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Climate resilient cities. Introducing two complementary projects' approaches to mitigate the negative impacts of climate change.

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Highlights

- Developing adaptive solutions to reduce climate change risks
- Increasing the preparedness of decision makers to cope with climate change issues
- Implementing Urban Living Labs as innovative environments for learning, producing and sharing knowledge, and developing resilient solutions
- Stressing the positive impacts of Ecosystem Services and Blue and Green Infrastructures on urban systems and human health
- Understanding wastescapes as a resource for implementing Ecosystem Services

Abstract

The risks related to climate change for urban settlements are referred, among others, to extreme weather phenomena as pluvial flooding and heat weaves. In the urban context, certain areas suffer more than others when an extreme climate event happens, having negative effects on the built environment and human health. Thus, exploring solutions to mitigate negative impacts of climate change is an urgent need for urban planners, architects and decision makers. This paper is aiming to introduce possible approaches and tools to identify adaptive solutions to reduce climate change risks, and also to increase the preparedness of decision makers to cope with these challenges. To do so, this paper, at first, introduces the problem, looking at it through the developing paradigm of Ecosystem Services and Blue and Green Infrastructures positively impacting on urban systems and human health; then it stresses the potentialities of the methodology of Urban Living Labs as innovative environments for learning, where to produce and share knowledge about the topic and developing related solutions. Then, it introduces two complementary projects' approaches belonging to the ongoing research program of the Department of Architecture of the University of Naples Federico II, in Italy, to cope with climate change issues. Finally, together with the identification of the strengths of the two experiences, this paper discusses to what extent the Urban Living Lab approach could be implemented in the further developments of the two projects, opening in this way to new possible perspectives of research.

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1. Introduction

Nowadays, climate change is an undeniable fact worldwide (European Commission, 2015; IPCC, 2014; 2019); studies and researches have been proving, through scientific evidence, that climate change is producing diverse harmful effects on urban and human health (McMichael, Woodruff & Hales, 2006; Orimoloye et al., 2019).
The risks related to climate change for urban settlements are referred to extreme weather phenomena as pluvial flooding and heat weaves; both are reduced or worsened due to the morphology, spatial structures and characteristics, as well as due to the functional qualities of both buildings and open spaces. It has been shown that, in the urban context, certain areas suffer more than others when an extreme climate event happens (D'Ambrosio & Leone, 2017). Thus, when severely high temperatures are registered, the phenomenon of Urban Heat Island (UHI) can be observed; this shows that certain urban areas are suffering more from higher temperatures if compared with others which are located close by; UHI can be exacerbated by heat waves which happen more often, due to climate change (Brown et al., 2018).
By building on the methodology developed in the project 'REPAiR: REsource Management in Peri-urban AReas: Going Beyond Urban Metabolism' (see more at: http://h2020repair.eu/project-results/) and on further literature review (e.g. Steen, K., & van Bueren, E., 2017a, 2017b), in this paper, we propose the Urban Living Lab (ULL) methodology as a tool to overcome possible knowledge gaps about climate change issues. ULLs are presented as environments where to develop a common understanding of climate change risks and where to co-create shared and sustainable eco-innovative solutions and adaptations to reduce urban vulnerability to climate change.
To do so, this paper is structured as follows: firstly, it explores, how to mitigate the negative impacts of climate change. From a theoretical point of view, the positive impacts of Ecosystem Services (ES) and Blue and Green Infrastructures (B&GI) on urban systems and human health are introduced. Secondly, it explores the potentialities of ULLs as co-creation platforms for learning, where to co-produce and share innovative knowledge about the development of adaptive solutions to mitigate the negative impacts of climate change.
Then, the paper shows two different research programs carried out at the Department of Architecture of the University of Naples Federico II, to define both spatial and socio-ecological adjustments to climate change, understood as a 'wicked problem' (Termeer et al., 2016). The first one is "PLANNER" (Piattaforma per LA gestioNe dei rischi Naturali in ambiEnti uRbanizzati, Programma Operativo Regionale POR CAMPANIA FESR 2014/2020, responsible authority STRESS Scarl - Sviluppo Tecnologie e Ricerca per l'Edilizia Sismicamente Sicura ed ecosostenibile), and it focuses on how the preparedness of decision makers in hazard situation can be facilitated and improved through the use of a technological platform. PLANNER is developing a platform for facilitating the management of natural risks in urbanized environments, based on the environmental, and socio-economic characteristics of the contexts investigated. The second study case explores how, through 'research by design' (Roggema, 2017), the planning process for the Municipal Plan of Volturara Irpina (AV) implements adaptive solutions to mitigate climate change related problems with the purpose to improve the resilience of urban systems. Finally, both projects are discussed into the framework of ULLs to highlight to what extent this methodology could be helpful to structure more sustainable planning processes leading to the implementation of innovative solutions. In agreement with this interpretation the conclusions stress the strengths and the weakness of the two experiences, and open to new possible research perspectives.

2. Background

2.1 The influence of climate change on urban and human health

Hazards related to climate change are involving urban settlements directly, as well as having specific health impacts. The main effects are – at the same time – generated from, and they produce relevant effects on, urban settlements (United Nations, 2019), which are not always resilient to disturbances.
Studies on the capacity of the territory to adapt to, and thus to cope better with climate change effects are becoming increasingly relevant in the scientific debate. Recently, in the urban planning field, ES are emerging as a new paradigm to develop an innovative approach able to take into account simultaneously environmental, functional and societal issues, and to assess the effects of climate change on urban settlements (European Commission, 2016). In this sense, the knowledge about the connection between human and ecosystems' health has been increasingly explored in the last years (Wolch, Byrne & Newell, 2014) toward the identification of adaptation strategies. "From an ecosystem perspective, enhanced or human-induced climate change resulting from human population increase, rapid urbanisation and fossil-fuel-based industrialisation is both a consequence as well as a driver for further ecosystem responses and urban environmental change" (Kearns et al. 2014, p. 54). This is an issue discussed at different levels, locally, nationally and internationally, focusing on the importance to put at the centre of the debate the human right to both health and healthy environment (Carlarne & Depledge, 2019). In fact, the European Union is engaging with climate change by providing directives and measures to reach the objectives related to climate, linked with the ones with energy, already by 2030; eventually, by 2050, there is the aim for Europe to become "the world's first climate-neutral continent" (European Commission, 2020).
There is great interest for this theme in the scientific disciplines, even if, only recently, it has been gaining attention for the fields of studies of urbanism and architecture, which aim to measure the impacts of climate change at different scales (D'Ambrosio & Leone, 2017). Therefore, this paper is aiming to introduce ULLs as a possible approach to improve the knowledge related to the identification of adaptive solutions aimed to mitigate the negative impacts of climate change. Moreover, it outlines how in ULLs strategies to improve the preparedness of decision makers to cope with climate change issues could be developed.

2.2 Ecosystem Services and Blue & Green Infrastructures to cope climate change

Ecosystem Services (ES) are affirming as a new paradigm and approach to systematize the different fields which compose urban settlements – buildings, infrastructures, services, facilities, environmental and people (Andersson et al., 2015; European Commission, 2011; Geneletti et al., 2020; UK National Ecosystem Assessment, 2011). In the planning field, the approach regarding ES starts from a nature-based point of view, which focuses on the mode of operation of natural cycles, underlying, at the same time, the importance of efficiency and efficacy of systems (Kabisch et al., 2017). Moreover, ES can contribute to change the approach to the evaluation of urban performance, considering both the demand and supply of environmental quality (Giaimo & Barbieri 2018; Cortinovis & Geneletti, 2018). Since its first definition by Millennium Ecosystem Assessment (2005), in which benefits obtained from ES are split into provisioning, regulating, supporting and cultural services, ES linked benefits to beneficiaries introducing a new point of view – which we call 'customer oriented' nowadays (Cortinovis & Geneletti 2019) – oriented to the beneficiaries rather than to the territories capacity to product and to use ecosystem goods and services.
The widespread classification of ES into different categories (Haines- Young & Potschin 2018) – provisioning services, regulating and maintenance services, and cultural services – helps to understand the importance of ES into planning processes and their potentialities to embed climate change adaptive solutions. The provisioning and regulating services can be considered the most important to produce efficient results for the reduction of climate change effects because they are linked to goods or energy output from ecosystems. Cultural services provide complementary benefits for health quality such as spaces for recreation, for mental and physical health care, tourism services. Benefits provided by ES can be more visible when ES are interrelated with urban design of public spaces.
Green Infrastructures (GI) – defined by the European Commission (2013, p. 7) "as a strategically planned network of high quality natural and semi-natural areas [...], which is designed and managed to deliver a wide range of ecosystem services [...]" – are a possible solution to implement ES approach and urban quality. In fact, GI integrate natural, artificial or hybrid solutions to protect biodiversity, to provide multiple, complementary landscape functions and to improve quality on both rural and urban settings (Ahern, 2011; European Commission, 2013). GI benefits can produce more relevant advantages if they are integrated with the ones implementing by 'Blue' Infrastructures (BI). This concept was introduced, since the early millennium, in relation to the need to keep and manage freshwater and coastal-marine ecosystems (Frischenbruder & Pellegrino, 2006). The main purposes of BI are related to the

reduction and management of flooding risk; BI are based on techniques which include the range of nature-based solutions able to store, infiltrate, or evapotranspirate stormwater and to reduce surface waters flows or ones to sewer systems (Environmental Protection Agency, 2016). ES are useful to identify and assess multiple functions and benefits provided by Blue and Green Infrastructures (B&GI) (Ahern, Cilliers & Niemelä, 2014): in fact GI are multifunctional and can function at multiple scales while BI work on stormwater management and natural cycles regulating.
B&GI have different functions and provide different benefits in relation to the referred spatial scale to which they operate (Environmental Protection Agency, 2016). They provide habitat and flood protection, increase biodiversity, improve air and water quality, reduce noise and atmospheric pollution and soil waterproofing, regulate microclimate, link natural areas and restore natural cycles (as water cycle or biotic cycle). At the county or city scale, the main advantages of B&GI consist in linking fragmented natural areas with high or potential levels of biodiversity, or in environmental restoring of railways networks fallen into disuse or in improving services provided by roads and streets buffer zones. At urban, neighbourhood or site scale, B&GI projects aim to pursue two main goals: on the one hand, they allow to interpret public services guaranteed by law, known as urban standards (Giaimo, 2020), according to a new perspective; on the other hand, they allow to manage problems related to stormwater runoff, one of the main effects of climate change on urban settlements (Sgobbo, 2018). At the urban scale, main functions of B&GI projects are public-collective spaces restoration and their quality improvement, green and sociality spaces increase, whole water, waste and energy cycles sustainable management.

3. Urban Living Labs as a methodology to achieve climate resilient cities

Urban Living Labs are innovative platforms for learning and developing knowledge, where eco-innovative solutions and strategies about complex urban issues are developed in co-creation processes with the involvement of a wide range of stakeholders. ULLs have the aim to develop innovation by producing and exchanging knowledge to increase urban sustainability; ULLs innovate not only products but also processes by involving private and public actors and knowledge institutes in co-creation dynamics: all stakeholders involved in the co-creation real-life settings of the ULLs have the same decision power (Steen & van Bueren, 2017a).
In ULLs it could be experimented how to cope with the wicked problems related to climate change, toward the transition to sustainable and resilient cities. Through this lens, ULLs could be understood as fertile arenas where to produce and share innovative expertise. In fact, ULLs are emerging as experimental environments "for reflexive, adaptive, and multi-actor learning environments (in which) collaborative ways to tackle wicked urban issues, such as today's sustainability challenges" (Puerari et al., 2018, p. 1.) are explored. Moreover, ULLs have been defined as a "transition arena" and "a multi-actor governance instrument" which has the aim to achieve sustainability goals through the engagement of many participants who co-create solution which aim to generate innovation. (Sharp & Salter, 2017; Steen & van Bueren, 2017b). They are "protected spaces" for conducting experiments and developing knowledge for the management of urban sustainability transitions (Sharp & Salter, 2017).
ULLs methodology - defined e.g. within the REPAiR project, - identifies five phases which compose the co-creation process: co-exploration, co-design, co-production, co-decision, and co-governance (REPAiR, 2018). Each one of these phases is strictly related to one or more Models of the Geodesign Framework developed by Steinitz (2012), and thus linked to the six geodesign questions (for more information about the phases see the REPAiR 2018). It is important to stress that each one of the phases informs and it is informed by the other one, so constituting an iterative process which could last as long as the Living Lab lasts.
Benefits of the implementation of ULLs for solving wicked problems related to climate change could be: (i) combining of different kinds of expertise to find more appropriate ways to cope with complexity "exploring visions, possibilities, and finding agreements between the different parties involved" (Puerari et al., 2018, p. 2); (ii) encouraging the "ownership of the problem through stakeholder participation and transparency" (Perry, 2015, p. 3); (iii) producing of "social learning, experimentation and a level of empowerment, leading to real changes in participants' lives" (Sharp & Salter, 2017, p. 9) due to the wide participation of stakeholders; (iv) generating a process innovation: in ULLs "existing constellations of urban actors" collaborate following novel methodologies to "create more collaborative and experimental ways of 'doing' urban development" (Voytenko et al., 2016, p.53); (v) implementing innovation in governance: ULLs "are doing more than simply fostering learning and innovation, they are part of the ways in which urban responses to sustainability challenges are governed" (Bulkeley et al., 2016, p. 16).

4. Exploring two complementary projects' approaches for climate resilient cities

Through the analysis and the description of their specific techniques, two complementary projects' approaches for achieving climate resilient cities are presented in this part of the paper: PLANNER project and Volturara Irpina draft Municipal Plan.
The main phases and actions of the two projects related to cope climate change are highlighted to explore to what extent it is possible to implement the Urban Living Lab methodology as an additional step to be followed which could allow further developments in the political and technical approach to solving climate change issues for these projects.

4.1 Supporting decision makers in understanding and coping with climate change issues. Tool and technological innovation of the project 'PLANNER'

The project 'PLANNER' is prototyping a GIS Platform for the management of natural hazards in urbanised contexts namely 'Spatial Decision Support System SDSS'. This project has the aim to realise a tool which could support decision makers in relation to environmental hazards such as seismic risk, and heat weaves related to climate change, by providing a complete kit of instruments. These will be methods and technological solutions which could support urban planners and decision makers in the evaluation, management and coping of issues related to the abovementioned hazards, and towards an improved resilience. The project adopts a methodology and hierarchical model for the assessment of the climatic vulnerability of the urban system (Di Martino & Sessa, 2017) focusing on: vulnerability, exposure and impacts. At first the identification of the degree of vulnerability, and the level of danger for urban contexts, with specific reference to open spaces and buildings. Secondly, the project is developing short, medium- and long-term impact scenarios of risk for sample urban areas for developing resilience. Specifically, PLANNER has the aim to build a complete set of vulnerability indicators for building and open spaces, identifying the weaker sectors of the population which is potentially exposed to the risk.
This platform is based on a WEB-GIS technology, in which different informative layers are combined in one SDSS based on the geo-spatial characteristics of the study area. Through it, it is possible to implement models for the evaluation of scenarios of risks in relation to natural hazards.
To do so, different databases are used about: (i) the environmental characteristics of the case study (e.g. morphology and geology); (ii) the characteristics of the built environment (e.g. buildings' typologies, age of constructions, and state of maintenance); (iii) the characteristics of the socio-economic contexts.
The models of evaluation of the vulnerability of the urban system in relation to natural hazards will explore the climate vulnerability of Naples and Avellino as pilot studies, at different scales and through their physical, technological, environmental and social characteristics. Eventually, a database including technical and design solutions will be developed, contributing to the identification of a model for the evaluation of scenarios of climate resilience for a sample area. On the one hand, the project identifies long term actions towards a strategic preparedness to identify priorities in any risk situation for specific contexts; on the other hand, it works on short term actions for early warning and managing emergencies (STRESS, 2018).

4.2 The role of Green and Blue Infrastructures in the case study of Volturara Irpina

The draft Municipal Plan for the Municipality of Volturara Irpina, located in Campania Region, in the province of Avellino, proposes different objectives and actions to purse environmental, economic and urban development strategies. Both of them aim to be adaptive and prone to cope with climate change issues; the draft plan intends to integrate productive processes with natural cycles,

to switch from a fragmented development model to an integrated one. The main integrated issues are the ecosystem services strengthening the landscape fruition of the territory, the increase of touristic supply linked to landscape and local gastronomic products, the completion of facilities and public spaces (Arena & Nigro, 2017).
The draft plan is structured on a place-based approach (Magnaghi, 1994; 2007; 2010): through the depth knowledge of the territory, strengths and weaknesses are shown and strategic solutions are developed to switch threats into opportunities. The main territorial peculiarity of Volturara Irpina, located on the northern side of the Picentini Mountains, in the province of Avellino, in south of Italy, is the Dragon Plain, a plateau of 4300 ha, which is characterized by being a closed watershed and on which edges the town center was born surrounded from the slope of mountains. The rainwaters coming from the mountain systems are collected and flow through the karstic sinkhole "Mouth of the Dragon", feeding the springs of territories located several kilometres faraway (Ragone, 1973). During periods of heaviest rainfall, usually in autumn and winter, the sinkhole fails to drain excess water, which accumulating in the plain forming a temporary lake, iced also, which can reach a size of 200 ha. The depth knowledge of this local resource, pursued by direct and indirect survey, allowed to define strategic solutions to integrate natural and artificial services and to improve environmental and urban quality.
Dragon Plain is a relevant opportunity from a landscape and touristic point of view but also an important resource to learn from nature the stormwater management, a relevant issue nowadays. Nowadays, because of global warming, winter temperatures are not so cold to ice the water and create the lake. Artificial works, with the B&GI realization (Depietri & McPhearson, 2017) can increase the water quantitative collected, restoring the characteristic lake, even if not iced. The new draft urban plan provides, among different strategies and actions, for the completion of infrastructures system (i) to restore and to improve natural cycles, (ii) to connect existent streets along the plain and the landscape ways along the slopes and (iii) to define urban morphology. A new system is designed as a B&GI including stormwater management solutions, whit the aim to integrate benefits of local natural features with artificial nature-based solutions. In fact, according to ecological restoration approach (Moccia, 2014), the design follows the traces of a tombed river brought to light through artificial reproduction where a natural restore of riverbed is damaging from economic and urban point of view. At the same time, the rebuilding and upgrading of drainage system allows to increase the carrying capacity of river and to improve the stormwater runoff management; the river runoff towards the plain naturally and supplying the temporary lake. Finally, the G&BI is designed through the urban regeneration of the central area using residual without function spaces allowing to complete public services, still uncompleted, despite economic resources were guaranteed by substantial funds to rebuilding post-earthquake of 1980.

5. Discussion, conclusion and future perspectives

This paper explored how to cope with climate change related problems, which generates clearly visible phenomena as the improved frequency, intensity, and duration of extreme precipitations, urban heat island, heat and cool waves. First of all, it showed the potentialities of the implementation of ES in urban contexts which allows to fulfil different objectives: (i) integrating different benefits provided by different areas in function of territorial scale; (ii) introducing multifunctional spaces able to guarantee both urban and natural services; (iii) regenerating open spaces and buildings to complete urban morphology (Arcidiacono, Giaimo & Talia, 2018; Colavitti, Floris & Serra, 2020).
Secondly, this paper focuses on two research projects which, despite their innovative characteristics, display still some aspects which could be further improved to effectively cope with the wicked problem of climate change.
Thus, possible innovations about processes and product of spatial planning solutions could be suggested. Having explored the ULLs methodology, this paper suggests how adaptive solutions and strategies can be planned in the ULLs co-creation environments. In fact, to develop long term and sustainable solutions, it is important to involve a wide range of stakeholders, having the possibility to largely involve them in all the stages of the process, as done in the five phases of a Living Lab, and to positively affect their political agenda towards the actual implementation of the strategies and solutions.
Specifically, it could be noticed that the utilisation

in ULLs of the SDSS platform developed by 'PLANNER' has not been deepened yet. In fact, further experimentations for the involvement of different stakeholders at the different stages of analysing/understanding and of the design/evaluation phases could be an interesting and unexplored features for the project which could display positive effects in the development of shared and sustainable solutions. In fact, in 'PLANNER', the study of the benefits of implementing ULLs, to carry out novel collaborative methodologies for the design of solutions - for buildings and open space - to activate the needed transition towards a climate resilient city, remains still open. This is leaving space for further research on how the work developed in the collaborative environments of ULLs could lead to experimenting novel insights and knowledge as instance for the identification of target areas where to implement the solutions identified for the project, which could be for example underused open spaces to be transformed in green areas and biodiversity reservoirs. In this sense, stakeholders could, for example, point out and draw on the maps all the wastescapes (Amenta, 2019; Amenta & van Timmeren, 2018) which could represent a resource for implementing further ecosystem services, understanding land as resource.
Moreover, even if the Municipal Plan for Volturara Irpina could be considered a pilot case into an adaptive, resilience planning, nevertheless, it presents still some points of interest to be deepened. The main lack is related to the local dimension of the proposal. In fact, the actions introduced by the plan would have most positive results if they could be implemented into an inter-municipal or provincial planned network of B&GIs. To do this, a cooperation among neighbouring administrations, which could be also experimented in ULLs, would be desirable.
Another gap lies in the cost effectiveness of the proposed actions. Indeed, the state of conservation of public spaces is good nowadays, while B&GI realization requires structural works that inhabitants could probably not endure. However, the environmental and health advantages and externality produced will be most important than probable and practice problems. In this case, an opener participation of residents, which can happen in each stage of the ULL process, could lead to the definition of innovative actions which could allow to increase deep knowledge of opportunity and threats and to extend social agreement around public decisions, in according to a shared decisional process approach. The multidisciplinary nature of ULLs could facilitate such approach, brining at the same table urbanists, landscape architects, engineers, designers, citizens and so on.
Finally, possible perspectives of research are linked. On the one hand, B&GI planning – for improving the resilience of urban systems to climate change hazards and as assessment of urban quality in relation to ES – are understood as an outcome of contemporary research which can read and interpret urban settlements through relationship of both natural/artificial, and public/private spaces (Angrilli 2016; Arcidiacono, Giaimo & Talia 2018). On the other hand, B&GI planning are related to the measurement of benefits provided into the field of Water Sensitive Urban Design approach (Brown and Clarke, 2007; Wong, 2006) and the stormwater management.
Moreover, this article aimed to stress the importance of increasing the participation of stakeholders in co-creation processes, which emerged as a crucial element to define solutions and strategies which could be more easily implemented; moreover the application of ULLs methodology for facing climate change issues is able to make decision makers more aware of the problem and ready to react to disturbances related to climate extreme events. Furthermore, through this paper the importance to valorise every portion of land which is wasted, is stressed; indeed, wastescapes could represent a resource for implementing further ecosystem services.

Attributions

All the parts of this article have been written and approved by all the authors Libera Amenta (L.A.) and Antonia Arena (A.A.). In fact, both authors are involved in the two above-mentioned projects as part of their research teams. However, the §§ 1 and 5 are by L.A. and A.A.; the §§ 2.2 and 4.2 are by A.A.; the §§ 2.1, 3 and 4.1 are by L.A.

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