trans-literate methods for working with data and scenarios that can be rapidly and repeatedly adapted to the study areas. To do this, it is necessary to bring together, dynamically, data and information often originating from different and divergent disciplines, with the purpose of attaining results of environmental analysis, predictive modelling, and the construction of systems in support of urban research, planning, and policy-making.

The first cognitive level in this sense is identification among various experiences and data. This consists of un-

derstanding which data are effectively capable of providing targeted, progressive responses to every dispute emerging in that physical, economic, political, and social space that is the urban basin.
The second level of this multi-form universe is the one referred to as algorithmic processing, which represents design's effective domination only if one is able to choose, with awareness and knowledge, the surrounding conditions and to understand and learn from the errors constituting powerful and original devices for collective learning and exploration.
The third level pertains to the implementation of environmentally sustainable and resilient design. In a context of globalization of economic exchanges, of information networks on a planetary scale, of interdependent development processes and of big data – in a long-term process – this requires, in order to face the great, epochal challenges before us, a technological culture of design that is mature, open, and critical of the role of science in society, that does not oscillate between prejudiced closure and expecting miracles.
Lastly, the final cognitive level may be seen in the search for the identity of a territory that is not understood, strengthened, and built with data alone, but also and above all through participation with the communities that experience, on a daily basis, the tangible and intangible spaces, representations, and phenomena that load them with symbols and with shared values marking their surfaces.
To activate public space, it is not enough to merely use data to intuit – as a geographer would do – the reasons, ways, and dynamics by which localizations express the spatial, climatic, and social dimension. One must also inquire about the ways it is possible to understand and elicit behaviour, potential solidarity, and tangible and intangible relationships that connect individuals, groups, and societies on the one hand, and geographical space on the other.
But what, then, are the characteristics upon which to seek data and map this urban open space?
Above all, the more problematic ones connected to the social, environmental, and political sphere.

Collecting and mapping data in the social sphere

The characteristics of the social sphere make reference to life in the spaces "between" buildings, marked by the various human activities, planned or spontaneous, that take place in them (Gehl, 1980). These characteristics contribute to quality of life and are closely linked to social cohesion and the feeling of identity and safety of the city's inhabitants (Whyte, 1980). These positive characteristics are often countered by those of a contrary process, the result of globalization, in which private interests capable of transforming open spaces into full-blown shopping malls prevail. Consequences of this include emptying the places of their identity (Battisti, 2014), cultural devaluation of the collective sphere (Carmona, 2010), and physical decline associated with phenomena of vandalism (UN-Habitat, 2010). The fabric of urban social networks establishes the data and draws from them in accordance with a strategic approach to identify concrete objectives capable of involving the most extended arc of social components. For this purpose, the Internet of Things makes it possible – using interconnected objects, GPS trackers, smartphones, I-buttons, parking sensors, motor vehicles, control systems, but also household appliances, light bulbs, video cameras, furnishings, apparel, and virtually any electronic device equipped with software and a wireless module – to exchange important social mapping data, also remotely, managing them with applications and exploiting the existing Internet infrastructure in combination with specially developed wireless communication systems.

In this logical framework, the IoT can generate an enormous amount of information that can certainly be used to improve the efficiency of activities and functions, create new services, and improve the security of companies and people.

Collecting and mapping data in the environmental sphere

The scientific debate over what data to sample, and how to sample them, in the environmental sphere is becoming increasingly dense and specialized. For urban basins, it regards above all those that cause perceived discomfort in open spaces due to ever-worsening air, water, and soil pollution. Moreover, European cities are continuing to grow warmer due to increasing temperatures, as demonstrated by numerous research efforts and by the annual summaries developed by the Intergovernmental Panel on Climate Change (IPCC, 2014; IPCC, 2018). These show considerable temperature differences between measurements in urban settings and in outside areas associated with the heat island, which is to say the increased temperature due to asphalt and masses of cement capturing solar radiation, on top of the heat produced by power plants and vehicle exhaust.

Many research works have presented the collecting data of the parameters of the UHI. To obtain maximum accuracy of results, it is in fact necessary to collect and process the various weather data (air temperature, surface temperature, relative humidity, wind speed and direction, solar irradiance, the sky view factor) in accordance with a place-based technique at the micro-scale of the urban basin.

Since the thermal and hygrometric behaviour of the urban fabric is quite variable, the scale of investigation is small scale, or urban micro-scale (Oke, 1978), of relevance from the social and architectural perspective as a scale suitable for framing people's needs and dynamics with regard to open space, and from the climate standpoint as a space within which to investigate the main tangible and intangible exchanges between humans and the built environment. In this framework, urban microclimatology permits investigating open space in a more integrated fashion, allowing us to understand the dynamics of energy and material flows, while also informing us as to questions of a compositional nature influencing environmental quality, energy balance, and outdoor comfort.

The city as a whole modifies regional climate conditions, with consequently different climates between the city and the surrounding territory. This modified climate belongs prevalently to the Urban Boundary Layer (UBL) – above the rooftops – and is rather homogeneous within the urban area. To the contrary, the climate within the Urban Canopy Layer (UCL), beneath the rooftops in the space between the buildings, may vary significantly in the space of a few metres. The acquisition of climate data relating to the UHI thus varies if the data have been measured by control units (usually placed in correspondence with the roofs of buildings) that undergo the influx of the building where the control unit is, or if they have been surveyed at the user's height, the latter data giving us a more accurate rendering of the temperatures and the state of well-being/discomfort as actually perceived (Chokhachian et al., 2017). This microclimate constitutes the immediate surrounding of the city's inhabitants, and can influence the user's well-being, serving as the space-climate environment of reference for collecting data.

In this regard, it is vital to more deeply examine the characteristics that most influence the microclimate with respect to the perceived well-being and the factors of greatest importance (excluding from the in-depth analysis such factors as acoustic and visual well-being, polluting factors). These are the effects related to the heat and ventilation of the urban basin, including various types of open space ranging from piazzas to courtyards to streets, that are the essential places of cities' external spaces and play a significant role in the urban metabolism (Chrysoulakis et al., 2009). In fact, properly designed open spaces can promote the integration of vegetation into cities (World Bank, 2012); they can support the urban hydrological cycle by providing temporary storage for rainwater, thus improving the drainage and purification of non-drinking water and fostering controlled infiltration (Magliocco, Perini, 2014); they can substantially influence the urban microclimate (Boeri et al, 2017); and they can help reduce energy and resource consumption (Santamouris et al., 2015).

The Internet of Things immerses us in a living and shared condition of well-being and microclimate data, in which it in fact mostly becomes difficult – and perhaps even irrelevant – to establish with certainty the line of demarcation separating the data sampling work from the work of algorithmic processing of mapping, given that it allows us, through the use of interconnected objects, temperature sensors, detectors of wind speed and relative humidity, and GPS trackers, smartphones, and I-buttons, to exchange and monitor climate data and the users' perceptions, and to map them in real time on every scale, and thus, again in real time, to predict the trajectories and the consequent choices. The climate walks of Rome (the MIUR DAAD research conducted in Rome with TUM) are included in this context, and allow to elaborate a dataset on the environmental conditions of the city that permit an analysis and of changes in well-being and their consequences in terms of the perception of the inhabitants. Current methods of analysis and simulation, such as the global integrated surface data set (ISD) together with the geographic information system (GIS), computer-aided design (CAD), computer-assisted engineering (CAE) and computational fluid dynamics (CFD), can really help urban planning in predicting and understanding local microclimatic conditions. In this context, the use and management of open source systems in the design process represents one of the greatest opportunities offered by digital computing and emerging technologies in the world of technological design. In recent times Grasshopper's growing popularity as a visual programming interface for Rhinoceros 3D (McNeel, 2018) is laying the foundations for a change in design paradigm that offers significant advantages for the analysis of environmental performance. Through dedicated environmental analysis plugins (such as Ladybug tools) (Roudsari et al. 2013), Grasshopper generates a natural environment for data flows together with the 3D Rhinoceros model, various performance simulation engines and post-processing platforms. Therefore, the coupling of tools expands in Grasshopper beyond the analytical calculation itself and facilitates the entire computational workflow from the formation of the input geometry to the processing of the results.

Collecting and mapping data in political the sphere

Lastly, it is extremely important to establish what are the data to be sampled that are closely linked to the political and socioeconomic sphere. In Europe, reference is made to the standard based upon a structuralist model that has gradually resulted in the dispersion of the city and in an urban void, with a consequent weakening of public autho-

rity, an indoor shift of numerous urban functions (Sennett, 20187), and an emphasis on and importance given to private transport networks (Newman and Kenworthy, 1999).
What, today, is the real interest of institutions as regards "open urban space", we wonder? What are the most significant political data to be collected to monitor and to best comprehend the influxes and transformations imposed from above?
In recent decades, urban renewal has been one of the chief strategies of the European Union as regards sustainability, in the desire to deal with the renewal of public space in order to intensify its use and therefore to indirectly influence the economic and ecological behaviour of the urban ecosystem as a whole. There are guidelines, specific regulations aimed at planning and recovering open space with a view to sustainability and the environment, such as those emerging at the most recent world meeting on the climate emergency, COP21 (Paris, December 2015). Moreover, all the European programmes and projects[1] find a template for common guidance in the results of Agenda 21, and particularly in one of the key concepts relating to a common vision for sustainable development. We also find these indications in the New Urban Agenda (UN-Habitat, 2017) and in the *Sustainable Development Goals* included in Agenda 2030 for Sustainable Development, and in particular for goal 11, *Sustainable Cities and Communities*. In Italy, 2015 saw the institution of "Strategia nazionale di adattamento ai cambiamenti climatici" (*National strategy of adaptation to climate changes*), followed by "Piano Nazionale di Adattamento ai Cambiamenti Climatici" – PNACC (*National plan of adaptation to climate changes*) in 2017. The two plans, joined by other strategies indicated by the Ministry for Environment, Land and Sea Protection (MATTM) for sustainable development and the climate-energy plan are guidance documents essential for helping the designer make choices of data and mappings functional to decision-making in constructing design scenarios for the regeneration of public space.
Lastly, there is growing recognition by EU institutions of the community's importance in guaranteeing the social and environmental quality of cities' open spaces (Carmona

& Tiesdell, 2007), and in this sense the retrieval and interpolation of data in a time of changing standards on the one hand, and of practices with and among people on the other, allows us to take on the data of the cultural changes in progress and to map, in a sort of inter-textuality, intermediate architectural space and human perceptions.

Conclusions

To date, the physical form of cities – the arrangement of streets and squares – has been influenced only marginally by the development of information and communication technology. However, at an ever quicker pace, the mapping of the data of the social, climatic, and political context of urban intermediate spaces through sensing has been increasingly configured as a scientific way to transfer social, climatic, and environmental knowledge to the language of design, thus improving the scale and resolution of the modelling and bridging the existing gap between climatology, meteorology, environmental studies of the air, planning, participation, and urban design. The impact on planning increasingly requires the involvement and participation of citizens, driven by growing interest in issues of the environment, health, and the quality of urban life. But while this work of understanding broadens the context's thematic horizon, it certainly does not facilitate the activation of communication that translates easily into design, thus producing a mass of data that, if not well governed, instead of generating information, at times ends up being just noise. Moreover, collecting data and the mapping of values on urban basins are based on the use of sophisticated technology, which only few can employ, and at costs that are still high and that not all research centres can afford. Lastly, another problematic aspect is linked precisely to an inversion of the perception of the city; in fact, for some time, cities have been perceived as a collection of physical objects, while today the perspective has been overturned, and we are dealing with a collection of knowledge and information data, to the point that we are at times interested more in knowing the how and the where, thus losing sight of the "what."

Smart cities will continue over time to attract increasing flows of energy and information, that collecting data, mapping, and the configuration of the development scenarios will help us regulate and control only if we never lose sight of the people who inhabit our spaces, bring them to life, and fill them with identity and culture.

Notes

[1] As regards the European initiatives, the first interesting programmes are URBAN I (1994-1999) and URBAN II (2000-2006). Upon the conclusion of these two experiences, an additional European Programme was initiated, named URBACT, and in particular URBACT I (2002-2006) and URBACT II (2007-2013), with the primary purpose of creating a platform for exchanging and sharing experiences.

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Shaping Urban Microclimates: An Agenda for the Next Decade

Daniele Santucci

Abstract
Climate is a condition that can't be avoided and is the primary factor that allows the use of public spaces. Climate change puts in sharp relief microclimatic conditions in cities because extreme climatic phenomena are exacerbated in urban systems, causing fatalities and heat stress for millions of citizens around the globe. Besides these extremes, also everyday life dynamics are affected by microclimatic conditions, that are exacerbated by climate change. As the thermal experience becomes crucial to health, an agenda for climate mitigation strategies becomes urgent and designers, urban planners, and policymakers are called to define its strategies and applications.
In this essay, we describe a method that represents an opportunity to this agenda: Climatewalks, geo-referenced human centred sensing experiments, that allow collecting data and formulating design indications for urban climate mitigation and regeneration for creating impacts on multiple scales.

Keywords
Microclimate, Anthropocene, Urban Space, Environmental Sensing.

"It is your human environment that makes climate."
Following the Equator, Pudd'nhead Wilson's New Calendar.
(Mark Twain)

Microclimate and urban space

Among many factors that determine the way in which people use outdoor spaces, microclimate has a fundamental relevance in dense urban environments. In particular, microclimate describes the conditions that human beings continuously experience through their senses when they are directly exposed to their immediate environment in terms of variations of sun and shade, changes in wind speed, and other characteristics.

The microclimate also influences decisions on whether to use the space. For example, in his seminal work, "Life Between Buildings: Using Public Space", (Gehl, 1971) first studied the influence of microclimate on outdoor activities by counting people sitting on sunny and shady benches. He showed that local sunny or shady conditions significantly impact the desire of people to either stay or leave.

In the past decades, broad applications in urban studies of concepts and equipment used in biometeorology and urban climatology have yielded a vast number of research projects on outdoor thermal comfort in various climates around the world. Some studies have focused on modeling and assessment methods from a thermophysiological perspective, whereas others have conducted detailed investigations of the climatic parameters that determine the thermal comfort level of humans (Chen & Ng., 2012).

According to the literature reviewed above, outdoor spaces are important in promoting the quality of life in cities. However, outdoor thermal comfort in an urban environment is a complex issue with multiple layers of concern. The environmental stimulus (i.e., the local microclimatic condition) is the most important factor in affecting the thermal sensations and comfort assessments of people. These assessments are both dynamic and subjective: dynamic in the sense that adaptation to an ambient thermal condition is progressive, and that thermal sensation is primarily affected by previous experience, and subjective in the sense that the evaluation of a thermal comfort condition is not always consistent with the objective climatic or biometeorological condition. In addition to the climatic aspects of thermal comfort, a variety of physical and social factors that influence perceptions of urban space come into play when people are outdoors.

Under the premise of a critical review, this article seeks to connect knowledge from climatology, urban studies, sociology and data science in a cross-disciplinary approach. It aims to describe, analyse and contextualise the interrelation of climate change, climatology, increasing population with the consequent carbon emissions, and the need for mitigation strategies in urban space.

This framework should allow establishing connections between the local microclimatic conditions and human sensations, as well as with the use of space in both spatial and temporal terms. In other words, it aims at detecting relations between subjective (i.e., physical and physiological characteristics) and objective aspects (environmental conditions) to generate 'climatic knowledge,' in its relationship to 'human knowledge'. Although people's subjective perceptions and responses to the urban environment are various and not yet well understood, simulation and scenario-testing tools are always of particular importance in an assessment framework because they provide a platform for the integration of knowledge from various perspectives and comparisons of various design scenarios. Generating climatic knowledge also allows predicting the influence of design and materiality on microclimatic conditions in urban space.

Vladimir Jankovich summarises the historical development of local climate and urban climate research. "The term microclimate was coined by German and British meteorologists and geographers in the first half of the 20th century. Rudolph Geiger, working at the Meteorological and Climatological Institute at the University of Munich, who first chose the term *Kleinklima* in his *Das Klima der*

Bodennahen Luftschicht (Geiger, 1927). But Geiger was not happy with its scientific status. He argued that with the extension of observational networks during the nineteenth century, scientists became aware that the consistency of measurements depended on the exposure of instruments. To avoid errors, national services agreed on 'the most suitable exposure' of 2 meters above the ground to diminish the influence of the layer adjacent to the ground, which Geiger informally termed 'zone of disturbance.' Piecing together data from a tract of land populated by the 2-meter shelters led to the construction of 'large scale climate' which played both the scientific and national role as exemplified in the multi-volume Climatic Information on the German Empire published by the German Imperial Weather Service during the 1920s. As the increased interest in meteorological information for economy made large-scale climate annuals too general to be of use, it gradually became imperative to look at the weather situation in the zone of disturbance: 'it was soon found that all plants have their lives conditioned by that very zone of disturbance which had been so meticulously avoided in meteorological observations'.

Geiger thought that microclimatology first appeared in Germany due to the lack of living space and 'the consequent necessity of getting the utmost out of the earth'. Stemming from practicalities of agriculture and urban congestion, microclimatology helped to understand and reduce risks of industrial pollution and its impact on local land, property and human settlement. It served the farmer, the doctor, and the tradesman and inspired the planner in thinking about 'the street construction, railroad building, house construction and the establishment of communication systems [...] While formerly the extent of science has led to the leveling out of research, and its depth to undue specialisation, in microclimatology the two formerly contradictory extremes seem to join hands'.
In the interwar period, it took further strides in addressing the urban 'ecoclimates' defined by atmospheric pollution, smoke and pestilential airs, with results that spoke to the urban planner and public health officers. Urban climatology thus remained a vibrant field, even more so because its

practitioners could provide useful information to municipalities“ (Jankovich 2017).

The work of geographers and urban meteorologists got low levels of public attention and support. In fact, “ Ironically, and despite such developments, Geiger’s ‘zone of disturbance’ has never received a public acclaim commensurable with that assigned to academic work on global atmosphere and the numerical weather prediction of national weather services. From the point of view of continental and global scales, the urban atmosphere (or technosphere) has always been treated as contaminated and unrepresentative of the processes in the free atmosphere. From the human and economic perspective, however, the layer is inexhaustible in meaning, defined by change and chance, maintaining its biocentric character over the course of modern history.
Moreover, a larger portion of human population is already a subject of dramatic climate change on local level and of a magnitude larger than is predicted for the global atmosphere in the next several decades. Urban heat island, urban runoff island, air pollution, decreased sunlight, split thunderstorms, flash-floods, street canyon turbulence, and carbon dioxide ‘dome’ have all plagued metropolitan areas for longer than is usually acknowledged. Urban populations have suffered a climate change for at least a century, but their plight is becoming visible only because small-scale climates are now imagined as places where global climate change manifests itself “ (Jankovich 2017).

These phenomena raised new attention even if the resurgent interest in urban mitigation represents a top-down policy driven by “downscaling” of global scenarios. “On a more informal level, we see this top-down culture in situations when people struggle to understand whether a single heat wave, a blizzard, or a hurricane represent instances of global change, as if their local manifestation does not make sense without a global driver. Their local effects, as painful and fatal as they might be, seem to be written by an alphabet of global climate change. In other words: the culture of global climate consciousness does not recognize the importance of taking urban weather as sui generis and the results which the tradition of municipal meteorologies produced in the last sixty years. This bias is additionally manifested in carbon-centered mitigation policies which are promoted regardless of whether the quality of urban life depends of reduced emission or bad planning, lack of green belts or some other factor. This also prevents the possibility of using the tools already available in fighting environmental stress on local level" (Hebbert & Jankovic, 2013).

Today's challenges and ways of approaching microclimate mitigation, strongly depend on politics of scale. Mapping techniques have been already used to create urban climate maps: they provide methodical approaches for correlating climate data and spatial characteristics of cities, to understand the effects, interactions and predicting conditions.

What is still a matter of research, is to put into evidence the impact of varying microclimatic conditions on human life, including the new extremes that climate change amplifies.

In this context, structuring on the culture of weather sensitivity – *Wetterfühligkeit* – which extends far beyond awareness of *Licht und Luft* and the atmospheric dimension of public health, we see the need of focusing on the human dimension with a bottom-up perspective that places the human to the center of our attention.

"The layer of air within two meters of the ground, the noosphere, that is the most important of all in Earth's atmosphere. It is located in what meteorologists have come to call the anthroposphere, nestled in the "boundary layer," a turbulent, well-mixed zone at the very base of the sublunar realm. This is a space in which the "natural" atmosphere gets entangled with human energy. This is the anthropocentric layer is the interdisciplinary sphere of human affairs, the most influential layer of our planet's atmosphere. This layer has not been fully or even adequately explored, which is unusual, since it is so accessible to us - as intimately close as our next breath. Indeed, it has been consciously excluded from environmental analysis" .

(Rodger Fleming & Jankovic, 2011)

Urban microclimate in the Anthropocene

In 2002, the term "Anthropocene" was proposed by Paul Crutzen as a new geological periodization in a now well-known article published in Nature, where he proposed that a new geological epoch had been inaugurated with industrialization and the liberation of intensive fossil fuels (Lahound, 2017).

According to Crutzen, "for the past three centuries, the effects of humans on the global environment have escalated. Because of these anthropogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to come. It seems appropriate to assign the term Anthropocene to the present, in many ways human-dominated, geological epoch, supplementing the Holocene – the warm period of the past 10–12 millennia. The Anthropocene could be said to have started in the latter part of the eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane. This date also happens to coincide with James Watt's design of the steam engine in 1784" (Crutzen, 2002).

The definition of a new geological era, the Anthropocene, throws in sharp relief the beginning of an age in which climatic conditions change constantly all over the planet. Moreover, extreme phenomena increase in frequency and intensity. These changes became well known as "climate change" or "global warming". They "became a public concern in the late 1980s when scientists advised governments that this was the biggest threat human civilization had ever faced and that the threat came from our civilization's dependence on the cheap and plentiful energy that fossil fuels provided. Climate change […] was anthropogenic in nature and what was worse, it was going to affect the poor of the world more than the rich, who were much more responsible for the emission of excessive greenhouse gases. […] Understanding the phenomenon of climate change required the development of a form of planetary thinking that was interdisciplinary" (Chakrabarty, 2015).

It required expertise of geologists, climatologists and economists, to clarify the relationships between the history of life, introducing "new questions of scale—astronomical scales for space, geological scales for time, and scales of evolutionary time for the history of life" (Chakrabarty, 2015).

Climatic conditions, and their effects on the anthroposphere, the microclimatic conditions, are fundamental factors for life: paraphrasing Vanderheiden (Vanderheiden, 2008), Venus would be too hot and Mars too cold for hosting human life[1].

Looking at the human scale, the "anthropocentric layer" becomes "deeply significant for all human transactions. Although "this layer remains out of sight, its very proximity rendering it invisible. And this invisibility means that the modern sense of "climate" has been eroded to an abstract three-dimensional geophysical system, rather than an intimate ground-level experience.

In history, "climate has been thought of as an element in economic modes of subsistence that, before mass production and division of labor, amounted to optimisation of agricultural yield and trade".

Also the history of climatology and, since it's first developments, microclimatology, "attempted to explain why certain species of grain grew in one region rather than another, why a textile was worn here rather than elsewhere, and why agricultural methods yielded better results in one place than in another. Climatic distribution of natural objects and living creatures embodied providential balance in a definitive way", learning that all forms of life, whether human, animal or vegetarian, exist where they were capable to adapt to the local climatic conditions. The relation between bodies and climate is not only a casual connection, it is in Focault's words a classical episteme, not a mere "exterior relation between things, but the sign of relationship" (Foucalt, 2004).

They are not "simply contiguous to each other, but also co-constituted each other. In other words, when bodies and things were found in a particular place, their very placement became a warrant of ontological affinity between and among them" (Egan, 1999).

During the industrial revolution, "early modern naturalists had developed a range of doctrines on how the atmosphere affects human physiology, health, and everyday life. Sociometeorological correspondence spawned an extensive literature on topics covering everything from national characterology, to ambiental medicine, to city planning. Naturalists linked the climate with social welfare and gave an impetus to medical topography, health travel, altitude physiology, eudiometry, and ventilation. Physicians recorded weather to understand epidemics; others asked about the relationship between health and social change in the wake of industrialization; and colonists reported on the physiological effects of the tropics or extreme cold and discussed the climatological reasons behind the moral and political differences of nations. Such richness preceded the modern sense of climatology" (Jankovic, 2010).

In the era of climate change and when its effects have been proved to be a threat to human health and lives, climatology has the power of influencing decision making with acts of paramount political magnitude and economic consequences (Rodger Fleming & Jankovic, 2011).

"Fuelled by two powerful human-induced forces that have been unleashed by development and manipulation of the environment in the industrial age, the effects of urbanization and climate change are converging in dangerous ways which threaten to have unprecedented negative impacts upon quality of life and economic and social stability".

(UN Habitat, 2011)

Scales of climate

"Cities have the special attribute that they are both cultural communities and distinct climatic singularities. Urban weather is a synthetic space of the social and the natural, a result of the interaction between the city's-built form and atmospheric dynamics. It is also the scale of weather phenomena that are experienced by the majority of world population. So, the atmosphere is a significant component of each city's identity. On the other hand, cities have common properties: concentrations of buildings create surface roughness, they create and retain heat, their street canyons constitute a distinct layer of atmospheric circulation. The urban setting alters patterns of humidity and precipitation, modifies wind-flows and produces temperature gradients that sometimes exceed the direst predictions on the global level. […] The city is a producer of weather. It generates atmospheric gradients with major effects on comfort, health, traffic, leisure, property value, and infrastructure. The three-dimensional complexity of built environments makes intricate microclimates of real weather and patterns of sharp contrast at every scale of resolution. As cities have changed, so have their climates, challenging traditional climatic responses that were learned by experience and embodied in local design vernaculars. 'Urban climatic change' has lacked the public and political visibility that is given to its global counterpart. While scientists and policy makers acknowledge the role of human settlements in contributing to the global carbon metabolism, the local-scale impacts of urban weather have been relatively little studied and weakly managed. However, as forecasts of the human and economic risks of global warming have grown more precise, they have focused increasing attention upon the urban environments where the greatest vulnerability is concentrated, and this has in turn stimulated concern for street-level climates and the scale of real weather".

In 2008, scientists from around the world launched the Urban Climate Change Research Network as a city-scale counterpart to IPCC. Its first assessment report highlighted the need for high-resolution, high-frequency weather monitoring, including the full range of impact variables that relate to the scales of everyday life, such as frequency of power failures and transportation delays (Rosenzweig et al., 2011). Furthermore, urban anthropogenic weather modification is at last becoming recognized as a significant factor for carbon mitigation as well as for local adaptation to global warming's weather consequences. City weather cannot be modeled without detailed understanding of the urban landscape and cities cannot plan for climate change without knowledge of atmospheric hazards and potentials (Jankovic & Hebbert, 2012).

In fact, cities create artificial climates, which we define as urban climates, that are shaped by morphology and materials. Studying the urban microclimate, its' anthropogenic origin becomes fundamental in becoming meteorologically self-aware and take responsibility for their role as 'co-patterners of their climate' (Kratzer, 1956)

The design of historical cities "embodies local knowledge of wind, sun, humidity and precipitation, and of what is needed to survive in a topography against the contingencies of weather and human enmity. The history of urban habitats is not just one of passive adaptation to regional climate but of active modification to produce microclimates radically unlike their surrounding terrain - hotter, cooler, drier, moister, less windy, more ventilated, or whatever is most conducive to human comfort at a given latitude" (Hebbert & Jankovic, 2013).

As such, cities are the most influential climate manipulators: while the effects of climate change are increasingly affecting existing urban structures, the existing policies seem to be underestimating these phenomena giving visibly weak responses to the climate emergency. Also, the Kyoto Protocol is neither mentioning cities in their role of contributing

to climate change nor as recipient of its effects.
This attitude has been changing in more recent years: “For its Fifth Assessment, IPPC has commissioned a new panel chaired by Arnulf Grubler from Yale University to investigate the overall relation between urban settlement patterns, energy and climate” (Hebbert & Jankovic, 2013).
Nevertheless, these policies are rather addressing the globality of weather instead of understanding its “local manifestation, the subjectivity of lived experience, and the specificity of urban/rural form. […] Small-scale phenomena such as urban weather remains below the threshold of visibility in representational tools and are thus rendered less relevant as meteorological events and building blocks of the environmental policy. This is surprising in the face of the fact that world cities account for of 75% of global energy consumption, 50% of population, 80% of GDP and 60% of luminosity. And while they comprise only 3% of land area, demographic growth of the twentieth-first is predicted to occur almost entirely in cities” (Jankovic, 2017).
In addition to that, the densification and the qualities of urban space have structural differences between cities of the Global North and South. Increasing urban population and worldwide urban growth have created cities that are no longer well adapted to the needs of citizens “largely because the rate of change is too fast for those involved in building to respond quickly enough to our changing needs and the innovations that seem to pile up and into other at an ever-faster pace” (Batty, 2018).
The above-mentioned phenomenon of discontinuous and unstructured growth pace calls for developing knowledge outside traditional scalar categories precisely because the problems climate change makes visible “adhere to none and can be observed across all”. This complexity requires to surpass all so far considered spatial scales and boundaries to become conscious about the transscalarity of urbanization (Graham & Blanchfield, 2016, p. 181).

The latter of scale reveals its limitations also in weather modeling: “Until recently, grid resolution of operational weather forecast could not resolve – i.e. made ‘visible’ on the grid – even the major cities of the world. Even the highest resolution of regional (meso-scale) models was (and still is) at a scale greater than can explicitly represent urban phenomena. As a consequence, cities have been usually ignored in such models. The introduction of the so-called tiled-land surface models – which account for the sub-grid heterogeneity by calculating an energy balance for each element (tile) within a gridbox – has enabled modeling of subgrid land use and has given the opportunity to include cities within models. However, the progress is slow and with mixed results" (Jankovich, 2017).

In the era of disruptive technologies and global connectivity, we are experiencing new dimensions of information and a transition "from a rural world into an urban world, from a world of highly local interactions to a world of global interactions, from a world based on physical technologies to a world based on information technologies" (Batty, 2018).

According to Michael Batty, the existing digital technologies allow "to make visible that form is composed of flows. […] Contemporary landscapes in populated places reflect not only physical flows but also humans […] presenting patterns in forms that are woven together by human and physical movements. […] Certain processes, such as the walking speed, intensify as a consequence of increasing urban population. Digital devices enable tracking walking speed, which becomes an indicator for city size and morphology leading us to think of it in an entirely different way" (Batty, 2018).

Making flows visible, allows to visualize and understand dynamics that regulate complex urban systems, such as pedestrian flows; visualizing and quantifying them opens the opportunity of finding a systematic relation between microclimate and human mobility and evaluating its extension.

Digital technologies allow operating at different resolutions, enabling transscalar approaches. Following Bruno Latour's concept of "agency", in the context of increasing temperatures and urban structure complexity, the urban climate is more likely to be encountered "as an agency rather than an index (Latour, 2004). Climate has more often been defined as what it does rather than what it is. Climate is generating

also increasing social pressure with different local effects from place to place." (Rodger Fleming & Jankovic, 2011).
Citing Jonathan Franzen's article published in the New Yorker in September 2019, "any movement toward a more just and civil society can now be considered a meaningful climate action" (Franzen, 2019).
Seeing the urgency and the pressure on people's lives, the local scale, the human, has to be considered the pivot for inverting the process and proposing downscaling as one relevant way of approaching the issue.

"As architects, planners and urban theorists, we delight in approaching the city in terms of its morphology. But morphology is not enough. It must be unpacked, and the only way to unpack it through its dynamics".

(Batty, 2018)

Climatewalks

The influence of microclimate on humans, particularly in artificial urban contexts, is a complex issue comprising both climatic and behavioral aspects. Analyzing and assessing these conditions demands not only innovative computational methodologies and tools but also the exploration of new sources of information. Furthermore, it requires a high spatiotemporal resolution to relate human physiology to other factors, such as subjective response and walking choices.
Digital models that integrate microclimatic conditions and people's mobility patterns, can lead us to work out the analytic capacities of digital transformation, in particular using data to evaluate and predict the effects of urban systems on wellbeing and health. In this sense, microclimate could be one of the fundamental factors to create the link between spatial configurations and movement.
To address this topic, and due to the lack of available data, we created the Climatewalk experiment: Climatewalks are designed to measure environmental factors with a mobile meteorological station equipped with environmental sensors and GPS tracking data loggers, to measure and map

transient condition in different seasonal scenarios. By relating individual and subjective responses to environmental conditions adaptation, the experiment allows relating microclimatic conditions to human thermal behaviour in urban spaces. The objective of the experiment design is to provide "climatic knowledge" of the urban context combining a geo-referenced method for monitoring and mapping microclimate and a longitudinal survey to obtain the thermal responses of pedestrians when walking in outdoor environments.

Climatewalks bring the human scale to the center of our observation and were carried out in several cities in different climatic regions: Munich, Seville, Malaga, Hong Kong, Amman, Singapore, Rome, Genoa, Copenhagen, Boston, and Barcelona.

The methodological setup allows us to include the human factor to a sensing technique, integrating not merely technological responses, such as human physiology and participation. This human centred workflow creates a bottom-up data collection method that can specifically analyze location, time in high resolution, and that can include the dynamic character of comfort, its cumulation in time and to highlight variations in transient status.

The experiments also defined metrics and produced data, giving evidence to phenomena that can be used to redirect planning and design strategies to use the methods on a larger scale.

Climatewalks have multiple impacts, working on a twofold level:

1. During the experiment, it involves participants from local communities and administrations, opening up a new dimension as a method to generate participation in design processes: stakeholders such as citizens and administrations take part to an inclusive and common experience that creates consciousness about conditions in public space not only from a bottom-up perspective but also with a deeply physical experience. Suffering and feeling extreme heat conditions along with physical engagement (such as climbing steep steps) are part of the format. Climatewalks generate consciousness for the thermal and environmental qualities, related to the urban morphology but also the

contiguous conditions in urban space (waste burning, the difficulty of walking, traffic safety, etc.) For locals, they also create additional knowledge about the neighborhood and set the basis for a common discussion platform for citizens and administrators.
2. After the experiment, through the data analysis and mapping, it allows detecting crucial points and heat and physical stress to intervene more specifically on the design strategies in a holistic design process.

Concluding, Climatewalks, as micro-climatological surveys, add to the human comfort experiment a new layer of a cultural and social focal point. Microclimate ethnography centers precisely on these cultural and social implications by seeking insights into urban ethnography in order to enrich our knowledge of urban thermodynamics. By directing attention to cities, microclimate ethnography takes the growing significance of urbanization processes into account" (Roesler, 2017). The task of these experiments is to build bridges between people and administrators facilitating an inclusive design approach to increase the quality of public space.
Within the challenges of our time, architecture can be considered as a collective response to climate, it's changes and the emergency we are experiencing. This role for the discipline and the involved actors needs new politics of interventions and scale.
When translating needs into form, architects are required to think beyond the conventional spatial and temporal scales. The digital revolution also allows taking into consideration dynamics, enabling interconnected, interdisciplinary workflows.
The combination of across scale thinking and digital tools enables new ways of approaching climate change needs, from the local human scale to the entire planet, exploring engagement at all scales to activate vast resources and interdependencies.
With our contribution, we aim at creating a new dimensioning for future cities, addressing particularly the commitment for less spatial inequalities and inclusion.
In full recognition of the built world as a single and simul-

taneous practice, the next decade is asked to ensure models and specific responses for different necessities.

Notes

[1] Vanderheiden acknowledges that without the greenhouse gases (GHG) and "the natural greenhouse effect," the planet would be inhospitably cold for life in general, and for human life in particular. "While some life," he writes, "might be possible to sustain within a small range of temperature variability beyond that seen since the last Ice Age, the climatic equilibrium produced by 10,000 years of GHG stability is responsible for the development of all terrestrial life [emphasis added], and even tiny changes from that equilibrium could throw those ecosystems dramatically out of balance" (Chakrabarty, 2015)

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2. POSITIONS

Embedded Architectures

An Overarching Approach to Compound Sustainability Problems including Urban Climate Mitigation

Michael Hensel & Defne Sunguroğlu Hensel

Abstract

This chapter portrays an effort to pursue urban climate mitigation in a larger complex of compound sustainability problems. In this context we recognize that addressing compound sustainability problems and raising benchmarks within current approaches is limiting. What is key is a change in attitude, which requires a grounding ethic, a guiding perspective and an open set of design principles.

We propose Leopold's land ethic, actor network theory and a nonhuman perspective as corner stones for an approach that we entitle *embedded architectures*. This approach seeks for architecture and environment integration along a series of guiding design principles that address the design of environments; interactions between objects, systems and actors; inclusion of natural processes and cultural practices; retaining terrain, considering micro-climate and incorporating ecosystems and agroecology. Furthermore, we introduce the concept of new generation *ecological prototypes*. We briefly discuss a current project in a suburban and rural area and briefly indicate that novel urban configurations can arise from the combination of different lines of inquiry. While the picture painted is much bigger than the theme of urban climate mitigation, the embedded architectures approach might offer a powerful way forward that is adaptable to locally specific conditions and circumstances.

Keywords

Nonhuman Perspective, Embedded Architectures, Ecological Prototypes

Rapid global urbanization, the unfolding environmental crisis and climate change are among today's greatest societal challenges. This involves among other aspects urban densification, urban ecology, urban agriculture, and urban climate. There exist numerous approaches that seek to tackle these problems. Some do so in a top-down manner, moving from overarching strategies to specific interventions, while others tackle this in a bottom-up manner by way of cumulative specific interventions. Both approaches merit careful consideration in an integrative and adaptative design approach.

Nevertheless, deep systemic changes are more rarely considered to the point of possible implementation since such changes require rethinking the fundamentals of our way of living, offering viable alternatives, planning for the long term, and working out the specifics in order to be credible. This involves unsurprisingly adequate politics, ethics, economics, ecology and what might be called design principles that guide the sustainable transformation of our environment.

We have taken on the challenge of a deeper change in attitude and approach in our practice and research and work towards an overarching approach that we entitle *embedded architectures*. In this chapter we summarily set out the basis for this overarching approach, which aims at its core for architecture and environment integration. This involves reconnecting architecture, landscape architecture and urban design and linking them to correlated aspects of culture, climate and ecology.

From the onset we base our approach on a *land ethic* and a *nonhuman perspective*. *Land ethic* was set forth by Aldo Leopold who pointed out that land and living species have intrinsic value above and beyond economic value, and that this intrinsic value must be foregrounded and protected (Leopold, 1949). In order to address this in an operational manner we base our approach on *actor network theory* (Latour, 2005) which locates agency in human and nonhuman actors, such as, for instance, the bio-systems and geo-systems that make up the natural environment. By extension, we embrace what is called the *nonhuman* perspective. Richard Grusin called for a shift in emphasis away from exclusively human actors towards nonhuman actors such as animals, organic and geophysical systems, etc. (Grusin, 2015, p.7) This does not imply that humans are no longer in the centre of concern, but instead, that a much more extended range of actors occupy this centre. The combination of *land ethic*, *actor network theory* and *nonhuman perspective* deliver the basic framework and ethical guideline for the development of our approach.

Embracing a nonhuman perspective and interactions between a broad scope of actors implies that approaches based on hard division of land runs counter to engendering the scope of actors that are affected by the transformation of environments. Moreover, parcellation of land coupled with individual ownership makes wider planning frequently cumbersome or impossible without difficult intervention. This also applies to wider regional and national boundaries where claims of sovereignty get into the way. Bruno Latour pointed out that from the perspective of an inclusive scope of actors the insistence in national, regional, or other types of boundaries makes no more sense since their territories hardly coincide with such boundaries (Latour, 2018, p. 93).

The problem for planning that individual ownership poses was already recognised by the garden city movement in which collective ownership combined with individual leasehold was proposed to engender coordinated sustainable transformation of the environment. In today's political climate and context of rampant commodification it is clear that a sense of a new collective would likely be vetoed and possibly derided by way of predictable yet incorrect labels. For this reason, it is necessary to work on possible future scenarios that lay open how a new collective can be arranged and why it could be desirable.

To provide tangible future scenarios requires design principles that are aligned with *land ethic*, *actor network theory* and *nonhuman perspective*.

For this purpose, we are currently developing a series of guiding principles which include the following:

1. Designing Environments;
2. Foregrounding Interactions between Systems, Objects, and Actors;
3. Incorporating Natural Processes;
4. Foregrounding Cultural Practices;
5. Retaining Terrain;
6. Considering Micro- & Topo-climate;
7. Incorporating Ecosystems & Agroecology.

Larry Busbea stated that “to design *in* an environment is to design *an* environment” (Busbea, 2019, p.7). This foregrounds the fact that we cannot continue to insist on the primacy of the discrete architectural object - the building - alone, as this excludes the many ways in which material operations and interventions lead to transformations of the environment. As such this requires an overarching perspective in which the architectural object seen as inextricably linked with other objects, systems and actors. While this sounds entirely self-evident, insufficient attention and effort is given to this realization.

Today the recognition of interactions between objects and encompassing systems is frequently reduced to questions of optimization of particular aspects pertaining to the architectural object or architecture and environment interactions. This is inadequate given that frequently changes are triggered in and across wider systems. For this reason, a comprehensive approach is necessary that entails multi-domain and multi-scalar considerations and methods that operate on the interactions between objects, systems and a broad scope of actors.

Christopher Alexander pointed out that modifications of the environment need to be aligned with its dynamics, i.e. its regeneration, such as to not disrupt its performance. (Alexander, 1964, p. 3). Currently insufficient attention is given to dynamics and processes related to the local and wider environment. This includes a variety of interactions between objects, systems and actors. Such processes can include non-consolidated landscapes that are in transition from one state to another, or processes of evolution, adaptation, etc. As far as human transformation of the en-

vironment impacts upon such processes, they must be considered on a primary design level.
Practices entail culturally specific ways in which people use land individually and collectively. This includes ways in which local communities, and indigenous and often nomadic people inhabit the land, as well as customary rights that are historically rooted, such as the right to roam or its Scandinavian equivalent the "everyman's right". This approach serves to several purpose, such as recognisability of coexisting possibilities of utilizing land due to cultural grounding, and also to preclude the instalment of green pastiche or generic green spaces that might satisfy current regulations, but are otherwise of no consequence and provide little opportunity for a broad range of actors. Such an approach would secure a meaningful correlation between cultural practices related to land and the transformation of land, also through constructions, such that local human actors do not feel alienated in their own setting by designs that are inaccessible to them.
Terrain is commonly levelled in preparation of construction. This is already assumed in the design process. The negative consequences of this entails removal of explicit landform, vegetation, ecosystems, and often profound disturbances of local water and soil regimes, as well as fundamental changes in local micro- and topo-climate. An alternative approach could be based on considering existing terrain as a resource, as can be seen in many vernacular architectures across the world, with the aim to maintain existing terrain or to transform it in such manner that key features are preserved and improved for the sake of climate, soil, water, and the broad range of species that depend on them.
Any transformation of the environment brings with it a change in local micro- and topo-climate. Accumulative changes can cascade upwards in scale with unforeseen consequences. Phenomena such as urban heat islands have alerted us to the fact that the effect of micro-climatic modifications can transcend critical limits in which changes are triggered that are wholesomely disadvantageous for human and nonhuman actors. For this reason, all aspects that modify micro-climate and are in turn modified by micro-climate must be in the forefront of design considerations,

given their impact on ecosystems, and human living conditions and wellbeing. As such this is at the heart of the proposed new mandate of architecture and relates to the topic of urban climate mitigation. What is at stake is not to exhaust design efforts in counter measures to existing problems, but rather to foresee such problems and to design differently from the onset.

Invigorating existing ecosystems or reimplementing eco-systems in the human dominated environment, as well as introducing agroecology into dense urban settlements can serve a variety of sustainability goals ranging from climate action to life on land preservation, cleaner water, good health and wellbeing, to quality food production, etc. In other words, compound sustainability problems can be addressed by the guiding design principles listed above in conjunction with granting equal priority to ecosystems, agroecology and construction in urban environments. This is currently not exactly the case as greening of cities and urban farming are frequently a question of left-over surfaces and areas in the densely built environment. Furthermore, this approach can be extended to the question as to how constructions can provide conditions for different species of local ecosystems and how close-range coexistence of humans and different species can be addressed and negotiated through design.

In order to address the relation between construction and ecosystem or agroecology support we pursue the development of what we term *ecological prototypes*, which are next generation green constructions and practices that can be adapted for sustainable urban and agricultural intensification and restoration of degraded land to enhance local ecosystems and the delivery of services. This implies correlating four principal ecological targets that match some of the sustainable development goals in relation to the above: (1) architectural intensification, (2) agricultural intensification, (3) sustainable resource use, and (4) ecosystem support. Prototypes are the data points or model designs, constructions and practices that have enabled or have the potential for balancing these functions in various ways. We identify four general types in the related design space, classified as green houses, green buildings, agricultural heritage systems and *next generation ecological prototypes*. Extensive case studies show how the first three types have been shaped. In the next step we propose methods for clustering, and selection and analysis of existing prototypes, which serve to analyse and instrumentalise the study of trade-offs that have been central to this development , as well as help to define changing motivations and directions that will determine the traits of n*ext generation ecological prototypes*. For this purpose, we are currently analysing historical case studies that accomplished such integration in one way or another. This includes for instance the *limonaie* at Lake Garda that often integrate dense settlement clusters with adaptable spaces for growing lemon trees, or the fruit walls in Montreuil-sous-Bois to grow peaches at a quasi-urban scale. Such projects show how agricultural intensification in densely build areas can work and what role micro-climatic modulation plays in these settings.

Besides analysing and rethinking historical precedents for contemporary use we also undertake design projects as a way of thinking forward *en route* to embedded architectures. In order to assess and develop our approach we frequently undertake pro bono projects in practice that we initiate without an initial client, in order not to curtail our approach through prevailing preconceptions as to what is possible or not. These works are often linked with dedicated research projects in our academic contexts. One recent project of this kind was a study for densification in Nessoden, a municipality on a peninsular in the Oslo Fjord, a short ferry ride away from Oslo's city centre. As Oslo is gearing up to massively increase its population nearby municipalities will be forced to densify. Nessoden is a typical case of lower density and mostly single-family housing, agriculture and nature reserve with most of the terrain still intact. However, as new projects are built terrain is flattened to make way for construction of infrastructure and buildings. The flattening of terrain necessitates the removal of vegetation and the exposure of the thin substrate to erosion due to increasing precipitation levels. Our project started by analysing the terrain in various ways in order to see whether there exist latent circulation paths in the already existing terrain, i.e. by way of continuous height-lines that only require fill-ins instead of wholesale remodelling of the terrain. We catalogue a large number of building types that were designed for specific terrain situations, i.e. slopes with particular orientation. In a second step we developed computational methods to (1) match selected types with terrain situations and in such a way as to maintain as much existing vegetation as possible, (2) to analyse various criteria, i.e. daylight and sunlight exposure, to orient the types or to adapt their layout, and (3) to calculate and rank the resulting density in relation to the necessary total amount of terrain, soil and water regime modification, as well as vegetation loss.

What is key in this project from a larger perspective and from the perspective of the design guidelines is the fact that most projects touch the ground only where absolute necessary. No basements are provided so as not to disturb the ground and most buildings have a small on-ground footprint. The ground is maintained as natural as possible and stays in collective ownership. It therefore can maintain its status in relation to the Scandinavian Everyman's Right in its contemporary version the Norwegian Outdoor Recreation Act (1957). Moreover, the area can maintain numerous characteristics of a nature reserve area. Equipping each type with the possibility to grow food stocks, either by converting part of the building into greenhouses or by implementing lessons learned from the ecological prototypes research in relation to the building envelope or the roof gardens, helps further with maintaining terrain and ground largely as is. Unavoidably some damage will be done during the construction process, which will have to be organized around minimizing in situ construction and by utilizing prefabrication.

Such suburban and rural area projects can subsequently be rethought as urban configurations in which no longer existing natural terrain is replaced by constructed terrain that engenders the close-range co-existence of construction, ecosystems and agroecology. We are currently undertaking studies in this direction. We anticipate that the results will show how supporting and invigorating urban ecosystems, constructed landscapes, soil and water regime considerations and protection and agroecological systems integration can perhaps be some of the most powerful measures in urban climate mitigation.

At any rate much more work is required to gain valuable insights. However, we are working ceaselessly in practice, research and research-integrated teaching on these questions and we are building an expending international collaborative network to set into motion locally specific experiments and projects that take on board the above.

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Adapt_ability
The Leaf Plane Project

Mosé Ricci

Abstract
What is the destiny of architecture (as the complex of the design disciplines) in the revolution of sharing information technolgies? In an age that seems to consider at least with absolute priority the development of the Net and of the connecting devices? If today -and in the future more and more- the focus of cities development is no longer the growth but the resilience and environmental quality? When not the new constructions, but the efficiency and re-signification of existing ones become the central issue of building sector? Is it possible to think about a new statute for the architecture of the present time?

Investigating the opportunities of the city and landscape architecture project in the context of major environmental changes is for us an obligatory and innovative choice even if the issues of major environmental changes have seemed hitherto unrelated or complementary to the disciplines of the project. It is a research to be done because architecture or proves to be a resilient discipline - even when school enrollments decrease in most of the western world and especially in Italy - and finds a decisive, sustainable and convenient role in improving the conditions of the contemporary living or will not be able to stop its decline in the presumption of the superfluous.

Global warming, low CO2 emissions, the cost of oil, renewable energies, great social migrations, the explosion of the city, the fragility of large concentrations in the face of natural events that turn into catastrophes, the defense of

contexts premises hired as bulwarks of identity. The culture of architectural and urban planning cannot remain insensitive. It is an epochal transformation that starts from the bottom. It proceeds through quality of life goals, autopoietic practices and survival strategies.

The research approach of the consulting group of the University of Trento is not just an urban retrofitting action, but the activation of regenerative processes that involve the environmental performance of the city. The Plan tends towards the composition of an ecological mosaic, of a projective and visionary collage of shared landscape and urban quality: the Leaf Plan. Trento like a leaf. A Plan that defines the new shape of the city to a landscape dimension, which brings together the urban and the rural in a single metabolic icon representative of the new quality of Trento habitat.

Keywords
Adaptability, Leaf Plan, Performing Landscape, Ecological Urbanism

Formgiving the exhibition of the work of BIG (the Bjarke Ingels Group) at the Danish Architecture Center in Copenhagen from June 2019 to January 2020 begins with a film on the rise of the oceans' level due to the effects of global warming. The one of Rehm Koolhaas and AMO's research at the Guggenheim in New York from February to August 2020 (the first of an architect in the Wright museum) is titled Countryside the Future and is all centered on the exploration of the most urgent environmental, political and socio-economic issues through the researches by students from Harvard, Beijing, Wageningen and Nairobi. As also Koolhaas states in the launch clip, exhibitions like these would have been unthinkable just a few years ago. Perhaps for once it was Italy that inaugurated a season of a new socio-political commitment for the design disciplines with the exhibition Re-Cycle. Strategies for Architecture, the City and the Planet at MAXXI in Rome in 2011. Without a doubt, these exhibitions mark the decline of the metropolitan modernist horizon and the triumph of the landscape (rural, urban, but above all ecologically performing), as *topos* of the quality of the life.

The simultaneous action of three key factors: the economic crisis, the new environmental awareness and the sharing information technologies revolution is so deeply changing our lifestyles and the way we imagine and we want the solid forms of our future that all our design knowledge suddenly seems inadequate both as an interpretative tool of the current condition and as a device capable of generating new environmental, social, economic performances and new beauty for the living spaces.

What is the destiny of architecture (as the complex of the design disciplines) in the revolution of sharing information technolgies? In an age that seems to consider at least with absolute priority the development of the *Net* and of the connecting devices?

What is the destiny of architecture (as the complex of the design disciplines) in the revolution of sharing information technologies? In an age that seems to consider at least with absolute priority the development of the Net and of the connecting devices?

If today -and in the future more and more- the focus of cities development is no longer the growth but the resilience and environmental quality? When not the new constructions, but the efficiency and re-signification of existing ones become the central issue of building sector? Is it possible to think about a new statute for the architecture of the present time?

Nothing surprising. In the history of architecture and the city the great technological changes have always produced major changes in the styles and in the forms of living and consequently in the way in which is conceived any design action. One of the main principles of modernity was to consider architecture as the best possible spatial synthesis between form and function. Today, with the information technology revolution, we have the opposite problem. Namely to give meaning, narrative and uses -even temporary uses- to residual and abandoned spaces that have already given forms. And turn them into attractive and ecologically efficient living places.

Investigating the opportunities of the city and landscape architecture project in the context of major environmental changes is for us an obligatory and innovative choice even if the issues of major environmental changes have seemed hitherto unrelated or complementary to the disciplines of the project. It is a research to be done because architecture or proves to be a resilient discipline - even when school enrollments decrease in most of the western world and especially in Italy - and finds a decisive, sustainable and convenient role in improving the conditions of the contemporary living or will not be able to stop its decline in the presumption of the superfluous.

This phase of modernity disposal demands new paradigms (such as new points of view on the future) and a new project idea of physical space. It is a major challenge for the architectural culture. A challenge that puts the existing value with conceptual devices that work on the slip way and new life cycles of living spaces. A challenge that considers the environment as a project and the landscape as infrastructure that produces ecological value and the future of the city as a collective project and not authorial.

Society has for obvious reasons always been interested in the quality of the forms of living, but this is increasingly identified in the environmental, economic and social sustainability of the interventions. Aesthetic values remain fundamental, but they are rapidly changing. Innovation in architecture today seems to move on the definition of a new theoretical / practical context of conceptual reference for the interventions and on the affirmation of three main non-oppositional quality objectives, which indeed are almost always integrated: the project as narrative, the project as a social action, the project as a performance and not as a sign. These are three points of view on architecture as an expression of beauty in the city of our time: narration, social action and performance, which refer to the landscape as the new context of intervention.

The paradigm of the project as narrative expresses the need to give sense to the existing, to discover with new eyes

what's already there. Rem Koolhaas declines it superbly in the project for the Prada Foundation in Milan, as it covers the old industrial building with a golden patina. Narrative architecture, as written by Giancarlo De Carlo is able to listen, to accept, to annex what are the tensions of the city and its inhabitants. An architecture that has to become process, breaking up the consolidated view of the building as *unicum* perfect and complete (Marini, 2013).
But also, in the strict etymological sense the narrative reveals different meanings, tells us the story of the building and its inhabitants through material signs. Sometimes it is the citizens themselves, or artists to write their stories on artifacts such as Dan Pitera with the Detroit Collaborative Design Center or Francesco Giorgino, alias Millo, with murals of Turin. More often it is the same architectural ratio of intervention to clarify the meaning of the narrative tension, evocative as in the Hannah Arendt School of Claudio Lucchini in Bolzano or anti-rhetoric and pop as in the Ski Slope on top of the incenerator by Big in Copenhagen.
The project as social action is the focus point of many contemporary works for (even temporary) inhabiting spaces and systems for collective mobility. As it was said before is one of the key themes of the 2016 Biennale. Always Aravena writes: "*We would like to learn from architectures That despite the scarcity of means to intensify what is available instead of complaining about what is missing. We would like to understand what design tools are needed to subvert the forces That privilege the individual gain over the collective benefits, reducing We to just me. We would like to know about cases That resist reductionism and oversimplification and do not give up architecture's mission to penetrate the mystery of the human condition. We are interested in how architecture can introduce a Broader notion of gain: added as design value instead of an extra cost or architecture as a shortcut towards equality*".
The project as a social action concerns obviously buildings as neighborhoods, public spaces and infrastructure. It achieves the objective of emancipation and often through shared action design processes. Often in this type of projects the traditional concept of authorship is questioned by sharing the creative process and the implementation process is

self-managed *hic et nunc*.
It exceeds the long bureaucratic processes of public approvals. Among others interesting experiences, the works of Alfredo Brillembourg with Urban Think Tank, of Grávalos and Di Monte (Esto no es un Solar) and of Boamistura in Brazilian favelas, as well as the Italian *Guerrilla Gardens* are paradigmatic in this field.
The project as a performance and not as a sign is the technological paradigm declined as a conceptual principle of operational aesthetic. The architecture of performance versus the architecture of sign means put at the center of architectural changings not the use but the appreciable innovative results in ecological terms mainly, but not only. It is the contemporary evolution of *Advanced Architecture* by Manuel Gausa (2001), It is a matter which is being developed at the urban level -from policies for the smart city in Barcelona to Copenhagen biocity- as at the architectural scale (think LEED protocols or ClimateHouse), at the industrial design scale, or at the scale of the process design as Carlo Ratti does with his SENSEable design lab at MIT. "W*e are facing a change in the field of Architecture, to move towards a different form of "habitats", where architecture is not merely inhabited, but becomes interactive and evolutional; to technologically integrated interface*," says Areti Marcopoulou, academic director of the IaaC (Institute for advanced architecture of Catalonia), one of the most quoted international schools of architecture that functions as a laboratory of continuous technological innovation. The performance paradigm projects the design discipline in the contemporary age using it as an interaction device of a system of physical or intangible relationships that substantiate the same existence of architecture. It is at the same time the re-contextualization of the idea of designing within a new and not necessarily material space of intervention and the return to the idea of the project as a cure for the existing.
The result of this process of shifting from the aesthetics of the sign to that of the sense gives beauty to a new form of city-landscape where the buildings and the city are in harmony with the environment and describe a new settlement context. Where nature is the main connection infrastructu-

re between people and the quality of life, and the city can become the sensitive form of living into the present time.
The research approach of the consulting group of the University of Trento for the revision of the Master Plan -developed with Marco Tubino, Sara Favargiotti, Davide Geneletti, Silvia Mannocci, Francesca Marzetti, Matteo Aimini and with Giuliano Stelzer coordinator of the group of design of the Municipality of Trento- is based on these premises . It is an experimental work that investigates the possibilities of innovation of the general urban planning tools according to the fact that the object of the intervention is no more the urban expansion of Trento, but the existing city which does not want and no longer has to increase its urban footprint, with a huge amount of empty volumes and a substantially stable and not augmenting resident population. The intervention themes underlying the revision of the PRG are those of the quality of life, of the ecological and social function of open spaces in the city, of the mitigation and adaptation to climate change, of social inclusion, sustainability of development, abandonment-built spaces. Issues that in short have to do not so much with the uses and with zoning maps as with the environmental and social performance of the already existing built or open spaces. Even if it is not just an urban retrofitting action, but the activation of regenerative processes that involve the environmental performance of the city in relation to the quality of social life and the development of the sense of belonging of the resident populations and the attractive capacities of the city of Trento for the economies generated by students, workers and tourists.
The university group's proposal is based on a conception of the new visionary and metabolic planning instrument. It is the project of a Plan that works by challenges and not by objectives. There are no goals to be reached in a specific time but challenges to be continuously faced. The new tool is used to immediately accompany the change of the city with regeneration actions, also from below, aimed at continuously developing strategies and tactics of adaptation or contrast to the environmental, social and economic emergencies of the present time.
The Plan tends towards the composition of an ecological mosaic, of a projective and visionary collage of shared land-

scape and urban quality: the Leaf Plan. Trento like a leaf. A Plan that defines the new shape of the city to a landscape dimension, which brings together the urban and the rural in a single metabolic icon representative of the new quality of Trento habitat.

In the leaves the ribs are the conducting vessels, the channels that bring the life. The water and mineral substances that come from the roots reach the leaves through these channels, are processed in sap and brought back to the ground by the same ways. In Trento the ribs of a city are the lines, the concretions and the social relationships traced by its open spaces. It is the green and blue infrastructures that organize the system of public spaces and social life. The ribs describe a system of existing and magnetic spaces that continually tends to grow stronger. Their position represents the landscape / environmental corridors that descend from the mountain, the trace of the ancient ditches now underground, the tree-lined avenues, the main lines of urban crossing, such as waiting spaces, unresolved and abandoned places. The green rib system catalyzes public education, sports and recreational facilities, spaces for universities, places in the historic city and tends to attract spaces for new landscape and environmental compensations. Identifies the channels of the continuous aggregation of the landscape / environmental qualities of the city and the favorite places of social life. This is the structural vision of the framework of research actions in scientific support of the 2016-2020 General Revision under the Trento Plan.

Global warming, low CO_2 emissions, the cost of oil, renewable energies, great social migrations, the explosion of the city, the fragility of large concentrations in the face of natural events that turn into catastrophes, the defense of contexts premises hired as bulwarks of identity. The culture of architectural and urban planning cannot remain insensitive. It is an epochal transformation that starts from the bottom. It proceeds through quality of life goals, autopoietic practices and survival strategies. The protagonists are citizens, consumers and savers, who feed on the products of organic agriculture and make separate collection; prefer public transportation or bicycle; are attracted to low-emission cars; they appreciate bioclimatic houses and not buildings with high energy consumption; they want sustainable and landscape-sensitive public works.

In line with the themes outlined by the European Urban Agenda (Environment, Society, Demography, Mobility, Economy), the plan proposes some challenges for the future and development of Trento which intercept the main problems and potential of the city: the activation and regeneration of marginal areas, soil consumption, the role of agriculture (for communities, for the microclimate, for productivity and excellence), management of water use, landscape, environmental, social aspects, biodiversity , urban climate change (microclimate and urban heat island). These challenges materialize in the transformation of the physical space of the city and can be implemented through various action policies that form the foundation of the new PRG. These are also the premises on which the Strategic Document was drawn up which identifies five challenges for the city of Trento divided into 18 objectives and 68 strategies, in turn referring to the goals proposed by the 2016 European Urban Agenda:

1 - ECO TRENTO for a sustainable city, founded on a network of green areas, on the vitality of agricultural areas, natural and semi-natural areas that must aim at adapting to climate change. Urban sustainability is identified in the balance between the city and its surroundings and concerns traffic, water management, waste management, land use planning, urban and peri-urban green management. The system of green areas contrasts in a functional and ecological sense with the tangle of infrastructures and anthropic elements that characterizes the urban mosaic. The green in the city, also through the formation of corridors, tries to restore balance and ecological functionality essential for the quality of our life. To these prerogatives are added unexpected qualities, new functions related to the absorption of dust and heavy metals produced by means of transport and heating systems, the containment of thermal imbalances and rainwater losses and new possibilities for economic development related to the use of renewable energy sources. Trento must therefore aim at the energy transition, the good use of natural resources, to support the closure of resource cycles, mitigation and adaptation to climate.

2 - WELCOMING TRENTO for the provision of spaces and places that allow the meeting, the integration of people, the quality of life in the neighborhoods and suburbs, as well as the reception of visitors and tourists.
3 - ACCESSIBLE TRENTO to guarantee good supralocal connections by enhancing the places of railway mobility, limiting traffic flows and encouraging sustainable mobility.
4 - SMART TRENTO to qualify as a competitive and innovative city, which integrates the places of training and research with production activities.
5 - BELLA TRENTO to capture the beauty of urban spaces and the landscape as a common good and resource on which to base the well-being and attractiveness of the community.
The new Master Plan revision offers an answer to the new question of design competence at the various scales in the field of ecological design, the themes of landscape, environmental and construction sustainability, mitigation, climate change, resilience, collaborating for the definition of a figure of designer and manager capable of combining skills of architecture, territory, environment and contemporary technologies. It offers an offer tailored to the new needs of society in compliance with the local alpine context and the guidelines of the European programs. The preliminary actions of the plan focus on the management of the ecological and sustainable project, the reading and understanding of complex contemporary landscapes, natural and man-made ecosystems, together with the tools to analyze it in economic terms. In particular, there are three actions that guide the debate on the future of Trento. The Plan as a „urban narrative“ expresses the need to give meaning to the existing city through the project, it makes possible to discover what is already there with new eyes. It reflects a concept of urban planning capable of listening, welcoming and annexing the tensions of the city and its inhabitants. A narration that stages the meanings, rediscovers sensuality, reactivates the beauty of urban centers and the sense of belonging of its citizens. The Plan as a „shared urban action“ interprets the spirit of the time that leads us to overcome traditional participatory processes, taking directly part in the planning and design phases of the urban planning tool.

Conceiving planning as an open source system achieves a goal of social emancipation and increases the contribution of competence. This idea subtracts the Plan from authorship, by sharing the creative process and its implementation phase. Ideas and actions become common good by involving the technical skills present in the area and the experiences of those who live in the city. The Plan as „performance“, is the idea of scientific and technological innovation that meets urban aesthetics. The performance planning opposite to that of the functions puts at the center of the transformations not the uses but the predictable innovative results in ecological terms. Not only that, it makes the territory welcoming for the sustainable development of urban life. The mitigation of major climate changes, the relational quality of public spaces, the issues of energy and the waste cycle, mobility, knowledge as a growth engine, territory as a smart grid of ecological, landscape and social values. All of this is and must be measurable in the effects of the forecasts of a Plan which however remains a promise of happiness. A tool that promotes a new quality of life vision based on shared and continuously verifiable objectives.

Adaptive Design and Green Building Approach for the City of the Future

Fabrizio Tucci

Abstract

Several analyses and reports in the world of Sustainable Design are pointing in the direction of what is known as a 'Green Building Approach': an integrated, multi-sectorial approach to the implementation of improvements that aim to increase levels of well-being, social inclusion and longlasting development in cities, based on the now decisive aspects of the high environmental quality, efficiency and circularity of resources and on climate change mitigation and adaptation. A complete and up-to-date definition of this approach was drafted in 2017 on the basis of the methodology developed by the International Council for Local Environmental Initiatives, which was adopted by the European Bank for Reconstruction and Development.

In Italy, this new approach has been supported by significant contributions. In early 2017, the "*La Città Futura*" Manifesto, presented by lecturers from a dozen universities in the world, was launched as part of the initiatives of the States General of the Green Economy in Architecture, and over the past year the development of this new approach has been boosted by the international Green City Network. For the strategic development of the research and design experimentations, a large part of the activities of the in 'Environmental Technological Design' and the Doctorate in 'Planning Design Technology of Architecture' of the Sapienza University of Rome have been dedicated in all these last years.

The basic aim was to launch a research debate - with a close confrontation with the international design experimentation scenario – and elaborate Guidelines for orienting the *Processes*, Strategies to substantiate the Methods, Tools to make achievable the Policy Actions, fostering future signi-

ficant results as regards 'green' growth and redevelopment.

Keywords
Green Economy, Green City Approach, Sustainable Architectures, Environmental Quality, 'Green' Growth and Redevelopment, Circularity of Resources

Issues

It was stated that cities are not only the backbone of national economies; they are also the place where resource availability for future generations, as well as justice and equity, will be decided. Following the growing relevance of such topics, contemporary urban environmental conditions have become a determining attractive and distinctive factor of overall quality: an aspect towards which cities with the ambition of becoming the most advanced worldwide are diligently investing.

There are no doubts cities play a decisive role both in the unsustainable aspects of current development and in the changes dictated by the transition to a green economy. On a European level – according to the *Eurostat Urban Audit 2017*- the economic activity of Ue28 is mainly concentrated in urban regions, which represent the engines of the economy: 59% of the world population lives in urban areas, where 62% of the jobs and 67% of the GDP is concentrated. In 2016 the Dual Citizen di Washington research centre carried an international survey on 50 major cities, employing a *Global Green Economy Index* based on four parameters (air quality, water availability and treatment, biodiversity, and vegetation), attraction of green initiatives (web visibility of the green initiatives, green business opportunities, initiatives to favour green interventions, environmental data accessibility), sector efficiency (energy certified buildings, renewable energy share, sustainable tourism initiatives, transport emissions, waste recycling percentage), climate change and leadership (greenhouse gasses' reduction progress, media coverage on green thematic, participation to international forums on climate issues, CO2 emissions per capita, per GDP unit, and per primary energy consumed).

The research was published in Italy by the *Relazione sullo stato della Green Economy 2016* by the Sustainable development Foundation: it places Copenhagen, Stockholm, Oslo, and Helsinki in the first four places, but also New York at the sixth, Berlin at the seventh, Paris at the ninth, Tokyo at the tenth and London at the eleventh. Unfortunately, Rome is at the end of the list, and it occupies the forty-fifth place (SUSDEF, 2016).

Processes of a Green City Approach

Also browsing through the sectors of the green economy we realize that on the one hand they have a key role in determining the quality of contemporary cities, and on the other, that they grow towards a green direction if the city offers a suitable ground. The relationship of key sectors related to green economy transition and city is relevant and obvious when it comes to energy, dwellings, transport, waste, and tourism. However, in order to better understand how the city can offer fertile ground for a Green Economy and an Adaptive Design to develop, it's not enough to examine the key sectors, we need to consider a reference model capable of proposing, guiding, and qualifying solutions to ecological problems in contemporary cities, in an unitary and integrated fashion.

This model, which is advancing on a European and International level, is called "green city": an integrated and multisector approach to cities, based on key aspects of environmental quality, resource efficiency and circularity, mitigation and adaptation to climate change. The green city approach has been recently wisely defined by ERBD (The European Bank for reconstruction and development) based on the OECD-ICLEI (International Council for Local Environmental Initiatives) methodology in 2017 (OECD, 2017). Such model was also adopted as a basis for a green economy development program in cities with the *Economics of Green Cities Programme* by LSE Cities (London School of Economics), led by Nicholas Stern. The integrated approach towards green city had already been adopted, in 2010, by the European Commission for the *European Green Capital Award*: an award which, by promoting the green city model, aims at supporting the advanced and sustainable development of European cities.

The relationship between the green economy, the green city

and an adaptive design for the urban systems was the focus of the contribution of the Italian PRIN Research (Project of Relevant National Interest) "Adaptive Design and Technological Innovations for the Resilient Regeneration of Urban Districts in System of Climate Change" (original title: "Adaptive design e innovazioni tecnologiche per la rigenerazione resiliente dei distretti urbani in regime di cambiamento climatico") funded by the Italian Ministry of Scientific Research , developed these themes for three years (2016-2019).
Furthermore, in coordination with PRIN research developments, in Italy there have been important developments that led to the elaboration and presentation of the '*Future city*' Manifesto, proposed by a group of faculty coming from twenty Italian and foreign universities in 2017, in the framework of the *States General of the Green Economy* initiatives (Antonini & Tucci, 2017). On the one hand, Italian cities bare great potential, as we can also observe in a review of the key sectors, on the other, except for a few excellent exceptions, they lag behind and have a hard time positioning themselves next to the leading group composed by the most advanced European and world cities.
The extraordinary cultural, historical, and architectural patrimony composed by cities and small towns in Italy, which had great importance in the rich history that characterizes this country, remains an important reference value also for the future and an ever important base, but not enough for the relaunch of contemporary cities. As a matter of fact, these cities and towns are not keeping up the pace on the road heading towards the transitioning to a green economy, with cities far ahead and others left behind.
In the 2017 Report on the state of green economy in Italy, the Sustainable Development Foundation presented a focus on city green economy, carrying an analysis on some of the most significant trends in the *capoluoghi di provincia* (administrative centres of the Italian provinces), strategically relevant for the development of green economy: commitment towards climate and renewable energy sources, the management of water resources, sustainable mobility, and public administration's 'green' purchases.
The emerged framework is characterized by moments of

light, with some excellent initiatives, and others characterized by shadows and delays. Adopting the integrated approach of the green city, which tackled different aspects and problems jointly, and enhancing possible synergies, and in order to come up with a general framework of Italian cities' current state, we propose the evaluation of some particularly important topics: urban regeneration, building, and urban upgrading, air quality, and circular economy.

Territorial planning and urban management in Italian cities obtained scarce results because they favored, or allowed, decades of real estate expansion with low-quality dwellings, particularly in the peripheral areas of cities and with high soil consumption. Even though we are witnessing a reduction in the last years, in Italy soil consumption keeps increasing. Between November 2015 and May 2016, the new artificial roofs invested 50 km^2 of the territory, a little less than 30 hectares per day (ISPRA, 2018).

Moreover, the analysis of data concerning the 14 Metropolitan cities shows how the total amount of soil consumed in 2016 represents 21,4% of the national total, constituting a higher increment than the national average. High soil consumption, dispersal and sprawl phenomena recorded in most of the urbanized areas, have caused the erosion of agricultural land, extended the impermeabilization of soils, increased hydrogeologic risks, and required the employment of significant amounts of resources in terms of urban development works and increase in the time and cost of transportation.

Work in progress: Objectives, Methods

Heading towards urban renewal following a green city model requires an organic and integrated design aimed at guaranteeing different urban requirements, ensuring high ecologic quality and the effective annulment of soil consumption, by reusing and using efficiently the existing dwelling patrimony and the urbanized areas, and reorganizing soil use for settlement systems following compact and efficient models (Tucci, 2018).

As a matter of fact, today urban renewal projects require a more extended, effective, and fast approach towards the demolition of numerous unfinished and non-recoverable

constructions - illegal and degraded ones without historical or architectural value - which spoil cities and territories, and the restoration and recovery the areas they occupy. In urban and peri-urban systems' renewal, it is also important to improve the safeguard and availability of natural capital, particularly multifunctional green infrastructures and vegetation.
Architectural and urban renewal following the green city model aims at improving, recovering, and reusing the existing public and private patrimony, adopting an integrated approach through energy efficiency measures and measures aimed at improving the other ecological characteristics of the buildings. Moreover, considering the increased hydrogeologic risk and the great extent of the areas subject to high seismic risks, such operations ought to be verified and integrated into preventive measures aimed at reducing vulnerability.
City Urban renewal requires suitable attention towards public spaces, both in the central areas and in the peripheral ones, as they represent a determining factor of urban quality: piazzas, boulevards, streets, arcades, urban parks and gardens, pedestrian areas and bike paths, influence greatly the city's environmental quality and how the latter is perceived and experienced. In Italian cities, it is also important to consider the direction, criteria, and standards for the conservation of the existing historical patrimony, and the management, maintenance, and aesthetic and functional improvement of the built patrimony (Battisti & Tucci, 2017).
The safeguard and the enhancement of the urban and peri-urban natural capital – tree rows, gardens, parks and green areas, green walls and roofs, kitchen gardens and green bels – are of growing importance for the quality of cities ad they are contributing to the reduction of pollution, air quality, reduction of climate change damages and risks, and the safeguard of water and biodiversity.
The too often neglected natural capital essential components for the quality of the urban landscape, and cultural, recreational, sport activity services aimed at the wellbeing of citizens. The analysis of public green in the '*comuni capoluogo di provincia*' confirms its quite reduced size, with

values lower than 5% in 96 of the 119 analyzed comuni, and with an availability per person between 10 and 30 m2/person in half of these *comuni*, whereas only in ten cities the value is higher than 100 m^2/person. The trend between 2011 and 2016 shows a slight reduction in the availability of green public spaces per person in most of the *comuni capoluogo di provincia*.

Given the situation, it would be good to define pluriannual programs, coordinated through the existing urban management and planning tools, to increment and protect urban green, paying attention to its potential in terms of urban and peri-urban open space renewal, and aiming at the creation of ecological corridors and green belts, in a circular economy perspective (EEA, 2017).

Also climate adaptation measure ought to be integrated into the city's architectural, technological, and urban renewal, to reduce vulnerability and exposure to risks. It is a rather complex topic, neglected until recent times, but also in this sense it is now time to face it urgently, indissolubly integrating it with other types of interventions in the city.

Climate change causes dangerous heat waves, prolonged drought and high temperature periods, together with intense rain for short periods of time, and increase in flooding and landslide phenomena. It is now time to acquire full consciousness that such extreme atmospheric events can cause serious consequences on Italian cities, with risks for our health and great damage because, thanks to its geographical position and the characteristics of the territory, Italy is particularly exposed to such risks.

It is important to operate specific technical analyses in cities – related to local climate and territorial characteristics, but also demographic and socio-economical – to quantify the risks related to climate change, and paying special attention towards extreme atmospheric events. It is important to identify and program integrated strategies aimed at preventing and reducing the vulnerability to such phenomena and mitigating the seriousness of their consequences.

In order to face heat waves, we need to acquire evaluations on the adaptive capacity of the built environment, adopt the most effective technical and managerial solutions for buildings, outdoor spaces, and green infrastructures. In order

to reduce risks and vulnerability linked to extraordinarily intense rainfall, it's important to halt waterproofing and new soil consumption and increase urban area de-waterproofing operations, to use green infrastructures also for absorbing and filtering greater quantities of rainwater, to dedicate open spaces, such as piazzas and gardens, to the absorption and retention of greater quantities of rainwater, favouring the discharge of such water from cities to peri-urban humid areas; the latter can be converted into ecological reserves for welcoming biodiversity and recreational and sport activities (Battisti, 2014).
Even though technological improvements contributed to the reduction of emissions by some pollutants, the climate change underway is significantly contributing to the deteriorating condition of air quality, making the air we breathe in our cities a danger to our health. Rainfall is less frequent and draught periods are longer, the stagnating air phenomena are more frequent and last longer, the heat waves are more frequent and intense as are the recordings on high ozone levels.
Such considerations are permanently linked with the issue of atmospheric pollution and the threats brought forward by the worsening condition of the air quality. With more than 80.000 premature deaths caused by the exposure to atmospheric pollution in 2014, Italian cities pay the highest bill of all European countries for pollution.
Moreover, they are not in line with the objectives of the NEC (*National Emission Ceilings*) directive entered into force since the 31st of December 2016, for four of the five atmospheric pollutants considered. Italy is subject to a European violation procedure because it did not comply with the limits dictated by the air quality directive.
The percentage related to the *capoluoghi di provincia* with more than 35 days of limit excess for particulates (PM10) has improved, nevertheless, in 2016, it was still 33%. The situation is better in Central and Southern Italy, while in Northern Italy, the percentage of *capoluoghi* who have failed to respect the particulate limits in the last years remained unchanged and at a high level: 54% in 2016. Most probably the current trend will not allow respecting the current limits and the most urgent objectives set for 2020-2030.

If we were to apply the indications of the World health organization, which are more preventive for our health; we would have to record that even in cities that respect the European limits the air quality is not good. What emerges from the analysis of indicators for the evaluation of urban population exposure to atmosphere pollutants is, in fact, a critical condition: 82% of the population in the Italian comuni appears to be exposed to average annual levels greater than the reference value for the PM10 (20 $\mu g/m^3$), 79% to the PM2,5 (10 $\mu g/m^3$), and 32% to the NO_2. Air pollution in Italian cities, underestimated if not even neglected by public debate, is relevant and cause for concern. Good air quality in cities represents a decisive factor for health and wellbeing, in particular when it comes to children, elderly, and in general people that are more exposed and vulnerable.
Green cities have a crucial role for the activation of a circular economy process, which is key for a transition to a green economy, as they can stop the consumption of new soil and activate reuse and renewal operations in already built-up areas and existing building patrimony. Moreover, they play a key role for the promotion of waste production reduction, including food waste.
First of all we need to recover the delays and increase by 75% the separate urban waste collection, increasing and consolidating the demand for recycled materials, removing technical and cultural barriers, and applying public green purchases. Also promoting initiatives aimed at isolating and collecting construction and demolition waste material and recycling it locally to satisfy a market which is increasingly oriented towards renewal and recovery of the existing building patrimony can be relevant, but also fostering the integrated design of building components and systems to favour their future recyclability.
Green cities are important to build IT platforms that work together with industries so that by-products and waste coming out of the production process can be easily employed in other processes. They are important also to promote product reuse in preparation and repair centres and through networks for selling used goods, and to promote shared use of goods and services, activating different forms of sharing. Green cities promote the application of technologies based

on Information and Communication Technologies (ICT) for monitoring, collecting, and regulating information fluxes, and use and management modalities, tending towards the eco-innovation of strategic urban supply chains such as: public lighting, intelligent buildings, mobility, diffused generation, energy distribution and consumption, management of matter fluxes and waste recycling.

Adaptive Actions for an urban and architectural regeneration towards Green Cities

As regards the success of improvement work based on those objectives, processes and methods, the issue of urban and architectural regeneration is key, a category that can orient all the most efficient and effective actions designed to achieve a Green City model.

The strategic priority of urban regeneration, when inspired by a green city approach, is ecological quality, so as to ensure the sustainability and resilience of improvement programmes and projects at a time of climate change and dwindling natural resources.

Green city-inspired urban regeneration calls into question both its overly simplistic version – based on small actions that lack context, vision and the necessary ecological quality – and its general-generic version, which though based on wider economic, social, cultural, residential and infrastructural content is nevertheless inconsistent with, and fails to prioritise, urgent ecological challenges, and is therefore weak and qualitatively inadequate.

In contrast, the green city-inspired urban regeneration model focuses on making the various connected aspects of high ecological quality the real priorities on which improvement programmes and projects should be based, adopting an integrated and multi-sectorial approach.

This, combined with the awareness that we now have – thanks to confirmation amply provided by research and greater knowledge as well as the consolidated experience of the best practices put forward and verified in many cities – that social objectives (the quality of well-being, safety, cohesion and social inclusion) and economic development (reviving and relaunching local economic activities and job opportunities) are inextricably linked to, and dependent

on, ecological quality both in big cities and small towns: dependent on the liveability, appeal and the renovation and repair of degraded areas and buildings. Although we are forced to proceed by concentrating on separate parts, we need to work with an organic and consistent plan that aims to create high ecological quality.
To this end, we need to establish and update an overall town strategy and the guidelines for town planning, creating suitable occasions for participation and consultation, using the green city vision as our benchmark for urban regeneration projects and improvements, whilst establishing a list of recommendations in order to ensure the right level of ecological quality and make the most of possible combinations and synergies.
Land consumption reduces the availability of a resource that is scarce, essential and basically unrenewable. Cities that expand by consuming greenfield sites have a significant impact on their quality. High land consumption, which we find in most urbanised areas, has had a negative impact on the landscape, leading to the loss of natural areas and farmland, erosion and soil sealing, increasing hydrogeological risk.
Halting land consumption is not just an outcome: it is a central aim of urban regeneration plans and projects, as part of a framework of measures designed to strengthen land protection, reducing artificial land cover, efforts that are consistent with the European aim of reducing greenfield consumption to zero.
Today, urban regeneration is the strategic choice if we want to restore the appeal of our cities by efficiently using and reusing our existing built heritage and urbanised areas, thanks to the renovation of public and private buildings, improving urban quality, thus tackling such phenomena as decay, functional decline and urban chaos, redesigning marginal spaces without consuming greenfield sites and reducing artificial land cover.
Before embarking on regeneration projects, available urbanised areas and unused building stock should first be surveyed, such as derelict, abandoned and under-used areas: not just the usual former industrial estates but degraded urban fabric as well, unplanned fabric featuring a combi-

nation of random functions, former railway infrastructure and infrastructure of other kinds, former small business premises and craft workshops, as well as degraded, abandoned and unused buildings, unauthorised or unfinished constructions that can be renovated if they are of a suitable quality or demolished if not.
If we want to achieve zero land consumption, we need to tackle the growing demand for urban development with an innovative approach to urban regeneration, adopting an integrated strategy applied to various different sectorial policies, designed to meet various needs as well as heighten the ecological efficiency of the urban network, resulting in social and economic benefits.
Today's climate crisis is having a significant impact on cities, an impact that is increasing, and cities must play a leading role in adopting mitigation measures so as to lower greenhouse gas emissions. Urban regeneration work should include the energy upgrading of entire buildings, combining active and passive solutions thanks to the use of innovative materials and technologies. It also needs to promote the use of systems that can assess the energy and environmental performance of buildings, building complexes and networks, as well as outdoor spaces in the urban environment, based on indicators that allow us to highlight our priorities and the most effective solutions, restoring the role these systems once played as climate modulators.
We need to make the best passive technical solutions as widely available as possible so as to reduce energy requirements and improve living comfort: from natural ventilation and passive cooling systems to limiting solar radiation, from natural lighting to passive heating and the natural regulation of humidity. We need to reduce and manage energy demands using monitoring systems and intuitive interfaces for users; to promote forms of energy distribution and exchange between 'prosumers' using smart grids and by combining local resources, such as capturing the excess heat produced by manufacturing and tertiary activities in order to meet residential heating needs, or using dynamic modulation systems that change to suit different demands depending on the time of day, the season or even the time of year.

We need to analyse which renewable sources can be used locally and promote the best production technologies available, which can be integrated into buildings and cities in order to move towards a 'positive energy' model: active solar energy systems, mini and micro wind turbines, geothermal energy supply systems using either vertical or horizontal heat pumps, systems that run on biomass using suitable emissions-reducing technology or on biomethane produced from organic waste, fuel cell systems that can be used in urban areas, micro-cogeneration systems, trigeneration systems and the use of district heating networks, etc.
Integrated strategies designed to prevent and reduce the vulnerability of the built environment to extreme weather events must be identified and planned so as to improve resilience and mitigate their effects. Regeneration projects should draw on specific expertise regarding local climate characteristics in order to carry out technical analyses of the risk caused by climate change. They should stop soil sealing and increase the number of projects designed to reverse it. Nature-based adaptation solutions should be given pride of place both in urban regeneration plans and specific projects.

As regards problems caused by pluvial flooding, the increasing frequency of floods and, in general, the difficulty of managing water resources during emergencies, green and blue networks and infrastructure are extremely important both as microclimate moderators and when absorbing and retaining larger quantities of rainwater. For example, city squares or parks below road level can help accumulate rainwater during extreme weather events, and particularly intense rainwater can be channelled towards specially created areas, existing urban drainage networks should be monitored more closely and we should ensure that sewage systems – complete with spillway – remain isolated from the network of canals and rivers, even during intense rainfall.

Tools that can analyse and assess the ability to adapt to increasingly frequent heat waves and growing heat islands should be used. On the basis of such analyses and assessments, adaptive technical, administrative and design solutions should be included in urban regeneration and when renovating buildings and their outdoor spaces. We need to promote measures controlling the bioclimate of buildings, measures for shading and solar radiation control systems, measures encouraging natural ventilation and cooling and improving insulation using, among other things, innovative materials. It would also be useful to use and expand green infrastructure and improve cooling by employing, whenever possible, phreatic zones and surface water bodies.

If we aim to achieve high town planning quality when carrying out urban regeneration programmes, we have to protect and enhance the wealth of identity-forming and historical values, cultural manifestations, know how, works and products that are typical of the areas concerned. To this end, a systematic interpretation of the vast combination of relationships that form the urban and territorial metabolism of the areas involved in regeneration programmes is essential in order to identify, safeguard and improve their quality, adopting project proposals that take their cue from the value of identity and local cultural and natural capital, even when working on areas considered peripheral or in small towns.

When carrying out urban regeneration work, particular attention should be paid to redeveloping public spaces, both in central and peripheral areas, as they play a decisive role when creating urban quality: city squares, streets, porticoes, parks and gardens, playgrounds and pedestrian zones all have a significant effect on environmental and social quality.

As regards the problems associated with sustainable mobility in the areas included in regeneration programmes, the availability of pedestrian zones and/or zones that limit access to motorised vehicles, slow traffic zones, the availability of protected footpaths and cycle paths, public transport services and mobility sharing, not to mention infrastructure for recharging electric vehicles, are all essential.

The proper attention should also be paid to measures designed to reorganise areas of urban sprawl and 'hybridised' single-function areas with the creation of complementary and compatible uses, including spaces for collective use, in keeping with the principle of *mixitè*, at the same time ensuring that land permeability is maintained and increased, that ecosystem functions are restored and green infra-

structure developed.
When implementing urban regeneration programmes, social housing projects should not only meet the demand for homes: they should also guarantee residential well-being and social integration, supporting the development of resident communities by, among other things, designing shared and open collective spaces.
Urban regeneration requires the implementation of projects designed to redevelop and enhance existing urban heritage, both historic, consolidated building stock as well as new buildings, which combine increased environmental performance with the improvement of design and architectural quality and benefits for the community, and that can ensure the creation of buildings that are pleasant to live in and inspire a heightened sense of belonging. Such projects should be designed to suit the urban environment, particularly encouraging the integration of buildings with the open spaces near them, adopting a unified architectural approach. To this end, it is worth identifying guidelines, criteria, best practices, indicators and standards when drafting projects and assessments of the architectural, urban and environmental quality of urban regeneration programmes, whilst updating and improving existing ones. Such preparatory work should concern both conservation and enhancement work carried out on historic buildings, both when renovating architectural heritage and when embarking on new projects that nevertheless aim for zero land consumption (densification, substitution, etc.), as well as the maintenance and the aesthetic and functional improvement of existing building stock.
When implementing urban regeneration programmes, we should also encourage the use of construction materials and components that boast a high ecological quality during their entire life cycle, products that can be reused or recycled.
When carrying out renovation, restoration, reuse or maintenance work on existing public and private building stock, we should not only increase comfort, we should also improve energy efficiency, the efficient use of water and the proper ecological management of waste; keeping in mind the increased hydrogeological risk and the widespread areas

at seismic risk, such improvements should be verified and combined, whenever necessary, with measures designed to reduce vulnerability and prevent such risks.
In urban regeneration programmes, urban and peri-urban greenery, and particularly the development of green infrastructure, carries out an essential role. Everything from tree-lined avenues to vertical gardens and roof gardens, from public and private gardens to allotments, from parks to green belts significantly contributes to improving air quality and reducing pollution, mitigating and adapting to climate change, safeguarding water, managing surface water run-off and protecting the biodiversity of the urban environment.
We should support and promote nature-based solutions by focusing on green infrastructure, which can carry out a number of functions and ecosystem services. Such solutions also provide facilities for cultural activities, recreation, sport and support the well-being and health of residents.
The development of green infrastructure as part of urban regeneration programmes not only requires the active contribution of public authorities: it should also involve the private sector (businesses, shops or even private citizens) that, as is already happening in some cities, can fund both the construction and the maintenance of urban greenery, both public and private (trees, hedges, gardens, balconies, vertical gardens and roof gardens on homes, shops and tertiary premises).

Conclusions

Public policies have a key role in the path towards green cities, through direct involvement of administrations on all levels: municipal, regional, and national. We can state that such path demands equally great attention to the use of available European funds and national and regional public funds, employable, in their totality or in part, to implement measures for green cities.
A green city project ought to be supported by suitable information tools, so as to be known and shared by citizens. We need to foresee punctual and recurring information and documentation tools to monitor activities, objectives, and results. It is also good to foresee broad consultation

forms, which are nowadays possible thanks to digital technologies, aimed at stakeholders involved in projects and actions (Ronchi, 2018).
Also involving the private sector is quite useful, through agreements aimed at promoting the social responsibility of enterprises involved in the race towards the improvement of cities and territories, making their actions and contributes to the green city transparent. Enterprises ought to be also involved in the promotion of targeted investments, services, and other policy instruments, with the scope of improving cities' environmental performance efficiently and sustainably in terms of costs, and maximizing economic and social benefits.
The implications for green city local development are quite interesting: support of a more suitable local development, promotion and development of technologies, green innovations, and tools and strategies for the exploration, identification, and application of green business and governance models, supporting identification and diffusion of new opportunities for green investments (GIZ & ICLEI, 2012).
As highlighted by UNEP in the 2011 report Towards a green economy, the development of green cities can contribute to the improvement of social inclusion and the quality of well-being. The strengthening of public transportation systems, for instance, can reduce disparity by increasing access to the service and contribute at the same time to the reduction of traffic congestion in peripheral areas. Cleaner fuels for transportation and energy production can reduce local pollution, which usually damages the weaker part of the population. Traffic reduction and the improvement of conditions of pedestrians and cyclists can sustain social cohesion. In fact, evidence demonstrates how children who live close to green areas are more stress resistant, less inclined to have social disorders, and have a higher sense of personal value. Green areas stimulate social interaction and improve well-being.
According to UNEP, the transition of cities to a green economy can create new job opportunities. Also, the EU Green Week 2019 dedicated to green jobs, underlined the high potential of new and good job opportunities generated by a green economy.

The Guidelines/Strategies and primary Measures/Action Categories generated by a green economy and taken in the implementation of the international experimental initiatives would appear to provide incisive responses when it comes to making a practical, feasible change in the accepted approach to 'thinking', 'building' and 'inhabiting' architecture and the city, or what by now we refer to with a unified term of the Green City Approach. Because, as has been demonstrated, this is the true key to entering once and for all into a fully operative outlook from which to promote the Green Economy – and, therefore, the Circular Economy – as an economic model characterised by a search for ways in which to arrive at maximum levels of inclusion and social wellbeing, as well as the best possible ecological-environmental quality of Dwelling; and, to the extent it proves to be based on substance, a new conception of Building, in the ecosystemic, interrelated sense of the term, taking in the regeneration and upgrading of sites, the use of renewable energies, the reuse of raw materials, the augmentation of energy and bioclimatic efficiency, the development of forms of resilience, mitigation and adaptation to climate change, along with the optimisation of natural, culture and social capital, all grounded in the formulation of specific procedures for the planning and design of technologies, materials, products and systems designed to promote and favour truly circular flows for the use and management of resources, so as to limit impacts on our biotic system, and on the biosphere in general. The policies represented under the categories of recurring Measures/Actions that can be found in the two figures/tables are probably only some of those that a future rich in experimentation holds for us. Others may take shape following the activities of research and experimentation which are constantly moving ahead in Italy, as well as on the international scene.

The important thing, in any event, is that we have achieved a heightened awareness of the fact that the activities involved in the planning, design, implementation and management of the initiatives regarding the transformation of the architectonic and urban systems which are to be regenerated and upgraded, along with the activities involved in the preservation, safeguarding and optimisation of historic or well-consolidated resources of construction and dwelling call for precise 'green-oriented' perquisites to be met, and for strategic guidelines to be pursued, in addition to which a framework must be established that proves adaptable, flexible, always ready to be challenged and rendered obsolete by the ongoing evolution of experiences, though it must also be scientifically grounded, in addition to offering good practices, meaning measures and the actions that can represent, for a technologically and environmentally oriented approach to planning, a practical reference for proper conceptualisation and elaboration of the solutions to be tested and the results to be achieved.

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3. PRACTICES

Local Thermal Improvement of Urban Climate with Evaporative Technologies

Michele Zinzi & Letizia Martinelli

Abstract

Local and global climate changes are major causes for urban overheating and heat island, phenomena with severe impacts on several dimensions: from health to environment, from social relationship to urban vulnerability. Many studies and projects demonstrate benefits of mitigation and adaptation strategies and technologies to pursue architectural and environmental regeneration in urban spaces. Blue technologies, in particular, are emerging as a promising solution for mitigation and adaptation purposes, this paper explores a specific application: the use of evaporative systems, characterised by the use of the latent heat evaporation of the water to reduce the air temperature locally, thus improving thermal comfort and wellbeing conditions for the human beings. The technology has an interesting potential in many climatic conditions, and the practical application can be the starting point for re-design form and function of public spaces. Evaporative technologies are, in fact, used since decades in urban projects and contribute to re-design outdoor spaces, as documented by several case studies, here presented and discussed. Those cases, however, prove that the architectural needs often exceed the environmental performance, resulting in limited mitigation benefits; moreover, such impacts are scarcely monitored, so that in many cases no quantitative data are available. This is the major drive of the experimental case study carried out in Rome during summer 2018 and presented in this paper. A very basic and cheap evaporative system is installed, then instrumental and subjective monitoring actions are carried out. The results show that air temperature drop up to 5°C

can be achieved, as well as average drop above 3°C during the whole monitoring period. Also, the comfort perception is enhanced as demonstrated by the analysis of distributed and collected questionnaires.

Keywords
Urban Thermal Mitigation, Evaporative Cooling, Water Spray Misting, Case Study.

Introduction

The urban overheating is one of the major environmental concerns in cities and it is a combination of global and local climate change effects. The increase of air and surface temperatures of the planet during the last decade is a well-documented phenomenon, and the further increase of temperatures respect to pre-industrial values, as well as the associated risks and consequence are estimated by Intergovernmental Panel on Climate Change of United Nations, with several scenarios predicting different level of mean global temperature rise. The panel produced several report, the latest focus on 1.5°C temperature rise respect to pre-industrial level (Intergovernal Panel for Climate Change, 2019). Climate changes, on the other side, are emphasised at local scale by the Urban Heat Island phenomenon, defined as the increase of air temperatures in urban areas respect the surrounding countryside.

The phenomenon is documented and explained in its basic physical mechanism since the first decades of the 19th century, with the studies carried out by Howard for the city of London, UK (Howard, 1818). A huge literature is nowadays available documenting the existing of UHI in towns and cities at whatever latitude, exhaustive reviews can be found in (Hien, 2016; Deilami, Kamruzzaman & Liu, 2018; Santamouris, 2019). UHI is a complex phenomenon, time and space dependent. City centre neighbourhoods and densely built areas suffer more overheating than peripheral ones, the presence of large parks or water bodies may change the typical temperature rise profile. The size of the city, obviously, is another cause in shaping the intensity of the phenomenon. Concerning the time evolution of UHI, intensities above 10°C and up to 12°C were monitored in many cities

around the world and daytime and daily values between 2 and 6°C are well documented as well. It has to be noted that, according the specific characteristics of the site, the UHI peak might take place at night or during daytime.
Causes for urban heat island formation are related to anthropogenic actions, as the modification of the land surface with vegetation and natural soil replaced by construction surfaces, which are characterized by high solar absorption, high impermeability and favourable thermal properties for energy storage and heat release. Another cause for UHI is the waste heat from building and transport systems. Also, the urbane texture of the city, as well as the interaction between the latter and the natural boundary conditions (prevailing winds, access to solar irradiation, presence of water bodies) has an impact of the amplitude of the phenomenon.
The impacts are at several levels: energy and environmental related, social, health, and comfort. All these impacts affect the usability of urban spaces, often thermally deteriorated by overheating and extreme phenomena (heat waves, tropical nights, etc). Mitigating the urban thermal environment might, hence, provide multi-scale benefit, rehabilitating the social dimension of common areas with improved comfort conditions.
Several solutions exist to mitigate urban heat island and overheating based on high reflective materials, use of intensive and extensive greenery, urban shading systems and water-based solutions. To achieve meaningful mitigation effects, the above cited applications must be extensive and require strong investment in time and money. However higher benefits can be achieved by using the cooling effect of water evaporative technologies, in these cases the applications are concentrated in relatively small areas, providing improved thermal conditions within the application itself or in its vicinity.

Climate mitigation and adaptation strategies within urban design

Spatial planning is recognized as a central policy to integrate mitigation strategies in the built environment (Davoudi, 2009). In fact, within the vertical scale of Urban Canopy

Layer (UCL), approximately from the ground to the rooftops of buildings, the effect of urban design factors on microclimate becomes substantial (Oke, 2004): anthropogenic heat, urban surface covering, vegetation and urban geometry can modify short and long radiation fluxes, air movements and evapotranspiration. These factors, which trigger the different cooling rate of urban and rural areas leading to UHI, could provide designers, architects and planners with significant opportunities to create or remodel outdoor spaces and buildings that are resilient in the face of future climates (Carter et al., 2015).

Moreover, well designed outdoor spaces represents an essential part of cities' aesthetic and they accommodate several activities, planned or spontaneous, promoting the interaction of citizens and their feeling of identity and security (Gehl & Gemzøe, 1996; Knez, 2005). This fundamental social and cultural function is inextricably linked to urban microclimate, as human thermal comfort, defined by ASHRAE as the "condition of mind that expresses satisfaction with the thermal environment" (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1997), have a strong effect on people's behaviour and usage patterns in open spaces. Enhancing resilient climatic responsive outdoor spaces has thus the double integrated outcome of boosting cities adaptation to climate change and UHI and promoting the liveability of urban areas (Martinelli, Battisti & Matzarakis, 2015).

Basic functioning of water evaporative technologies

Within existing cities, mostly applied strategies of outdoor space cooling, such as greenery, shading devices, cool materials, require massive and high-costly urban renewal projects. A much less appraised cooling category is that water evaporative technologies, which display an attitude for proactive, local, effective urban microclimatic changes, open to continual adjustments. Water-based technologies exhibited the highest local impact, compared to an equal coverage of greenery, cool materials or solar shadings and especially in the close neighbourhood of the cool medium (Santamouris et al., 2017).

Evaporative cooling relies on the energy (latent heat) required for the phase transition of liquid water into vapour, by subtracting heat from a medium (generally air). The result of this process is a net decrease of the air temperature and an increase of vapour pressure. Its effectiveness largely depends on surface-area-to-volume ratio: the more water surface area is exposed, the more energy can be exchanged with water. Therefore, among water evaporative technologies, fine water spraying (mist), in place of surface watering or sprinkling, was found to exert the highest local impact (Santamouris et al., 2017). In fact, it guarantees total or almost total evaporation immediately after the injection, with minimum water usage and wetting risk at pedestrian level, also when vapour pressure is relatively high, thus enhancing its use in relatively humid countries, where other evaporative technologies are less apt. Moreover, sprayed mist expels dust and pollen, repels insects and attenuates solar radiation in the long wave ranges of near infrared (Ulpiani, 2019).

To be effective, an outdoor misting system should be adapted to climatic conditions, considering air temperature, air speed, vapour pressure and precipitation. Also the characteristics of the system are important: height of the nozzles from the ground, their relative distance, the different type and display of nozzles, which create different sizes of water droplets and thus different evaporation patterns.

Water evaporative technologies: examplary cases of urban integration

Historically, misting systems in open spaces design have customarily focused upon aesthetic and sculptural purposes, with symbolic, visual and auditory features, with the indirect advantage of cooling. Although primitive evaporative techniques were used in ancient times (in combination with convective and ventilation devices like windcatchers and Qanats in Iran) and porous water jars are still used in many hot areas in combination with *Mashrabiya* and other ventilation apertures to naturally cool down the interior of buildings, the use of evaporation to cool down outdoor spaces is very recent. One of the first known misting techniques with clear aims is the *Uchimizu* Japanese practice dating from the 17th century, which consisted in the sparkling of water in parks and along streets, not only for hygiene purposes, but also as a ritualistic and contemplative practice. In summer, it has the direct effect of cooling the immediate surroundings and reduce dust. From the nineteen century on, misting has been widely employed in public open space design and landscape design as a creative device to build the space, with stem occupying a central role in spatial formalization.

The growing interest in sustainable design for outdoor spaces and the importance of adaptation strategies to reduce overheating has lead to the combination of plastic design principles with the study cooling efficacy. An overview of a number of significant contemporary implementation of water evaporative techniques manifests the increasing use of misting as an integrated design solution, tackling aesthetic concept and thermal comfort simultaneously (Nunes, J. et al., 2013; Santos Nouri et al., 2018; Ulpiani, 2019).

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Pepsi Pavilion in Osaka Exposition of 1970 was one of the first outdoor space project to employ misting strategies for their dual character, even if aesthetic symbolic purposes were still paramount. It was a joint project of artist Japanese artist Fujiko Nakaya and engineers of the Experiments in Art and Technology group, who covered a white polyvinyl chloride building with a permanent thick layer of mist. The mist was generated by generated by 2.520 jet-spray nozzles, capable of spraying 40 tons of water per hour, increasing the humidity of the air surrounding the pavilion and cooling it.
In the Seville 1992 Exposition, the effect of water and mist for thermal comfort amelioration was widely used: large fountains and water basins were placed all around the exposition area along all the main paths and squares to increment climatic comfort, vertical water walls were used to increase the evaporation volume ratio, continuous blowing of moist air, micro water nozzles integrated in trees, structures, and the many green shading roofs. One of the main attraction of the exposition was the so called "bioclimatic sphere", a tubular sphere was placed in the middle of one of the most important boulevards of the exhibition rounded by fountains and water basins; however, its contribution to thermal comfort was negligible, as the diffusion of mist was not at all controlled. The best cooling effect was reached where evaporative strategies were coupled with other cooling strategies, such as correct sun exposure, shading elements and wind exposure, to enhance effectiveness. While the use of mist was generally favourable, it was argued that the use of large basins of still water would lead to stagnancy and resource wastage (Velazquez, R., Alvarez, S., Guerra, J., 1992).
Regarding the use of water evaporation usage in public space design, the2006 project Le Miroir d'Eau by Michel Corajoud, Pierre Ganger, and Jean-Max Llorca in Bordeaux is notably one of the most successful examples, with a primarily aesthetic and social function and a clear indirect

cooling effect in summer. The square, just in front of the historical Place de la Bourse and facing the Garonne river, is designed to be the emblematic centre of a comprehensive urban development strategy aiming at freeing the river banks from former industrial installations and developing urban open spaces and, parks and an effective public transport system. On a surface of 3.450 square metres, 900 nozzles embedded in the granite slabs of the pavement spray water from the floor in two ways: tall water gushes with limited evaporation or mist clouds with high evaporation rate and a significant cooling effect. In order to avoid algae and water wastage, the water that temporarily floods the square recedes back into the slabs after a few minutes, leaving the surface dry. Grooves were installed in-between the granite slabs, to allow the water to be recollected in a reservoir with a capacity of 800 cubic metres, from which water is pumped for each successive "flood"(L. et al., 2009).
The renovation of Place de la Republique in Paris in 2013 by TVK is based on the concept of an open scene with multiple urban uses. The new square creates a large-scale landscape and becomes an urban resource, available and adaptable for different uses. During the hot summer season, a fine sheet of water is released and incorporates the use of spraying systems upon a 1% slope over an area of 270 square meters and the monument basin in the centre of the new pedestrian esplanade is filled with water through small water spouts, to provide additional evaporative cooling and ensure acoustic comfort for the users by contribute a pleasant background noise. According to the architects, the utilization of mist has a fundamentally climatic purpose, yet it is designed to boost sociality, recreation and underline the symbolic function of the square. Other thermal comfort amelioration strategies, working together with mist, include the use of reflective tiles for the pavement to minimize solar absorption and of vegetation for shade, evapotranspiration and air quality optimization (Rafaël Magrou, 2015).
Ecosistema Urbano employed evaporative cooling in the Vallecas Ecoboulevard project, consisting of three "air trees", self-sustaining steel cylindrical structures dislocated along a boulevard, designed to mitigate the effects of rampant urban development with little concern for environ-

mental and social conditions by creating public space whilst also tempering Madrid hot summer conditions. Climbing plants and water spraying nozzles along the cylinder surface, oriented towards the circular public space beneath them, act as cooling devices. A crown of photovoltaic panels, wind sensors and atomizers, make it possible to regulate the flow and the pressure of the water flowing to the spraying nozzles constantly adapting it to the weather conditions. The protective design of the cylinder and the shade provided by greenery not only foster the sense of place of these protected "public rooms", but enhance the efficacy of evaporative cooling, allowing the cooled air to linger in the "inhabited" space and not being immediately dispersed (Aurora Fernández Per & Javier Arpa, 2008).
Some recent projects, still in the development phase, integrate the use of evaporative cooling techniques within a more general approach toward urban renovation, centred on adaptation and mitigation climatic strategies.
As part of the winning proposal of the "Re-Think-Athens" urban renovation competition to revitalize the city centre of Athens, the project of Omonia square by OKRA integrates ideas of thermal comfort amelioration with a pedestrian-orientated space design. Serving as a focal point of the square, a mist fountain act as an evaporative cooling device, particularly effective due to the low vapour pressure of Athens: during a microclimatic analysis field study, the ambient air temperature peaked at 39 °C, while vapour pressure remained at only 30%; with the aid of software projections, it was estimated that the evaporative system could aid lower surface temperatures down to 23 °C. However, to enhance the sustainability of the project in such a warm and dry climate, water retain systems, such as underground water storage and filtered rainwater should be used for both surface and greenery irrigation in periods of drought. As in other presented project, the thermal comfort amelioration strategy also integrated greenery such as grass, hedges, climbing plants, and trees, as part of a defined "heat mitigation toolbox" (Martin Knuijt, 2013).
Proap winning project to re-develop the Khan Antoun Bey Square in Beirut proposed a misting system, in combination with vegetation, canopies and materiality, to improve

outdoor thermal comfort during hot-humid summers. The project was an occasion for a deeper research into the effectiveness of temperature control systems in outdoor spaces by inducing evaporation through misting systems. The research concluded that misting-cooling systems can be complex, and its associated equilibrium with encircling air humidity is fundamental (Nunes, J. et al., 2013).

Mitigation potential of an outdoor evaporative cooling system: a case study in Rome

General consideration about UHI in Rome

Urban overheating and heat islands were studied for a three years period (Zinzi, Carnielo & Mattoni, 2018), through ground measurements in several neighbourhoods and a reference station, in a countryside site, west of the city. The city observation points used for detailed analyses were placed in: historical city centre; a semi-peripheral area with small apartment blocks and high building height to road width ratio; a semi-peripheral area with high rise blocks and low building height to road width ratio; a peripheral zone. Maximum hourly UHI intensities of 8.4°C were measured. On seasonal basis UHI ranged between 1.9°C (outskirts) and 2.8°C (city centre) in summer, while the values decreased to 0.7/0.8°C in winter without significant differences among zones. The UHI was higher than 3°C in 25% of the summer hours as an average of the four zones and higher than 5°C in 10% of the hours in city centre.
According to these data, it can be inferred that the thermal quality of the city can be deterioreated during many daytime hours in summer, thus affecting the liveability of the outdoor spaces by the population.

The thermal environment in the case study neighbourhood

The case study was carried out in Centocelle neighbourhood, a semi-peripheral area in the eastern side of Rome. Even if surrounded by parks and green area, the neighbourhood itself has a high construction density with few small green zones inside. A monitoring campaign was carried out in July 2017, with the objective of quantifying the thermal quality of the area and develop proposal for urban mitigation and rehabilitation. In particular two zones were identi-

fied: Piazza dei Mirti, the square representing the hystorical hear of the Centocelle, and Isola Felice, few hundred meters southern than the former, which is one of the few small green parks in the neighbourhood. This allowed to check temperature profiles in a thermally stressed environment, completely covered by dark absorbing construction materials and in a zone theoretically mitigated by the presence of large trees. The monitoring was carried out during a heat wave and the air temperature peaked 40°C in three consecutive days in Piazza dei Mirti and Isola Felice. To be noted that no relevant differences were found in maximum temperatures between the two zones, but the average temperature of the small park was 1.1°C lower than the square, thus confirming benefits on urban greenery in mitigating the urban overheating. Concerning the urban heat island effect, the peak air temperature in the extra-urban measurement station was 35°C leading to a UHI peak of 5.8°C respect to Piazza dei Mirti. To be noted that UHI was greater than 2 and 4°C during respectively 80 and 23% of the monitoring period (Battista, de Lieto Vollaro & Zinzi, 2019).
Starting from the monitored data, also some estimation of temperature reduction was carried out by simulation works, run with a thermo-fluid dynamic software (ENVI-met). Several mitigation strategies and technologies were taken into account, assigning to each of them a variety of performance indicators. Fixed an observation point, the maximum potential temperature reductions in Piazza dei Mirti resulted to be the following:
0.9°C - Blue tech (presence of a fountain beside the observation point)
0.4°C - White tech (0.3 solar reflectance increase of urban pavements)
0.5°C - Green tech (trees and lawns in the square)
1.2°C - Urban shading device (by the observation point)
1.9°C - Combination of all mitigation technologies/strategies in their top performance
To be noted that the above values do not refer to the average across the square but only the specific assigned point.
This experience proves two relevant aspects for urban mitigation and rehabilitations:
Lot of efforts are needed to achieve significant results, com-

bining extensive technologies (greening of urban spaces and replacing current pavements with high reflective materials and components) with punctual applications (based on water and/or solar protection.
If such large scale applications become successful, several meaningful results are achieved: reduction of energy use in buildings for cooling; improvements of health and comfort conditions in the built environments, especially in low income people dwellings, where the energy poverty is a permanent conditions and there is no access to active cooling systems. However the potential mitigation does not create the conditions for a significant improvement of outdoor liveability, in terms of thermal comfort, due to the very high temperature that may be reached during summer.
According to the above statements, alternative solutions, mainly aimed at mitigation in specific spots, must be pursued to achieve more intensive temperature drops and significantly enhance the thermal comfort conditions.

Evaporative cooling systems: the field application
The case study was implemented in 2018, in a scientific and technical collaboration with Polytechnic University of Marche. The study area, already mentioned above, is a small green park belonging to the IV Municipality of Rome, which went through years of deterioration before being adopted by the citizen association "100 e a capo" and being baptised as Isola Felice (Happy Island). The association is still carrying on a rehabilitation project to provide a recreation area for babies and children and accompanying adults. The neighbourhood is authentically proletarian and multiracial; thus, the presence of an aggregation spot is crucial to build social relation. It was hence decided to install the pilot project in the park, so to make it liveable also during the hottest hours of the day.
The experimental tool consists of 24 nozzles (placed along a 6x4 grid) covering an area of about 50m2 and placed at 280cm from the ground; the system was fed by a 900W electric pump grid connected and by a public water station connection. The whole system was designed according to low-cost criteria, in a perspective of future self-construction by different stakeholders.

A number of thermo-hygrometers were installed to monitor the performance of the system. They were placed as follows:

1. 1 sensor in San Felice in Cantalice square, totally paved and nearby the park; the sensor was mounted at 250cm from ground (for security reason) and used as reference;
2. 4 sensors vertically mounted below the evaporative system in central position. The sensors were mounted at the following distance (in centimetres) from the ground: 110 (reference for seated person), 170 (reference for standing person), 210 and 250 (to observe the temperature changes in proximity of the nozzles);
3. 1 sensor mounted below a large crown tree at 130cm from the ground, to check the impact of greenery as shading as passive mitigation technique.

Figure 1 shows the evaporative system at work during monitoring. The park is equipped with recreation tools for toddles, who enjoyed also playing under the sprays. The testing zone is equipped with a bench to investigate comfort issues for citizens both, seated or standing. Time evolution of air temperature during three days in August is plotted for the reference station and for sensor at 170cm from the ground under the spray system.

Full details can be found in (Ulpiani, di Perna & Zinzi, 2019), picking here the most signficant, they prove the positive impact of the evaporative system, especially during the central hours of the day. With the system always switched on, the measured peak temperature reduction was 5.5°C, the average reduction across the whole period was 3.2°C. Alterntive system management solutions were also tested: 1) time sequence 20 on and 10 off in seconds; 2) control strategy based on outdoor thermal comfort indices. The following air temperature reductions were achieved for peak and average, respectively: 1) 3.8 and 2.3°C; 2) 2.4 and 4.2°C. The results based on active control are of interest because they activeate the system only when it is really needed (respect to comfort expecations), and optimise the energy use in a stand alone system perspective.

Another investigated aspect if the impact of the system on users' thermal comfort, whose full campaign analysis can

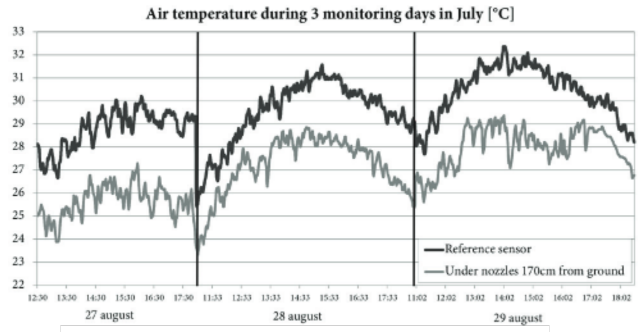

Figure 1. Air temperature profiles in the reference station and under the evaporative installation at 170 cm from the ground.

be found in (Ulpiani et al., 2019). Without going into details, it has to be noted that, according to the well-known thermal sensation scale from -3 (very cold) to +3 (very hot), the average sensation decrease from +1.5 to -0.7, being the comfort zone in the -0.5/+0.5 range. This proves the effectiveness of the system in improving thermal conditions under thermal stress conditions; on the other side, it is important an accurate management of the system to avoid overcooling, when the thermal environment is not under overheating risks.

Conclusions

While urban level mitigation applications require consistent investments, small scale applications can be useful to locally mitigate urban overheating and enhance thermal comfort and livability of outdoor space, with advantage at health, social and environment levels.

Water evaporative technologies displays an attitude for proactive, local, effective urban microclimatic changes and exhibited a high local impact on cooling, while retaining a significant traditional aesthetic, symbolic and social role in urban design. This dual function leads to the increasing use of evaporative cooling, especially trough misting, to define pedestrian cool spots in urban locations, notably as more efficient components, stronger constructive methodologies and more adapted management practices came into play.

Regarding the case study carried out in the Centocelle neighborood in Rome, the field test provided positive answers:

1. It is possible to implement low-cost solution that effectively reduce the air temperature under the installation but also in the close surroundings;
2. The feedback of users was very positive, since the hot thermal sensation felt in the reference zone was strongly mitigated under the sprays. Attention should be paid in activating the system only when needed, to avoid under cooling when the temperature are lower in the morning or late in the evening;
3. The system was well accepted by citizens and kids, in particular, who enjoyed the installations and started living the park also during the hotter hours of the day.
4. Future actions should be aimed at refining the installation in smart city and urban rehabilitation perspectives.

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Mainstreaming Salutogenic Urban Design for People and the Environment

Maria Beatrice Andreucci

Abstract

Urban ecosystems are characterized by rich spatial and temporal heterogeneity: a complex mosaic of biological and physical patches in a matrix of infrastructure, human organizations, and social institutions. Worldwide urban ecosystems are under pressure from competing resource demands, protracted inconsistent land uses and climate change. The need to assess vulnerability and adapt to critical environmental phenomena calls for new ways to understand, interpret, experience, and interact –since the early stages of the design process– with all the components of the urban ecosystem, and primarily with the elements and systems of the Natural Capital. Landscape architects, urban ecologists and planners are linking open space design with ecosystem structure and functions to restore habitats and improve life quality in cities. By providing ecosystem services, the emerging paradigm of urban green infrastructure promotes environmental protection, economic feasibility, health and wellbeing, equity and social inclusion. In particular, Salutogenic design levering on nature-based solutions has become central, introducing in architecture and urban design a focus on metrics and performances, alongside form and aesthetics. The importance of different ecosystem benefits varies significantly with spatial scale and according to stakeholders' groups. The social benefits related to thermal comfort, in particular, are acknowledged as key outcomes of green infrastructure by local residents and visitors alike, and include recreational opportunities, improvement of the home and work environment, impacts on physical and mental health, as well as cultural and historic values. Integrated approaches can help designers to explore the ideas and concerns core to landscape architecture in the

Anthropocene, such as designing with social ecological systems, working with landscapes in flux, or adapting to the extreme weather events caused by climate change.

Keywords
Urban Green Infrastructure, Salutogenic Design, Pedestrian Thermal Comfort.

Introduction

Urban ecosystems are characterized by rich spatial and temporal heterogeneity—a complex mosaic of biological and physical patches in a matrix of infrastructure, human organizations, and social institutions (Machlis et al., 1997). Worldwide urban ecosystems are under pressure from competing resource demands, protracted inconsistent land uses and climate change.

As cities expand and urban populations soar, competition for space from various land uses has become more intense, resulting in green space and nature being squeezed out of many cities and marginalised from urban decision-making processes. Moreover, high urban land prices have made it harder to justify urban greening, and it has become undervalued and long regarded as an aesthetic nicety, rather than a fundamental component of the urban ecosystem. This situation is hugely detrimental for many city inhabitants and their environments, as well as the economic wellbeing and robustness of urban areas.

Urban geometries, surfaces, building forms and envelopes (wall, roof, floor, physical characteristics such as insulation, glazing ratio, etc.) were designed according to organizational and aesthetic principles, rather than to adapt to climatic changes, which is only becoming an issue nowadays.

A particularly critical factor affecting urban ecosystems is microclimate, due to its influence on the quality of life of urbanites. The lack of green open space impacts, in particular during the hot summer, on the radiative properties of the environment, with negative effects on the urban microclimate, and potentially very harmful consequences on the population and the entire ecosystem. Dense urban geometries and lack of permeability of the site's surfaces most of the time determine thermal discomfort and the presence of

Urban Heat Island (UHI) effects , with various degrees of intensity depending on the time of the day and the seasons. Although the projected increase of air temperature due to climate change is much smaller than local UHI magnitudes, the combined effect of both is actually expected to increase thermal stress within the urban environment and may even be synergistic. UHI intensity has already reached significant levels under current climatic conditions, and thus, thermal stress can be expected to further increase with projected global warming (Hiemstra et al., 2017). Moreover, the increase in frequency, intensity and duration of heat spells, also projected by climate models, will further aggravate thermal stress and discomfort of citizens and therefore affect health negatively leading to increased morbidity and mortality of the population in urban areas.

The Lancet's Commission on Health and Climate Change warns that climate change is affecting health , and these health effects will continue to grow and magnify, if efforts to mitigate and adapt to these changes are not addressed globally in a collective and timely manner (Watts et al., 2018). Further, these climate change health effects amplify existing inequities—placing marginalized people, who generally have contributed the least to the climate change problem, at the greatest risk (Watts et al., 2018).

Many of the climate-driven forms of vulnerabilities, indirectly caused by human activity, have not been experienced before and can have a multitude of ecosystem and socioeconomic knock-on effects that impact human well-being. The expected impacts are unfortunately significant (IPCC, 2019).

Mitigation of the Urban Heat Island effects represents consequently a priority challenge for a healthy urban development and inclusive public space design, and cities around the world have started to design and implement adaptation strategies, often independent of existing national planning frameworks. City-level actions concentrate on a range of sectors, including water, energy, waste, infrastructure, land use, human settlement, and disaster management. The identification of risks by downscaling climate models and by the analysis of vulnerability generate political interest in understanding how the local climate is likely to change, how the city will be affected, and what local response options seem appropriate to confront expected impacts. In an attempt to address existing uncertainties about climate change effects, significant reliance is put on research centers, practitioners and education programs, as well as on consensus-building processes with all potentially affected stakeholders.

The urban green infrastructure design paradigm

Studies on microclimate of cities have already proved that human comfort, health and wellbeing are strongly influenced not only by the geometry and the level of soil sealing, but also and mostly by the presence of natural elements and systems, and their integration within the built environment (Watts et al., 2018).

In spite of the profound aesthetic values of urban biota, there are also many other benefits that are provided by urban biodiversity. Trees cool local climate, and together with herbaceous vegetation they take up excess nutrients and reduce runoff. Community gardens utilize vacant public spaces in an inclusive way, i.e., in addition to growing vegetables or flowers, they provide a meeting place for the neighbourhood and promote social interaction. They add to the city's public spaces and, by attracting pollinators and nectar feeders, they help maintain biodiversity. Green roofs reduce storm water runoff, regulate building temperatures—thus conserving energy, and increase wildlife habitat area.

Landscape architects, urban ecologists and planners are linking landscape design with ecosystem structure and functions to restore habitats, mitigate climate, and improve life quality in cities. A new paradigm is being adopted to try and better integrate the interaction between man's activities and nature: the 'green infrastructure' approach promotes the elements of biodiversity and organized systems that are part of natural capital in any urban area, be it valuable or derelict, including individual technological devices that leverage biodiversity and are integrated in the architecture. Green roofs and living walls, permeable pavements, rain gardens and other systems for the collection and management of rainwater are just some examples. By providing ecosystem services (MEA, 2005), urban green infrastructu-

re promotes climate change adaptation, environmental protection, economic feasibility, health and wellbeing, equity and social inclusion (Andreucci, 2017).
The social benefits related to pedestrian thermal comfort are acknowledged as key outcomes of green infrastructure by local residents and visitors alike, and include recreational opportunities, improvement of the home and work environment, impacts on physical and mental health, as well as cultural and historic values.
There are several design strategies to mitigate the UHI by manipulating the urban energy balance and changing some terms and/or factors: (i) varying the albedo (the ratio of irradiance reflected to the irradiance received by a surface) to reduce net radiation, (ii) improving ventilation affecting human heat load, and (iii) augmenting evaporative and shading potential.
The first issue that arises in bioclimatic design is the seasonal use profile of open spaces. With the exception of acoustic comfort, which is only relatively affected by seasonality, the levels of visual and especially thermal comfort require different design actions, in order to offer pleasant and comfortable environments compared to the changing microclimatic conditions. In the summer, temperature control is essential, especially in the southern latitudes, where shading is the most important factor, as well as being a significant parameter for visual comfort.
A multitude of environmental devices, in the various practices that see the use of vegetation in the foreground, can be used effectively depending on the desired shading and the potential trade-offs, represented by particular effects of such solutions on ventilation flows.
One of the most promising measures to mitigate heat stress in urban areas is the appropriate planting of urban green. Greening, especially tree planting, has a positive effect on the outdoor thermal comfort, intercepting solar radiation and preventing the underlying surface to absorb shortwave radiation, a process known as shading effect.
Especially large-scale planting of trees, known as 'urban forestation', is considered effective for creating cooler areas in cities, an effect known as the 'Park Cool Island' (PCI). The cooling effect of trees results from two mechanisms,

i.e. shading and evapotranspiration. The shading effect is by far the strongest. By blocking part of the incoming solar energy, it reduces the mean radiant temperature, and consequently strongly enhances thermal comfort. Secondly the process of evapotranspiration reduces air temperature directly. However, this second mechanism is highly dependent on water availability for the tree. Finally, the amount of shade provided and the level of the evapotranspiration are related to volume and biomass of the tree. Therefore, tall trees with large, dense crowns are much more effective than smaller trees.

Trees, compared to other shading solutions, have the dual advantage of offering air cooling through evaporating in summer and desired sun exposure in winter, in the case of deciduous trees.

Particularly high-performing, in terms of microclimate regulation, are the trees belonging to the genre:

Acer, Aesculus, Juglans, Platanus, Populus, Quercus, Tilia and Ulmus, and the species: Fagus sylvatica, Ficus microcarpa, Liriodendron tulipifera, Prunus avium, and *Salix alba* (Samson, 2017).

Horizontal devices, such as vegetated pergolas, can provide shading for more hours during the day and are particularly useful for pedestrian paths or linear areas. Even in these cases, designers need to be careful that hot air does not get trapped below the project architectures. Channelling summer breezes is equally significant in order to subtract heat from the open spaces. Vertical elements and systems and vegetated screens can be used, in such cases, to divert ventilation towards specific areas.

The use of water as a project material or solution is also an important strategy to ensure the best levels of microclimatic comfort. In the forms of water veils, waterfalls, ponds, linear systems or fountains, such nature-based solutions can usefully contribute to the best environmental conditions, also in a synergistic and integrated way with other solutions aimed at managing not only ventilation, but also other factors such as, for example, the production of solar power from renewable sources. The materials used as design surfaces are also important choices to be made carefully for the effects produced both in terms of visual and thermal

comfort. Most vegetated surfaces, in fact, not only prevent reflection but contribute to the cooling of the air thanks to the evapotranspiration.
The use of light colours and reflective surfaces also helps prevent overheating in the surface and in the air, even if they can also cause glare and thermal reflection towards users, surfaces and the surrounding buildings. Dark surfaces, on the other, can easily overheat when exposed to direct solar radiation, causing discomfort. Very interesting in this regard is the ongoing international research and experimentation on materials and innovative technologies to mitigate heat islands - such as 'highly reflective (HR)' materials, i.e., cool roofs and cool materials; retroreflective (RR) and photocatalytic materials for decomposition of chemical contaminants and disinfection of pathogens in the air (Ren et al., 2018; Akbari and Matthews, 2010; Santamouris et al., 2011).
In winter, the main purpose of the design process is to protect open space from cold winds and rain and maximize solar exposure. Soil models combined with planting to protect unfavourable ventilation are the most suitable strategies to achieve adequate levels of winter microclimatic comfort. Among trees, deciduous species in particular maximize sun exposure, while the evergreen trees are more effective as protective barriers from the wind.
However, ecosystem functionality is generally compromised by rising temperatures, leading to significant decreases in biodiversity, ecosystem service delivery, and resilience. Incongruous materials—through the physical and optical characteristics of albedo and emissivity—negatively affect the urban microclimate, and the same vegetation's ability to cool down thanks to evapotranspiration are reduced if not inhibited, more frequently than expected and for longer periods in many European countries (EEA 2012).

Salutogenic design and digital technologies

Salutogenic design (Antonovsky, 1996) for health promoting environments has become central only in the late XX century, introducing in landscape architecture and urban design a focus on metrics and performances, alongside form and aesthetics. The 'art' of landscape practice is still the heart of landscape architects' work, and both researchers and practitioners are still behind the curve on supporting the scientific side of the practice with necessary evidence.

The concept of "Design with Climate" (Olgyay, 1962; Givoni, 1969) has rapidly evolved in the last decades, and identifies a climate sensitive approach to the planning and design of outdoor spaces.

Within this framework, outdoor thermal comfort models provide critical tools for evaluating the suitability of spaces for various nature-based solutions and environmental design strategies.

Recent feedback (Coccolo et al., 2018) suggests that different digital tools (Ecotect, ENVI-met, CitySym, Revit Insight 360) holds great potential in describing the microclimatic conditions of the built environment, the interactions with its natural capital, and the related impacts on human comfort. In order to understand specifically the impact of greening on the urban microclimate, as well as on the outdoor thermal comfort of the pedestrians, the evapotranspiration potential from trees and grass can be computed, also thanks to evapotranspiration models.

Including these tools and parameters at the local scale, with pre- and post-operam simulations, makes the openspace design more responsive to the goals of psychophysical well-being, than traditionally conducted in landscape architecture and in the urban design.

Combining public space design with the increased attention to nature-based technologies and increased accessibility to digital tools supports a new approach for challenging static design solutions (Watts et al., 2018). Developments like the Downtown Parks and Public Realm Plan (PUBLIC WORK Office for Urban Design & landscape Architecture, Toronto, Canada), Bishan-Ang Mo Kio Park (Ramboll, Singapore), Brooklyn Bridge Park (Michael Van Valkenburgh Associates, Inc., Brooklyn, NY, USA), and Houtan Park (Turenscape, Shanghai, China) represent successful attempts to mainstreaming regenerative architecture and appropriate technologies through the lens of contemporary landscape architecture.

Concluding remarks

« *Open space is an essential part of the urban heritage, a strong element in the architectural and aesthetic form of a city, it plays an important educational role, is ecologically significant, is important for social interaction and in fostering community development and is supportive of economic objectives and activities. In particular, it helps reduce the inherent tension and conflict in deprived part of urban areas in Europe; it has an important role in providing for the recreational and leisure needs of a community and has economic value in that of environmental enhancement.* » (Council of Europe, 1986).

The definition of public openspace above, through the concepts of: 'heritage', 'ecological significance' 'economic objectives', and 'social interaction', expresses very well the integrated approach with which the many ecological, social and economic challenges must be addressed in the urban project.

The beauty and intrinsic value of nature is inspirational for most, but it seems talking more about its functional qualities may, for now, prove to be the most persuasive way to bring the benefits of green infrastructure into sharper focus. Integrated approaches can help designers to explore the ideas and concerns core to landscape architecture in the Anthropocene, such as designing with social ecological systems, working with landscapes in flux, or adapting to the extreme weather events caused by climate change.

Urban green infrastructure can be extensively used to mitigate the effects of the UHI. Of all urban green elements and systems, trees seem to be the most effective in this respect. Moreover, they have the additional benefit of contributing to several other functions at the same time.

Outdoor comfort simulations are useful tools to assess microclimate, and the different parameters influencing human energy balance and thermal comfort. The potential of bioclimatic design is confirmed by the increasing testing of the simulation tools supporting regenerative projects, and thus offering useful insights for evidence-based design of urban degraded sites (Andreucci et al., 2019). Processes of feedback, sensing the environment, managing the identified data, and visualizing climate adaptive responses represent the core design focus in the development of inclusive public space and resilient communities.

Landscape performance will in the near future increasingly underlie debates about restorative architecture, green infrastructure and nature-based solutions, playing an important communicative and collaborative role in climate change policy and practice responses, improving people's quality of life—making them healthier, happier and more productive. The growing body of global research we now have on nature and green public space ably demonstrates the critical importance of green infrastructure within urban environments and the intrinsic relationship that humans as a species have with it. Evidence validates the multifunctional benefits green infrastructure delivers at all scales, which is crucial for humans to enable them to flourish in urban environments, and the role it can play in supporting the economic, social and environmental health of city environments.

Notes

[1]The UHI effect is defined as the air temperature difference between the city and the rural area, and varies in each urban environment in time and space, as a function of the meteorological and urban characteristics (Chow & Roth, 2006; Howard, 1818; Morris et al., 2016; Ng, 2010; Oke, 1987).

[2] Some well-known health implications of climate change include: a rise in vector-borne diseases; heat-related morbidity and mortality; injury and illness from extreme weather events; increased cardiovascular disease and increased aeroallergens from poor air quality; and water and food security concerns from water and food-borne illnesses and malnutrition (Berry et al., 2014; Crimmins et al., 2016; Watts et al., 2015; Luber and Lemery, 2015). Lesser known climate change impacts on mental health include direct climate impacts, like extreme heat or extreme weather events (including floods, wildfires, hurricanes, heat waves, etc.); and indirect ones, like the social strain and resource loss related with drought, sea-level rise, melting permafrost, or overarching impacts associated with the knowledge and awareness of climate change impacts on planetary and public health (Fritze et al., 2008).

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Re-Cool Trento
Designing Blue and Green Flows for a Hot City

Sara Favargiotti

Abstract
The challenges facing communities and cities today are climate change, the vulnerability of territories, the availability of limited resources (primary, material, territorial, economic), the loss of the collective sense of community, cultural degrowth, inequality and social inclusion. In response to these challenges, many planners, designers and planners are rethinking cities, through new paradigms and models guided by strategies of adaptation to change. Today we often find ourselves having to repair the many mistakes made sometimes unconsciously and sometimes driven by models and conditions that are no longer valid. In this context, it is even more urgent to stop and ask ourselves who the future belongs to, what is the temporal dimension of the future and the respective effects in designing it.
The contamination of disciplinary boundaries between landscape, architecture, urbanism, ecology, and futures studies (a recent branch of social sciences) has forced to expand and redefine the practice of designers and their field of operations. Following this, the contribution will briefly focus on the expansion in approaches and definitions of relevant themes such as uncertainties, resilience, urban adaptation, blue and green infrastructure, climate change that have undergone during the last decade and the consequent emergence of new design methodologies. It will do so through sharing knowledge, data, perspectives, and design experiences among the fields of urban, landscape and ecological design, as well as environmental and social studies.

Keywords
Blue and Green Infrastructure, Landscape Reserve, Urban Adaptation.

Introduction

Walking along the river Tevere in Roma, between Ponte Sisto and Ponte Mazzini, original murals will suddenly appear. It is an artistic interventions with a double signature: the first, in 2005, by Kristin Jones titled "She Wolves", that "had originally envisioned the potential for a major site-specific intervention […]"; and the latter in 2016 by William Kentridge, "Triumphs and Laments". This installation represents our histories: the ancestors of the Roman Empire but also the fragility of our world. It also wants to be the society more aware of the impacts that every human action can have on the planet. The illustration of the frieze emerged from subtraction: they are obtained eliminating the biological patina of silt and pollution that has been slowly but progressively accumulated on the travertine of the walls. The prevision states that - in a time of three or four year - the pollution will come back by "naturally" covering the illustration, with the lost of the entire installation but more critically, the increase of the environmental contamination. The installation push our responsibility as citizens and researchers to face and urgently question on the most urgent and pressing environmental problems: the violent fire in Australia, the big floods in Liguria or in Toscana, the reduction of ice in the Alps, the extreme dry season in Sicily, urban heat island, the wind storm like Viaia, the CO2 emission alert, are increasingly pressing environmental issues that, with the expanding urban configurations and the changes in technology, economy and lifestyle, have significantly shaped our life environment. All these trends call for a new ecological dimension for a more sustainable and sustained world.

The contribution insists on three main concepts to address the social, environmental and urban challenges that communities and territories transformation have to be faced.

UNCERTAINTIES. The main threats that affect cities and communities are climate change, environmental degradation, globalization, security, migration, automation, crisis and poverty that are all characterized by non-linear, unpredictable, and unstable dynamics. The growth of "immaterial" inequalities affects the physical spaces of urban

environments as well as the community dynamics. Uncertain growth is connected to the use of the space and the production of culture. Innovative anticipatory, forecasting and monitoring methods will be needed in order to address potentialities of such spaces. Therefore, which policy recommendation and urban strategies can help to address these global issues and to drive a more equal, sustainable and resilient development?
RESILIENCE. Resilience is the capacity of an ecosystem to recover from perturbations. Interpreting this concept for urban environment, urban resilience refers on the one hand to the adaptation capacity of physical spaces to the ongoing (unpredictable) changes; on the other hand it refers to the capability of communities to change accordingly to nonlinear dynamics or shocks by designing innovative social, economic and environmental responses that allow them to withstand the stresses of environment, economy and history in the long term. How urban resilience could activate processes and drive governances for the urban and social regeneration?
ADAPTATION. Adaptation strategies in urban environment aim at to reduce the waste of spaces and resources, as well as preserve natural and human assets, limit the costs for reconstruction, stimulate economic growth, and enhance a more sustainable and secure wellbeing. Cities need to be guided from one unstable condition to another, and citizens are the main actors to contribute to this change. How a city (or parts of a city) and communities could adapt to the unstable, unpredictable, uncertain socio-political-economic flows?

Fragile landscapes, resilient communities
Italy is a fragile territory. From 2010 to 2017, 126 Italian Municipalities have been damaged, 242 severe weather phenomena happened, and 56 States of emergency have been declared. All these caused damages and costs to the territories and to the communities: to land and soil, public and private heritage, production and economic, since rebuilding after such events is much more expensive than preventing them, but above all direct impacts direct and indirect impacts on the health of inhabitants. From 2010 to 2016

over 145.000 have been died due to floods and over 40.000 have been evacuated. From 2013 to 2016 damages caused by landslides and floods amounted to 7.6 billion euros. In 2017, 738 million euro (about 10%) has been invested by the national government to respond and prevent risk.
The fragility of the territories has been influenced by human actions and impacts. Most of the population lives in cities and the numbers will grow. An increase in urban density and land consumption, have led to a reduction in green spaces and water, nature reserves and biodiversity (source WWF). Since 1970 the Italian population growth of 28% with a growth of the construction as 166% that highlight how we have built much more than the real demands. This trend has happened all over Italy, also in the Province of Trentino where since 1960 the growth of the population is 20% population with a development of the built-up land as 190% and consequent reduction of agricultural land and natural ecosystems. According to the 2019 ISPRA Report, "the soil continues to be consumed even in protected areas that are subject to water hazard and landslide and seismic hazards. Soil consumption - not necessarily abusive - is also growing in protected areas (+108 hectares in the last year), in restricted areas for landscape protection (+1074 hectares), in areas with medium hydraulic hazard (+673 hectares) and landslide hazard (+350 hectares) and in areas with seismic hazard (+1803 hectares)." In this dense and consumed territory, the hydrogeological risk area in Italy is widespread: 88% of the Italian municipalities and 7 million inhabitants are considered areas with a high hydrogeological risk. In Trentino Alto-Adige 80% of the municipalities are located in an area of high hydrogeological criticality (Source: CRESME elaboration on ISTAT and Ministry of Environment data). In addition, the precipitation trend has varied in the last decades: the rain patters show unpredictable weather phenomena of great intensity that last for a very short time. Short but vey intense rainfall, with unexpected floods and windstorms, followed by the increase of temperature in the urban areas more than in the rural areas (urban heat island). The conjunction of this phenomenon with the increase of urbanization and soil consumption and the consequence of the reduction of non-permeable areas, have

brought to a more vulnerable and fragile lands but more urgently it entails a strong risk to citizen wellbeing.

Global challenges, local solutions: blue and green flow to adapt cities to climate change

The Sustainable Development Goals (SDG) are a set of 17 objectives adopted by the UN Member States in 2015 as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals. They include 169 targets whose aim is to address a wide range of issues related to economic and social development, such as poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, urbanization, environment and social equality. Cities and community's adaptation to climate change is outlined as one of the most emergent and urgent challenges in the near future. In that sense, the city can be considered as resilient systems by getting the inhabitants more aware of its vulnerabilities and becoming adaptive to extreme wheatear phenomena.

Why resilience is so important and widespread concepts at the moment?

Resilience is the capacity of an ecosystem to recover from perturbations. Urban resilience is referred to the definition of ecosystem resilience, intending the capacity of complex systems to react to stress phenomena by adapting to change, not so much to return to their initial state, but to achieve a new balance (but aiming at restoring functionality). All the dynamics above mentioned bring to a shift in urban design a planning, where the landscape and its "renaissance" is at the center of the design discourse and ecological approach for more livable cities. Above all, the reality of climate change for administrators and practitioners as well as citizens bring to a renewed sensitiveness underneath the conceptual approach of a perfomative design. Cities need to adapt to absorb and resist the unpredictable and unexpected events. Communities need be resilient by knowing their vulnerabilities and transform the dramatic event into of opportunities to become adaptive to these phenomena.

Climate related vulnerabilities refer to two phenomena: extreme events - which are increasing with climate change - and microclimatic phenomena - phenomena that depend

on local climatic conditions. Their combination leads to vulnerabilities, for humans, for the natural and urban environment, and for services. The mapping of local climate zones highlights how the microclimate changes within the city, both longitudinally and transversely. On this base, the climate risk is calculated from the combination of three factors: natural hazard, vulnerability, and exposure. In the urban context they are represented by temperature, presence of vulnerable population (including children and senior), urban density.
Urban climatology is the field that allows to define the positive and negative elements for the climate in space and it is our goal to study the tools it offers to propose solutions for the city that also improve the quality of urban space. Two are the approaches to address climate-related risks: mitigation (acting directly on CO2 reduction to reduce climate change) and adaptation (accepting that certain changes happen and will happen and acting on space to make it safer and more adaptable to future changes). If mitigation is more related to political actions, adaptation is local and can be implemented with large but also small actions.
Using nature-base solutions is one of the most efficient and cost-effective ways to adapt cities and territories to climate change. The green infrastructure approach is the most cost-effective because it enables the achievement of a range of ecosystem services that improve ecology, society and the economy. The process adopted is multi-scalar, from the scale of the city by defining guidelines, going down to the scale of the neighborhood, which in turn helped to better define the interventions at the urban scale. But the process could also be extended to the strategic and metropolitan scales.
Blue and Green Infrastructure (BGI) becomes a fundamental tool for the adaptation of cities in order to achieve resilience and sustainability, quality, health and environmental safety objectives. Indeed, according to the EEA (European Environment Agency), the concept of green and blue infrastructure is based on the principle that the protection and enhancement of natural processes can be integrated into spatial planning and development. The fundamental character of green and blue infrastructure is multifunctionality

(i.e. the ability of a single area to perform multiple functions and provide numerous ecological benefits: food, material, clean water and air, climate regulation, flood prevention, pollination and recreation). This characteristic is complemented by two others: connectivity and multi-scalarity. The first refers to the relationship between different characteristics of the urban landscape; this definition does not consider the size, composition or shape of the environment, but only the existing networks and matrices. Multi-scalarity allows green and blue infrastructures to be effective at any scale of intervention, without binding the provision of ecosystem services to it.

The project of a multi-functional landscape, advocating ecological potential and socio-economic opportunities, started as early as the 19th century. The resilient urban landscape projects by US landscape architect Frederick Law Olmsted offer innovative urban and infrastructural quality solutions based on local needs such as the continuous flooding of the Charles River in Boston. This is the Emerald Necklace project in Boston that creates a system of parks as a green and blue infrastructural network capable of producing multiple benefits for residents and visitors. This example, like many others, makes us understand how green and blue infrastructure should not be considered as separate elements from the built environment but vice versa as an integral and complementary part of the natural-anthropic urban system. Urban blue and green infrastructure can be defined as "the elements of biodiversity and organized systems that can be traced back to the Natural Capital, of any urban area, valuable or degraded, including individual technological devices that leverage biodiversity integrated into the built environment, such as green roofs and vegetated walls, permeable pavements, rain gardens and other rainwater collection and management systems, designed to promote environmental protection, economic viability, well-being, equity and social inclusion through the provision of ecosystem services"(Andreucci, 2017). These are not, therefore, natural accessory elements of purely aesthetic value, the so-called "beautification", which often leads to the negative and widespread consideration of considering the inclusion of the natural element within the urban project as a luxury, i.e. the first item of expenditure to be eliminated in case of budget cuts. On the contrary, the multiple benefits provided by green and blue infrastructures touch different areas, providing services not only from an ecological but also economic and social point of view. The aim, therefore, is to maintain and improve the provision of services for society: this makes their implementation in the most densely populated urbanized areas particularly important.

Blue and green infrastructure in the design and redevelopment of more or less densely populated urban areas is an opportunity to improve the quality of life in urban and peri-urban areas. Thanks to their ability to respond to multiple needs through the systematization of individual interventions, these elements make it possible to address the climate challenge at different integrated scales. The strategies and devices used must be flexible enough to be able to be deployed in different contexts, evolving over time in line with the urban structure. Planning, in fact, is a process that considers different dimensions (spatial, environmental, social, economic), where the choices of individuals involve effects not only within blocks and buildings, but also on collective spaces up to the climate in the surrounding area. To develop effective adaptation strategies and actions, it is therefore necessary to consider all scales of intervention (Rovers et al., 2014).

Italy in 2014 approved the Strategy to adapt to the effects of the changing climate. A strategy whose main objective is to develop a national vision on how to deal with the impacts of climate change through a framework aimed at: describe the vulnerability of the territory; improve current knowledge on climate change and its impacts; promote participation and raise awareness of all actors, through a broad process of communication and dialogue, in order to integrate adaptation into sectorial policies; raising awareness through information; identify the best options for adaptation actions. The city must make plans because the problem is not only environmental but also economic, since repairing the damage is more expensive than intervening preventively.

Interesting examples of an adaptation plans, strategies, city guidelines can be proposed by Bologna BLUAP, Milan 2030 Parigi, or Barcellona. Specifically, the review of the urban plan in Milan, Milano2030, has been adopted in March 2019. Milan's resilience challenge is to address flooding, air pollution, and climate change, while increasing affordable housing access (Source https://www.100resilientcities.org/cities/milan/). On of the most innovative approach in the plan structure is a resilient-based plan on the following goals: performance rules for new buildings, to minimize energy consumption, re-naturalize and maximize the permeable surface area in the city, to reduce the carbon footprint of new buildings that in the regeneration of the building stock; and urban forestation on private area, with high investments on green maintenance and management, as well as environmental regeneration. Other 298 Italian municipalities have included the topic of climate adaptation in their local buildings' regulations. The territorial plan of Houston greenways proposed a "path" offer a matrix of multiple ecosystems that intertwine and connect harmoniously. In a stretch of about 1.5 km you could meet at least seven different ecological conditions: from forest, to meadows, to riparian areas. At the neighborhood scale, interesting examples are the water squares in Rotterdam. With low rainfall, the water squares would perform as a simple "organized collector" of rainwater, which before being reused, would be stored in hidden storage basins; in case of particularly heavy rainfall, instead, the water squares would be transformed into a real rainwater settling basin, which would then be introduced into the sewer system gradually, to avoid overloading problems.

A pro-active contamination

The landscape design approach is a valuable resource for regenerating, restoring and renewing urban, peri-urban and rural areas, often obsolete or abandoned. Land recovery and transformation processes find an opportunity in urban agriculture to improve the quality of life in cities, interpreting the abandoned areas as reserves capable to mage climate, ecological and social complexities. This process becomes an opportunity to reconnect society with its landscape identity and geographical characteristics (urban, rural, regional, territorial), make initiatives economically sustainable and scalable, build a comprehensive and flexible framework to guide cities to implement projects adapted to multifunctional use on different scales. For this, a change of perspective is necessary, based on values such as social integration, climate adaptation, enhancement of environmental and ecosystem services (protecting against erosion, facilitating pollination, supporting tourism and biodiversity) in a perspective of sustainable development and circular economy for urban regeneration.

In response to global challenges, cities around the world are adapting, innovating through nature-based strategies for sustainable development. The growing sensitivity to contemporary emergencies such as food scarcity, climate change, land consumption, together with emerging trends such as ICTs, alternative economic development models, bring back the community's interest in the land by finding in agriculture a test-bed to drive innovative production systems. Here green and blue infrastructure presents itself as a field of investigation on which to apply the concept of urban resilience and climate adaptation to contribute to integrated sustainable production to temperature mitigation and improvement of city comfort.

The approach of adaptation is not only proposed to solve the environmental problems, but also to make the city more adaptable to future changes that are unknown and to improve its urban quality. Indeed, adaptation drives to a paradigms shift: to think not only to solve the environmental problem but to make the city more adaptable to future changes that are not yet known in order to improve urban qualities. It is a different approach to the traditional engineering practice that relies exclusively on centralized hydraulic systems to capture and convey rainwater away as quickly as possible, where instead the natural material becomes a design element. It is a change of approaches both in practice as well as in theory: a multidisciplinary approach where landscape and architecture, urban design and planning, engineering and agronomy, are co-creating and collaborating in the discourse on adaptation to reduce the ongoing effects of anthropogenic climate change.

A pro-active contamination is required due to the contemporary socio-cultural-economic-ecological conditions and the uncertainties perspectives of multiple possible futures, through the sharing of knowledge and experiences between scholars. The concept of as landscape as cultural common drive territories and cities though a sustainable development in a mutual exchange between research, planning and design to foreseen crucial (critical) changes. Within this framework, some recommendation can support the education, the dissemination and the sharing of emerging attitudes. The contamination and the proactive exchanges of disciplinary boundaries between landscape and architecture, art, urbanism, ecology, but also engineer, technology, and science in a broad sense, has forced to expand and redefine its own terms and field of operations, in order to tackle the critical environmental and social needs. A cross-disciplinary education by integrating architecture, urban design, landscape architecture, engineering in ways that blend the knowledge of construction engineering with knowledge of architectural and urban planning tools, with a balanced learning with practice and theory. An iterative process offers to the students the methodological framework to develop assessments of landscape, infrastructure and urban space thought the different scales, with specific focus in the Alpine context, in order to design the renovation or remodeling of existing buildings and territories.

Indeed, to respond to the complexity of the territory, territorial development policies must pursue collective values with territorial qualities integrating: agricultural production and technological production; territorial and social connectivity; environmental awareness and tourist attraction; natural and cultural diversity; collective spaces, parks and therapeutic green areas; territorial governance, common goods, participation and training. This is how green and blue infrastructures constitute a multifunctional strategy to help develop a more sustainable urban management process, in which the expansion of cities is curbed by exploiting and upgrading the existing building heritage. Moreover, when thought of in a systemic way, they are a key building block to connect and improve the ecological value of the landscape.

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Urban Water Management and Climate Change
The case of Bologna

Giulio Conte

Abstract
In 2015 the Municipality of Bologna approved its Climate Change Adaptation Plan (CCAP) aimed at increasing the resilient capacities of Bologna area, preparing institutions and citizens to face more effectively the consequences of the climate changes, while reducing existing vulnerabilities in the territory. To tackle the adaptation challenge, the actions envisaged by the Bologna CCAP rely largely on Nature Based Solutions (NBS) and includes the use of non conventional water resources (rain water and grey water) for non potable use and the diffusion of Sustainable Urban Drainage Systems (SUDS) to reduce urban runoff. In 2016 the Municipality of Bologna developed a feasibility study to apply the concept emerging by the CCAP, on the urban area of Lazzaretto - a 73 hectares area of new development, North-West of Bologna, nearby the central station - to identify the most suitable adaptation technical options and to assess the possible environmental benefits and estimate the additional costs, compared to conventional water management solutions. Both the alternatives envisaged the use of NBS to reduce the effects of heat waves, reduce water consumption by recovering non conventional water resources and improve runoff management through SUDS. However alternative 1 envisaged rainwater collection near the settlements, to be reused to flush WCs and the use of treated greywater to irrigate green areas during the summer, while alternative 2 was focused on the restyling of the green areas - including several ponds to store rainwater to be used for irrigation - and used treated greywater as non conventional resourto flush

WCs. The costs of the two alternatives was comparable (5.8 and 5.2 millions €) and the increased cost compared to conventional water infrastructures was negligible (around 1%). However alternative 1 have higher performance in terms of adaptation to key climate risks and have was more acceptable by the local population, compared to alternative 2.

Keywords
Water, drought, adaptation, Nature Based Solutions (NBS), Multi Criteria Analysis (MCA),

Introduction

The Municipality of Bologna developed its Climate Change Adaptation Plan (CCAP) through the project BLUE AP (Bologna Local Urban Environment Adaptation Plan for a Resilient City), a LIFE+ project (LIFE11 ENV/IT/119). The plan has been approved in 2015 and is aimed at increasing the resilient capacities of Bologna area, preparing institutions and citizens to face more effectively the consequences of the climate changes, while reducing existing vulnerabilities in the territory.

Bologna CCAP is focused on 3 main vulnerabilities and hazards:

- Heat waves
- Water scarcity
- Extreme rain events

The issue of urban water management is very important for all the vulnerability issues. To tackle the adaptation challenge, the actions envisaged by the Bologna CCAP rely largely on Nature Based Solutions (NBS) and includes the use of non-conventional water resources (rain water and grey water) for non-potable use and the diffusion of Sustainable Urban Drainage Systems (SUDS) (Huber, 2010; Woods Ballard et al.., 2015) to reduce urban runoff.

In 2016 the Municipality of Bologna, with the financial support of European Investment Bank and the technical support of Atkins and IRIDRA, developed a feasibility study to apply sustainable water management (SWM) solutions, on the urban area of Lazzaretto, as a pilot area for the implementation of the SWM envisaged by the CCAP, to identify the most suitable SWM adaptation technical options and to assess the possible environmental benefits and estimate the additional costs, compared to conventional water management solutions.

Class	Alternative 1	Options	Alternative 2	Options
Heat	Watering for green areas	1	Watering for green areas	1
	Centralized greywater treatment and reuse	4	Water sensitive re-design of green areas	3
	White roofs (90% of the roofs)green roof 10%	2	White roofs (95%) Green roof (5%)	2
Drought	Decentralized rainwater reuse for WC	6	Decentralized greywater reuse for WC	5
	Water saving measures	7	Water saving measures	7
	Centralized greywater treatment and reuse	4	Water sensitive re-design of green areas	3
Heavy Rainfall	Rainwater reuse for WC	6	Water sensitive re-design of green areas	3
	Impermeable SUDS on roads and parking	8	Impermeable SUDS on roads and parking	8
	Green roofs (10% of the roofs)	10	Green roofs (5% of the roofs)	10

Table 1. The technical options envisaged by the two alternatives

Lazzaretto is a 73 hectare area in the Navile District, North-West of Bologna, nearby the central station, where a masterplan, integrated with the urban plan of the Municipality of Bologna, envisaged a new mixed use development/neighbourhood including residential, education (University of Bologna), tertiary (directional offices), and commercial (shops, restaurants and a supermarket) with public use (municipal services, parks and green spaces). The Lazzaretto masterplan dates 2000 (Figure 1) and had a net floor area of 215.000 m2, but due to the economic situation only 13.742 m2 of floor area has been developed up to now.

Several technical options to be adopted in Lazzaretto area to increase the "resilience" of the settlement to Climate Change have been analyzed and discussed in public hearings: finally ten of them have been selected.

1. Watering for green areas to improve thermoregulation;
2. White roofs;
3. Water sensitive re-design of green areas;
4. Centralized greywater treatment with CWs in green are-

as;
5. Decentralized greywater treatment in the lots and reuse for WC;
6. Decentralized rainwater harvesting and reuse for WC;
7. Water saving design, educational campaigns, metering strategies;
8. Impermeable SUDS on roads and parkings to reduce peak flow and improve water quality;
9. Treated rainwater connected to Ghisiliera canal to improve water quality;
10. Green roofs.

Two alternatives that implement different technical options or the same ones but with a different extension have been envisaged: in the following table the two alternatives are showed in relation to the 3 main key climate risks.

The more effective solution to mitigate the **heat island effect** is to maintain wet as more as possible the green areas located on the boundaries: the watering of green areas is considered in both the alternatives because on the basis of the urban characteristics of Lazzaretto; the two alternatives are mainly differentiated by the different approaches to recover not potable water for the watering: in the first alternative the greywater produced within the lots are diverted towards the green areas, where they can be directly reused during the summer after a treatment with constructed wetland systems allocated in the parks. In the second alternatives instead the water source for watering is constituted by the rainwater harvested by roofs and internal courts and already collected by a separate network; the rainwater is stored in large ponds to be realized in the parks. The overall green area extension is about 30 ha, considering a seasonal consumption of 3000 m^3/ha and to irrigate at least a total area of 15 ha, about **45.000 m^3/year** should be available.

Also the application of white roof has been considered in both the alternatives, with a low fraction of green roofs considering their high investment cost and the uncertainty in their realization by the investors.

The key aspect in the mitigation of the **drought** is the reduction of the pro-capita water consumption. Currently the average consumption in Bologna is 160 l/a.e. x day, that is still much higher than the average consumptions in other

European "green" cities where this value is less than 100 l/a.e. The CCAP sets a target of 110 l/s per p.e. to be fulfilled in the next years, for Lazzaretto we have considered as optimum the goal of a **reduction of 40%** of the potable water consumption, in order to obtain an average consumption of 96 l/person x day. In the two alternatives two different strategies have been considered: the first one is to reuse the rainwater for WC cassettes within each lots; the second one is to reuse greywater for the same scope.
Considering the effectiveness of the application of water saving devices and the low cost of investment, the option has been considered in both the alternatives. This option is already provided by the NTA of the POC-PUA of Lazzaretto, even if it is not compulsory but only suggested without precise indications on what device need to be applied.
About the mitigation of the **runoff due to heavy rainfall**, the existing masterplan envisaged first flush tanks and other retention facilities to provide a storage volume of about **225 m^3/ha** of impervious surface. However, to reduce the flow to the Reno river downstream Bologna, our study did propose as optimum the value of **400 m^3/ha**, therefore additional **175 m^3/ha** should be provided to increase the retention capacity of the new development. Impermeable SUDS on main roads and parking have been considered in both the alternatives, together with the co-benefits available from other options in terms of hydraulic retention capacity.

Alternative n° 1

Alternative 1 for Lazzaretto area in facing the risks of climate change effect is comprised of:

- Drought: decentralized rainwater reuse for WC, water saving measure, and centralized greywater treatment & reuse
- Heat: watering for green area, centralized greywater treatment and reuse, and white roof (90% of the roof) & green roof (10%)
- Heavy rainfall: rainwater reuse for WC, impermeable SUDS on roads & parking, and green roofs (10% of the roofs)

Water saving measures

In order to reduce water consumption with efficient and low-cost equipment, water saving devices are one of the most reliable solutions. Water savings can be achieved by using various devices. However, it needs also behavioural changes in water consumption. Study shows that the application of the devices on taps and toilets in households decrease the water consumption up to 50% (EEA, 2002).

Rainwater reuse for WC

Rainwater reuse is intended to overcome the issues of drought, heat, and extreme rainfall. Rainwater collected from the roof and internal courts will be transported into gutters and pipelines, after a pre-treatment, to a storage reservoir, where it can be reused for WC flushing or other purposes especially when water is scarce. In the Lazzaretto masterplan, the rainwater collection system envisages 2 collection networks which are: (1) roofs & internal court and (2) roads & parking lots. We assume that the potential water source as rainwater will be collected only from the roof and the internal courts of building since the quality of water is better compared to those drained from roads and parking lots.
Potential recoverable water is estimated with the data of the total effective runoff surface and the total yearly precipitation in the area. In addition, total effective runoff surface is influenced by the total area of roofs and internal courts and their coefficients. For instance, the runoff rainwater from the roof is assumed equal to the 90% of the total rainfall. The result of reclaimed water available from the roofs and internal courts in total is 84,060 m^3/year.

Centralized greywater treatment

Centralized greywater treatment and reuse of the treated water for irrigation are proposed to reduce the impact of drought and overheating. Grey water are collected by a separate sewer (implemented mostly adding a pipe in parallel with the wastewater pipelines), pre-treated by simple static degreasers, piped into a treatment wetland to reach the reuse limits and then stocked in a reservoir (underground tank) to be stored to be pumped, when needed, into the watering network of the green areas.

Watering for green areas

Watering for green areas is intended to reduce overheating problem. Greywater is stored in underground concrete tanks and reused by a pumping system linked to an irrigation network. The pumping system is equipped with a UV disinfection unit to ensure the maximum safety in terms of hygienic-sanitary conditions.

White and green roofs

Other effective measures to overcome overheating issue are the implementation of white roofs and green roofs. Green roof stands as natural insulation to reduce and disperse heat absorbed by the building, instead white roof will help building to reflect back the heat with a high efficiency to the atmosphere.

The style of recommended green roof for the case study is the extensive roof. Comparing with intensive green roofs, the extensive green roofs use smaller plants and are also less cost to be spent for the construction and the maintenance. In addition, extensive roof's plant does not need much water because the type of the plant, increasing the lifespan and the sustainability of the system.

Impermeable SUDS on roads and parking

Sustainable Urban Drainage Systems (SUDS) are applied to reduce the peak flow generated by heavy rainfall. Parking

Alternative 1 - options	Option	Indicator	Cost (€)	O&M Cost (€)
Rainwater reuse for WC	6	12.5%	2 167 387.00	5 941.00
Water saving measures	7	20%	213 607.00	0.00
Watering for green areas	1		1 100 000.00	1 000.00
Centralized greywater treatment and reuse	4	60 000 m^3	1 334 187.00	14 949.00
White roofs (90% of the roofs)	2		0.00	0.00
Rainwater reuse for WC	6	2 760 m^3	0.00	0.00
Impermeable SUDS on roads and parking	8	2 463 m^3	419 825.00	4 647.00
Green roofs (10% of the roofs)	10	334 m^3	573 000.00	9 550.00
TOTAL			**5 808 008.00**	**36 089.00**

Table 2. Total cost of Alternative 1

lots and roads are considered to be the potential locations. Starting from parking lot, it is planned that both private and public lot will be modified in order to make it more sustai-

nable by creating bioretention area and swales for the flow of runoff to the first-flush tank.
In total, the overall hydraulic retention capacity of the SUDS applied in the parking lots and roads are **2463 m^3**. The cost of SUDS implementation is **€ 419,825.00**.

Total cost estimation of alternative 1
Based on all the technical solutions within the alternative 1, the total investment cost and O&M would be € 5.808.007,15 and € 36.088,11 consecutively (Table 2).
By improving the water facility in Lazzaretto with the technical options envisaged by alternative 1, the water consumption will decrease from 160 L/person/day to 108 L/person/day.
A considerable amount of water will be available during summer for watering the green public areas.
The additional retention volume is about 5600 m^3, about 170 m^3/ha, increasing the total retention capacity of Lazzaretto to about 400 m^3/ha.
For alternative 1, the additional climate change adaptation cost for water and green aspects is only 1% of total cost or is equal to 6.8% of urban infrastructure cost of Lazzaretto.

Alternative n°2
Alternative 2 solutions for Lazzaretto area in response of climate change issues are as following:
- Drought: decentralized greywater reuse for WC, water saving measure, and water sensitive re-design of green areas
- Heat: watering for green area, white sensitive re-design of green areas, and white roof (95% of the roof) & green roof (5%)
- Heavy rainfall: water sensitive re-design of green areas, impermeable SUDS on roads & parking, and green roofs (5% of the roofs)

Decentralized greywater reuse for WC
In this option we have considered the reuse of greywater within each lots for WC reuse, instead of the rainwater harvesting as per alternative n°1.
The treatment scheme is similar to the centralized option in

alternative 1: the greywater collected by the separate pipes already provided by the Lazzaretto design are pre-treated by simple degreasers, piped into a treatment system to reach the reuse limits and stored in reservoir from which the treated water will be pumped into the dual network that feeds the WC cassettes.
Constructed wetlands (CW) will be built in the building internal courts to treat the greywater to be reused inside the buildings. CWs are most effective and less costly than compact systems for greywater treatment (such the SBR Hansgrohe Aquacylce available on the Italian market), and can be easily integrated in the urban design of green and common areas; however the application of a compact system could also be considered in the cases where some difficulties can be created by the allocation of the CWS in the internal court.
To achieve the expected water quality for WC reuse (BOD < 10 mg/l), in order to supply 228 m^3/d for WC cassette, the total area of constructed wetland will be 4850 m^2 and storage tank has to be 684 m^3.

Water sensitive re-design of green areas
Green areas layout has been re-designed d to include water bodies with both landscaping and storage functions. The main issue is that the sewer level is lower 2-3 m than the ground level: considering that Lazzaretto is mostly plain, it is difficult to divert all the rainwater by gravity towards the green areas.
In the northern park, a modification of the rainwater network could help to collect the rain water from the nearest lots into 2 lakes. It is possible also for the south green areas to divert some rainwater by gravity. In the western park, however, the only possibility is to provide a pumping station that feeds the lakes with the water collected by the existing rainwater network (ideally the events with low intensity < 10 mm/h).

Watering for green areas
Watering for green areas is proposed for both alternatives. However, alternative 1 assumes that irrigation will be provided by treated greywater, that can provide 60.000 m^3/y

and allows to irrigate up to 20 ha, while in alternative 2 the irrigation water comes from rainwater stored in the water basins located in the park. In case of very dry summers that total amount of available water will be 27,000 m^3/y, and the total irrigated area will be only 9 ha.

White and green roof

To overcome overheating problem, 2nd alternative will apply less area of green roof compared to alternative 1: 5% of green roofs and 95% of white roof. The cost of the construction of the green roof is estimated about 60 €/m^2, while the cost of white roof will be 22 €/m^2.

Cost estimation

Alternative 2 - options	Option	Indicator	Cost (€)	O&M Cost (€)
Dec greywater reuse for WC	5	20%	2 565 119.43	17 601.67
Water saving measures	7	20%	213 607.09	0.00
Watering for green areas	1	28 050 m^3	585 000.00	467.50
Water sensitive re-design of green areas	3		1 082 909.98	9 680.00
White roofs (95%) - green roof (5%)	2		0.00	0.00
Water sensitive re-design for green areas	3	2 340 m^3	0.00	0.00
Impermeable SUDS on roads and parking	8	2 467 m^3	425 425.00	4 647.50
Green roofs (5% of the roofs)	10	143 m^3	286 500.00	4 775.00
TOTAL			**5 158 561.49**	**37 171.67**

Table 3. Total cost of Alternative 2

From all the measures recommended in the alternative 2, the total investment cost and O&M would be € 5.158.561,49 and € 37.171,67 consecutively (Table 3).

The technical solutions in alternative 2 allows Lazzaretto to have a water consumption of only 89 L/PE/day, performing a 45% reduction from the current water consumption (160 L/PE/day). However, it has less amount of water available during summer for watering green areas compared to alternative 1.

The additional retention volume is about 5000 m^3, i.e. 150 m^3/ha, increasing the total retention capacity of Lazzaretto

to about 380 m^3/ha. But the most interesting aspect is that in parallel with the achievement of this result, the measures provide additional benefits with the introduction of green infrastructures in the urban development; especially the large ponds can provide a higher contribute to evapotranspiration than the constructed wetland systems for greywater reuse provided in alternative 1 in the parks, balancing the less water destined to the watering of the green areas.
For alternative 2, the additional climate change adaptation cost for water and green aspects is only 0.96% of total cost or is equal to 6% of urban infrastructure cost of Lazzaretto.

Multicriteria Analysis of the two alternatives
The two alternatives have been submitted to a Multi Criteria Analysis (MCA), that allows preferences to be quantified, where variables with different units are involved. One widely accepted framework for standardising different units is the value function approach (Nijkamp & Beinat, 1998).
Defining the value function requires measuring preference, or the degree of satisfaction produced by a certain alternative option for a measurement variable (indicator).
To determine the satisfaction value for an indicator a few preliminary steps have to be guaranteed (Alarcon et al., 2010):
1. Definition of the orientation (increase or decrease) of the value function.
2. Definition of the points corresponding to the minimum (Smin, value 0) and maximum (Smax, value 1) performance/satisfaction.
3. Definition of the kind (ordinal or cardinal) and of the shape (linear, concave, convex, S-shaped) of the value function.
4. Definition of the mathematical expression of the value function.

Definition of the criteria and the weights
The assessment logical framework has been set up on four "macro" criteria:
• Costs
• Administrative feasibility
• Social acceptability

Intensity of impact	Score
Significant changes compared to the original design that may require procedural burden	0
No changes compared to the original design	5

• Effectiveness on key climate risk
The "Costs" criterion it is expressed by 2 attributes:
• Capital costs (CAPEX)
• Operation and maintenance costs (OPEX)
The value functions for the CAPEX and OPEX attributes are: (1) negative orientationl; (2) with absolute maximum and minimum values, which are assumed equal to the 10% and the 5% of the total costs estimated for the urban infrastructure of the Lazzaretto area, respectively (3) cardina; (4) with a linear shape and mathematical expression.
The **Administrative feasibility** criterion has only one attribute defined as "Coherence with the existing design and compatibility with the on-going administrative procedure", with the evaluation done by expert judgment.
The value function for this attribute has been built on an ordinal scale of 5 classes, with positive orientation and linear shape, as follows:

Intensity of impact	Score
Management of part of the rainwater collection and greywater treatment systems rely on final users	0
All management is public or in charge to a collective body	1

The **social acceptability** criterion has 2 attributes:
• Open water surface (considered as source of nuisance by the local community)
• Management burden on the final users
The "Open water surface" attribute is evaluated with the square metres open water area foreseen by the alternative and with the following value function: (i) negative orientation; (ii) with relative maximum and minimum values, i.e. equal to the maximum and minimum values among those calculated for all the alternatives; (iii) cardinal; (iv) with a linear shape and mathematical expression.
The "Management burden on the final users' attribute is evaluated by expert judgment. The value function for this attribute has been built on an ordinal scale of 2 classes (ty-

pical “yes or no” condition) with positive orientation as follows:

Finally, the **Effectiveness on key climate** criterion has 3 attributes:

- Hydraulic risk reduction
- Heat reduction
- Drought

The “Hydraulic risk reduction” is evaluated on the basis of the contribution to store runoff locally (storage volume), expressed in mc per hectare of impervious surface. The value function of this attribute is: (1) positive orientation; (2) absolute maximum and minimum values, which are assumed equal to 175 and 75 m^3/ha or additional retention volume on the basis of the volume necessary to reach 400 m^3/ha and 300 m^3/h in Lazzaretto considering the retention volume provided by the current design; (3) cardinal; (4) with a linear shape and mathematical expression.

The “Heat reduction” is evaluated in terms of available volume for watering (m^3). The value function of this attribute is: (1) positive orientation; (2) absolute maximum and minimum values, which are assumed equal to 60000 m^3 and 20000 m^3 respectively (considering the maximum and minim volume per ha 3000 and 1000) necessary to the watering of 20 ha during summer; (3) cardinal; (4) with a linear shape and mathematical expression.

The “Drought” attribute is evaluated from the water consumption per capita (l/day per person) designed for the two alternatives. The value function of this attribute is: (1) negative orientation; (2) absolute maximum and minimum values, which are assumed equal to 160 l/day/pe (i.e. the current average water consumption for the Bologna municipality) and 80 l/day/pe (i.e. an estimation of the best performance achievable), respectively; (3) cardinal; (4) with a linear shape and mathematical expression.

The **weights for the attributes** were given on the basis of the feedback of the several stakeholders during the meetings and the workshops of the project, and considering the final judgment of the experts involved in the study and of the Bologna municipality technical office; they are resumed in the following table. The weights of the cost attributes highlight a greater interest to favour lower OPEX in com-

Attribute	Relative Importance	Weight
COST		
CAPEX	5	0.33
OPEX	10	0.67
Total	**18**	**1.00**
SOCIAL ACCEPTABILITY		
Open water surface (considered as source of nuisance by the local community)	2	0.40
Management burden on the final users	3	0.60
Total	**5**	**1.00**
EFFECTIVENESS ON KEY CLIMATE RISKS		
Hydraulic risk reduction; Contribute to store runoff locally (storage volume)	4	0.20
Heat reduction; available volume for watering	8	0.40
Drought; water consumption per capita	8	0.40
Total	**20**	**1.00**

parison to lower CAPEX, in order to have a lower impact on the yearly future expenditures of the municipality and the citizens. The weights of the social acceptability attributes shows a slightly higher interest to the management of final users instead of the open water surface extension; this is due to higher risks expected if the management of the systems is requested by the private sector. In terms of effectiveness on key climate risks, the municipality has given a lower importance to the hydraulic risk reduction since the city currently faces a low risk of flooding, thanks to the spillway pipe discharging in the Reno River and the flood retention capacity of the sewer network.

FINAL INDEX			
Ojectives / Criterias	**Relative Importance**	**Weight**	**Weight (%)**
COST	7	0.32	32%
Administrative feasibility	3	0.14	14%
Social acceptability	2	0.09	9%
Effectiveness on key climate risks	10	0.45	45%
Total	**21**	**1.00**	**100%**

Also the **weights of the criteria** were given by the stakeholders of the Bologna municipality and are resumed in the following tables. From the values is clear the interest of the municipality of Bologna to the effectiveness on key climate risks, i.e. the main aim of the project, which was evaluated with the maximum rank. The second most important criterion resulted the COST since the building costs for Lazzaretto are already high and it is important to limit additional costs for climate risk adaptation. Both administrative feasibility and social acceptability received a low rank since the solutions proposed are considered generally feasible and acceptable.

EFFECT MATRIX

Criteria	Attribute	Unit	Orient.	A_1	A_2
Costs	CAPX	€	down	5 808 007	5 158 561
	OPEX	€/year	down	36 088	37 172
Administrative feasibility	Coherence with the existing design and compatibility with the on-going administrative procedure	-	up	3	4
Social acceptability	Open water surface	m^2	down	0	12 100
	Management burden on the final users	-	up	1	0
Effectiveness on key climate risks	Hydraulic risk reduction;	m^3/ha	up	168	150
	Heat reduction; available volume for watering	m^3	down	60 000	28 050
	drought; water consumption per capita	l/daypers	up	108	96

Results of the MCA

The **effect matrix** is built on the basis of prediction of the effect methodology described in the previous section and it is following reported. Note that the attribute of management burden on final users was judged by expert equal to 0 for alternative 2 since this alternative foresees an autonomous management of the grey water recovery by the inhabitants of each lot.

On the basis the defined value functions, each attribute was normalized to a value from 0 (worst rank) to 1 (best rank) building the **evaluation matrix of attributes** reported in the following table.

Using the given attribute weights the normalized attributes has been aggregated, building the e**valuation matrix of the criteria**, in which each criterion has a rank from 0 to 1. The **final rank** is obtained aggregating the normalized ranks for criteria with the criteria weights given by the Bologna municipality.

EVALUATION MATRIX OF THE ATTRIBUTES			
Criteria	**Attribute**	**A_1**	**A_2**
Costs	CAPX	0.63	0.79
	OPEX	0.38	0.36
Administrative feasibility	Coherence with the existing design and compatibility with the on-going administrative procedure	0.60	0.80
Social acceptability	Open water surface	1.00	0.00
	Management burden on the final users	1.00	0.00
Effectiveness on key climate risks	Hydraulic risk reduction;	0.93	0.75
	Heat reduction; available volume for watering	1.00	0.20
	drought; water consumption per capita	0.65	0.80

The best alternative according to the MCA analysis is the **Alternative 1**.

Conclusions

Even if the cost ranking of the two alternatives is comparable, alternative 1 fit much well than alternative 2 the targets of the study, that are the adaptation to main climate risks of the climate change. Other factors that have conditioned the final ranking in favour of Alt n°1 are: - the absence of large ponds in alternative 1 (that during the several meetings have been considered as a potential risk in term of social acceptability and as a concern about their maintenance cost during extreme dry periods); - the most simple approach and familiarity of the final users towards the decentralized rainwater harvesting and reuse in comparison with the decentralized reuse of greywater within the lots.

EVALUATION MATRIX OF THE CRITERIA		
Criteria	**A_1**	**A_2**
Costs	0.46	0.50
Administrative feasibility	0.60	0.80
Social acceptability	1.00	0.00
Effectiveness on key climate risks	0.85	0.55
FINAL RANK	**0.71**	**0.52**

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The book - Activating Public Space - deals with the regeneration of the public realm from different points of view, with the main purpose of optimizing its social, functional, technological and energetic requirements.
Under this premise, the text aims at identifying intervention strategies that, in addition to satisfying the basic needs for fruitive, aesthetic and safety qualities, address the environmental compatibility for an outdoor comfort upgrade.
For this purpose, the authors' group analyses different scales ranging from the global climate macroscale analysis, the mesoscale for the urban analysis and ultimately to the microscale for the local and pedestrian comfort analysis.
In light of the complex relationship between climatic, social and urban conditions, the text aims to enhance awareness on the urban requalification practices, and proposes interventions that address microclimate mitigation, urban resilience, process, and social innovations as an adaptive approach to compensate extreme heat waves and health risk conditions.

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