ACHIEVING ADAPTATION IN MEDIUM-SIZED CITIES: THE CONTRIBUTION OF URBAN CLIMATE TRANSITION STRATEGIES IN INCREASING SOIL PERMEABILITY (1113)

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Abstract. Soil sealing and land take have produced negative impacts on urban areas, leading to adverse phenomena such as loss of ecosystem services, the urban heat island effect, and flooding. In this critical context, increasing soil permeability through desealing interventions is considered an effective solution against these problems. Over the past years, desealing has begun to be recognised in the scientific literature and in spatial planning practice to meet various needs. The approaches to desealing considered today are either top-down, as a result of political actions and choices by local and regional governments, or bottom-up, i.e. promoted by local associations.

Within this complex framework, the aim of this contribution is to investigate and compare some specific innovative strategic urban planning instruments in medium-sized cities, specifically the Sustainable Energy and Climate Action Plans (SECAPs), which were examined focusing on how these tools have interpreted and proposed desealing interventions.

Keywords: desealing, soil sealing, climate change, adaptation, urban planning transition plans.

1. Introduction

It has been broadly demonstrated that soil sealing and land take have strongly impacted urban and metropolitan systems, leading to adverse phenomena such as loss of ecosystem services, the urban heat island effect, and flooding. The severe impacts on urban areas caused by increasingly frequent extreme or abnormal weather events can no longer be defined as ‘unpredictable’, and strongly impact on society social, economical, and environmental dimensions. These urban challenges call for specific mitigation and adaptation actions (i.a. Biesbroek, Swart and Van der Knaap, 2009), given also the growing awareness of a substantial change in approaches to the urban and territorial transformations governance that climate change requires (Zucaro and

Morosini, 2018).

The increasing urbanisation and land take that were observed in the last centuries, both in European and Italian cities, contribute to sharpen the effects of climate change (Intergovernmental Panel on Climate Change, 2022; Munafò, 2022). Indeed, in urbanised areas, the effects of water runoff during heavy rainfall are aggravated; this requires adequate infrastructure in order to reduce probable negative impacts (Gibelli *et al*., 2015). Traditional grey infrastructures are still broadly being implemented, but the potential role played by Nature-based Solutions (NBS) is being increasingly recognized both in literature and in urban planning practices and tools (De Luca *et al*., 2021; Voskamp *et al*., 2021; De Noia *et al.* 2022).

In this context, increasing soil permeability is considered an effective intervention against climate change and its effects. By restoring soil permeability, the ecosystem services provided by the soil can be partially restored, with benefits for the environment, human health, and society as well (Bockarjova *et al.*, 2022). This can be achieved through desealing interventions, i.e. restoring part of the soils to their previous state, recovering the main functions inhibited by transformative processes, through the removal of the waterproofed layers, the loosening of underlying soil and the removal of foreign material (European Commission, Directorate-General for Environment, 2013; Tobias *et al*., 2018).

Over the past 30 years, desealing has begun to be recognized as a possible compensation and mitigation measure in the scientific literature (SOS4LIFE-Save Our Soil For Life, 2017; SOS4LIFE-Save Our Soil For Life, 2018, Ceci, 2023) in European policies (European Commission, Directorate-General for Environment, 2012) and in spatial planning practice, e.g. in the German cities of Berlin, Dresden and Stuttgart (presented as case studies in the European research programme SOS4Life) or in the city of Eindhoven (Augusto *et al.*, 2020). The approaches to desealing known in literature and practice are either top-down, i.e. the result of political actions and choices by local governments (Prokop, Jobstmann and Schönbauer, 2011; SOS4LIFE-Save Our Soil For Life, 2017), or bottom-up, i.e. promoted by associations and volunteers sensitive to the issue[1] (Artmann, 2014; Caselli *et al.*, 2022; Garda, 2020; SOS4LIFE-Save Our Soil For Life, 2017; Stobbelaar, van der Knaap and Spijker, 2021).

Within this framework, the aim of this contribution is to investigate how desealing actions have been adopted and implemented in innovative strategic planning

[1] One example is the 'Depave' association founded in Portland (Oregon) in 2007: for more than ten years, it has managed to stimulate the activation of desealing projects for collective space by actively involving thousands of citizen volunteers. https://depave.org/

instruments, specifically the Sustainable Energy and Climate Action Plans (SECAPs). The SECAPs are developed within the Covenant of Mayors urban climate network (Global Covenant of Mayors for Climate & Energy, n.d.), a specific European policy aimed at increasing urban and regional resilience to the energy emergency and climate change. SECAPs are chosen as a case study as they are new tools that incorporate climate strategies and actions (sometimes with spatial implications) but are still little explored in the scientific literature, especially in their interactions with ordinary urban planning tools.

The proposed analysis focuses on the SECAPs drafted by three medium-sized cities in Northern Italy, investigating the conditions, measures, and processes related to desealing actions. Medium-sized cities show the same environmental, social, and economical issues of bigger urban areas, but have often fewer financial resources to manage urban challenges, in addition to limited technical and administrative structures, including the reduction of climate change effects (Häußler and Haupt, 2021).

The expected results of the comparative analysis are to realise a synthesis of three innovative experiences in the Italian context aimed at increasing the resilience of cities to climate change with a systematic approach, trying to investigate the different interpretations and applications of the desealing concept. The outcomes of the study will be useful to investigate the criteria and processes underlying the choice of priority areas to be de-sealed and the physical interventions on the urban soils. It will also allow the development of a first critical reflection on the opportunities and limits of strategic plans for climate resilience, and their interactions with the ordinary urban plans.

The paper is structured as follows: chapter 2 provides insights into the Covenant of Mayors and the evolution and content of SECAPs; chapter 3 introduces the three SECAPs chosen as case studies and the main geographical, morphological and climatic features of the cities involved; chapter 4 outlines the methodological approach adopted for the comparative analysis; chapter 5 presents and discusses the results of the analysis; and finally, chapter 6 draws some concluding remarks.

2. Insight Into The Covenant Of Mayors And The SECAPs

The Covenant of Mayors (Global Covenant of Mayors for Climate & Energy, n.d.), launched in Europe in 2008 and at a global level in 2015, is an initiative and opportunity for local governments to concretize their efforts towards an increased urban resilience, thus reducing greenhouse gas emissions and alleviating energy poverty. In the Green Deal and Agenda 2030 context, the Covenant of Mayors signatories' commitment is to keep the global temperature rise below 1.5°C, in line with the Paris Agreement.

The Covenant of Mayors for Climate and Energy intends to support local activities and set up a network of cities while raising public awareness about climate adaptation and mitigation. Based on transparency, flexibility, data evaluation, and exchange of experience, the initiative supports a bottom-up approach, a multilevel cooperation, and a context-driven framework for action. Participating municipalities can, therefore, take a direct and voluntary step for their transition towards resilience by adopting a local action plan.

The 'first generation' action plans, called Sustainable Energy Action Plans (SEAPs), included mainly mitigation actions to achieve at least a 20% reduction in CO_2 emissions by 2020, but since 2015, signatories to the Covenant have the opportunity to adopt the SECAP that includes both mitigation and adaptation strategies to achieve a 40% reduction (at least) in CO_2 emissions by 2030. More specifically SECAPs address the key mitigation sectors of Municipal buildings and equipment/facilities, tertiary buildings and equipment/facilities, residential buildings, and transport. They can also include sectors such as industry, local electricity, or heat/cold production. For what concerns adaptation, the main sectors included are infrastructure, public services, land use planning, environment and biodiversity, agriculture and forestry, and economy.

Since the beginning, the Covenant of Mayors initiative has helped develop climate strategies in European cities, years before climate policies were implemented at a regional and national level. It is debatable if the transformational momentum of the Covenant and SECAPs is still relevant when climate policies and strategies are gaining more importance across different governance levels (Tedeschi, 2023).

3. Presenting The Three Case Studies

In this contribution, we focus on SECAPs implemented by Italian medium-sized cities. Medium-sized and small cities constitute a significant asset both in the European and Italian context (European Commission, Directorate-General for Regional and Urban Policy, 2016). Indeed, European countries, for historical, political, and geographical reasons, register a higher share of population living in medium and small cities compared to the rest of the world. Though their urban densities result lower than in Asian cities, they are much higher than those of the U.S. cities (European Union and United Nations Human Settlements Programme, 2016). This peculiarity has been taken into account for several years by European institutions, with programs such as URBAN II, with the aim of fostering and funding the sustainable development of areas characterised with this specific type of urban distribution (European Commission, Directorate-General for Regional and Urban Policy, 2003). Other research programs seek to better define the specificities and challenges of European medium and small cities,

through morphological, functional, and administrative analyses in order to elaborate more defined territorial development policies (European Spatial Planning Observation Network, 2006; Servillo *et al*. 2014). Medium-sized cities also participate in European coordination networks, such as Eurotowns network (Eurotowns, n.d.), as well as in forms of competition that enhance and reward the implementation of sustainable development policies, such as the Green Leaf Award (European Commission, n.d.).

The Italian situation traces and further highlights the role and importance of medium-sized cities as nodes of development and territorial *praesidium*. About one fifth of Italian citizens reside in medium-sized urban areas, with populations between 200,000 and 500,000, and an additional 19% in small urban areas, with populations between 50,000 and 200,000, 2014 data (Organisation for Economic Co-operation and Development, 2014). The definition of the extension and features of the medium-sized city in Italy has been the subject of several studies (Associazione Nazionale Comuni Italiani, 2013; Associazione Nazionale Comuni Italiani, 2022), with the aim of enhancing the functional and strategic role played by these areas and defining the criteria for allocating resources, in order to implement the necessary development policies. In Italy, SECAPs have been implemented in 3,619 municipalities, from the bigger metropolitan areas with more than 500,000 inhabitants such as Milan and Rome, to the smallest towns with less than 10,000 inhabitants. Among all the urban areas, this contribution focuses on three Italian medium-sized cities - Mantua, Modena, and Parma - which have been selected for their common scattered and polycentric urbanisation which characterises the southern section of the 'Megalopoli Padana' (Figure 1). This term has been used by Turri (2001) to define the urbanised system of the Padana Valley. From the most western point in Piedmont to the Adriatic Sea, this area is characterised by a diffuse urbanisation, where natural and agricultural areas represent the interstices of the built-up areas. The 'Megalopoli Padana' develops within two large 'linear cities' which rise along the feet of the mountains (Muscarà, 1978; Turri, 2001). As shown in Figure 2, the 'Megalopoli Padana' is also the area where the percentage of land consumption is higher than in the rest of the peninsula.

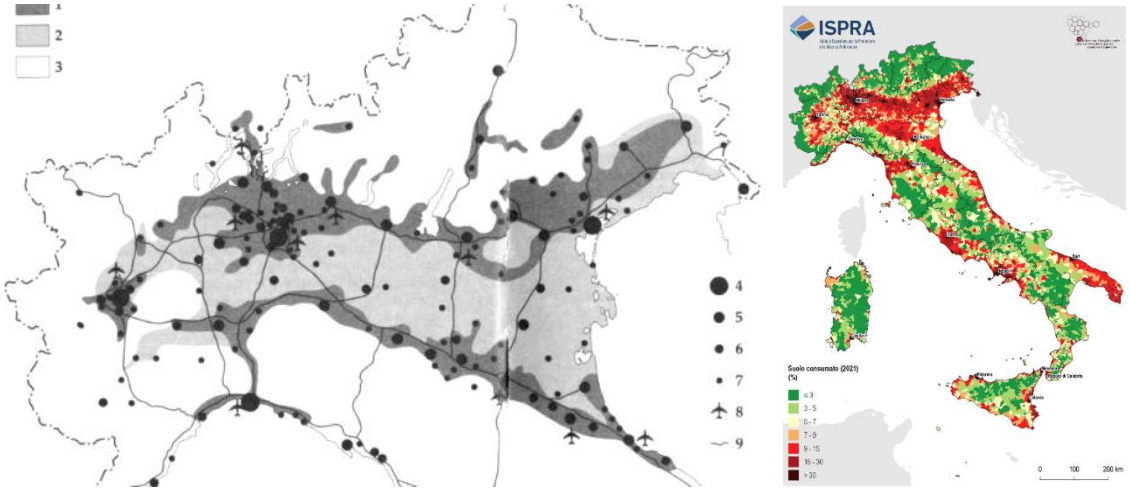

Figure 1 and Figure 2. On the left, the 'Megalopoli Padana' (Source: Turri, 2001); the dark-grey area identifies two 'linear cities', i.e., high-density urbanised areas, while the light-grey areas identify lowland areas where agricultural systems and scattered urbanisation prevail. On the right, land take mapping of the Italian Peninsula
Source: Munafò, 2022.

In the three case study cities an increase in soil consumption has been observed in recent decades, and more than one fifth of their municipal area has been classified as consumed (Table 1). Between 2020 and 2021, Mantua consumed 6.98 more hectares, Modena 11.20 hectares, and Parma 28.04 hectares (Istituto Superiore per la Protezione e la Ricerca Ambientale, n.d.).

Table 1. Soil consumption trends in Mantua, Modena, and Parma (2006-2021). Data retrieved from the Italian Institute for Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale, n.d.)

City	Consumed soil 2006 [ha]	Consumed soil 2006 [%]	Consumed soil 2021 [ha]	Consumed soil 2021 [%]	Increase 2006-2021 [ha]	Increase 2020-2021 [ha]
Mantua	1493	23.4	1579	24.7	86	6.98
Modena	5048	19.4	5620	21.5	572	11.20

Parma	4422	24.1	4620	25.1	198	28.04

The path towards the approval of the SECAPs for all three cities has seen a constant interest in the issues of containing CO_2 emissions and combating climate change through mitigation and adaptation actions: from the initial adhesion to the Covenant of Mayors to the subsequent approval of the SEAP in each city council (Modena was the first). The table below (Table 2) shows the chronology of events for the three case study cities.

Table 2. Adhesion to the Covenant of Mayors and approval of the local action plans of the Municipalities of Mantua, Modena, and Parma.

Municipality	Year of adhesion to the Covenant of Mayors	Year of SEAP approval	Year of SECAP approval
Mantua	2013	2014	2020
Modena	2010	2011	2021
Parma	2013	2014	2021

3.1 The SECAP Of Mantua

The first case study is the SECAP of Mantua, approved by the local government in 2020 (Comune di Mantova, 2020). An in-depth urban analysis and specific guidelines 'Mantova Resiliente. Verso il Piano di Adattamento Climatico - Linee Guida' (Resilient Mantua. Towards the Climate Adaptation Plan - Guidelines, particularly focused on adaptation) (Musco, 2018) preceded the drafting phase. These guidelines offered suggestions and examples of best practices, mainly focused on NBSs and increasing the soil permeability, on the basis of the vulnerability analysis (Musco, 2018). Then, the SECAP incorporated some of these suggestions. The analysis of the SECAP from a desealing perspective, focuses in particular on the section addressing adaptation actions, but all the other sections have also been examined.

3.1.1 Document Characteristics

The SECAP of Mantua is divided into seven main sections. The first and the second trace the steps of the global fight against climate change, as well as the European 2050 Strategy and the Italian 'Piano Nazionale Integrato per l'Energia e il Clima' (National Integrated Plan for Energy and Climate) 2030; the third chapter presents the vision of the action plan, while chapter 4 presents its strategy and mitigation actions and chapter

5 presents its strategy and adaptation actions; chapter 6 and 7 address dissemination, formative activities, and monitoring of the SECAP.

This contribution approaches the analysis of the SECAP from the desealing perspective, focusing in particular on the adaptation action section, but all the sections have been examined/reviewed.

3.1.2 Characteristics Of The Urban Context

Mantua is an Italian medium-sized city geographically located in the Po Valley, in the southeastern sector of the Lombardy Region (Figure 3). It rises along the course of the Mincio River, in the foredeep between the Apennines and the Alps. The total population consists of about 48,000 inhabitants (ISTAT), has an extension of 63.96 km^2 and a population density of 778.88 people/km^2.

Figure 3. The City of Mantua and its administrative boundaries. Elaboration by the authors based on Google satellite images and ISTAT data (municipal administrative boundaries).

Eight percent of the total surface area of the Municipality of Mantua is occupied by three lakes (Lago Superiore, Lago di Mezzo, and Lago Inferiore), along with a vast

marshland area. From a geomorphological perspective, the territory is characterised by sediments with a silty-sandy composition and an average acclivity of around 0.1 percent. The circulation of surface water, also due to a reduced water supply from Lake Garda, is relatively slow, while the impermeable levels of the soil favour the formation of a multilayer aquifer.

Mantua has a strong relationship with the water system. In ancient times, the historic city centre was completely surrounded by water, and the presence of the port ensured the city's economic, architectural and cultural development. Works to reclaim land and regulate the river led over the centuries to the formation of the current three lakes that embrace the historic centre (now UNESCO world heritage) on three sides.

Even today, the territorial economic system is still closely linked to the presence of the river, both in the secondary sector for the presence of one of the main river ports of the Po Valley and a large industrial hub (developed in the twentieth century), and in the tertiary sector. The river, the lake system and the conterminous areas have been protected since the 1980s within Mincio Park which has become, indeed, an important tourist attraction.

The climate of the Municipality of Mantua is in some respects continental, and it is conditioned mainly by the physical conformation of the Po Valley. Being completely enclosed by the mountains, there is no inflow of cold winds from northern Europe, while the Adriatic Sea does not impact the climate. Winters tend to be long and cold with average temperatures often below the freezing point that, in some periods, fall below -10°C. High humidity causes intense and persistent fog, enhanced by the area's poor ventilation. Summers are muggy, and average temperatures hover around 23-26°C, with the maximums as high as 35°C. Rainfall is not very abundant, but it is evenly distributed across the seasons, although it is at its highest in spring and autumn. In winter, precipitation consists sometimes of snow, while, in summer, thunderstorms are frequent, often accompanied by hailstorms (Musco, 2018).

3.2 The SECAP Of Modena

The second case study is the SECAP of Modena, approved in 2021. Similarly to the case of Mantua, the analysis focuses in particular on the adaptation actions section, even if all the other chapters have also been explored.

3.2.1 Document Characteristics

The SECAP of Modena has seven sections. The first chapter provides a summary of the action plan, while the second introduces the history of the Covenant of Mayors, as well as the work group; the third chapter addresses the criteria and objectives of the

inventory of the emissions encompassed by chapter 4; while chapter 5 provides the description of mitigation actions; chapter 6 evaluates the risks and vulnerabilities of the urban area, while the last chapter encompasses the adaptation actions envisioned by the action plan.

3.2.2 Characteristics Of The Urban Context

Modena is a medium-sized city located in the centre of the Emilia-Romagna region, along one of the oldest Italian roads, the Via Emilia in the Po Valley (Figure 4).

Modena has a population of 184.971 inhabitants (Provincia di Modena, n.d.), and an extension of 183,19 km^2 and population density of 1,017.1 inhabitants/km^2, a much higher value than the provincial and regional average. The Province of Modena encompasses one of the most thriving economic areas in Europe, due to the concentration of high-value industries and services.

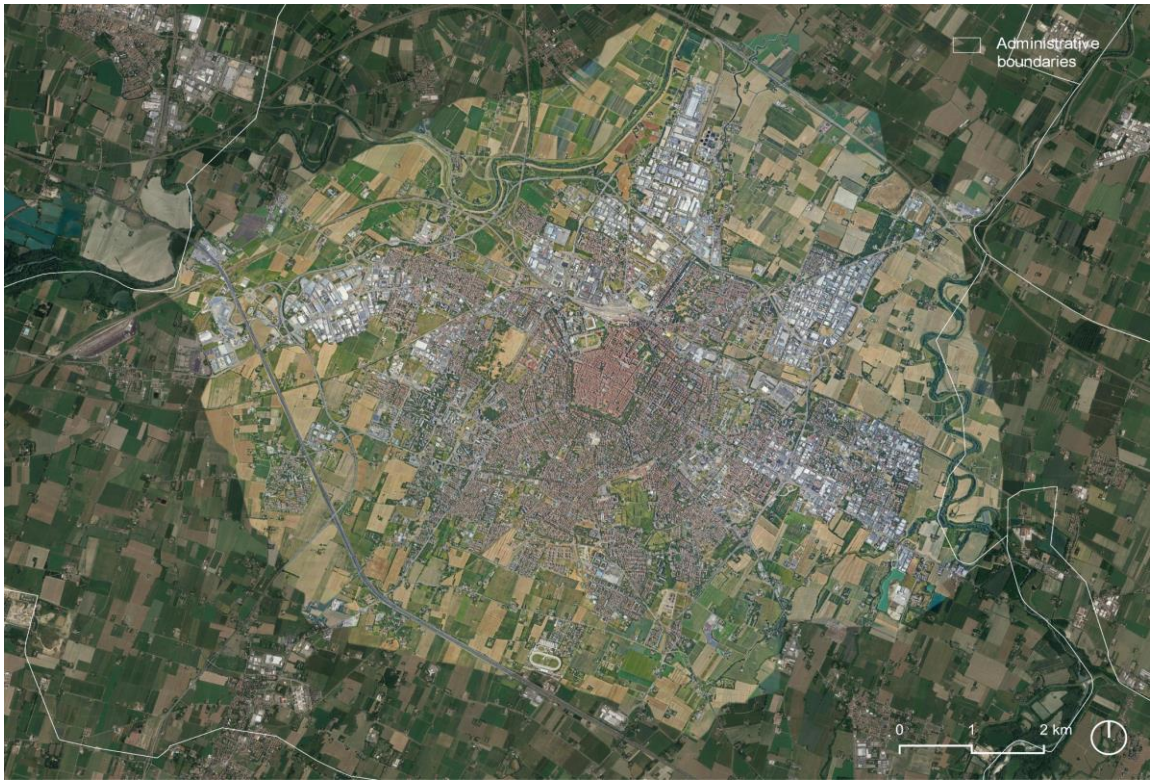

Figure 4. The City of Modena within its administrative boundaries. Elaboration by the authors based on Google satellite images and ISTAT data (municipal administrative boundaries).

The municipal area of Modena is flat throughout its extension. The urban centre and the

historical city are located in the central part while the industrial areas extend mainly in the northern part of the municipal area. The municipal boundaries consist of the Secchia river on the north-western side, and the Panaro river on the eastern. Among other geomorphological and hydraulic aspects, the two rivers contribute to the area's particular sensitivity to floods and extreme weather events.

The Climate Atlas 1961-2015 (Antolini, *et al.,* 2017) of the Regional Agency for Prevention, Environment and Energy of Emilia-Romagna ('Agenzia regionale per la prevenzione, l'ambiente e l'energia dell´Emilia-Romagna' - ARPAE) compares the regional climate data of two-time frames: 1961-1990 and 1991-2015. In the first-time frame, the average temperature registered was 11.7°C, while in the second the average value reached 12.8 °C, highlighting a temperature rise of 1.1°C. Precipitation is generally decreasing, except in autumn, where an increase in rainfall has been observed.

The SECAP and its synthesis document (Comune di Modena, 2021) focused on the future climate projections for 2050, in particular, on the foreseen extreme heats, droughts, intense precipitation events, and flooding. Storms, fires and subsidence are taken into account as well. By 2050, the maximum summer temperature is expected to increase by 2.8°C (from 27.8 °C in the time frame 1961-1990 to 30.6 °C in the time frame 2021-2050) together with the number of tropical nights (that will rise by 45%) and heat wave duration. On the other hand, the annual precipitation will probably decrease from 630 mm (1961-1990) to 590 mm (2021-2050).

3.3 Parma

The SECAP of Parma was approved in 2021. Also in this third case, all document sections have been thoroughly examined, while focusing in particular on chapter four, which encompasses both mitigation and adaptation actions.

3.3.1 Document Characteristics

The document is divided into six main sections. The first introductory chapter highlights the context of the global fight against climate change, the second chapter summarises the elements which were considered for building the SECAP's vision - the pre-existing SEAP and the stakeholders' engagement, while the third chapter encloses energetic, climatic, and risk and vulnerability profiles of the city; chapter 4 encloses the vision of the action plan, highlighting its targets and actions; dissemination, formative activities, and monitoring are addressed in chapter 5 and 6.

3.3.2 Urban Context Characteristics

Similarly to Modena, Parma (Figure 5) is located along the axis of the ancient Via Emilia

in the western side of the Emilia-Romagna region, in the Po Valley. Parma has a population of about 200,000 inhabitants. Along with an extension of 260,77 km^2, Parma has a population density of 769,2 people/km^2, which, compared to the other regional capital municipalities, is lower than the average (Comune di Parma, 2021).

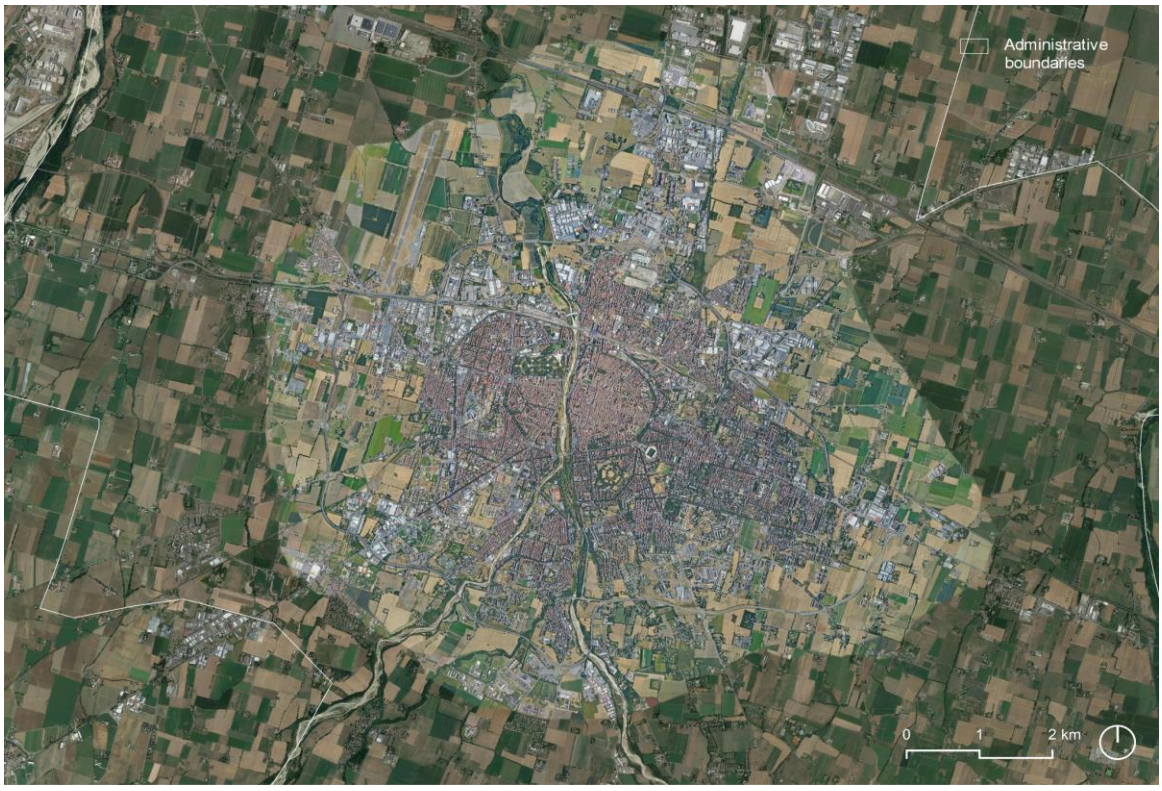

Figure 5. The City of Parma within its administrative boundaries. Elaboration by the authors based on Google satellite images and ISTAT data (municipal administrative boundaries).

Within the regional context, the Province of Parma is characterised by the highest percentage of territory defined as mountainous (43.5%) and the lowest percentage of territory defined as lowland (25%). The municipal territory is entirely flat and two watercourses, the Taro river on the west and the Enza stream on the east, delimit its boundaries. Two other watercourses characterise and divide the city: the Parma and the Baganza streams. The first stream is a tributary of the Po River, which receives the waters of the Baganza stream before crossing the historic centre.

The urban territory of Parma is characterised by a continental temperate climate, a wide annual temperature range corresponding to low winter temperatures and high summer temperatures. Rainfall is mainly concentrated in autumn and spring, while in summer,

the lowlands can concentrate heat causing thunderstorms. The area and its surroundings are not generally windy, causing fog during winter and mugginess during summer. This favours the accumulation of pollutants, such as PM10 in winter and ozone in the summer, thus decreasing air quality. The temperature trends highlight climate change in their average values. The maximum and minimum temperatures show increasing trends both in their average and extreme values, especially for what concerns the summer season. Precipitation data show an increase of years with low precipitation in the last decade, an increase of drought lengths during the summer season and an increase in precipitation in autumn (Comune di Parma, 2021).

4. Method For The Comparative Analysis

The comparative analysis is carried out consulting the technical documentation retrieved from the official websites of the analysed municipalities: specifically the three action plans, any guidelines for the drafting of the SECAP, if present (in this specific case only for the city of Mantua), and the urban planning tools of the analysed cities (e.g. local urban plans). The main aim is to understand how the practice of desealing is approached in the three urban contexts, what are the recurring and common approaches or features, and what are the discrepancies. Furthermore, it is interesting to investigate the relationship with traditional local urban plans which, in the regional and national legislative framework, are the ordinary tools used to guide decisions and interventions in the built and open spaces.

The comparative analysis of the three SECAPs is conducted in three parallel steps, as indicated in the matrix below (Table 3).

Table 3. Matrix for the comparative analysis of the three case studies.

STEPS	INVESTIGATED FEATURES	VALUES
1. ACTION PLAN CHARACTERISTICS	1.1 Declared relationships with upper-level policies, strategies and plans	
	1.2 Declared relationships with local policies and plans	
	1.3 Period of action	
	1.4 Main funder(s) and integration with funded research	

	programmes	
2. URBAN CONTEXT	2.1 Geographic features	
	2.2 Geomorphological features	
	2.3 Climate features	
3. DESEALING ACTIONS	3.1 Actions	
	3.2 Correlation with desealing	D. Direct I. Indirect
	3.3. Promoters / Funding source	
	3.4 Declared goals	
	3.5 Description	
	3.6 Relations with ordinary spatial planning tools	
	3.7 Urban space use	a. Current b. Planned
	3.8 Urban space ownership	a. Private b. Public
	3.9 Addressed urban challenges	a. Soil quality and water cycle b. Biodiversity c. Heat Island and air quality d. Urban space quality

Firstly, the characteristics of the action plan are highlighted with particular attention to:

- declared relationships with upper-level policies, strategies and plans, such as the international, national, and regional regulatory framework of climate and energy planning taken as a reference for the development and drafting of SECAPs;
- declared relationships with local policies and plans, where some actions of the SECAP are recalled, thus becoming a binding element in land management;

- period of action of the SECAP, dependent on the target year for achieving the goals set by the Covenant of Mayors (2030) and the plan's approval year;
- main funders of the action plans or involvement in funded European programmes or projects.

Secondly, the main characteristics of the urban context are identified, with a focus on the geographic, geomorphological, and climate features. The three case studies, although located in a uniform geographical macro-area, have some local characteristics that differentiate them.

In this phase, both the information encompassed by the SECAP and by other urban planning tools are considered, in order to understand the peculiarities of the analysed urban areas, and their influence on the SECAPs' priorities, aims, and actions.

Finally, the third activity involves the direct investigation of the action plans contents, focusing specifically on the meaning functions, and role played by desealing actions. A fundamental prerequisite for this phase, which is the most complex, is the definition of the actions to be investigated. These are identified as actions that directly or indirectly refer to desealing by generally contributing to restoring soil permeability and ecosystem services (Maienza *et al*., 2021), even if only partially. This assumption, therefore, leads to considering, in the first instance, also actions that merely restore a soil layer with surface permeability, such as the implementation of green roofs in existing buildings or underground car parks, as well as actions that potentially (and indirectly) may include desealing practices, such as urban forestation. It should be noted that actions that might potentially envision desealing interventions, such as river contracts, were also included among indirect actions.

For each identified action, the following aspects are investigated: action promoter(s) and financing methods; goal, i.e. declared urban problems that the action aims to solve or to reduce; description of the interventions envisaged; relations with the ordinary spatial planning tools, i.e. local urban plans and implementation plans; types of spaces involved within the action, sorted by space use and ownership.

The second activity of this last step includes an interpretative work that aims to associate each action with the urban challenge(s) addressed. Four main urban challenges are identified based on the literature review evidence: restoring and protecting soil quality and water cycle, enhancing biodiversity, reducing heat island and improving air quality, and improving urban space quality (soil quality and water cycle, biodiversity, heat island and air quality, urban space quality). This activity was meant to investigate the potential gap of knowledge of the municipalities between the goals they set and the positive effects of desealing which have been recognized in literature.

5. Results And Discussion

The comparison of the three SECAPSs highlighted similar contents as they refer to the same template and instructions published by the European Union (Bertoldi, 2018). Considerable space is given to the description of the projects and the responsible subjects, relations with traditional urban planning instruments and initiatives, spaces affected by the project proposals, funding sources, costs, monitoring indicators, and any results already achieved are indicated. Modena and Parma, moreover, visually report for each action whether they are consistent with the goals of the Agenda 2030, in order to enhance their synergy.

However, some significant differences can be found in the structure and organisation

of the action planning sheets as the SECAPs of Mantua (MN) and Modena (MO) dedicate two separate chapters to adaptation and mitigation, while the SECAP of Parma (PR) is the only one dealing with mitigation and adaptation in a single section of the document. This might underline a more integrated approach adopted by the city.

Furthermore, adaptation actions are often articulated according to different classifications. The cities of Mantua and Parma articulate them according to three major criticalities produced or aggravated by climate change: 1) heat waves and urban microclimate, 2) drought and water shortage, 3) floods and flooding with strong winds. Otherwise, the SECAP of Modena classifies them according to possible tasks or thematic sections: 1) green and blue infrastructures, 2) optimization of the maintenance and management of public services, 3) training and awareness.

The analytical tables comparing desealing features in three case studies can be found in the appendix. Overall, municipal authorities aim to encourage urban regeneration interventions of built-up areas and the recovery of sealed soils, limiting resource consumption and improving soil permeability and urban drainage. However, reference to desealing does not always emerge clearly and directly, and often needs to be sought.

Desealing, intended as an effective action to increase soil permeability has been approached in various ways also from the terminology perspective. For instance, the SECAP of Mantua does not directly refer to desealing but proposes various actions aimed at increasing soil permeability declaring clearly this intention in the actions' goal. On the other hand, the Municipality of Modena dedicates a specific action to promote the depaving of squares and parking lots, re-designing existing impervious public spaces according to a sort of more urban design-oriented approach, while also addressing soil permeability in the action goals. The SECAP of Parma, similarly to Mantua, encloses indirect reference to desealing actions as well, while addressing the increase of soil permeability in the actions' goals and description.

This underlines the fact that the three cities have recognized or, in some cases, perceived the role and potential played by desealing, but appear to have different perceptions and awareness levels, as they address desealing both as an action and as a goal. Direct mentions to the term desealing (or depaving) have been highlighted (especially in the case of Mantua and Modena), in parallel to indirect mentions diffusely employed in all three SECAPs. Indirect references to desealing were traced back to actions that envisage desealing as a potential preliminary stage, i.e., urban regeneration involving urban reforestation or greening interventions.

While desealing plays a role in the SECAPs of all three municipalities, it has been observed that the range of possible direct or indirect actions is broad, underlining the wide scope of these interventions. These range from general intervention strategies, without a specific spatial location, e.g., green roofs, infiltration trenches, rain gardens, etc. to be implemented in a widespread manner; to specific actions associated with a precise spatial location and funding source or actor(s) (PR, in particular); to traditional/innovative planning instruments or programming strategies, e.g., river contracts.

In this regard, a dichotomy between tradition and innovation has been observed. The analysis of the SECAPs showed a wide variety in the instruments used to promote an increase in urban soil permeability. Desealing is encompassed in more traditional instruments such as river contracts (MN and PR), water plans (MN), municipality emergency plan (MN), hydraulic risk management regulations (PR), as well as in more innovative tools, such as green plans (PR) and urban naturalisation plans (MN) and in relatively new practices, e.g., Sustainable Urban Drainage Systems (MN). The case of the Municipality of Mantua is interesting as it envisions a revision of its urban planning instruments (town plan and building regulation) with new dedicated regulations in order to stimulate these actions. As a final remark, it has been observed that desealing has been envisioned also by participatory or engagement actions such as web platforms (MN), Info-points (MO), and discussion tables (MO).

Concerning the typology of spaces involved in desealing practices, it has been noted that in the majority of cases, the current and planned space use are not specified, and while the urban spaces ownership has been generally more defined, the actions of the SECAP remain, especially in Mantua and Modena, quite theoretical.

The analysed SECAPs appear to have been intended as a container of adaptation and mitigation actions, more than an instrument to implement them systematically, acquiring a catalogue role to be put on the side of the other planning tools.

6. Conclusion

The increase in soil permeability, and, more specifically, the removal of the impervious layers of soil, is foreseen by many actions envisioned by the three analysed SECAPs. Actions are meant for different typologies of spaces (public/private, with different uses, dimensions, and spatial location), where desealing emerges with different roles, purpose and weights. Some actions foresee the increase of permeability as a priority goal (as in MO and PR case studies), while other actions, such as urban reforestation (MN) includes soil desealing and the increase of its permeability as a secondary outcome (e.g., to create the initial conditions to support priority actions).

In this frame, the SECAPs show their strategic function and acquire the role of a 'container' for various actions to be applied at different scales and in different frameworks. This voluntary and performance-based tool has the potential to provide municipalities with the data and tools for gaining insight, summarising actions to guide the resilient transition of cities, monitoring constantly the effectiveness of the actions undertaken, while creating a dialogue and synergy with traditional planning instruments. Unfortunately, the expected relationship with traditional town planning tools, often declared within SECAPs, is not yet fully expressed in the planning practice, at least in the Italian context. In addition, the future of SECAPs with the advent of 'new generation' urban planning tools, more attentive to climate change and sustainable energy issues, is still to be investigated.

Therefore, while on the one hand these planning documents may be seen as an added value for the municipality, on the other hand they may also become ineffective strategic directions if they do not provide an adequate connection with the instruments responsible for implementing urban transformations, especially for those actions involving the transformation of land use or land cover. The cases analysed revealed a multiplication of tools for implementing actions (e.g., water plans, municipality emergency plan, hydraulic risk management regulations, green plans, urban naturalisation plans) making the situation articulated and often complicated for administrations to manage.

Furthermore, the 'container tool' nature of SECAP, which encompasses a variety of different actions, makes it extremely difficult to set up a comparative analysis between different cities even when focusing on a specific theme such as desealing. That is why the comparative analysis carried out required considerable effort: the SECAPs documents, although quite similar in their general purposes and contents, as previously mentioned, had different articulation of sections and topics and, therefore, the comparison was not straightforward. Standards were sought in order to be able to make a homogeneous comparison and to point out useful information for the research. The various actions were, therefore, carefully analysed in order to extract from each one any possible direct or indirect reference to desealing actions.

The analysis of SECAPs highlights that in all three analysed cases, the increase in soil permeability is a topic of considerable relevance and significant flexibility in application. However, this does not always translate into the use of the term desealing, reflecting what happens in recent Italian regional legislation regarding land management (Garda, 2022) and the absence of a national regulatory framework and a common glossary consistent with the new global and local challenges. Nevertheless, SECAPs are useful tools in their strategic nature, rather than planning tools, for spreading awareness, providing tools, connecting the different urban planning instruments and policies, and implementing concrete actions aimed at addressing the main current urban challenges.

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Appendices

This annex collects the comparative analysis of desealing features collected from the three case studies: the SECAPs of Mantua, Modena, and Parma. The analysis matrix is reported in table A1 while results are shown in table A2-A3-A4.

Table A1. Matrix for the comparative analysis of the three case studies.

STEPS	INVESTIGATED FEATURES	VALUES
1. ACTION PLAN CHARACTERISTICS	1.1 Declared relationships with upper-level policies, strategies and plans	
	1.2 Declared relationships with local policies and plans	
	1.3 Period of action	
	1.4 Main funder(s) and integration with funded research programmes	
2. URBAN CONTEXT	2.1 Geographic features	
	2.2 Geomorphological features	
	2.3 Climate features	
3. DESEALING ACTIONS	3.1 Actions	
	3.2 Correlation with desealing	D Direct I Indirect
	3.3. Promoters / Funding source	
	3.4 Declared goals	
	3.5 Description	
	3.6 Relations with ordinary spatial planning tools	
	3.7 Urban space use	a. Current b. Planned
	3.8 Urban space ownership	a. Private b. Public
	3.9 Addressed urban challenges	a. Soil quality and water cycle b. Biodiversity c. Heat Island and air quality

	d. Urban space quality

Table A2 - SECAP of Mantua

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Dispersing wells	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Increase soil permeability and/or groundwater recharge 3. Increase soil retention 4. Reduction of flood areas 5. Avoid stormwater accumulation in "critical" urban areas	Dispersing wells are underground structures that store surface water and allow it to infiltrate into the ground*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	N.S.	N.S.	N.S.	N.S.	X			
Ditches	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Water lamination 2. Runoff and erosion reduction 3. Increase evapotranspiration 4. Increase soil permeability 5. Reduce temperatures 6. CO2 absorption/retention 7. Reduce of flood areas 8. Urban landscape improvement	Large vegetated linear channels that can store or convey surface water and remove pollutants*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	Green areas	Green areas	N.S.	N.S.	X	X	X	X
Filtering areas/stripes	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Runoff reduction 2. Increase evapotranspiration 3. Increase soil retention 4. Increase groundwater recharge 5. Reduce erosion 6. Reduce temperatures 7. CO2 absorption/retention 8. Reduction of flood areas 9. Urban landscape improvement	Vegetated, gently sloping areas for slow transport of water and its infiltration into the soil*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	Green areas	Green areas	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Green roofs	D	Public and/or private funding according to the property	1. Reduce UHI phenomenon by Increase evapotranspiration 2. Water lamination 3. Runoff reduction 4. Increase permeability and/or groundwater recharge 5. Reduce erosion 6. CO2 absorption/retention 7. Increase places of refreshment and recreation 8. Decrease the exposure of 'at risk' groups	Multi-layered drainage technology systems that cover the roof of a building with vegetation*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	Public offices, schools, commercial buildings, warehouses factories	Public offices, schools, commercial buildings, warehouses factories)	X	X	X	X	X	
Infiltration trenches	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Water lamination 2. Runoff reduction 3. Increase soil permeability and/or groundwater recharge 4. Increase soil retention of water 5. Reduce erosion and/or low sediment transport	Shallow excavations filled with rubble or stones*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	N.S.	N.S.	N.S.	N.S.	X	X	X	X
Interventions in specific areas with a high risk of flooding	D	N.S.	1. Reduce the minimum and eliminate harmful effects due to flooding and stagnation produced by stormwater.	Rehabilitation and redevelopment of the sewerage system and of surface rainwater runoff	Areas of intervention are defined by the urban planning tool (i.e., PGT).	N.S.	N.S.	N.S.	N.S.	X			
Permeable pavements	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Water lamination 2. Runoff reduction 3. Increase permeability and/or groundwater recharge 4. Water storage 5. Reduction of flood areas	Pavements designed to allow rainwater to infiltrate through the surface at a controlled rate*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	N.S.	N.S.	N.S.	N.S.	X		X	

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
SuDS (Sustainable Urban Drainage System): Channels and Drains	D	Assessment as a result of the Sewerage and Stormwater Drainage Works Plan	1. Water lamination 2. Runoff reduction 3. Increase evapotranspiration 4. Increase soil permeability and/or groundwater recharge 5. Reduce erosion 6. Reduce temperatures 7. CO2 absorption/retention 8. Reduction of flood areas 9. Urban landscape improvement	SuDS (Sustainable Urban Drainage System), can be identified as canals, streams or other open surface water paths embedded in the ground*	-Municipal Emergency Plan - Water Plan - Urban Renaturalization Plan - River Contract - PGT -Building Regulations	N.S.	N.S.	N.S.	N.S.	X	X	X	X
Forest protection zones (buffer)	I	Public and/or private funding according to the property	1. Reduce UHI phenomenon by Increase evapotranspiration 2. Water lamination 3. Runoff reduction 4. Increase permeability 5. Reduce erosion 6. CO2 absorption/retention 7. Soil improvement 8. Increase places of refreshment and recreation 9. Decrease the exposure of 'at risk' groups	Tree-covered areas that provide a relatively undisturbed zone (buffer) along watercourses and other water bodies *	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	Fluvial areas	Fluvial areas	N.S.	N.S.	X	X	X	X
"*Green Infrastructure*"	I	Integrated project "*Mantova Hub*"	1. Improve environmental quality 2. Contrast the climate change 3. Urban microclimate control 4. UHI phenomenon control	Actions aimed at increasing the resilience of the territory and the sustainability of transformations	N.S.	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Mantova Water Plan "Piano Acque"	I	N.S.	1. Improve the knowledge about urban whitewater networks 2. Verify the hydraulic compatibility of future urban developments 3. Reduction of the damages to people and properties 4. Avoid indemnity and repair costs	Innovative planning instrument addressing hydraulic issues	The outcomes of the document must be incorporated into the urban planning tool (i.e., PGT)	N.S.	N.S.	X	X	X			
Mincio River Contract	I	N.S.	1. Increase the hydraulic resilience of the area 2. Avoid damages to people and properties 3. Avoid water consumes during droughts 4. Avoid indennity costs	Coordination between institutions on environmental and landscape requalification, water quality and availability of Mincio River	The River Contract envisions a Climate Adaptation Plan for the Municipality of Mantua	N.S.	N.S.	N.S.	N.S.	X	X		
Municipal Emergency Plan "Piano di emergenza comunale"	I	N.S.	1. Minimise and eliminate the harmful effects of flooding and stagnation caused by stormwater in the specified areas.	Drawing up a municipal emergency plan	Coordination with PSAI and PGRA supra-municipal instruments on hydrogeological safety	N.S.	N.S.	N.S.	N.S.	X	X	X	
Public green web-portal	I	N.S.	1. Facilitating diffuse knowledge about public green, its functions and the related activities of the public administration.	Updated web-portal on green areas	N.S.	N.S.	N.S.		X	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Rain garden	I	Public and/or private funding according to the property	1.Reduce UHI phenomenon by Increase evapotranspiration 2. Water lamination 3. Runoff reduction 4. Increase permeability and/or groundwater recharge 5. Reduce erosion 6. CO2 absorption/retention 7. Increase places of refreshment and recreation 8. Decrease the exposure of 'at risk' groups	Small gardens used for water storage and infiltration, planted with vegetation capable of withstanding flooding*	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	N.S.	N.S.	X	X	X	X	X	X
Urban reforestation	I	Regional funding and public-private co-financing	1. CO2 absorption/retention and reduction of pollutants 2. Promote social cohesion through the direct involvement of citizens in the design and management of new and existing green spaces 3. Improve the liveability of the urban environment 4.Reduce UHI phenomenon by Increase evapotranspiration 5. Water lamination 6. Runoff reduction 7. Increase permeability and/or groundwater recharge 8. Reduce erosion 9. Increase places of refreshment and recreation 10. Decrease the exposure of 'at risk' groups	Increase of the tree stock	New regulations in the urban planning instruments (e.g., PGT) and in the Building Regulations	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Urban Renaturalisation Plan "Piano di rinaturalizzazione urbana"	I	European project H2020 "*Urban Green Up"*	1. Improve urban resilience performance through natural solutions (NBS) 2. Avoid damages to people and properties 3. Health costs resulting from extreme weather events 4. Avoid indennity costs	Plan to include NBSs in areas where they can be effective in achieving the objectives	Integral part of the urban planning instrument (i.e., *PGT*)	N.S.	N.S.	N.S.	N.S.	X	X	X	X

N.S.: Not Specified.

*: Retrieved from *"Towards the Climate Adaptation Plan - Guidelines"* (Musco, 2018).

Table A3 - SECAP of Modena

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
De-paving of squares and parking lots	D	N.S.	1. Contrast heat waves 2. Increase permeability	De-paving of sealed surfaces with the replacement of drainage material.	N.S.	Squares Parking lots	Permeable squares and parking lots	X	X	X		X	X
Urban forests (of public street spaces and green areas)	D	N.S.	1. Increase the level of thermal comfort 2. Mitigating polluting factors and the concentration of Volatile Organic Compounds	Urban forestation of public street spaces and green areas, with the planting of tree species.	N.S.	Public street spaces and green areas	Public street spaces and green areas	X	X	X	X	X	X
Small, gardens, equipped green spaces vegetable gardens or shared gardens	D	N.S.	1. Promote sociability and social gathering	Creation of equipped, welcoming and inclusive public spaces.	N.S.		Green areas	X	X	X	X	X	X
Laminating basins	D	N.S.	1. Water purification of sedimentation of suspended solids 2. Removal of nutrients 3. Natural infiltration of rainwater	Creation of flood basins and/or flood ditches	N.S.	N.S.	N.S.	X	X	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Changes to municipal urban planning instuments	I	Municipality of Modena	1. Contrast heat waves 2. Contrast cold waves 3. Runoff reduction 4. Contrast flood risk	Approval of the new Urban Building Regulation, which gives priority to urban regeneration processes, soil permeability requirements, sustainable mobility	New regulations to keep soil sealing as low as possible	N.S.	N.S.	N.S.	N.S.	X	X	X	X
Urban forests	I	N.S.	1. Contras heat waves 2. Contrast heavy rainfall	Creation of a new urban forest in continuity with the existing forest area in via Tignale del Garda, next to a residential complex under construction	N.S.		Urban forest	N.S.	N.S.	X	X	X	X
Cavo Cazzola	I	European project H2020 HERA	1. Contrast heavy rainfall 2. Contrast flood risk 3. Contrast drought	Increase of the natural section of the Cavo Cazzola canal and a calibrated hydraulic gate. Biofilter treatment of the mixed water. Part of the project “Grow Green - Nature-based Solutions per la resilienza idrica e climatica”	N.S.	Watercourses	Watercourses	N.S.	N.S.	X	X		
Rain gardens	I	N.S.	1. Contrast heavy rainfall 2. Contrast flood risk	Creation of rain gardens, reconfiguring existing roadside flowerbeds to intercept rainwater from roofs, roads and car parks.	N.S.	Roadside flowerbeds	Rain gardens	X	X	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Promotion of NBS strategies	I	N.S.	1. Contrast heavy rainfall 2. Contrast flood risk	Definition of guidelines for the promotion of NBS strategies through awareness-raising and capacity-building in cities, supporting the creation of an appropriate policy framework, business models for NBS investments and an NBS market (within the European project "Grow Green")	Integration of NBS strategies into urban planning.	N.S.	N.S.	N.S.	N.S.	X	X	X	X
working table on local floods	I	N.S.	1. Identify strategies and pilot experimental and demonstration actions	Coordination with the competent territorial bodies to identify strategies and pilot actions	N.S.	N.S.	N.S.	N.S.	N.S.	X			
Climate-Energy Info Point	I	N.S.		Reference office for the coordination of all industrial cluster activities related to the topics of climate change mitigation and adaptation, resilience and sustainability	N.S.	N.S.	N.S.	X		X	X	X	X

N.S.: Not Specified

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3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Channels and Drains	D	N.S.	1. Water lamination 2. Increase soil permeability and/or groundwater recharge 3. Reduce erosion 5. Improve water management 6. Avoid damage to buildings and people 7. Avoid stormwater accumulation 8. Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	Green areas	Green areas	N.S.	N.S.	X	X	X	X
Desealing	D	University of Parma	N.S.	Future desealing initiatives.	N.S.	Sealed surfaces		X		X		X	X
		ASP-Ad Personam	N.S.	Desealing of outdoor spaces converted to grass and draining paved surfaces.	Villa Parma Park redevelopment project	Urban park	Urban park		X	X	X	X	X
		Committee for the Regeneration of the Productive Area North "Comitato per la rigenerazione dell'Area Produttiva Nord"	1. Promote environmental sustainability	Carry out interventions to increase permeable surfaces in the productive area.	A project for the redevelopment and enhancement of this area is underway.	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
		Municipality of Parma Shopping Centres and Supermarkets (Possible funding from participation in European calls for tenders)	1. Heat waves reduction 2. Decrease the exposure of 'at risk' groups 3. Transform car parks into integrated reception areas 4. Increase the green/concrete ratio	Co-design desealing and enhancement initiative focused on shopping centers' and supermarkets' parking areas.	N.S.	Parking areas	Green areas, equipped areas		X	X	X	X	X
Dispersing wells	D	N.S.	1. Water lamination 2. Increase soil permeability and/or groundwater recharge 3. Increase soil retention 4. Contrast the climate change 5. Improve water management 6. Avoid damage to buildings and people 7. Avoid stormwater accumulation in urban areas 8. Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	N.S.	N.S.	N.S.	N.S.	X			
Ditches	D	N.S.	1. Water lamination 2. Runoff reduction 3. Increase soil permeability and/or groundwater recharge 4. Reduce erosion and/or low sediment transport 5. Contrast the climate change 6. Improve water management 7. Avoid damage to buildings and people 8. Avoid stormwater accumulation in urban areas 9. Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	Green areas	Green areas	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Filtering areas/stripes	D	N.S.	1. Runoff reduction 2. Increase soil retention of water 3. Reduce erosion and/or low sediment transport 4. Contrast the climate change 5. Improve water management 6. Avoid damage to buildings and people 7. Avoid stormwater accumulation in urban areas 8. Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	Green areas	Green areas	N.S.	N.S.	X	X	X	X
Green roof	D	N.S.	1. Reduce heat flow 2. Reduction of temperature peaks 3. Runoff reduction 4. Increaging evapotranspiration 5. CO2 absorption and/or retention	N.S.	"Piano del Verde"	Buildings	Buildings	N.S.	N.S.	X	X	X	
Infiltration trenches	D	N.S.	1. Water lamination 2. Runoff reduction 3. Increase soil permeability and/or groundwater recharge 4. Increase soil retention of water 5. Reduce erosion and/or low sediment transport 6. Contrast the climate change 7. Improve water management 8. Avoid damage to buildings and people 9. Avoid stormwater accumulation in urban areas 10. Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Laminating or storage systems for new interventions	D	Municipality of Parma IRETI	1. Avoid overloading the hydraulic network and receptors 2. Avoid damage to buildings and people 3. Avoid repair/compensation costs	Prescribing lamination or storage systems for new interventions, also encouraging maximum reduction of impermeable surfaces.	N.S.	N.S.	N.S.	N.S.	N.S.	X		X	
Permeable pavements	D	N.S.	1. Water lamination 2. Runoff reduction 3. Increase permeability and/or groundwater recharge 4. Water storage 5. Contrast the climate change 6. Improve water management 7. Avoid damage to buildings and people 8. Avoid stormwater accumulation in urban areas 9 Avoid repair/compensation costs	Sustainable urban drainage technical solutions (SuDS solution).	Inclusion of stringent and binding rules for implementing Sustainable Urban Drainage Solutions (SuDS) in municipal urban planning instruments.	N.S.	N.S.	N.S.	N.S.	X		X	
Stormwater collection	D	Municipality of Parma IRETI	1. Runoff reduction 2. Soil erosion reduction 3. Storage, in distributed form, of significant quantities of rainwater to allow multiple use of water for non-drinking purposes (watering lawns and gardens, washing cars, roads, etc.).	Example of a measure against drought and water scarcity, for residential, tertiary, industrial, agricultural sectors.	Introduction of water cycle regulations in municipal urban planning instruments that incentivise these actions.	N.S.	N.S.	N.S.	N.S.	X			

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Forest protection zones (buffer)	I	N.S.	1. Reduce UHI phenomenon by Increase evapotranspiration 2. Runoff reduction 3. Increase permeability and/or groundwater recharge 4. Reduce erosion and/or low sediment transport 5. Soil improvement 6. CO2 absorption and/or retention	N.S.	"Piano del Verde"	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Green Plan "Piano del Verde"	I	Municipality of Parma	1. Decrease the urban heat island and contain summer heat waves by Increase shaded areas and evapotranspiration 2. Increase 'islands' and 'corridors' (including cycle and pedestrian corridors) as places of cooling and recreation 3. Increase CO2 absorption and/or retention (CO2 storage and fixation) 4. Immobilise atmospheric particulate matter 5. Decrease soil sealing with desealing operations 6. Increase biodiversity 7. Increase the socio-psychological benefits of "open" areas 8. Laminating water through flood basins or similar systems 9. Limit surface runoff by slowing it down 10. Increase soil permeability and/or groundwater recharge efficiency 11. Reduce erosion and/or sediment transport 12. Avoid the deployment of people from 'risk' groups (the elderly and children)	Voluntary instrument of government that places public green as a strategic asset for the future development of the city.	The Plan should be incorporated into the municipal urban planning instruments. The three-year public works programme (an integral part of the Single Programming Document - SPD) can become a tool at the junction between the 'adaptive' measures of urban planning and the implementation of public works.	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Hydraulic Risk Management Regulation "Regolamento di gestione del Rischio Idraulico"	I	Municipality of Parma	1. Limiting the degree of soil sealing 2. Choose surface runoff paths wisely and carefully 3. Favouring dispersion on the ground or in the surface layers of the subsoil for water from roofs and green areas that are free of potential pollutants and sedimentable solids sedimentable solids 4. Adopt permeable paving where possible 5. Avoid damage to buildings and people 6. Avoid stormwater accumulation in urban areas 7. Avoid repair/compensation costs	The Hydraulic Risk Management Regulation is a substantial document that pursues the principle of 'hydrogeological and hydraulic invariance' of the anthropic areas of the municipal territory.	Full transposition of the Regulation into the municipal urban planning instruments.	N.S.	N.S.	N.S.	N.S.	X		X	X
Integration and maintenance of public green	I	Committee for the Regeneration of the Productive Area North "Comitato per la rigenerazione dell'Area Produttiva Nord"	1. Promote environmental sustainability	Implementation of measures to integrate and maintain public green areas in the productive area.	A project for the redevelopment and enhancement of this area is underway.	Green areas	Green areas		X	X	X	X	X
Public green web-portal	I	Municipality of Parma	1. Facilitating diffuse knowledge about public green, its functions and the related activities of the public administration.	Update web portal on green areas	N.S.	N.S.	N.S.		X				

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Parma-Baganza Stream Contract "Contratto di Fiume"	I	Municipality of Parma Po River District Basin Authority	1. Increase the resilience to climate change 2. Mitigate the hydraulic risk and the prevailing hydrogeological instability phenomena (erosion, local and superficial landslides, overbanking) affecting the Apennine piedmont sector 3. The improvement of water quality and water balance in the Basin 4. The increase and better management of flow rates in the streams 5. The implementation of agri-cultural interventions to improve environmental quality 6. The preservation and restoration of the river landscape 7. The "basin" territorial co-ordination/governance overcoming "municipal" logics 8. The dissemination and sharing of information on the basin 9. Environmental education activities on the theme of water quality with the local population (adults, schools, farmers) 10. Avoid damage to buildings and people 11. Avoid water consumption in drought periods 12. Avoid compensation costs	Coordination between institutions on environmental and landscape requalification, water quality and availability of Baganza Stream	N.S.	Fluvial areas	Fluvial areas	N.S.	N.S.	X	X	X	

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
Structural works for hydraulic defence	I	Municipality of Parma Emilia-Romagna Region "Consorzio di bonifica Parmense"	1. Contrast heavy rainfall 2. Contrast flood risk 3. Making part of the city safe 4. Water lamination 5. Avoid damage to buildings and people 6. Avoid stormwater accumulation in urban areas 7. Avoid repair/compensation costs	Construction of two lamination cases and a hydraulic defence work.	"Piano Invasi 2020-2029"	N.S.	N.S.	N.S.	N.S.	X			
Rain garden	I	N.S.	1.Reduce UHI phenomenon by Increase evapotranspiration 2. Water lamination 3. Runoff reduction 4. Increase permeability and/or groundwater recharge 5. Increased water retention in the soil 6. Reduce erosion and/or low sediment transport 7. CO2 absorption and/or retention	N.S.	"Piano del Verde"	N.S.	N.S.	N.S.	N.S.	X	X	X	X
Urban reforestation	I	Province of Parma	N.S.	In 2020, as part of the KmVerdeParma initiative, about 80 (eighty) trees were planted at the I.T.I.S. Da Vinci in Via Toscana.	N.S.	N.S.	N.S.	N.S.	N.S.	X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
		University of Parma	N.S.	"Tree Project" with the already completed planting of 340 tree and shrub species in various green areas on the university campus.	N.S.	Green areas	Green areas	X		X	X	X	X
		ASP-Ad Personam	N.S.	Total planting of 40 new plants.	Villa Parma park redevelopment project	Urban park	Urban park		X	X	X	X	X
		Barilla	N.S.	More than 1,000 trees and shrubs planting on a 5 hectares area	N.S.	N.S.	N.S.	X		X	X	X	X
		Chiesi Farmaceutici	1. Improve air quality 2. Realising permanent forests	Forestation interventions in the Province of Parma	N.S.	N.S.	N.S.	X		X	X	X	X

3.1	3.2	3.3	3.4	3.5	3.6	3.7.a	3.7.b	3.8.a	3.8.b	3.9.a	3.9.b	3.9.c	3.9.d
		Davines	N.S.	Inclusion of approximately 270 plants in their own area and by 2022 a further 250 to 300 plants in the former Morris area.	N.S.	N.S.	N.S.	X		X	X	X	X
		Molino Grassi	N.S.	Planting of an area of 5 hectares (approximately 3,000 trees)	N.S.	N.S.	N.S.	N.S.	N.S.	X	X	X	X
		Municipality of Parma	1. Reduce UHI phenomenon by Increase evapotranspiration 2. Runoff reduction 3. Increase permeability and/or groundwater recharge 4. Reduce erosion and/or low sediment transport 5. CO2 absorption and/or retention 6. Capture of pollutants in the atmosphere 7. Capture of ultrafine dust (PM10. PM2.5)	New plantings, such as for the four large "Kyoto Forest" areas, according to the urban reforestation projects in the "Piano del Verde".	"Piano del Verde"	N.S.	N.S.	N.S.	N.S.	X	X	X	X
		KilometroVerdeParma Forestry Consortium Emilia-Romagna Region	1. Improve the landscape impact of the highway artery 2. Mitigating its negative impact in terms of air quality and fine dust dispersion 3. Raising awareness in the municipal and provincial territory of the important functions performed by green areas and the consequent ecosystem benefits	11-kilometre tree-lined strip parallel to the section of the "Autostrada del Sole" highway alongside Parma.	Action foreseen in the Municipal Structural Plan (i.e., PSC).	Free and available land	Urban forest	X	X	X	X	X	X

N.S.: Not Specified.