TeMA

Journal of
Land Use, Mobility and Environment

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THE RESILIENCE CITY/THE FRAGILE CITY. METHODS, TOOLS AND BEST PRACTICES

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SUSTAINABLE LAND USE AND CLIMATE ADAPTATION: A REVIEW OF EUROPEAN LOCAL PLANS

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ABSTRACT

Adaptation plans are the result of a political decision based on the awareness that climate change has altered environmental conditions and action is therefore needed in order to return to, maintain or achieve the desired outcome. A crucial role in defining adaptation actions is played by the use of resources, in particular of non-renewable resources such as soil. This paper, based on a sample of recent Italian and European adaptation plans, seeks to investigate the presence of actions aimed at guaranteeing a sustainable use of natural and non-natural soil, in order to minimize the consumption of non-anthropized soil andalso contribute to containing the effects of climate change.

The paper is divided into three sections: the first one describes the methodology employed; the second one focuses on the most up-to-date plans regarding the effects of climate change in some urban systems; the third one proposes hints for further reflections and useful recommendations to local decision-makers in the development of tailor-made adaptation actions aimed at guaranteeing an efficient use of both natural and anthropized soil.

The reading of the plans has exposed that soil consumption is not among the factors that need direct action to reduce the vulnerability of urban systems to current climate change, but rather it is a phenomenon that can be contained by increasing green areas and/or infrastructures and encouraging agricultural and environmental regeneration. The attention seems to be drawn to not yet sealed soil, thus leaving out the already anthropized one that, as such, would require, instead, greater adaptation efforts.

KEYWORDS:
Soil, climate changes, adaptation plans, overview, review.

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土地可持续利用与气候适应：欧洲规划回顾

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摘要

适应规划是基于认识到气候变化改变了环境条件的政治决策的结果，因而需要采取措施以恢复、维持或实现期望的结果。明确适应措施的关键作用是利用资源，特别是土壤等不可再生资源。
本文以近来的意大利与欧洲适应规划为样本，研究是否存在旨在保证天然与非天然土壤的可持续利用的措施，以使非人为化土壤的消耗降到最低，并且有助于遏制气候变化的影响。
本文分为三个部分：第一，描述所采用的研究方法；第二，聚焦在某些城市系统中有关气候变化影响的最新规划；第三，为当地决策者就旨在确保天然与人为化土壤的有效利用所量身定制的适应措施的发展提供进一步反思的线索与有用的建议。
这些规划的解读表明了土壤消耗并不是需要采取直接措施以减小城市系统对当前气候变化的要害/脆弱性因素之一，而是一种可以通过增加绿地和(或)基础设施以及鼓励农业和环境再生来遏制的现象。人们的注意力似乎只关注尚未封盖的土壤，而忽视了需要作出更大的适应努力的已经人为化的土壤。

关键词：
土壤；气候变化；适应规划；概览；回顾

1 SCIENTIFIC OVERVIEW AND OBJECTIVE

Climate on Earth has always undergone natural changes and so will be in the future. About 11.000 years ago, during the Holocene era, climate became progressively warmer and wetter thus determining more comfortable life conditions that facilitated the spread of flora and fauna and consequently the development of human activities (Gupta, 2004; Wanner, et al. 2008).

Nevertheless, in addition to these natural factors, others related to human activities arise. Over recent years, the scientific community has been investigating the rapid global warming phenomena that could potentially determine a 0.3 °C increase (at least) of global mean surface temperature by the end of the 21st century compared to the period 1986–2005 (IPCC, 2014a). This projection is related to the rate of greenhouse gases emissions caused by human activities that have increased by about 90% from 1970 (Le Que´re´et al., 2009; IPCC, 2014b) to 2011.

Even though modeling extreme weather events such as heat waves, floods, etc. may be difficult and the effects of climate change vary differently from one city to another (depending on place-specific micro-climatic, geomorphological, etc. charateristics), global warming is unequivocal and, as a result, many studies have focused on the urban scale.

In fact urban settlements are areas of high vulnerability mainly due to "a high concentration of 'elements at risk' to climate and weather impacts, such as people, critical infrastructure, and buildings" (Scatterthwaite et al., 2007; Reckien et al., 2014).

The vulnerability of urban areas can be due to three main factors: location, as they can be situated near the coast, mayor rivers, low-lying zones exposed to the risk of coastal erosion, flooding, sea-level rise, etc.; economy, as many activities and sectors can be weather-related; size, the biggest they are, the most aggregated risks they can have (Rosenzweig & Solecki, 2001; De Sherbinin et al., 2007).

According to several authors (Bigio, 2003; McEvoy, 2007; Wilby, 2007) who identified the main climate change effects on cities, these can be mainly resumed as follows:

- health: heat and cold mortality, food and water security and availability, increase of diseases;
- energy use: e.g. heating and cooling, energy price shock;
- accessibility and supply: critical infrastructure out of order;
- forced migration: e.g. due to disease, overcrowding;
- economic and fiscal crises: related to the concentration of economic activities;
- social instability.

In addition to the points listed above, the specific characteristics of each urban area can worsen both the climate change and extreme weather effects. For instance, focusing on the soil resource which is one of the research issues of this work, the high rate of non-porous surfaces can intensify the flood risk as a sealed soil is not able to retain large portions of atmospheric precipitations and hence contribute to regulating surface run-off (Whitford et al., 2001; Wood et al., 2005; Woods-Ballard et al., 2007). Indeed, it has to be considered that a natural soil can store up to 3,750 tons of water per hectare, or about 400 mm of rainfall and that the infiltration of rainwater through the soil should cause it to take longer to reach the rivers, thus reducing the flow rate and therefore the risk of flooding. Soil and artificial surfaces leaching by surface runoff waters also determines an increase in the solid load and the content of pollutants, causing a strong impact on the quality of surface waters and aquatic life (EEA, 2006; ISPRA, 2013).

The gradual expansion of urban areas and the consequent soil sealing causes less vegetal transpiration and an increase in the surfaces with a high heat refraction coefficient; moreover, the decrease of the evapotranspiration must be combined with the heat produced by the anthropic activities, determining the heat island phenomenon (EC, 2012).

These effects may have an even greater impact on the Mediterranean arid areas with consequent negative effects on human life (Salvati et al., 2011; Potchter & Ben-Shalom, 2013).

Soil is a fundamental natural resource for ecological balance and human labour productivity. However, a serious environmental problem detected in many parts of Europe is soil degradation caused by its improper use or poor management (European Environment Agency, 2006). The European Commission, on the basis of the Soil Thematic Strategy (COM(2012)46), carried out important research activities regarding land-take assessment and soil sealing monitoring (Joint Research Centre and European Environment Agency, 2012). According to Genske (2003) & Scalenghe et al. (2008), phenomena such as soil erosion, decline in organic matter, local and widespread soil contamination, sealing, compaction and salinization are the result of changes in the use of land that can adversely affect soil functions and ecosystem services (see, for instance, Sauer et al., 2011).

Furthermore, in the continuous effort to improve the resilience of urban areas and promote the integration of climate change issue into governance and planning practice, Europe has developed a Climate Change Adaptation Strategy in 2013 with the following three primary aims: encourage all Member States to adopt global adaptation strategies and their action plans, inviting them to make a commitment drawn on the model of the Covenant of Mayors and supporting them with funding useful to develop their adaptability; further promote adaptation in particularly vulnerable sectors such as agriculture; foster awareness in the decision-making process by addressing knowledge gaps in adaptation plans and increasing the European Climate Adaptation Platform (COM(2013) 216 final). The adoption of this strategy represents a further attempt of the European Community to lead the way towards sustainability and resilience to climate change at all levels (national and local) of territorial governance.

In particular, the adaptation plans provided are the result of a political decision based on the awareness that climate change has altered environmental conditions and action is therefore needed in order to return to, maintain or achieve the desired outcome (Parry et al., 2007). Everything should be renewed and redesigned to increase resilience, thus reducing the risk.

The adaptation should be undertaken and developed by the local authorities, as it is at the local level that the greatest impacts occur. Historically, efforts have focused more on mitigation but the challenge must be double (Blanco et al., 2009), that is to say, actions must be geared towards an integrated mitigation and adaptation perspective. A decisive role in defining these actions is played by the use of resources, as climate change will challenge the ability of the current reserve network to provide protection for biodiversity, to satisfy human basic needs and to carry out their ecosystem functioning (Lawler, 2009; Blanco et al., 2011). "For instance, changes in the global climate have a significant impact on local and regional hydrological regimes and processes, which in turn affect ecological, social and economical systems" (Lin et al., 2012). Protection of soil as a precious resource means being able to guarantee the functional capabilities of the land and, therefore, the ability to absorb water by infiltration in case of meteoric events and decrease the volume and speed of surface flow, improving water management in the event of floods that are much more frequent due to climate change. Furthermore, soil is the second carbon tank after the oceans, therefore ensuring a sustainable use of the soil means helping to reduce the presence of carbon dioxide in the atmosphere, with a consequent reduction of the greenhouse effect. Lastly, soils with a high content of organic carbon are more fertile and productive, more capable of purifying water and contribute to increasing the resistance capacity of livelihoods to the impacts of climate change. An exasperating soil sealing generates further negative effects on the quality of water, air and products consumed by both the population and animals, as well as on biodiversity and climate change. Preserving soil use by promoting, for example, interventions, such as green infrastructure, can represent an effective response to the impacts of climate change like flooding phenomena: "the climate adaptation benefits of green infrastructure are generally related to its ability to moderate the expected increases in extreme precipitation or temperature.

Benefits include better management of storm-water runoff, lowering incidents of combined storm and sewer overflows (CSOs), water capture and conservation, flood prevention, accommodation of natural hazards (e.g., relocating out of floodplains), reduced ambient temperatures and urban heat island (UHI) effects, and defense against sea level rise (with potential of storm-surge protection measures). The U.S. Environmental Protection Agency (EPA) has also identified green infrastructure as a contributor to improving human health and air quality, lowering energy demand, reducing capital cost savings, increasing carbon storage, expanding wildlife habitat and recreational space, and even increasing land-values by up to 30%" (Foster et al., 2011; Gargiulo et al., 2017).

The green infrastructure can provide more efficient and more flexible benefits compared to the "network of infrastructures and urban settlements, namely that system consisting of buildings and equipment connected by various types of linear infrastructures" (the so-called grey infrastructures, see Socco et al., 2008), as the improvement to adapt to the impacts of climate change.

In other words, soil and its vegetation contribute to mitigate and balance the local climate, regulating waterflows and energy between the Earth's surface and the atmosphere and storing large quantities of carbon. Conservation and sustainable soil management are therefore an important opportunity in the context of actions to be taken to mitigate and adapt to the effects of climate change and to offset emissions from fossil fuel consumption (Papa et al., 2016).

In this perspective, this paper proposes a reading of the most recent Italian and European adaptation plans in order to understand the effective role played by the containment of soil consumption in the choices of the urban setting and in the reduction of the negative impacts on climate change. There are many studies concerning the reading of successful tools and practices aimed at adapting to climate change, all of them faced in a broad and general way and at a supra-municipal level (Sovacool & Brown, 2009; Biesbroek et al., 2010; Baker et al., 2012; Carter, 2011; Reckien et al., 2014). The number of studies aimed at investigating the relationship between adaptation and specific components and/or characteristics of the urban system is lower than the above mentioned ones (Hamin & Gurran, 2009, Geneletti & Zardo, 2016).

The paper is divided in the following three sections: the first one describes the methodology employed; the second one focuses on the most up-to-date plans regarding the effects of climate change in some urban systems and the adaptation actions to be taken to contain soil consumption; the third one proposes hints for further reflections and useful recommendations to local decision-makers in the development of specific adaptation actions aimed at guaranteeing an efficient use of both natural and anthropized soil.

2 METHODOLOGY

This paper, through the reading of the adaptation plans of some Italian and European cities, seeks to investigate the presence of actions aimed at guaranteeing a sustainable use of natural and non-natural soil, in order to minimize the consumption of non-anthropized soil and also contribute to containing the effects of climate change.

It should be pointed out that the number of adaptation plans in force is still small, as they are "new" tools of territorial governance so far, which, together with the mitigation plans, define the actions to be implemented in order to reduce the risks to which the cities are subject because of the effects of climate change. In fact, on the basis of the national strategic guidelines, the cities have drawn up their own adaptation plans, since they have been affected – although in different ways - by the impacts of climate change in recent years.

The sample under investigation consists of 3 Italian and 5 European adaptation plans.

The choice of the Italian plans has been a rather simple operation, as the selected cities are the only ones to be provided with an existing adaptation plan. Having identified the Italian cities, the search for the related plan documents was carried out by consulting the websites of the municipalities chosen.

When the adaptation plan was not available online, local administrations were contacted directly. As for the choice of the European plans, the Covenant of Mayors for Climate & Energy platform was initially consulted. The platform was made available by the European Community in March 2011 and contains the initiatives and action plans adopted by the Member States to tackle the phenomenon of climate change. However, since these plans represent a rather recent initiative, those available on the platform are as yet very few and above all related to small municipalities (<5000 inhabitants). For the selection of foreign cities, the most vulnerable countries in terms of climate change and soil consumption have been identified, firstly, through the study of the National Adaptation Strategies (NAS); by the most vulnerable countries reference is made to those countries that since the publication of the Green Paper in 2006 began to develop the Strategies and update them over the years, and thus gaining a consolidated experience in terms of adaptation. Moreover, the Member States selected are also the ones that in their Strategies have referred to the soil sealing as one of the anthropic factors capable of increasing the negative impacts of climate change.

According to the most recent data (2016) by the European Environment Agency related to the Climate-Adapt platform, 29 EU Member States have already adopted a NAS: Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Lithuania, Luxembourg, Malta, Norway, Netherlands, Poland, Portugal, United Kingdom, Czech Republic, Romania, Slovenia, Spain, Sweden, Switzerland, Turkey, Hungary. In these countries, just some cities have drawn up the adaptation plan to climate change, but the ever increasing number of national strategies proves the awareness that climate-related extreme weather events are increasing in frequency and disastrous consequences, and the need for a concrete global climate policy that should encompass adaptation measures able to reduce and manage the risks associated with climate change.

In particular, Finland was the first European nation to develop a NAS in 2005, one year ahead of the 2006 Green Paper explicitly mentioning the need to reduce the use of non-anthropized soil.

“Better consideration of the impacts of climate change and natural conditions in general may require some adjustment to the planning principles applied to the use of areas and land. The damage risk posed by rains can be lowered by securing the capacity of drainage systems so that it corresponds to the heavy rains expected in the future. It will be possible to set restrictions and regulations for areas where flooding and a rising ground water level are expected in the future” (Finland’s National Strategy for Adaptation to climate change, 2005).

Other countries such as Serbia, Germany, France and Great Britain do not relate directly to the issue of soil consumption, but their strategies include numerous green infrastructure interventions to deal specifically with flood risk.

“There is a need to step up soil protection with regard to the risks of erosion and declining humus content, especially in hydromorphic soils. To avoid conflicts of objectives, the federal and the Länder authorities discuss and coordinate protection objectives and adaptation strategies for the soil with all stakeholders on a cross-departmental basis (agriculture, forestry and water management, nature conservation, atmospheric and climate research)” (German Strategy for Adaptation to climate change, 2008). With regard to natural risks, France was marked by the occurrence of large-scale floods, some of which severe and violent in the Mediterranean regions (Aude en 1999, Gard in 2002).

Worth mentioning is the episode of the floods of the Somme in 2001, which gave rise to a report by the Senate 1. However, according to several meteorologists and hydrologists, it is impossible to link the increasing number of these disasters to climate warming; some anthropogenic reasons, such as soil sealing, use of agricultural land, occupation of floodplains, etc., may provide a better explanation to these phenomena (Strategie Nationale d’adaptation au Changement, 2007). For each of these four countries have been identified the cities that have drawn up, in the last 10 years, an adaptation plan that would recall the phenomenon of soil consumption in relation to climate change. Another criterion for selection has been the availability of the adaptation plan in the English language.

In accordance with these criteria, the sample consists of five European adaptation plans. Once the sample was built, each plan has been carefully analysed to identify the most registered risks for that urban area and all direct and indirect actions linked to the containment of soil consumption.

As regards the numerous risks resulting from climate change due to the different physical and geomorphological characteristics of the urban areas, and for which direct and/or indirect actions on soil consumption are foreseen, they can be classified into four categories:

– Landslide risk: this risk, although linked to natural factors such as geological and geomorphological conformation, is also strongly conditioned by the continuous anthropogenic interference on land modification which, on the one hand has increased the possibility of occurrence of these phenomena, and on the other has raised the presence of goods and people in areas where this phenomenon occurred, despite its catastrophic effects;

– flood risk: the increase in the frequency of this risk is undoubtedly linked to the high anthropization and to the widespread sealing of the territory which, preventing the infiltration of rain into the ground, increases the quantity and the speed of the water that flows towards the rivers;

– soil erosion risk: this risk, in addition to being linked to natural causes such as sea level rise, is also due to anthropogenic causes such as the increase of urbanization in the coastal strip for tourism and industrial purposes;

– heat waves: this risk depends on the climatic conditions and on the physical and environmental characteristics of a specific area and is defined not only by the air temperature and relative humidity but also by the duration of heat waves.

The general objective shall be achieved through the implementation of direct or indirect actions. Direct actions explicitly limit the use of soil, such as the definition of a threshold for buildability, protection of the green belt land or reuse of existing buildings/structures and infrastructures. Indirect actions, instead, are all those that do not directly concern soil protection, however they contribute to promote a more sustainable use of it, since the risk for which this specific action is expected can be reduced if less soil is sealed, for example the actions envisaged to implement the water drainage system as to limit the landslide risk which can be reduced by ensuring a greater deal of permeable soil. In summary, the reading of each of the adaptation plans collected was carried out (i) investigating the impacts of climate changes and the risks related to them in order to understand how a city intends to "adapt" in view of its vulnerabilities (in this regard, it should be noted that the reading covered only the impacts and risks mainly linked to soil consumption); (ii) identifying direct and indirect actions with a view to protecting soil consumption; (iii) using an integrated approach to the issue of soil consumption, where integration is understood as referring to the need to both preserve the natural soil and improve the use of the anthropized one, in order to overcome this issue from the point of view of governance of urban transformations, that is taking into account the dynamic development of urban systems which inevitably entails the consumption of this resource.

3 ITALIAN AND EUROPEAN ADAPTATION PLANS REFERRING TO SOIL CONSUMPTION

There is a growing recognition that climate change requires a substantial change in approaches to the urban and territorial transformations governance, both in terms of reducing the production of carbon dioxide emissions (mitigation) and in making urban systems more resilient to the gradual climate variability (adaptation). Adaptation plans aim to tackle the inevitable consequences of climate change on the cities to reduce them in order to secure the territory and infrastructures from the risks linked to climate change phenomena, and thus ensure the safety of the inhabitants. With reference to the methodology adopted (section 2), the following paragraphs propose a reading of the following selected plans: the Italian cities of Ancona, Bologna and Padua, the European Helsinki, Belgrade, Berlin, Paris and London. This reading can provide some clarification with regard to the risks related to soil consumption that arise from climate change

(table 1) and therefore require certain adaptation actions, paying particular attention to those actions that provide - directly and indirectly - a reduction in soil consumption.
The reading of the plans has also been complemented by land cover data currently available, as an attempt to measure the effects determined by the actions contained in the adaptation plans in terms of soil saving. Through the use of CORINE Land Cover mapping - established by the EU-, sealed surfaces and green areas in the GIS environment were calculated for each of the currently examined cities. These measurements aimed to compare the prevalence of land use before and after adoption of the adaptation plans, so as to measure their effects quantitatively. However, this objective could not be reached because the most recent data available date back to 2012, when most of the plans were drawn up.

3.1 ANCONA

Ancona, the capital of the Marche Region, has just over 100,000 inhabitants and is characterized (above all from the environmental point of view) by several critical issues. After the event of the great landslide, which hit a large area of the urban territory (1982), the municipal administration developed a progressive adaptation policy in order to increase the resilience of the community and the territory. This policy, which led to the development of the Adaptation Plan in 2012, was developed on the basis of a direct knowledge of the territory, with its problems, sustainability of the solutions adopted and the potential impacts of climate change - direct and indirect - in the medium-long term.
The major climatic events involving Ancona in recent decades brought about the following phenomena: the "great landslide", caused by persistent and heavy rains; the flooding that occurred as a result of several extemporaneous and short-term but considerably intense phenomena; coastal erosion accentuated by intense rainfall and long-term periods of summer aridity and heat waves rising.
To reduce the landslide risk, the plan, in addition to drainage interventions which will allow an optimization of water consumption thanks to the use of the water collected from the landslide instead of drinking water, also includes naturalistic engineering interventions (based exclusively on reinforced soil systems and gabions) able to preserve the non-urbanized soil and therefore the draining and stability functions of the soil itself.
As regards the erosion risk, besides being due to natural causes, it is also determined by anthropogenic causes due to the increase of urbanization in the coastal strip and the reduction/destruction of dune systems to make room for seaside resorts and marinas. To cope with this risk, the plan envisages a regulation scheme to rehabilitate the existing green areas by means of felling (where necessary) and a retreat of the seaside resorts and restaurants in order to gain unbuilt soil. The plan also entails the construction of new green areas that could lead to an increase in the rate of permeable soil -2.70% of the entire municipal area in 2012 (Copernicus, 2012)- and a reduction in the rate of the paved, built and therefore impermeable ones -which occupy 21.56% of the municipal area-, with the aim of adapting the urban system to the risk of floods and heat waves.

3.2 BOLOGNA

Bologna, the capital of the Emilia Romagna Region, has been seriously affected by the impacts of climate change in recent years, registering an increasing number of landslides, floods and heat waves: "The City has felt the need not only to avoid the intensification of meteoric events that damage the territory but also to preserve the resources linked to local climatic characteristics, first of all the water resource "(City of Bologna, 2015).
Under the influence of the Italian National Strategy, the city of Bologna drew up the adaptation plan in 2015 with a view to identifying the strategies pursued to improve the territory response to climate change and to coordinating the action of the City with the other local authorities involved in the management and protection of the territory. Bologna adaptation plan was drawn up after an accurate cognitive phase from which all the

vulnerabilities of the urban system to climate change have arisen, associating each one of them with one or more strategies accompanied by specific measurable objectives.

The greatest risks to which Bologna is exposed, in relation to soil consumption –which in 2012 involved 56.46% of municipal area (Copernicus, 2012)- are flood, hydrogeological risks and heat waves. The adaptation plan, in an attempt to limit the rising temperatures in urban areas, provides the widespread increase of green areas in such a way that the temperature gradient between built-up areas and vegetated areas determines an important air flow which allows to eliminate heat but also air pollutants from the city. The plan refers to other urban planning tools, the quantification of urban redevelopment projects and the enhancement of public space, which can be pursued through sealing reduction.

In fact, as regards the green areas, to which only 5.16% of the municipal district in allocated (Copernicus, 2012), the widespread qualification interventions will lead to an increase of about 15,000 square metres between public and private green areas, in addition to the realization of private green roofs as well as semi-permeable floors. Furthermore, the green spaces allow to reduce the vulnerability of the system to the other two risks: floods and the hydrogeological one. In this regard, the plan emphasizes the need to reduce soil sealing because it causes a significant increase in the Navile and the Savena Abbandonato flows, thus increasing the hydrogeological risk in the municipalities downstream. To this end, numerous actions are envisaged to make previously sealed surfaces, such as flooring, and areas of rainwater storage permeable once again, so as to slowly return it to the surface circulation or directly to the atmosphere through evapotranspiration.

3.3 PADUA

Padua, the capital of the Veneto Region, drafted an adaptation plan in 2016 and was the only Italian city to use a methodology built from those already existing at the international level. The methodology is articulated in 6 fundamental phases through which the city has identified the vulnerable areas in order to adapt urban areas to the effects of climate change, with the aim of studying the kind of vulnerability and then increase the capacity of reaction to the shocks generated by the ongoing climate change. Identifying vulnerable areas in the urban sector has helped to determine the risk generated by the impacts themselves and therefore the definition of adaptation actions.

The most detected effects due to climate changes in Padua are the floods and heat islands, and actions are planned to adapt to these risks, in order to mitigate and compensate the effects of land consumption, considering that the percentage of the area concerned was 77.27% in 2012, while only 0.59% of the municipal area was allocated to greenery (Copernicus, 2012).

The plan emphasizes the importance of soil protection, promoting actions able to lead to urban growth without sealing new natural soil but reusing already urbanized soils, thus redeveloping existing urban fabric and selectively "densifying" the most accessible urban places. Among the actions scheduled for the city in the plan, there are the new areas of reconversion and urban redevelopment, the new urban axes to be redeveloped both morphologically and functionally and the creation of many multifunctional green areas which, in addition to absorbing large amounts of CO_2, allow greater water absorption compared to sealed paved areas, as well as urban heat absorption, and if properly designed and built they can become areas for water storage in case of extreme weather events.

The plan also includes a map of impermeability (figure 1) with the objective of identifying the percentage of impermeable surfaces opposed to the permeable ones, showing the soil ability to infiltrate and absorb rainfall, thus avoiding water flow downstream and cause flooding. In this way the portions of soil to be kept free in order to reduce water and hydrogeological risk have been identified.

Finally, a plan of solar irradiation is presented in the plan where the areas that register a high level of irradiation are those where most of the solar radiation is absorbed and stored by the streets with consequent urban heat island phenomena. Adaptation actions to reduce risks such as floods and urban overheating mainly involve actions that reduce soil consumption, such as respecting and increasing existing green areas and replacing floors (e.g. parking lots) with materials/techniques that make them permeable.

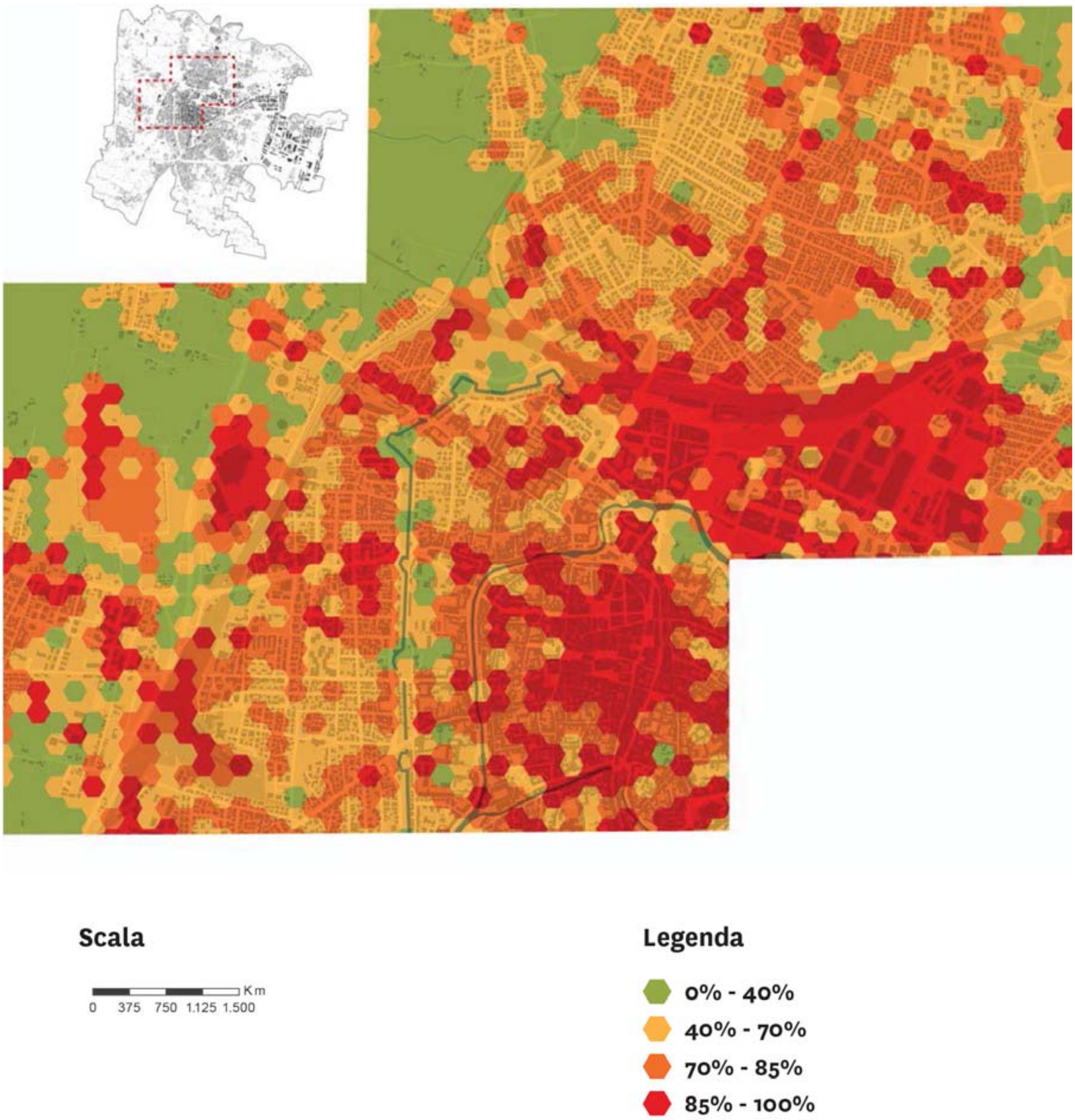

Fig. 1 Graphical representation of soil permeability percentage (Padua)

3.4 HELSINKI

Helsinki adopted a policy of adaptation in 2012 following some natural disasters, such as the storms of Summer 2010 and the Winter storm of December 2011, which showed the vulnerability of the Finnish city to climate change, in particular to the flood risk. Among the different actions proposed by the city, for flood risk there are also indications regarding soil consumption. In this respect, the plan proposes the construction of new green areas, 6.74% of the municipal area (Copernicus, 2012), and the conservation of large forest areas able to withstand events such as storms. Green areas are also essential to improve water management.

If, on the one hand, the plan aims to safeguard the use of natural soil, in order not to increase the percentage of the sealed area, 17.25% in 2012, on the other hand the housing demand must be met, as the Helsinki urban plan foresees a population growth of around 600,000 residents in 2050, hence, to adapt the city to the risks of climate change with actions that meet the demand for housing without sealing other soil, the administration should suggest redevelopment of unused buildings, also providing for changes of intended use. In fact, increasing sealed areas means increasing the risk of flooding, a risk that the city is particularly vulnerable to. However, this aspect within the Helsinki city adaptation plan is not addressed because the authorities can only suggest the protection of green and forest areas, instead it would be appropriate to define adaptation actions in a systemic perspective, starting to identify risks and considering the different subsystems that make up the entire city system.

3.5 BELGRADE

Belgrade drew up the adaptation plan in 2015 following extreme weather events which, according to data from the hydro-meteorological service of Serbia, occurred with increasing intensity: in the Summer of 1998, 2000, 2012 and 2013 heat waves caused a huge increase in temperatures (exceeding 39°C), carrying as a main consequence a great drought; in 2006 there were repeated floods caused by the melting of snow and heavy rains; in May 2014, heavy rainfall caused a large flood. Furthermore, in recent years the floods have increased significantly in intensity and severity.

With regard to these risks, the administration underlined all the main vulnerabilities within the adaptation plan (Figure 2) with the aim of identifying the most efficient actions to be taken. Green spaces, that in 2012 only covered 2.77% of the entire municipal district (Copernicus, 2012), have a high level of vulnerability to almost all the effects of climate change: extreme cold and drought can in fact cause a slowdown in the fundamental physiological processes of plants (such as photosynthesis, metabolism, transpiration and growth); heat waves slow down the growth of plants or even their drying; heavy rainfall leads to the physical destruction of plant tissues and green infrastructure.

There are a number of actions proposed by the administration in the adaptation plan which aim at adapting the city to these risks and do not directly refer to soil consumption, a phenomenon that until 2012 involved 13.34% of the entire municipal district (Copernicus, 2012).

It is possible to identify in the plan a series of indirect actions, transversal to the various types of risks identified, such as the creation of green infrastructures connected to blue structures (fountains, rivers, aqueducts), parks, gardens, forests connected to waterways, so as to encourage the infiltration and outflow of abundant rainfall, as well as the improvement of existing green areas. Creating green spaces means obtaining ventilation routes, which reduce the risk of heat waves that have proved to be very dangerous both for the ecosystem and for the health of local residents.

3.6 BERLIN

Berlin drafted the plan to adapt to climate change in 2016 to reduce environmental-related damage. In the city of Berlin the most recorded effects were the increase in temperatures, registered especially in the Summer of 2014 and 2015 when the heat waves phenomenon arose. Another phenomenon related to climate change detected in the German capital is the rainfall that has increased over the last decade; in fact, it is foreseen that "Berlin will experience an increase in the average annual precipitation of about 3 - 10% in the near future and 7.5 - 18% in the distant future" (City of Berlin, 2016). According to the forecasts performed, the strongest increase in rainfall should occur in Spring and Winter while it will be less relevant in Autumn and Summer

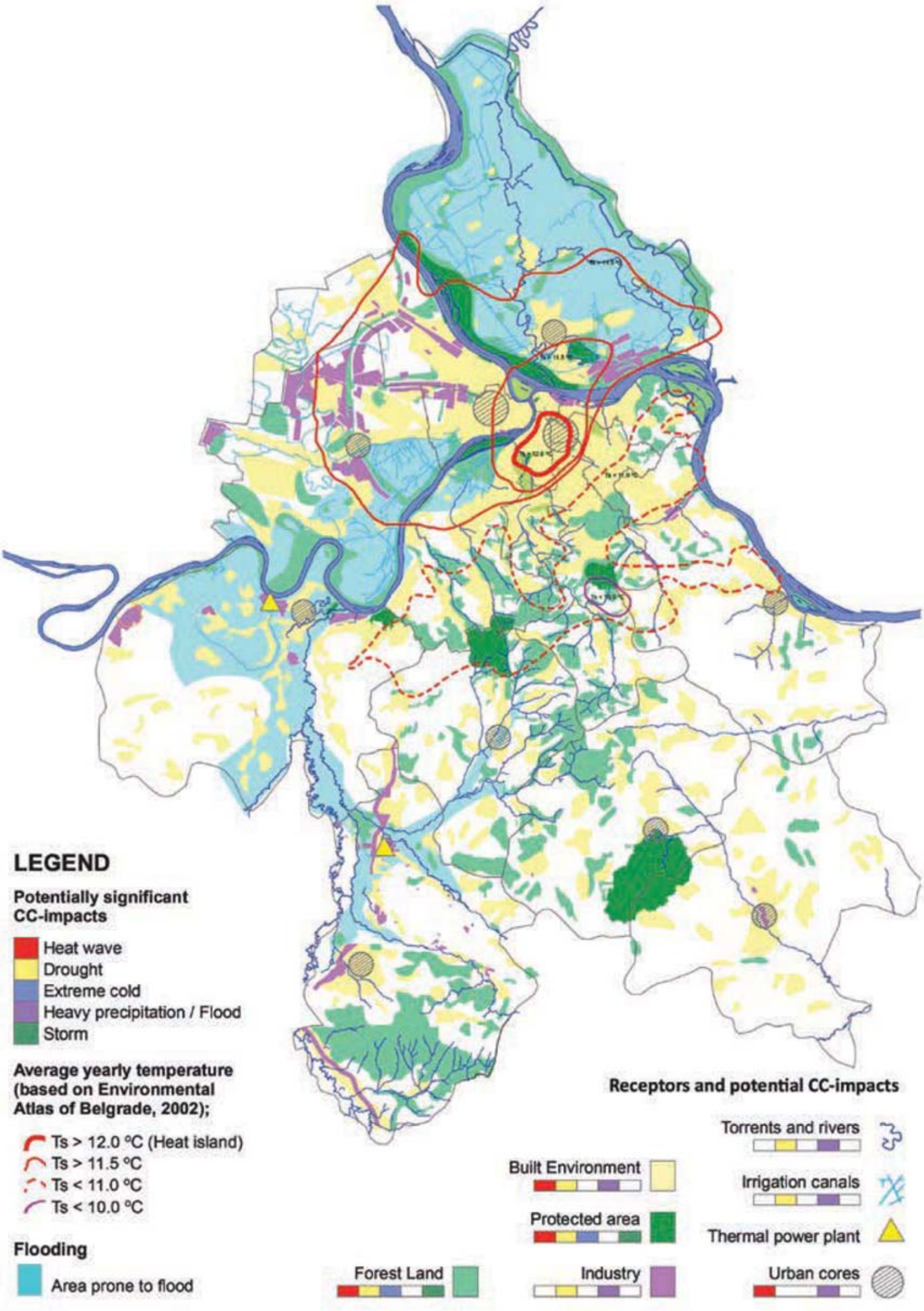

Fig. 2 Spatial distribution of potential climate change impacts related to the highly vulnerable receptors within the administrative territory of Belgrade

seasons, but the events of heavy rainfall will alternate, according to the City of Berlin forecasts, with drier periods. As temperatures rise above all during the winter, Berlin will have less snow in the future. Because of these two types of events, the municipal administration of Berlin has become aware of the fact that soil sealing, a process that in 2012 involved more than half (59.6%) of the entire municipal area (Copernicus, 2012), means increasing the built area and, as a consequence, also the health risks for the inhabitants linked to the higher temperatures. Furthermore, the increase in heavy rainfall will lead to more flooding, especially in the most urbanized areas. In this perspective, the adaptation plan recognizes, on the one hand, the need to build new residential housing units - a demand that arises from the huge flow of immigrants towards this urban area -, on the other it proposes strategies for adapting to climate change by means of recovery of already existing structures and infrastructures and planning of green areas that are "strategically important", in order to benefit from them in terms of temperatures and evaporation cooling processes. The plan also suggests intensifying the permeability of the city surface to rainwater to adapt it to the increase in heavy rainfall so as not to exacerbate the sewage system. These interventions envisaged in the plan are aimed at adapting the city to the risks due to climate change by transforming the city of Berlin into a "Sponge City", increasing that 13.88% of the already present green area (Copernicus, 2012).

3.7 PARIS

Paris adopted the climate change adaptation plan in 2007, then updated in 2012 following an increase in existing risks and the emergence of new risks for both human and natural systems.
"Climate in Paris is changing and will continue to do so throughout the 21st century" (City of Paris, 2012) and among the most recorded effects of climate change on the Paris metropolitan area it is possible to identify: heat waves increasingly frequent and intense; floods due to heavy rains; the gradual loss of biodiversity; drought. Changes in temperature as well as alternating drought with heavy rains can also have an impact on the stability of the ground, with the risk of collapses or possible landslips.
Because of these effects, the administration proposes actions to protect citizens and the city, preserving existing services and resources. As regards the heat waves, aggravated by the phenomenon of urban heat island, the plan suggests the protection of green areas - which in 2012 covered 19.09% of the entire municipal area (Copernicus, 2012)-, as well as the opening times H24 all year round of municipal parks so that citizens can benefit from the freshness of these areas ideally connected by waterways or through green corridors such as hedges, gardens and escarpments, since water and the greenery help to cool the city and limit the effect of the heat island. Evaporation and plant evapotranspiration consume heat and contribute to reducing the surrounding temperatures. Moreover, other advantages could be the biodiversity conservation, the increase in permeable areas, the consequent mitigation of the sealing process that affects a whopping 78.58% of the municipal area (Copernicus 2012), and therefore a better flood risk management. In order to adapt the city to this type of risk, the plan also suggests other types of interventions on which this paper has not focused since they didn't take soil use into account.

3.8 LONDON

London, the capital of England, adopted the climate change adaptation plan in October 2011. London is very vulnerable to phenomena such as floods, droughts and heat waves, which are gradually increasing in intensity and frequency due to climate change. In the last decade, London experienced significant floods in 2002, 2004, 2005, 2007, 2008, 2009 and 2010, heat waves in 2003 and 2006, a severe drought in 2006 and unusually cold winters in 2009 and 2010. Each of these events affected residents' health and quality of life apart from having a negative impact on the economy. London is the engine of UK economy and an integral part of the world's economy, through providing workforce, energy, water and other consumables, thus any impact on London can have serious repercussions at the international level.
Among the various actions suggested by the plan, the one that takes soil use into account is related to the risk of flooding. In this regard, the plan identifies as possible actions the increase of green areas to absorb the flood water, in addition to cooling temperatures, and refers to the flood management plans (CFMPs) that identify actions to be taken for each London river. Another risk, as mentioned above, for London territory are

the heat waves. The plan, in this case too, suggests an implementation of the green areas -which in 2012 covered 1.42% of the entire municipal area (Copernicus, 2012)- in order to reduce the temperatures with a consequent reduction of overheating. Although the London City adaptation plan does not indicate direct actions to protect soil use, Britain was the first country to tackle the problems related to urban sprawl; in fact, the English land law is regulated by the "Town and Country Act "of 1947 which favored the creation of 14 green belts around the main cities, including London.
Among the various actions included in the plan, the increase of green areas to absorb the flood water is one of the most relevant too, but the plan doesn't provide other indications (from the point of view of soil consumption) to mitigate the other effects of climate change occurred in London territory.

	Landslide	Flood	Erosion	Heat waves
Ancona	x	x	x	X
Belgrade		x		X
Berlin		x		X
Bologna	x	x		X
Helsinki		x		
London		x		X
Padua		x		X
Paris		x		X

Tab.1 Risks detected in the cities where actions related to soil consumption are envisaged

	Sealed soil (ha)	Green area (ha)	Sealed soil (%)	Green area (%)
Ancona	2673,3	334,3	21,56	2,70
Belgrade	43582,4	9032,9	13,34	2,77
Berlin	51738,3	12049,6	59,58	13,88
Bologna	7962,9	727,1	56,46	5,16
Helsinki	54275,6	21192,3	17,25	6,74
London	130138,1	24663,5	7,50	1,42
Padua	7271,5	55,9	77,27	0,59
Paris	8244,9	2002,6	78,58	19,09

Tab.2 Sealed soil and green areas measured in 2012 in the examined cities, based on the Corine Land Cover Map

4 CONCLUSIONS

With regard to the risks to which each city is exposed because of climate change, the related adaptation plans include actions to reduce the damage associated with that risk.
In defining these actions aimed at reducing the vulnerability of urban areas to the present and future effects of "global warming", all those non-climatic factors should be also included, whose effects, combined with those of climate change, enhance the final impacts and/or condition the adaptive ability of the population and territory (see sections 1 and 2). Soil transformation processes are among the non-climatic factors that most influence local vulnerability (Cardona et al., 2012). For example, referring to the two effects of climate change Urban Heat Island and Pluvial Flooding, soil sealing increases these two phenomena due to the lower heat absorption and the lower water flow in the subsoil.

This work has been aimed at investigating actions to contain soil consumption included in the adaptation plans of the European cities under investigation, given that soil can play a crucial role to facilitate the adaptation of the urban system to climate change.
From the reading carried out, it is overall recognised that the soil resource plays an important role in the adaptation of urban systems to climate change, albeit indirectly. The limitation of soil consumption is explicitly excluded from the actions to be carried out, but there are widespread interventions such as the implementation of green areas and the mitigation and environmental compensation of impermeable surfaces, to encourage greater carbon storage in the subsoil and thus preserve the ecosystem functions of this natural resource. Only in the Italian plan of Padua, -which, among the three Italian cities currently examined, is the one that up to 2012 consumed a higher percentage of soil and is currently characterized by the lowest amount of greenery compared to all the case studies (tab.2)-, it is possible to find actions aimed at limiting soil use in a direct way, preventing new sealing interventions for the purpose of settlement expansion and aiming, instead, at the reuse of brownfields and reclaimed production areas; on the integrated regeneration of the existing building heritage, "where it does not interfere with the settlement safety, increasing, firstly, its drainage capacity"; on the integration of all urban-scale planning instruments able to guarantee emissions cut (in line with the Covenant of Mayors). As regards the most widespread risks that the eight cities under investigation are called to face, namely heat waves and floods (tab.1), the key actions to be promoted mainly concern the construction of green infrastructures. For example, the Helsinki plan proposes actions to protect green areas and agriculture, in order to preserve biodiversity and soil fertility; in the London adaptation plan green belts represent a fundamental support for cooling and the flowing of surface water, as well as for CO_2 capture. Greening 50% of the entire municipal area is a priority objective for the administration of London to be achieved by 2050 - foreseeing an increase of about 500 hectares in parks and green corridors (City of London, 2017)-, together with the one of a zero soil consumption that seems really feasible, given that in 2012 London showed a significantly reduced sealed area compared to that of the other countries examined (tab.2).
Each plan has also used a different approach for the definition of the system of actions to be implemented, in relation both to the risks and to the physical and environmental characteristics of each urban area. In particular, it is possible to state that except the city plans of Ancona, Padua and Belgrade, all the other plans have been developed on the basis of specific knowledge of the urban system and on the study of the natural disasters linked to climate change occurred in recent years. It is, basically, a qualitative approach which, as such, has led to the definition of adaptation actions "in broad terms" since they seem to be guidelines and strategies rather than concrete and effective actions to be carried out.
For example, the actions developed by the Ancona adaptation plan are defined starting from quantitative analyses related to three variables (temperature, precipitation and sea level), aimed at identifying the key sectors on which risk analysis and urban vulnerability should be focused. In practice, this plan used a quantitative approach to carry out, with a degree of uncertainty, the risk forecasts and define multiple and detailed adaptation actions for each risk. The Padua plan is based on a quantitative analysis too. Thanks to the support of digital tools such as GIS, this plan has conducted an analysis on the new vulnerabilities of the city system, obtaining data that allowed an accurate definition of adaptation actions to be implemented. Lastly, Belgrade performed a quantitative analysis of the vulnerabilities and impacts of climate change affecting the urban system, obtaining an assessment of risks and opportunities. Even in the case of Belgrade, the adaptation actions envisaged in the plan are more specific than those contained in the plans which use a cognitive approach.
Ultimately, it is possible to state that although the reduction of soil use is now a strategic issue in the international scientific debate on the sustainable management of urban systems, its key role in the adaptation actions to climate change is not yet consolidated, as called for more and more frequently by Europe in the steering documents for the Member States. In fact, soil consumption is not one of the factors that requires

direct action to reduce the vulnerability of urban systems to climate change in progress, but rather it is a phenomenon that can be contained by increasing green areas and/or infrastructures and encouraging agricultural and environmental regeneration.

Moreover, the adaptation actions concerning soil almost exclusively refer to the latter in terms of protection and preservation, considering this resource from a mostly ecological and naturalistic perspective.

The attention, in other words, seems to turn to not yet sealed soil, thus leaving out the already anthropized one that, as such, would require, instead, greater adaptation efforts: «if for a correct approach to the limitation of soil consumption it's absolutely essential to safeguard what is outside the urbanized space, it is likewise indispensable to redevelop what is inside the city" (Arcidiacono, et al., 2012). The actions aimed at preserving the natural and biodiversity features of soil not yet built on should be complementary to those aimed at ensuring a more sustainable use of the already transformed soil, that is, of the volumes and the adapted spaces that constitute that heritage of urban resources from which the improvement of urban resilience strictly depends. Measures mitigating and compensating land consumption can also be a lever to implement urban sustainability policies, in full agreement with the European Environmental Sustainability Strategy, and not to undermine the capacity of other natural systems as well as of some social and economic sectors to pursue adaptation (Fregolent, 2014; Filpa & Ombuen, 2014). The innumerable interrelations between «the top layer of the Earth's crust» (surface) (ISPRA, 2015) and all that has been realized and/or modified by man (abovesurface) with the possible negative effects that may derive from the climate and ecosystem point of view require a broader and more integrated approach to issues such as soil consumption, based on the systemic value of this natural resource. In this perspective, the government of urban transformations requires the definition of strategies and instruments capable of adapting to unforeseen phenomena that may occur in the urban system.

This paper can be a starting point for local administrations that have not yet drawn up a plan to adapt to climate change, in order to develop actions that take into account the multiple benefits that soil protection (and especially a more sustainable use of it) can determine in terms of improving urban resilience. Further elements useful to define strategies and measures to mitigate and compensate soil sealing with the consequent negative impacts on climate change, and to measure the effectiveness of existing adaptation plans, can be identified in a future research work based on most up-to-date European land cover data. Indeed, this paper has a limitation due to the fact that the open data used are updated to 2012 (Copernicus project), and consequently, it does not provide recent information on the processes of anthropogenic transformation of the soil and can't help understand if and to what extent the actions contained in adaptation plans examined (drafted mostly in 2012) have produced in terms of increasing the resilience and environmental sustainability of urban systems.

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IMAGE SOURCES

Fig. cover: picture of the authors. Central Park. New York; Fig. 1: adaptation plan of Padua; Fig. 2: Climate change: adaptation action plan and vulnerability assessment; Tab.1 and Tab.2: created by the authors

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