



Enhancing climate change adaptation strategies
and measures in the Metropolitan City of Milan

PRACTICAL HANDBOOK

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Abbreviations

CSO	Civil Society Organisation	MGN	Metropolitan Green Network
EU	European Union	MTP	Metropolitan Territorial Plan
FAO	Food and Agriculture Organization	NBS	Nature-Based Solutions
LIFE	Programme for the Environment and Climate Action	NDVI	Normalized Difference Vegetation Index
MCA	Multi Criteria Analysis	TGP	Territory Government Plan
MCM	Metropolitan City of Milan	UHI	Urban Heat Island



Foreword

"Many European cities, especially densely urbanized metropolitan areas in the Mediterranean, are facing serious climate challenges, which are part of a global context of serious environmental, economic and social suffering. The 2015 Paris Agreement recognized the crucial role that metropolitan areas play in the implementation of the global climate policy and in the climate change adaptation process in the European Union.

Accepting the challenge, the Metropolitan City of Milan began to look at European projects in order to be able to address these extraordinary challenges with special "tools". Through the LIFE Metro Adapt Project, the Metropolitan City of Milan has been covering a leading role, both as a public entity and as a territory, trying to understand and manage the specific effects of climate change. This project has provided our entity and our territory with learning, planning and technical tools to deal with climate change adaptation, and, at the same time, it has allowed us to build a real local system made up of entities, research institutes, companies and people.

Thanks to the synergies created with the various partners, the Project has taught us that it is necessary to work together, combining the different skills and expertise to enhance climate change adaptation in the territory and, the same time, to improve the well-being of citizens, ecosystems and companies. This is a legacy that goes far beyond the limits and deadlines of the project. Over the last three years, several technicians and public administrators have joined the numerous training courses on these topics organized by the LIFE Metro Adapt project, involving experts and key stakeholders in the field. We have always believed that the tools for territorial resilience and innovation should be shared and be available to everyone.

The global Pandemic of Covid-19 has not stopped this project, which, using all the available information technologies, has continued its journey boosting a constant dialogue and knowledge exchange both at the national level and with some of

the most significant metropolitan areas in Europe. Given its representativeness in terms of structure, environmental and social characteristics, the Metropolitan City of Milan may be a useful example for other similar contexts that are tackling this common challenge both at the national and European level. The systems we have employed are open source and all documents are public and available to all, precisely because transparency and sharing are the basis for common growth.

Investing in adaptation systems based on Nature (the so-called Nature-Based Solutions) is the most suitable solution for our densely urbanized context where environmental challenges are intertwined with social and occupational distress. The opportunity of adaptation must be seized, boosting and relaunching an ecological transition in which the Metropolitan City of Milan not only wants to be a part, but wants to be a protagonist, together with its territory.

I would like to thank all the partners who, thanks to their professionalism, have worked with us to make this project a real change".

Michela Palestra, Councilor for the Environment, Metropolitan City of Milan

About Metro Adapt

According to most climate models, Southern Europe, and the especially the Mediterranean basin, is particularly vulnerable to the impacts of climate change. The region of Lombardy (Italy), due to its geographical, territorial and socioeconomic features, presents a high vulnerability to the effects of climate change. The region – with mountainous areas and river valleys extensively urbanized – is exposed to both extreme weather events and longer-term impacts from climate change. Past trends and future scenarios suggest a marked increase in the temperatures and in the frequency and intensity of heat waves events, a decrease in snow and ice cover, and changes in seasonal precipitation patterns such as a rainfall decrease in summer season.

The Metropolitan City of Milan is among the most densely populated urban areas in Europe with a density of about 2,038 inhabitants/km² for a total of 3.2 million inhabitants (2016) and a demographic structure formed for 22% over 64 years old. Its territory is about 1600 Km² distributed over 133 Municipalities, including the city of Milan, and is about 41% formed by build-up areas and infrastructures, 50% formed by agricultural areas and only 8% formed by woodlands.

METRO ADAPT project is focused on some of the climate problems addressed in metropolitan urban areas, in particular heat waves and urban heat islands and local flooding due to runoff excess. The effect of heat waves in the urban structure of a wide territory like Metropolitan Area of Milan it is amplified in dense built-up areas (about 40,5% of the whole territory), and by anthropogenic factors such as traffic and other human activities. Moreover, the whole Metropolitan Area of Milan is prone to flood risk, due both to expected increase of peak flow of the Olona and Seveso rivers and to the runoff generated by the compact, not permeable urban fabric. These climate challenges have to be faced in many European cities and towns, in particular densely urbanized metropolitan areas.

Having to deal with this kind of problems, cities and towns have been recognized to play a crucial role in the adaptation process across the European Union. Climate policy in cities has been supported by the Paris Agreement recognition of cities as key actors in implementation and has been one of the priorities when implementing the EU Adaptation Strategy. Within the new Covenant of Mayors for Climate and Energy, adaptation has been merged with mitigation efforts in a European initiative involving over 7,000 cities around the world.

Local governments are in a unique position to engage local stakeholders and draw punctual responses to local climate related vulnerabilities and risks. At the same time, individual municipalities do not have the necessary resources (scientific knowledge, administrative competences, funding, etc.) to deal with climate problems.

Within this framework and context, over the past three years the Metro Adapt Project has been working to foster the creation of a common well-structured governance related to climate change adaptation among local authorities of the Metropolitan Area of Milan and to produce tools that allow local authorities to implement cost-effective climate change adaptation strategies and policies adapted to the local context. Besides its crucial role at the local level, the project has worked to create linkages and synergies with other territorial contexts both at the national and European level, through the dissemination of the project's tools and good practices and stimulating a knowledge exchange process with Italian and EU metropolitan areas.

The project is co-funded by the EU Programme for the Environment and Climate Action – LIFE, it is coordinated by the Metropolitan City of Milan in collaboration with six partners: ALDA – European Association for Local Democracy, Ambiente Italia S.R.L, CAP Holding S.p.A, e-GEOS and Legambiente Lombardia.

About the partners

The Metropolitan City of Milan

The Metropolitan City of Milan, leader of the LIFE Metro Adapt Project, is a local public authority established by the Italian Law 56/2014 and operating from the 1st of January 2015. The Metropolitan City of Milan governs the vastest metropolitan urban area in Italy. It includes the city of Milan and other 133 municipalities, representing a functional area of more than 5 million people. It implements and coordinates activities of strategic planning, sustainable mobility and urban public transports, including greening issues, territorial development, digital agenda and European policies and programming. The Milan Metropolitan City plays a crucial role in mainstreaming climate change adaptation measures in 134 municipalities.



**Città
metropolitana
di Milano**

ALDA – European Association for Local Democracy

ALDA is a key stakeholder in the field of local democracy, active citizenship, and co-operation between local authorities and civil society in Europe and its Neighbourhood, mainly acting through participatory methods and decentralized cooperation. In the framework of the promotion of good governance and citizens' participation at the local level, environment and sustainability are at the core of ALDA's thematic focus, representing one of the pivotal points of its strategic plan 2020-2024. Over the last decade, through the collaboration of its wide network and Local Democracy Agencies (LDAs), ALDA embedded the commitment to reach the targets of the 2020 climate and energy package within its priorities, thus engaging in climate change mitigation and sustainable energy projects. In line with the European Green Deal aim to make Europe the first climate-neutral continent by 2050 and in the framework of the Agenda 2030 for Sustainable Development, ALDA is collaborating with local, metropolitan and regional authorities and international key stakeholders to contribute to the new EU growth strategy putting its innovative methodology at the service of the fight against climate change and environmental degradation.



Ambiente Italia S.R.L.

Ambiente Italia is a consultancy leader group in Italy and Europe operating in engineering for sustainability. Ambiente Italia has a long and wide experience in managing EU funded projects, with particular reference to the implementation of innovative and demonstrative pilot actions and the exploitation of project results through dissemination activities at National and European level. In the field of climate change adaptation, Ambiente Italia has specialised in supporting local authorities in defining urban resilient strategies, as for example in Life+ CHAMP – Local Response to Climate Change; Life WATACLIC – Water Against Climate Change; Life+ BLUEAP – Bologna Local Urban Environment Adaptation Plan for a Resilient City; Life MASTER ADAPT – Mainstreaming Experiences at Regional and local level for adaptation to climate change.



Gruppo CAP

It deals with the Integrated Water Service within the Great Milano Area, which includes 148 municipalities. The service includes water supply, distribution, sewerage and waste water treatment. Regarding climate change adaptation, CAP is strongly committed in finding alternative rainwater management solutions in order to contribute to natural groundwater recharging, reduction of waste water collection and treatment costs, limitation of flooding and water volumes discharged into watercourses. It is in this framework that CAP collaborated with Lombardy Region, ERSAF and the University of Milan.



e-GEOS

e-GEOS, an ASI (20%) / Telespazio (80%) company, is a leading international player offering a complete range of products and services in the Earth Observation and in the Geo-spatial Information application domains, based on both optical and radar satellites as well as on aerial surveys and in-situ data. e-GEOS is one of the main industrial players in the Copernicus Program and is a world leader in environmental and maritime monitoring and in rapid mapping for the management of natural disasters and humanitarian crises. Among its partner, EMSA, EU SatCen (European Union Satellite Centre), JRC (Joint Research Centre of the European Commission), several UN Organizations and Italian Ministries.



Legambiente Lombardia

Legambiente is a non-profit organization whereby a group of individuals, joined together to improve and protect the environment. It gives priority-attention to the problems deriving from environment and urban degradation, to energy issues and the development of the renewable energy sources and to the links between economy and the environment. Legambiente Lombardia performs its activities on a regional basis, with more than 100 local groups. The members are involved in activities such as raising awareness, information, education, scientific issues. Since 2008 it has been developing specific actions and campaign on climate change, such as Marcia per il Clima in Milan, Ecolife, Viviconstile, etc. in order to stimulate citizens' awareness and engagement.



The Metro Adapt methodology

WHAT ARE NATURE-BASED SOLUTIONS?

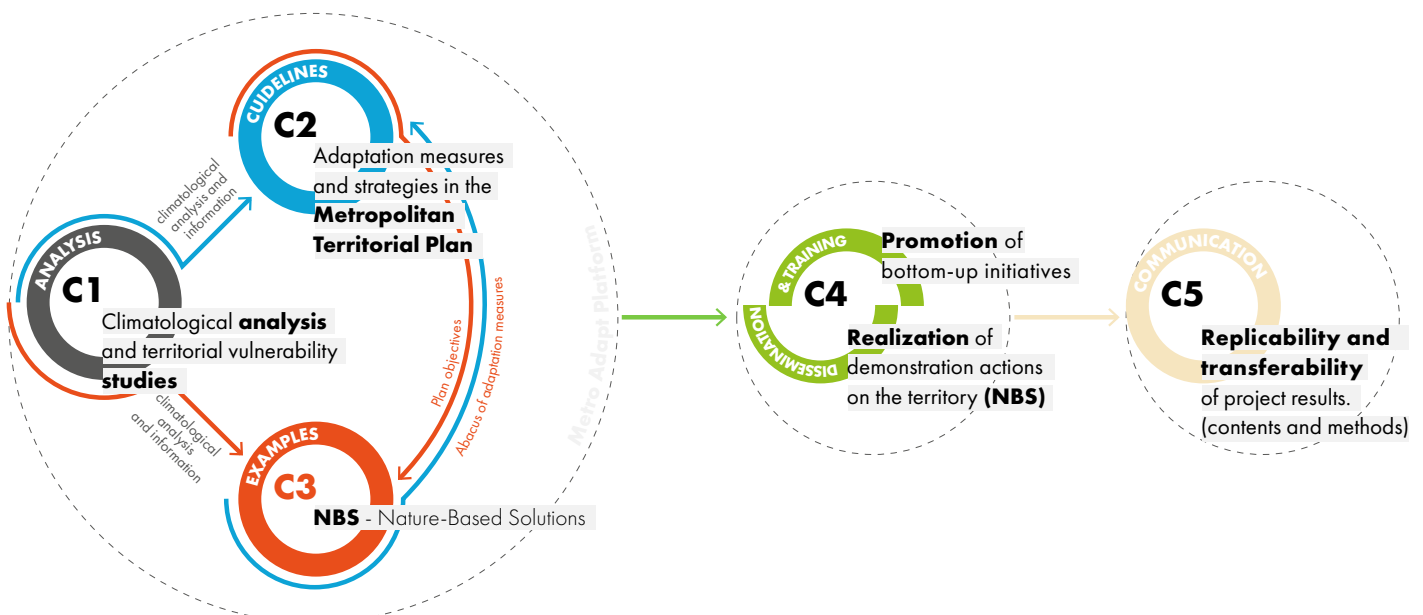
Nature-Based Solutions (NBS) are interventions inspired and supported by Nature that guarantee environmental, social, and economic benefits, contributing to improving climate change adaptation in urban areas and increasing territorial resilience. Green roofs, green walls, urban forests, alternative rainwater management systems and urban agriculture are just some of the solutions that can be implemented in urban and peri-urban areas.

The Metro Adapt Methodology starts from a deep analysis of the climate change impact on the metropolitan territory and on his citizens' life: all data are collected and studied to identify major vulnerabilities. Believing in the importance of sharing the generated contents to create knowledge and raise awareness, the results of the analysis are made available and accessible to all actors on a public repository on the Milan Metropolitan City's (CMM) website: the Metro Adapt Platform.

The second step of the project identifies the most suitable Nature-Based Solutions (NBS) and guidelines that can be used by local authorities with the aim of improving the quality of life of all people, in particular of disadvantaged groups of the population. For each NBS the project has developed a detailed data sheet and feasibility study. To encourage the use of NBS, some examples of implementation have been developed, shown and outlined to citizens and institutions.

In order to push for the adoption of all the guidelines at the local level, the LIFE Metro Adapt Project uses, as vehicle, the Milan Metropolitan City's most important territorial planning instrument: the Metropolitan Territorial Plan. The normative section dedicated to environmental emergencies, in fact, contains guidelines and directives for municipal plans aimed at the inclusion of specific parameters and rules closely related to climate change adaptation in the Milan metropolitan area.

All those actions are supported by the strong aim to raise awareness about climate change and climate change adaptation measures in order to promote actions and initiatives that can take place directly from people. In this context, some demonstration actions have been developed to confirm the value and performance of the proposed measures. The methodology applied by the project can be replicated at any level of complexity and in other territorial contexts: for example, it can be used by other metropolitan cities or even by small municipalities.



Climatological analysis and study of the territorial vulnerability to support climate change policies

In the first analysis, the project envisaged the study of **thermal anomalies** in the urban environment in order to identify the areas where night temperatures, in certain summer periods, exceed the admissible temperature for several consecutive days. This first study is crucial, since once these areas have been identified, it is possible to study which are the best solutions in order to reduce extreme temperatures, harmful to the health of the population. The study assessed the vulnerability of the resident population in these “dangerous” areas. Furthermore, a research has been carried on about the relationship between the increase in temperature and yield in the agricultural field, in order to better target the watering or treatment techniques of the plantations.

THERMAL ANOMALIES

One of the thermal anomalies which affect Milan Metropolitan Area the most is the Urban Heat Island (UHI) phenomenon. Climate change projections for the European continent, including the Po basin, agree that during this century heat waves will become more and more frequent, intense and they will last longer, especially during the summer season.

Thanks to the use of satellite remote sensing technologies, the project has been able to obtain updated data on the territory at various scales, from the municipal level up to very large areas (district basin management plans, landscape plans and regional plans in the water and instability sectors, etc.). In addition, satellite technologies, allowing a synoptic view of critical issues, favor the desirable integration of planning at different levels, which is essential for optimizing the available economic resources and for the implementation of multi-objective and integrated actions.



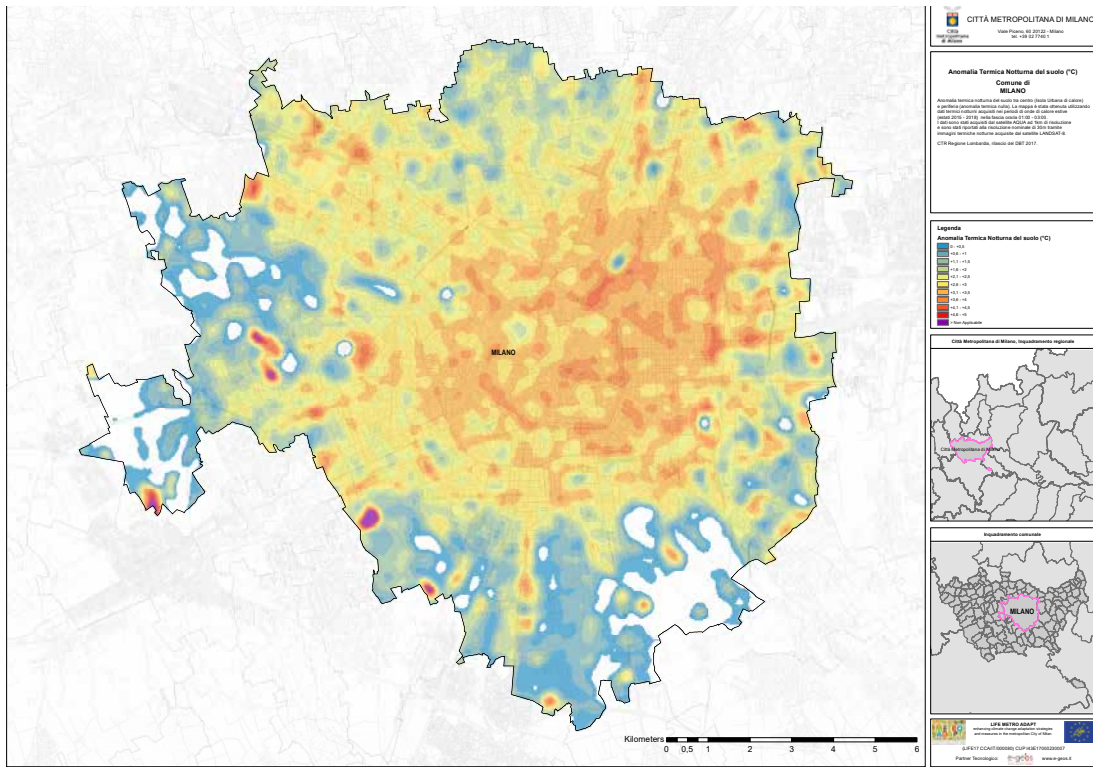


Figure 1. Thermal anomalies in the municipality of Milan, during the heat waves in the summers from 2015 to 2018.

Urban Heat Islands Risk Maps

For the area of the Metropolitan City of Milan, a risk analysis was performed for extreme temperatures, aimed at the most vulnerable population (the elderly and children), during the summer heat waves. In particular, in some areas of the city, due to the urban conformation and the anthropogenic effect, very high temperatures are encountered even during the night and for several consecutive days (Urban Heat Islands, UHI). Various studies have found that mortality in urban areas increases significantly during heat waves. Below is an example of the municipality of Milan.

The maps were produced starting from the identification of the periods in which heat waves phenomena occurred, during which data from the MODIS AQUA and Landsat satellites (both managed by NASA) were used. The data were classified into 5 classes of ground thermal anomalies.

Here the need for ground data has been reduced to zero, thus using only satellite data provided free of charge. In this way it is possible to renew the maps quickly, a need that may however only be necessary in or due to variations in the conditions of land use of a certain importance and significance.

The following figure shows an example of how the distribution of the temperature variation is the same at different times.

WHAT ARE URBAN HEAT ISLANDS?

An "Urban Heat Island" is defined as an area of the city in which the measured temperature is much higher (5 ° C and above) than the minimum reference measured in the surrounding rural. These heat islands have been reported on a map of "thermal anomalies" which takes into account the satellite thermal data available throughout the entire summer season.

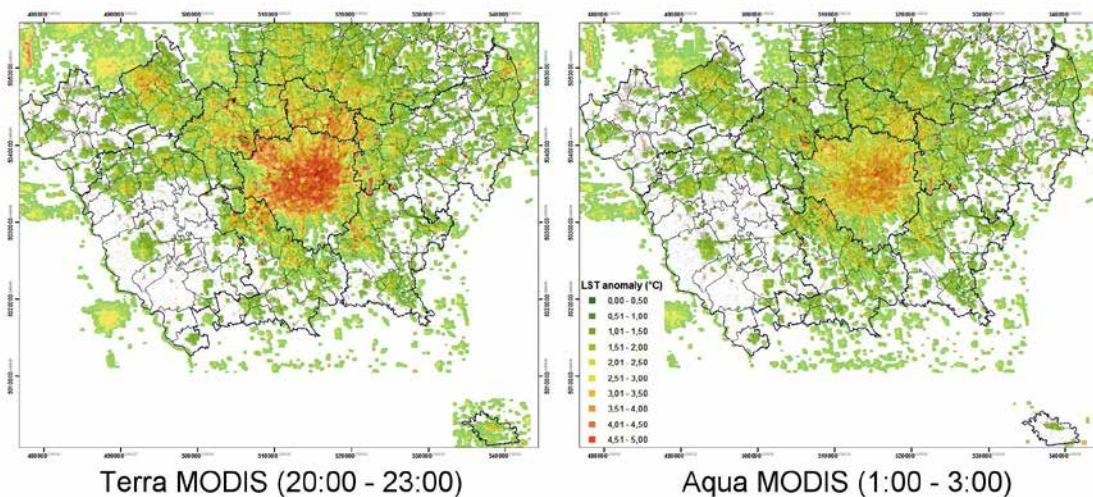


Figure 2. Night-time thermal anomalies in the CMM area observed by satellite (MODIS / Landsat) during heat waves in the summers from 2015 to 2018.

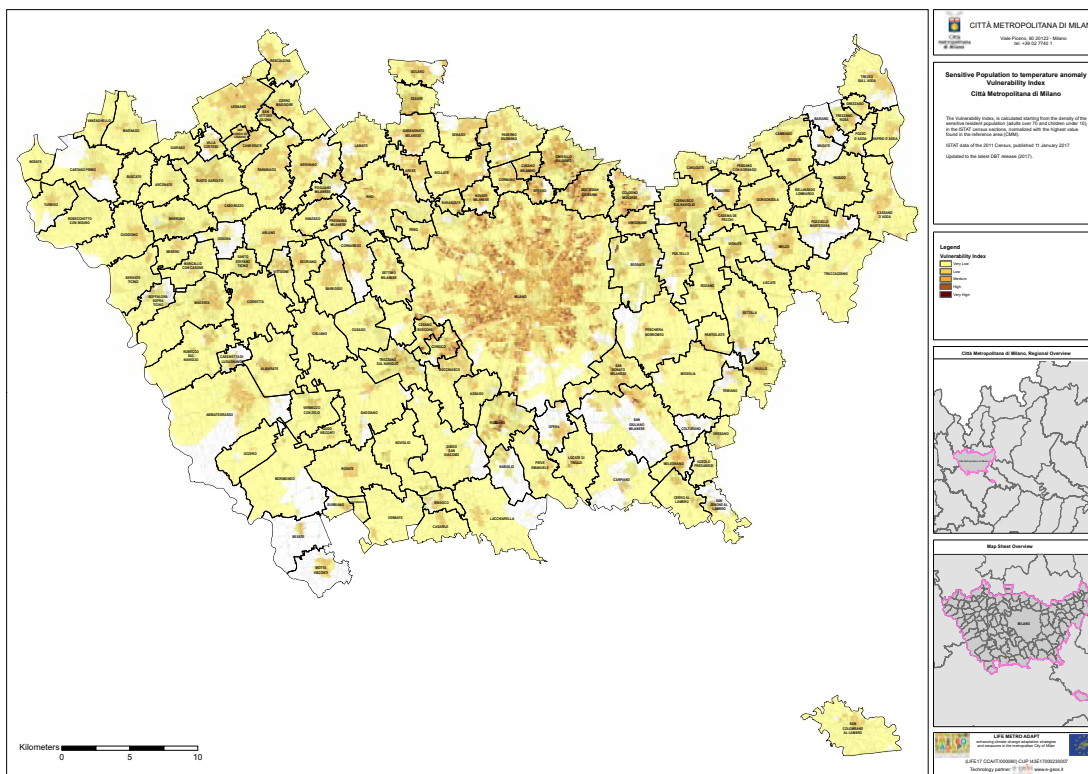


Figure 3. Population Sensitive to temperature anomalies, Vulnerability Index.

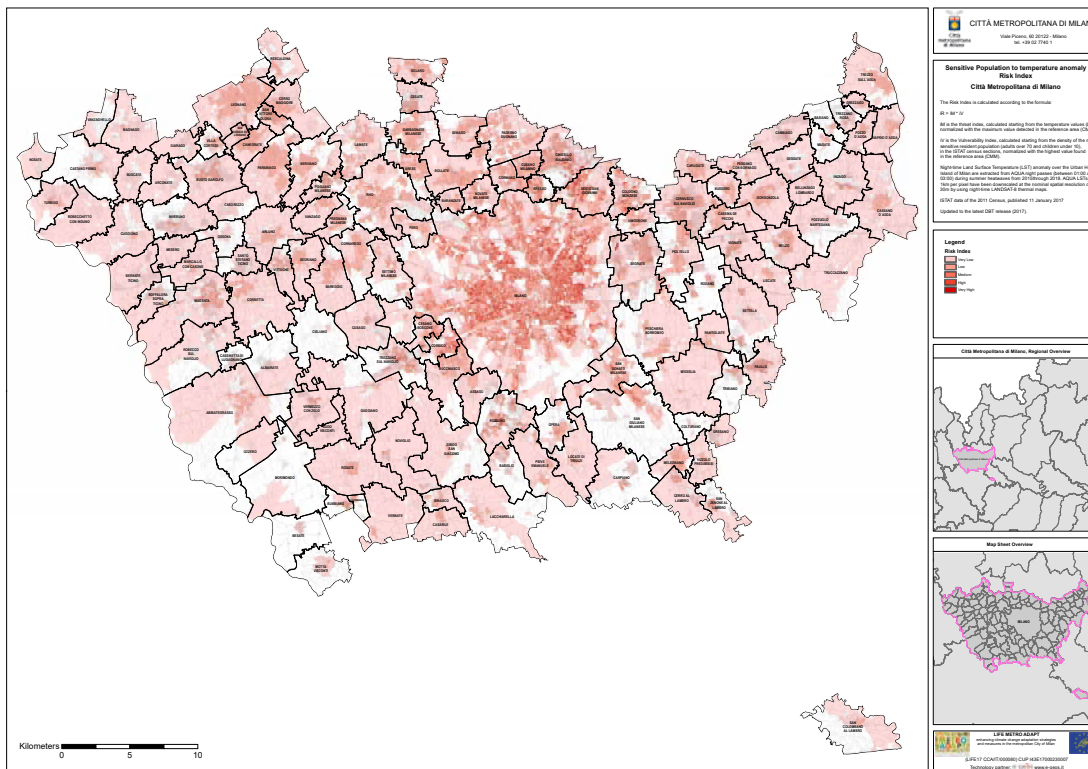


Figure 4. Population Sensitive to temperature anomalies, Risk Index.

Urban Heat Islands Vulnerability Maps

The map of thermal anomalies was then integrated with the data of the ISTAT 2011 population census, to identify, at the territorial level of the census section, the areas of the city with the highest population density vulnerable to extreme temperatures (elderly over 70 years and children under 10). The intersection in the GIS of satellite information on the areas which are most prone to thermal anomalies of extreme heat, with the data on the vulnerable population, has allowed the production of risk maps for the vulnerable population following the phenomenon of urban heat islands.

WHY IS IT CRUCIAL TO STUDY TERRITORIAL VULNERABILITIES?

Several studies have determined that, during heat waves, mortality in urban areas increases significantly. For public administrations and the bodies responsible for prevention and rescue (Civil Protection), it is therefore of great importance to have a precise knowledge of the areas of the city where the heat wave phenomenon occurs, in order to provide for urgent interventions (e.g. water distribution or relocation of vulnerable people to cooler areas) and urban planning measures aimed at adopting climate adaptation instruments, such as the installation of green and blue infrastructures.

Urban Heat Islands Vulnerability Maps and Risk maps have been distributed as standard maps, as well as all data have been included in an interactive and open tool available on the Milan Metropolitan City's website: the Metro Adapt Platform, that will be illustrated in the next sessions of the handbook.

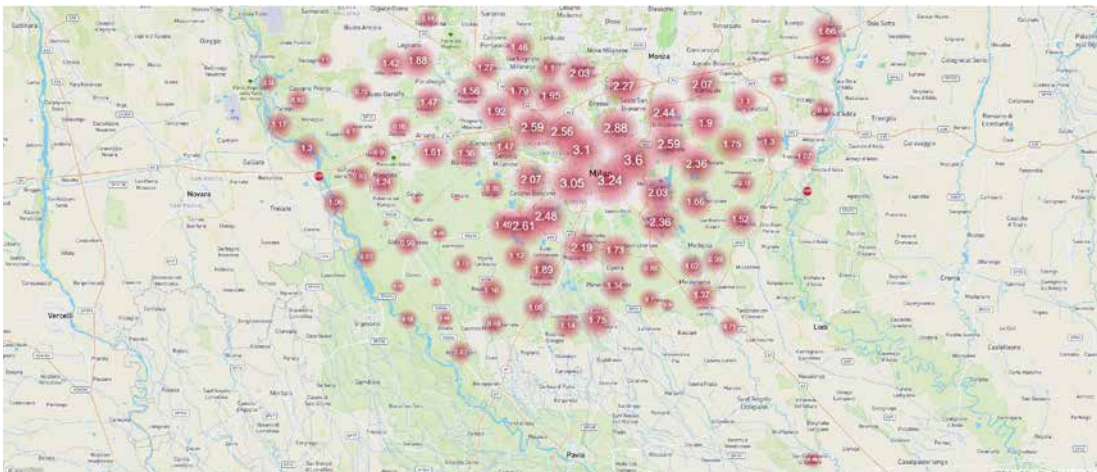


Figure 5. Metro Adapt Platform: distribution of thermal anomalies on the territory of the Metropolitan City of Milan.

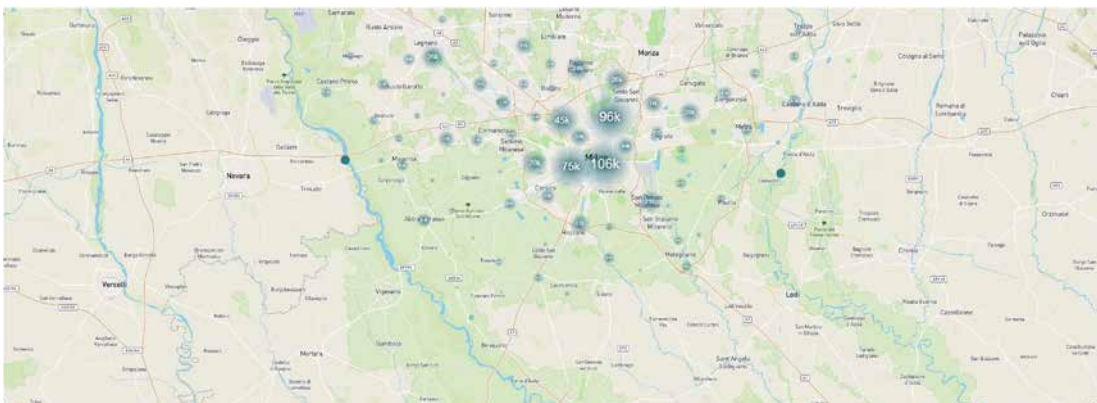


Figure 6. Metro Adapt Platform: distribution of the vulnerable population in the Metropolitan City of Milan. (map + table)

Popolazione sensibile per Comune		Popolazione Sensibile per classe di età			
COMUNE_NOM	Popolazione Sensibile	0 - 5 anni	5 - 9 anni	10 - 36 anni	oltre i 36 anni
MILANO	3.880	+55.453	+53.405	+76.442	+150.464
BESTO SAN GIOVANNI	216	+3.350	+3.362	+5.141	+5.066
CINISELLO BALSAMO	17.76	+1.199	+3.207	+4.432	+6.910
LEGNANO	12.40	+2.788	+2.629	+3.032	+5.818
RHO	12.40	+2.210	+2.112	+2.867	+5.166
COLOGNO MONZESE	119	+2.065	+2.152	+2.439	+4.301
PADERNO DUIGIANO	10.16	+2.094	+1.970	+2.679	+4.265
COZZANO	9.066	+1.466	+1.467	+2.448	+3.793
CORBICO	8.819	+1.483	+1.742	+2.940	+3.571
BOLLATE	8.659	+2.047	+2.609	+2.909	+3.405
SEGRATE	8.038	+1.581	+1.520	+1.838	+2.201
SAN DONATO MILANESE	8.229	+1.366	+1.630	+2.059	+1.190
ABBATEGRASSO	8.159	+1.656	+1.140	+1.937	+3.153
SAN DONATO MILANESE	8.140	+1.674	+1.763	+2.183	+5.014
BRESSO	8.140	+1.706	+1.620	+1.838	+2.978
CERNUSCO SUL NAVIGLIO	8.140	+2.041	+1.875	+1.863	+2.872
PROTTELLO	7.879	+984	+1.806	+1.470	+2.597
PARABADO	7.298	+1.320	+1.214	+1.418	+2.548
GARRIGIANATE MILANESE	6.51	+1.946	+1.893	+1.576	+2.452
MAGENTA	6.036	+739	+745	+1.343	+2.317
LANATE	5.471	+1.135	+1.294	+1.484	+2.199
BUCCONASCO	5.471	+1.276	+1.299	+1.310	+2.091
CESANO BOSCONI	5.471	+784	+710	+1.114	+2.087
CORMANO	5.126	+1.028	+1.021	+1.182	+1.957
CUSANO MILANNO	4.936	+1.009	+1.015	+1.411	+1.540
NOVATE MILANESE	4.936	+722	+752	+1.199	+1.876
PESCHIERA BORSCOMIO	4.936	+903	+1.009	+1.652	+1.793
BENAFIO	4.936				
GORGONZOLA	4.936				
APICE	4.756				

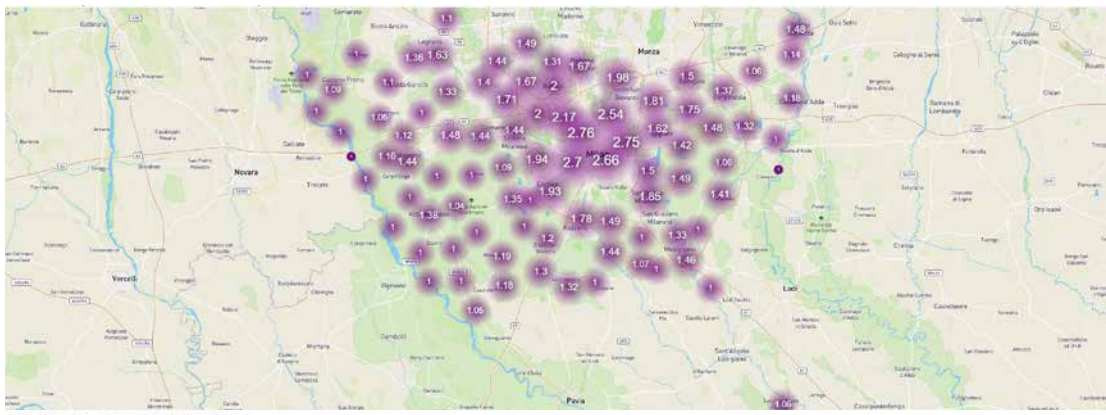


Figure 7. Metro Adapt Platform:
Thermal risk class for census section
normalized for the Metropolitan City
of Milan (map + beginning of table).

Popolazione Sensibile per classe di rischio siccitativa per Comune

Comune_NOM	Classe_ris	Popolazione sensibile
ASSEMBLICOLO	1	-1.226
ASSEMBLICOLO	2	-4.039
ASSEMBLICOLO	3	-1174
ASSEMBLICOLO	4	0
ASSEMBLICOLO	5	0
ASSEMBLICOLO	6	-1.018
ASSEMBLICOLO	7	0
ASSEMBLICOLO	8	0
ASSEMBLICOLO	9	0
ASSEMBLICOLO	10	-1.452
ASSEMBLICOLO	11	0
ASSEMBLICOLO	12	0
ASSEMBLICOLO	13	0
ASSEMBLICOLO	14	0
ASSEMBLICOLO	15	0
ASSEMBLICOLO	16	0
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ASSEMBLICOLO	97	0
ASSEMBLICOLO	98	0
ASSEMBLICOLO	99	0
ASSEMBLICOLO	100	0

Flood hazards maps

About the hydraulic hazard, the analysis considered the capacity of the soil to retain rainwater, based on the characteristics of use/soil cover and pedological characteristics of the soil.

The value calculated here, and mapped, estimates the volume of potential runoff of rain that follows a meteoric event.

Potential runoff was calculated according to the U.S. Department of Agriculture Soil Conservation Service (CN-SCS) method. Dept. Agric., Soil Conservation Service, 1972¹.

In particular, two maps of potential runoff were produced, one for a critical event, referring to an intense rainy day, and one for an annual figure that takes into account the maximum value of rainfall per territorial unit.

The aim in the production of those maps is to identify potential criticality hotspots according to the soil type.

During the period 2016-2018, 52 critical cases were registered on the Metropolitan territory excluding the city of Milan.

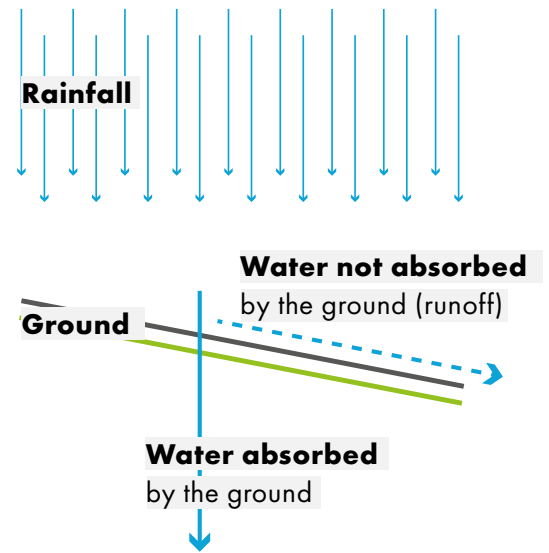


Figure 8. Runoff (mm of water rejected by the ground) on november 5th 2017



Figure 9. Medium value runoff (mm of water rejected by the ground) in one year (01/11/2017-31/10/2018)

¹ In using the data, it must be taken into account that:

- The data returns a static value, therefore it takes into account the mm of water potentially not absorbed in each cell (territorial unit), following a daily accumulation. In other words, the data quantifies the mm of water potentially rejected by the soil (runoff), due to characteristics related to the type of land cover / use and the type of soil itself (pedological characteristics of the land).
- The data does not take into account the geometric characteristics of the urban drainage network and the hydrographic network.
- The data returns a map of attention for the identification of areas where to intensify Sustainable Urban Drainage interventions (see par. 7.2), for example of soil de-waterproofing.
- Runoff is one of the aspects to be taken into consideration when mapping vulnerability to flooding. In any case, the reading of the danger requires an integrated reading on the basis of additional information such as Flood Risk Management Plan (PGRA), and the results of the activity provided for by art. 14 of RR 7/2017 for the preparation of Simplified Documents and Municipal Studies on Hydraulic Risk.
- The runoff, in this phase, remains a fundamental data for structuring attention maps in reference to those areas potentially exposed to flood risk due to heavy rains in relation to the use / cover of the soil in association with the pedological characteristics of the soil.
- Runoff is measured in millimeters (mm) of rain per unit of time. The final data, referring to a regular grid (raster) with a resolution of 30 meters per pixel, can be consistent with an operational scale of 1 : 100,000. The final map is available in GeoTIFF format, with the WGS84 / UTM32N spatial reference system.

Agricultural vulnerability analysis

The objective of this type of analysis is to evaluate the impact of thermal anomalies in agriculture. Previous studies, confirmed by the work carried out within the LIFE Metro Adapt project, have shown how significant differences in temperatures, both positive and negative, compared to the reference seasonal averages, reflect differently on the state of a crop, depending on the season in which they occur and the type of crop itself.

From the analysis conducted over a historical period of 15 years (2003-2018) it has been seen that very high temperatures in summer, probably often associated with drought phenomena, stress the growth of the crop, especially for summer or non-irrigated arable land. While summers cooler than average, usually combined with more frequent rain phenomena, generally favor a greater development of the crop in the summer period. Variations in winter temperatures can also have an impact on the state of crops, especially winter ones. Higher winter temperatures generally have a positive impact on phenological development which is reflected in the following two seasons.

The analysis was conducted on the area of the South Agricultural Park of Milan, and some illustrative maps of the correlations described above were generated, between thermal anomalies and the Normalized Difference Vegetation Index (NDVI) representative of the state of the vegetation. This type of results, on the basis of which a forecasting model could be developed, can be an important support tool, both for public administrations and for entities involved in the agricultural sector (farmers, agricultural consortia), in order to provide alerts on the state of crops during the agronomic season.

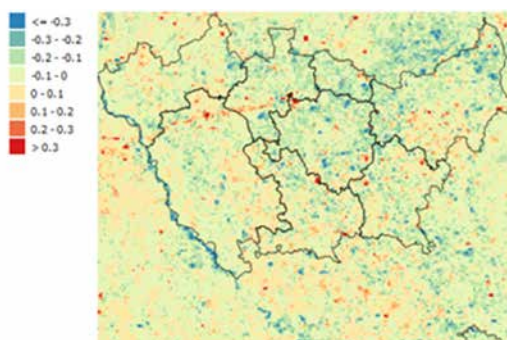
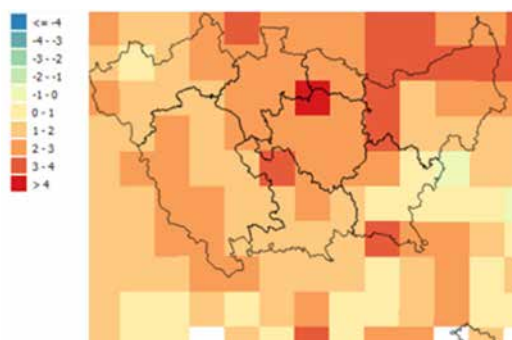
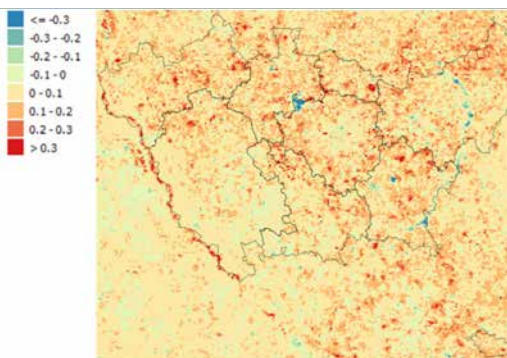
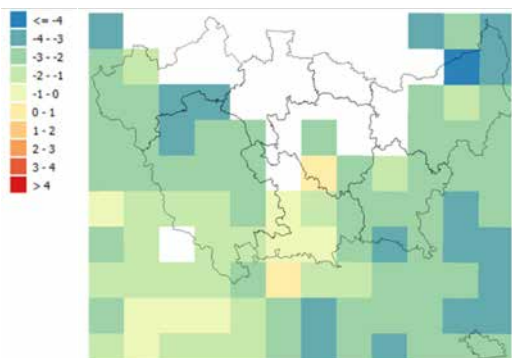
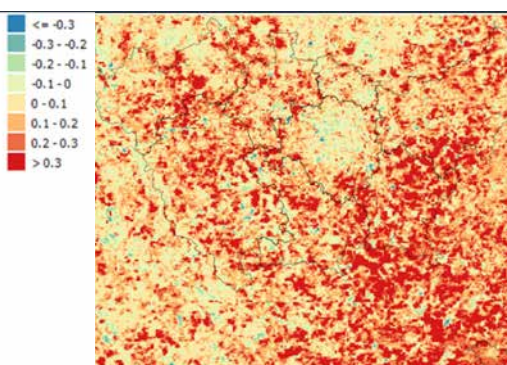
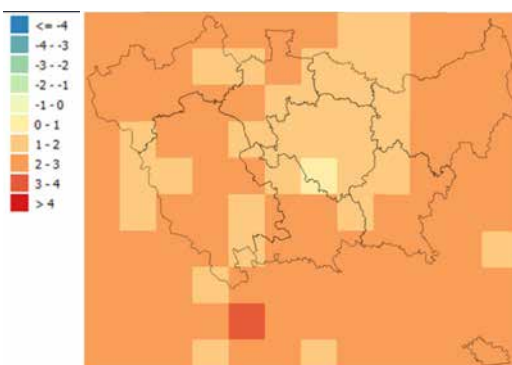


Figure 10. Examples of the relationship between thermal anomalies and Green Index Anomalies in the area of the South Agricultural Park of Milan.

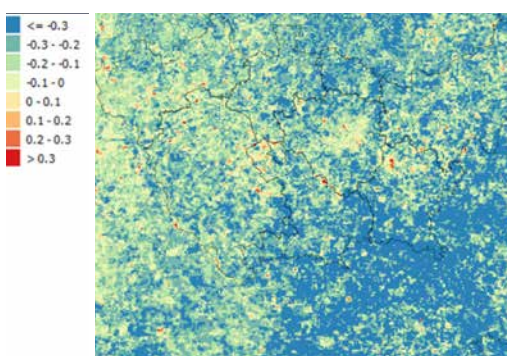
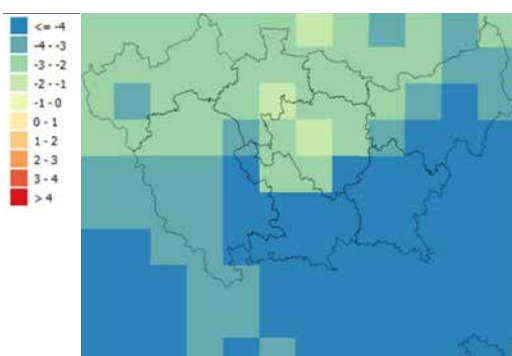
Positive summer thermal anomaly and negative NDVI anomaly (2003)



Negative summer thermal anomaly and positive NDVI anomaly (2014)



Positive winter thermal anomaly and positive NDVI anomaly (2007)



Negative winter thermal anomaly and negative NDVI anomaly (2006)

Climate change adaptation and mitigation strategies within the milan metropolitan territorial plan

The Metropolitan City of Milan (CMM) is a medium level local public authority established in 2014 and governs the vastest metropolitan urban area in Italy. The CMM implements and coordinates activities of strategic and territorial planning, sustainable mobility and urban public transports, including greening issues, digital agenda and has responsibility in the environmental field especially for land reclamations and waste dumps, among others. The CMM plays a crucial role in the climate change adaptation process, just like all Metropolitan cities authorities. Its role is fundamental in setting a comprehensive strategy for its wide and whole territory, enhancing the mainstreaming of adaptation measures at all the local levels and coordinating all the different planning and operative tools.

The Metropolitan City of Milan has therefore defined within its general planning tool, **the Metropolitan Territorial Plan (PTM)**, an action strategy for its entire territory, improving the integration of adaptation policies within territorial planning and creating the necessary framework for the concrete implementation of initiatives that contribute to increasing the resilience and adaptability of the territory to the most appropriate scale. The drafting of the MTP was carried out during the second part of 2019 and the first part of 2020 and it will go on until the end of this administrative mandate (2021 spring or autumn). On the 29th of July 2020 **the MTP was adopted by the Metropolitan Council** with approval n.14/2020².

The Plan provides municipalities with guidelines and instructions to include mitigation interventions in the urban planning tools and building regulations. The integration of mitigation and adaptation measures in the PTM is aimed at creating a unitary system that can fight climate change causes and effects together. This integration additionally aids to diversify the various levels of management, involve a plurality of actors and differentiate the areas of intervention.

The normative section dedicated to environmental emergencies contains guidelines and directives for municipal plans aimed at the inclusion of specific parameters and rules closely related to climate change adaptation of the Milan metropolitan area. At the municipal level it will work to ensure that the different components of the Territory Government Plan (TGP) transpose these guidelines and directives in the municipal regulations and sector plans/programmes (Green Plan, Urban Traffic Plan, Urban Mobility Plan, Building Regulations, etc.) criteria and rules oriented to a proactive urban planning towards climate change. For projects of supra-municipal importance, the MTP intends to proceed through specific agreements, and to assist municipalities to pool their own resources for this purpose (such as a share of urbanization fees of metropolitan and supra-municipal land use interventions; municipal fund rights), including in the search for additional sources of funding from other entities (regional, national and European co-funding)³.

SOME KEY INFORMATION ABOUT THE METROPOLITAN TERRITORIAL PLAN:

- It introduces general objectives consistent with the Sustainable Development Goals (SDGs) of the 2030 Agenda and with national commitments on sustainable development.
- It contains an innovative part dedicated specifically to the government of environmental emergencies with a specific section reserved to climate change that includes rules enhancing resilience measures in the local planning tools.
- Its first purpose is dedicated to the protection of non-renewable resources (soil, water, air energy from fossil sources) and explicitly includes also the enhancing of resilience to climate change.
- Its first general objective is to enforce the actions of the plan with respect to the content and timing of international environmental agreements.
- The general objective n°7 is dedicated to the construction of a Metropolitan Green Network with functions of rolling of atmospheric events and heat islands mitigation as well as CO₂ containment.
- The general objective n°8 is dedicated to the enhancing of the instruments for water cycle management together with the development of municipal planning provisions for the qualitative and quantitative protection of drinking water resources, for the protection of aquifer charging areas and for the recovery of the irrigated grid, including disused sections, for landscape and ecological purposes and as a reservoir volume for flood lamination.

The PTM also contains the project of the Metropolitan Green Network (MGN), together with the definition of rules for its implementation by the Municipalities.

The project of the Metropolitan Green Network, besides helping to restore rural, natural and wooded landscapes, defines the territorial areas with different features for taking action and funding priorities to mitigate the heat islands and the runoff. On the basis of the characteristics and criticalities of each area, the project priorities and the specific measures to be taken have been identified.

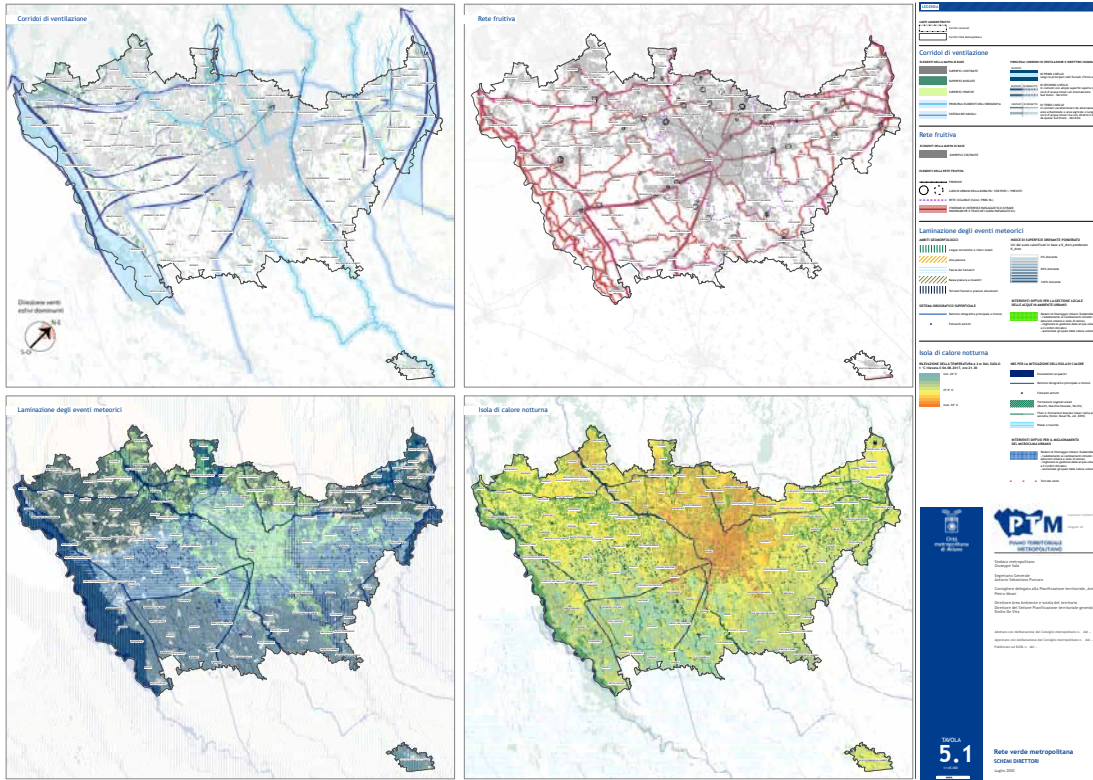


Figure 1. PTM Table 5.1 about Metropolitan Green Network

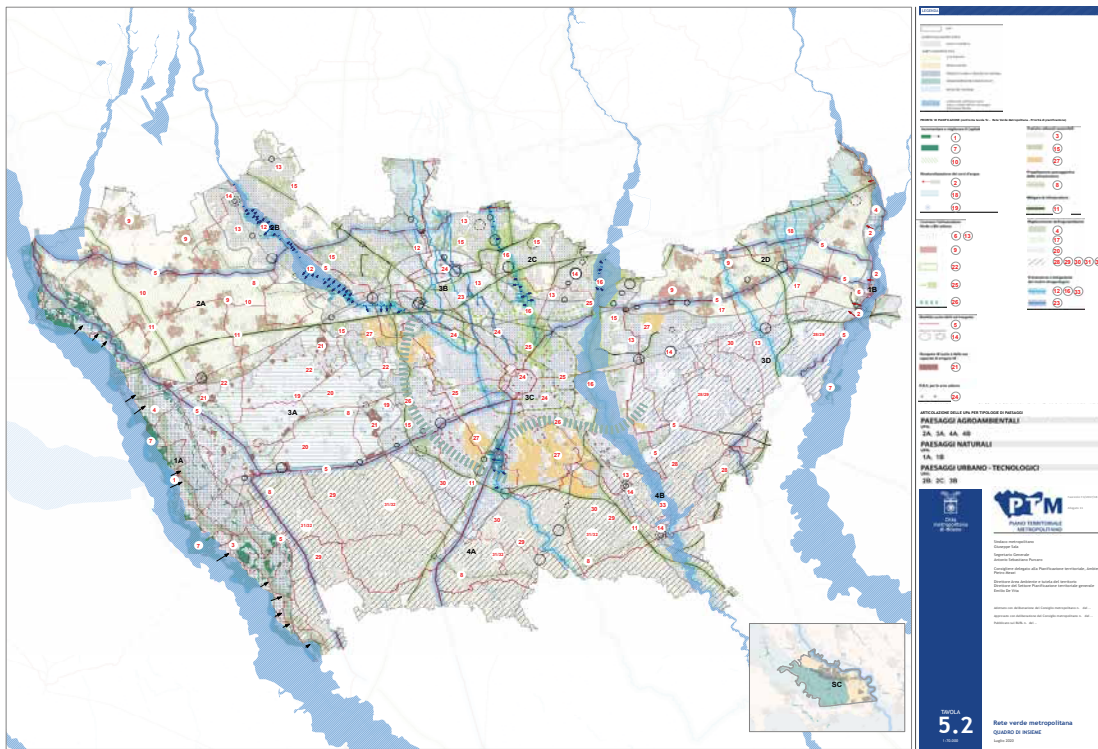


Figure 2. PTM Tables 5.2 and 5.3 about Metropolitan Green Network planning priorities



²The PTM adopted can be seen and downloaded from the CMM Territorial Planning Sector website (<https://www.cittametropolitana.mi.it/PTM/iter/adozione/index.html>).

³All the material in the legal document of MTP adopted is available at the following CMM web page: https://www.cittametropolitana.mi.it/export/sites/default/PTM/iter/documenti/adozione/allegati_dispositivi/All_1_Norme_di_attuazione.pdf.

Data accessibility: the Metro Adapt Platform

Ensuring access to up-to-date data on climate vulnerabilities of the metropolitan territory by local authorities is crucial to ensure the implementation of climate change adaptation policies and strategies suited to the needs and characteristics of the territory.

The **Metro Adapt Platform** is an open and interactive tool, hosted on the institutional website of the Metropolitan City of Milan, designed as a dissemination tool, with the aim of providing a comprehensive overview of the main issues addressed by the project. In addition to the general information on the objectives and the achieved results, the Platform offers the possibility to have access to all the tools, analyses and collected data. In this way, information on climate vulnerabilities affecting the territory can be shared with local administrations and authorities within the Metropolitan Area of Milan.

Services and information provided by the platform

Through the use of the DeCiMetro system of the Metropolitan City of Milan, it is possible to have access to updated data on **thermal anomalies and hydraulic risks** concerning the metropolitan area of Milan and to consult the informative documents produced by the members of the project related to climate change adaptation strategies and the different Nature-Based Solutions that can be adopted in urban areas.

Within the following services it is possible to consult and download maps for the entire territory of the Metropolitan City of Milan and on each of the 133 Municipalities:

Interactive platform:

<http://desk.cittametropolitana.mi.it/superset/dashboard/life>



It is an open platform accessible via the web by all users that does not require installation, any application or particular plug-in. Access to this page allows anyone to view the data, to interact with it through guided queries and to be able to save and download the data also via mobile devices. The platform provides three constantly updated maps illustrating valuable data on the urban heat island phenomenon:

1. **Hazard map of the urban heat island phenomenon:** it shows the areas where the heat island phenomenon occurs, in order to provide for urgent interventions (e.g. water distribution or relocation of vulnerable people to cooler areas) and urban planning measures, the adoption of climate adaptation tools, such as the installation of green and blue infrastructure.
2. **Map of vulnerability to urban heat islands:** it represents the distribution of the vulnerable population (elderly people over 70 and children under 10) over the territory by census section based on ISTAT 2011 population census data.
3. **Urban Heat Island Risk Map:** by integrating data on the areas where heat island phenomena occur with data on the distribution of the vulnerable population over the territory, this map shows the areas of the city with the highest density of population vulnerable to extreme temperatures.

USEFUL RESOURCES:

On this web-page anyone can download the maps of all municipalities in .pdf format

Download:

https://www.cittametropolitana.mi.it/Life_Metro_Adapt/servizi/DOWNLOAD



This standard provides a simple HTTP interface for requesting map images from one or more servers spread across the Internet. The response to the request is one or more map images (in JPEG, PNG, ... format) that can be displayed in an Internet browser

Web Map Services:

https://www.cittametropolitana.mi.it/Life_Metro_Adapt/servizi/web-map



In this section people will find other territorial data useful for the preparation of the Action Plans for Sustainable Energy and Climate (SECAP) both in the form of maps (land cover, permeability and naturalness maps), and indices (morphological and socio-economic indicators). Finally there is a section with the most important numerical data concerning the territory of the Metropolitan City of Milan.

Other useful data :

https://www.cittametropolitana.mi.it/Life_Metro_Adapt/servizi/altri-dati-utili



As said, anyone can query the platform to extract data of interest.

People can, for example, choose their own municipality and look for the areas where the thermal anomalies exceed from 1 to 1.5 degrees. The system will produce a detailed view of the results on a custom map.



Figure 1. User interface of the Metro Adapt Platform, with queryable fields.

In this example user will see all areas with thermal anomalies higher than 3° in the municipality of Sesto san Giovanni.

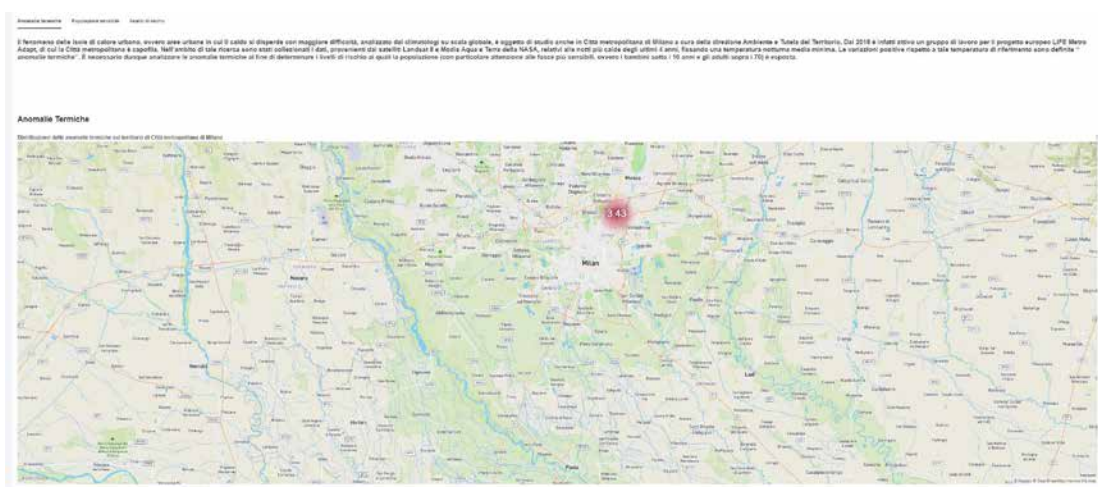


Figure 2. Result of the previous query

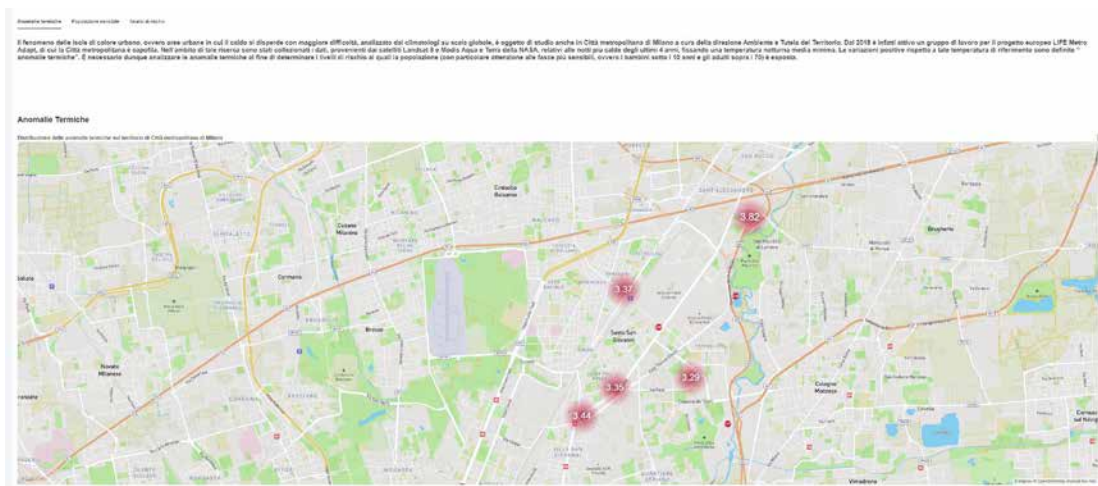


Figure 3. Zoomed view of the municipality of Sesto San Giovanni

Nature-based solutions: characteristics and benefits for urban climate change adaptation

Nature-Based Solutions (NBS) are interventions inspired and supported by Nature that guarantee environmental, social, and economic benefits, contributing to improving climate change adaptation in urban areas and increasing territorial resilience. Green roofs, green walls, urban forests, alternative rainwater management systems and urban agriculture are just some of the solutions that can be implemented in urban and peri-urban areas. NBS are cost-effective solutions that contribute to protecting biodiversity, species conservation, energy savings, social cohesion, among many other benefits.

The main types of NBS and the NBS catalogue

The main types of NBS applicable to the urban context concern: water management (infiltration trenches, rain gardens, detention basins, etc), green solutions on built environment (green roofs, green walls, green noise barrier, etc), and ground green spaces (street trees, pocket parks, vegetable gardens, etc).

NBS for Water management

Managing water and urban drainage systems through the implementation of NBS allows to improve the hydrological response of urban areas, obtaining additional benefits in terms of water quality, increased biodiversity, and increased use of public areas. NBSs, whose design and implementation are supported by ecosystem services, can be applied both on roads, squares, and related infrastructures and to the requalification of urban and peri-urban green areas and small watercourses.

Green on built environment

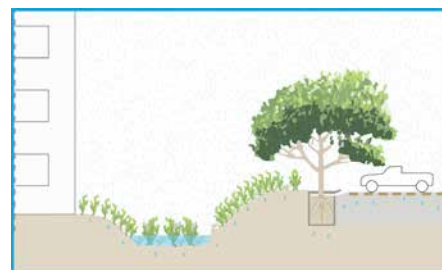
In highly urbanized areas, the development of vegetation on buildings and urban furniture is becoming an important tool for climate change adaptation, with a strong focus on measures for the reduction of urban heat island effect. The integration of vegetation into the built environment encompasses a variety of urban 'artifacts' from buildings to infrastructural elements and street furniture.

Ground green spaces

The design and implementation of urban green solutions represent a great opportunity for environmental requalification and climate change adaptation. In this regard, it is relevant to apply a multi-purpose approach, responsive to climate change adaptation, recognizing the role of urban greenery in pollution reduction, but also more focused on the requalification of urban spaces, to make urban areas more livable and social friendly.

DOWNLOAD OF NBS CATALOGUE

https://www.cittametropolitana.mi.it/Life_Metro_Adapt/adattamento/index.html



The LIFE Metro Adapt Project has selected 20 NBSs whose implementation and replication is expected to be more feasible in the metropolitan urban area of Milan. A catalogue showing these 20 NBSs has been prepared in order to illustrate the solutions that can be implemented in urban and peri-urban areas, specifying their scale of application, describing their environmental and socio-economic benefits, the advantages and disadvantages and providing examples of good practices. Each NBS schedule reports a brief description of the NBS, technical information on planning and design, pros and cons, management and maintenance aspects and selected best practices.

NBS for Water management

Bioswales

Bioswales are designed to handle much runoff from a sizeable impermeable area, such as a parking lot or streets. They absorb, store, and convey surface water runoff and remove pollutants and sediments as the water flows through vegetation and the soil layer. The choice of vegetation for bioswales varies, but rooted native plants are common and preferable. Their wide application represents a significant contribution to the local management and rainwater control.



© Green Earth Operations

Environmental benefits/ technical role

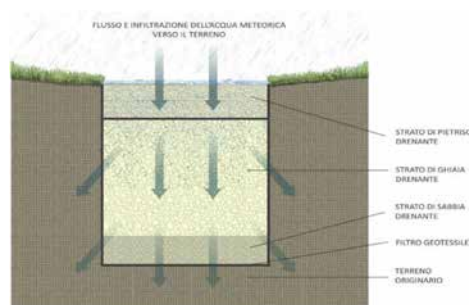


Socio-economic benefits/urban value



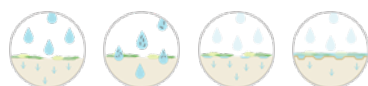
Infiltration trenches / filter drains

The infiltration trenches are built to facilitate the infiltration of runoff volumes through the trench's upper surface and subsequent filtration into the subsoil through the sides and bottom of the canal. They can remove a wide range of pollutants from rainwater through absorption, precipitation, filtration, chemical, and bacterial degradation. This kind of NBS is called "infiltration trench" when it is employed as a point of accumulation and infiltration. In contrast, if the goal is to create a linear component to bring rainwater from point A to point B, they are typically equipped with a drain and they are called filter drains.



© Comune di Bologna

Environmental benefits/ technical role



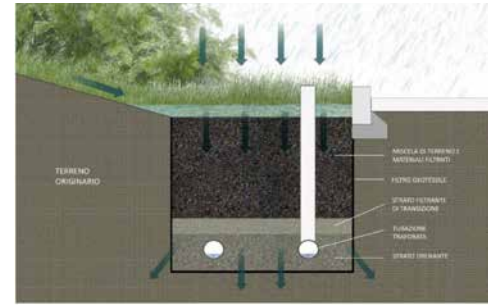
Socio-economic benefits/urban value



Bioretention systems

The bio-retention areas are slight soil depressions, covered with green elements, aimed at collecting and treating the rainwater drained from the surrounding impermeable surfaces by filtration and removal of polluting agents. These systems allow a natural filtering and purification of the collected water with the excellent removal of the main pollutants carried by the rainwater runoff: SST:> 90%, P tot> 80%, N tot 50%, Metals (zinc, lead, cadmium)> 90%. Furthermore, the bio-retention areas have a beneficial effect in reducing hydraulic risk, increasing biodiversity, and being able to be used as an element of urban furniture.

Environmental benefits/ technical role



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Socio-economic benefits/urban value

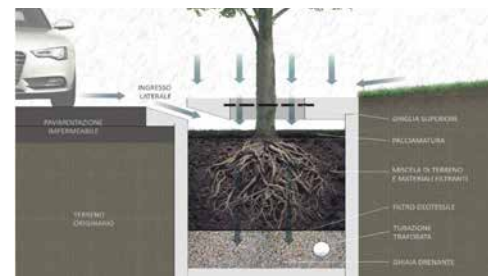
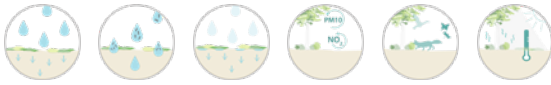


Tree planters and tree pits

The tree planters are small biofiltration systems consisting mainly of three elements: a box, soil and a plant species.

These systems allow a completely natural filtration and purification of water, in analogy to areas of bioretention, combining all the major advantages provided by trees in the urban environment, in terms of reducing heat islands and improving air quality.

Environmental benefits/ technical role



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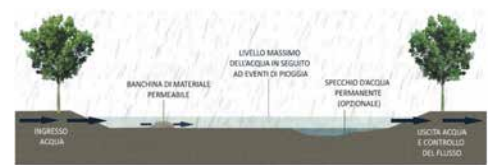
Socio-economic benefits/urban value



Detention basins

The detention basins are shallow vegetated spaces, suitable for temporary surface storage and for rainwater flows control.

Environmental benefits/ technical role



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Socio-economic benefits/urban value

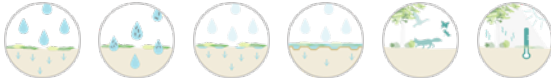


Ponds and constructed wetlands

Ponds and constructed wetlands are basins with a permanent water surface in which rainwaters convey and can be designed to achieve multiple objectives such as lamination, rainwater treatment, increase in biodiversity, and the area's fruitful potential.

We speak about phytoremediation when these systems are primarily designed for the treatment of primary rainfall water from separate nets or the overflow water from mixed nets.

Environmental benefits/ technical role



© Comune di Bologna

Socio-economic benefits/urban value



Permeable pavements

The permeable pavements are made with drainage surfaces and guarantee the surface runoff of rainwater that permeates into the ground through modular elements, such as concrete blocks or reinforced plastic mats, characterized by the presence of voids or joints that are filled with absorbent material (sand or gravel), to allow the infiltration of water runoffs.

Environmental benefits/ technical role



© Masseroni 2018

Socio-economic benefits/urban value



Reopening of closed waterways

The reopening of closed waterways (natural or artificial) covered or ducted in the past includes the demolition of the roof and, when possible, of the unnatural artifacts (pipes, riverbed linings, and/or banks), the reconstitution of a natural substrate (pebbles, gravel, or sand), and the regeneration of vegetation with aquatic plants and, if possible, a shrub / arboreal riparian belt. It may require the use of naturalistic engineering techniques to stabilize banks or riverbed.

Environmental benefits/ technical role



© <https://rm.coe.int/16806f5e75>

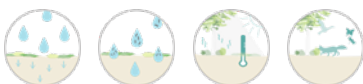
Socio-economic benefits/urban value



Environmental requalification of small peri-urban ditches

There are small water streams in the urban outskirts, artificial or natural, that have been modified over the centuries. The requalification of these waterways and the areas of relevance, sacrificing some land for agricultural production, allows for a better management of excess flows by adapting to extreme weather events.

Environmental benefits/ technical role



© www.cif.org

Socio-economic benefits/urban value



Green on Built Environment

Green roofs

The green roof is a specific solution for the completion of the top of a building, characterized by a plant installation on an impermeable support layer. The green roof differs from all other roofing types because the visible "finishing" material is made up of plants species instead of artificial material. Green roofs constitute an element of re-naturalization with several functions, capable of obtaining an environmental mitigation effect following the construction of a building.



© ROOFmatters/ Ambiente Italia, 2019

Environmental benefits/ technical role



Socio-economic benefits/urban value



Green walls

By green walls we mean all the different forms of vegetated vertical closures. Greening can be obtained with plant species planted on the ground, with support panels and container elements anchored to the facade or modular structures integrated into the vertical closure. As same as the green roofs, green walls also constitute an element of re-naturalization with various functions capable of obtaining an environmental mitigation effect following the construction of a building.



© Ri-adapted from Sempergreen

Environmental benefits/ technical role



Socio-economic benefits/urban value



Balcony gardens

An accurate design of the green of balconies and terraces, even in limited spaces, can produce interesting effects to mitigate the summer temperatures inside the premises and represent a filter to prevent atmospheric pollutants' entry. The balcony gardens are generally considered mainly for their aesthetic value, since they offer an aesthetically appreciable image of the building, thanks to the choice of the species and the knowledge of the blooming calendar.



© Boeri, 2017

Environmental benefits/ technical role



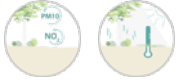
Socio-economic benefits/urban value



Green barriers

Green barriers protect residential areas from noises produced by roads, highways, railways, and industrial plants. Through the vegetation belt (trees, bushes, tall grass), the sound is forced to undergo a tortuous path that tends to degrade it into heat. The attenuation produced by natural barriers depends on the depth and height of the protective screen, size and density of the foliage and on the foliage duration.

Environmental benefits/ technical role



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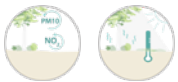
Socio-economic benefits/urban value



Pergola paths

The so-called "Pergola Paths" can be an efficient solution on mainly sunny streets and open areas during the hot season, characterized by intense pedestrian crossing in which it is impossible to plant any vegetation due to technical reasons. These are support structures for climbing plants that can quickly become a shaded area, protected from excessive exposure to the sun and vehicle exhausts and noises.

Environmental benefits/ technical role



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Socio-economic benefits/urban value



Urban green furniture

The urban green furniture design can represent an interesting opportunity to equip public urban spaces with fixed and movable elements that can increase the environmental benefits to the advantage of the spaces' users, such as the mitigation of heat islands and reducing some atmospheric pollutants.

Environmental benefits/ technical role



© www.fuorisalone.it

Socio-economic benefits/urban value



Ground Green Spaces

Street trees

Street trees are trees' arrangement along city streets, such as residential neighborhood streets, transit roads, traffic arteries, or squares. Street trees represent a relatively small fraction of the urban arboreal heritage but play a crucial role both from the point of view of visual impact and air pollution from traffic and climatic comfort.

Environmental benefits/ technical role



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Socio-economic benefits/urban value



Community gardens

A community garden is a public space with socio-cultural and environmental purposes. Unlike the traditional public gardens, the community gardens allow citizens to have an active role in managing a redevelopment project for abandoned areas to make public spaces more livable and improve social opportunities.

Environmental benefits/ technical role



© agricity.it

Socio-economic benefits/urban value



Urban farming

Urban farming has a high potential of innovation and knowledge, strongly related to specific contexts (local markets, social relations, use of urban areas, traditions, cultural heritage, etc.), carrying out socio-cultural, environmental, recreational, educational and therapeutic roles. At the same time, urban vegetable gardens are an agricultural activity with a potentially high environmental impact concerning the significant inputs required to support the production. Therefore, it is essential to pay attention to the conservation of soil fertility, the rational management of water resources, the protection of crops from atmospheric agents and pathogens, minimizing the use of chemicals.

Environmental benefits/ technical role



© Matteo Zarbo

Socio-economic benefits/urban value



Pocket parks

Pocket parks are small-scaled urban design tools that set the goal to reactivate and fix some urban areas by creating a network of green spaces for the citizens. The dimensions are indicatively those of a building lot, generally delimited on two or three sides by neighboring buildings or facing the sidewalk. Micro-parks can represent a strategy for the redevelopment of residual spaces, transforming them into small green laboratories of creativity and social inclusion. They can be a resource to improve the environmental impact of urban environment and, at the same time, improve the physical, mental and social well-being.



© Ambiente Italia

Environmental benefits/ technical role



Socio-economic benefits/urban value



Urban forestation

The Food and Agriculture Organization (FAO) guidelines define urban forestry as a network or system that includes forests, a group of trees and single trees found in urban and peri-urban areas. Urban forests represent the "backbone" of green infrastructures, able to connect rural areas with urban ones.



© Parco Nord Milano

Environmental benefits/ technical role

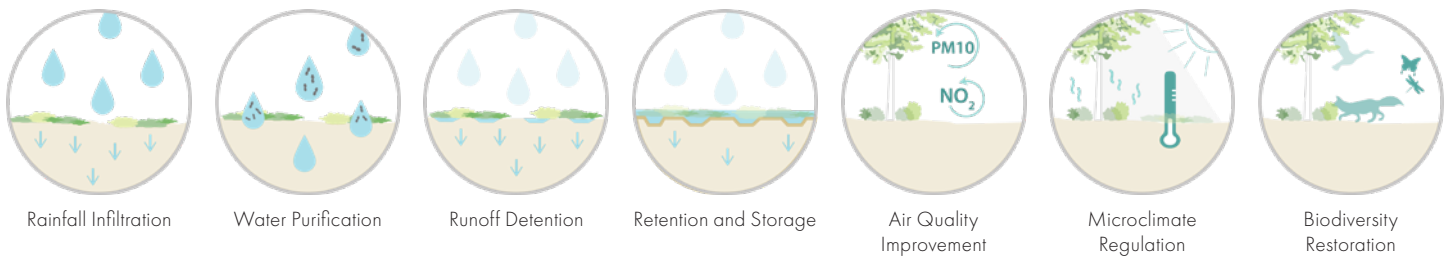


Socio-economic benefits/urban value



Legend

Environmental benefits/ technical role



Socio-economic benefits/urban value



Guidelines for the development of Nature-Based Solutions in Urban Areas

The tools available to public administrations, in particular municipal administrations, to develop Nature-Based Solutions on their territory are different and diverse. The LIFE Metro Adapt Project has developed guidelines that target public administrations, to provide them with **useful knowledge for NBS implementation**, to foster a better management of water resources and enhance the mitigation of the heat island effect. The guidelines have been structured as a guided review of tools which are available mainly at the municipal level and which are able to support the development of different kinds of NBS, highlighting the most interesting case studies, selected both at local and national level. For example: municipal plan for planting and maintaining trees; environmental indexes to be applied in the building rules, guidelines for sustainable water management, and funding of green areas.

For each typology of NBS (water management, green solutions on built environment, and ground green spaces) four different types of tools that can be used by local administrations have been identified:

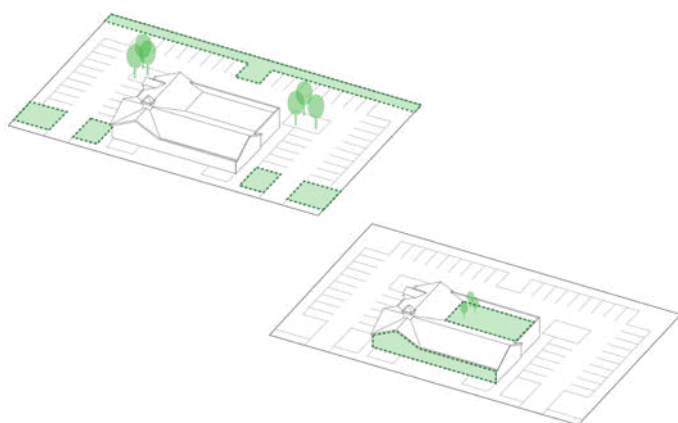
Strategies and plans



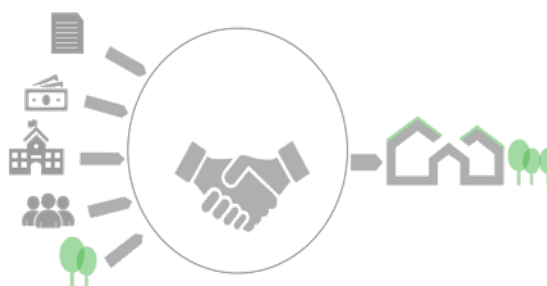
Technical tools

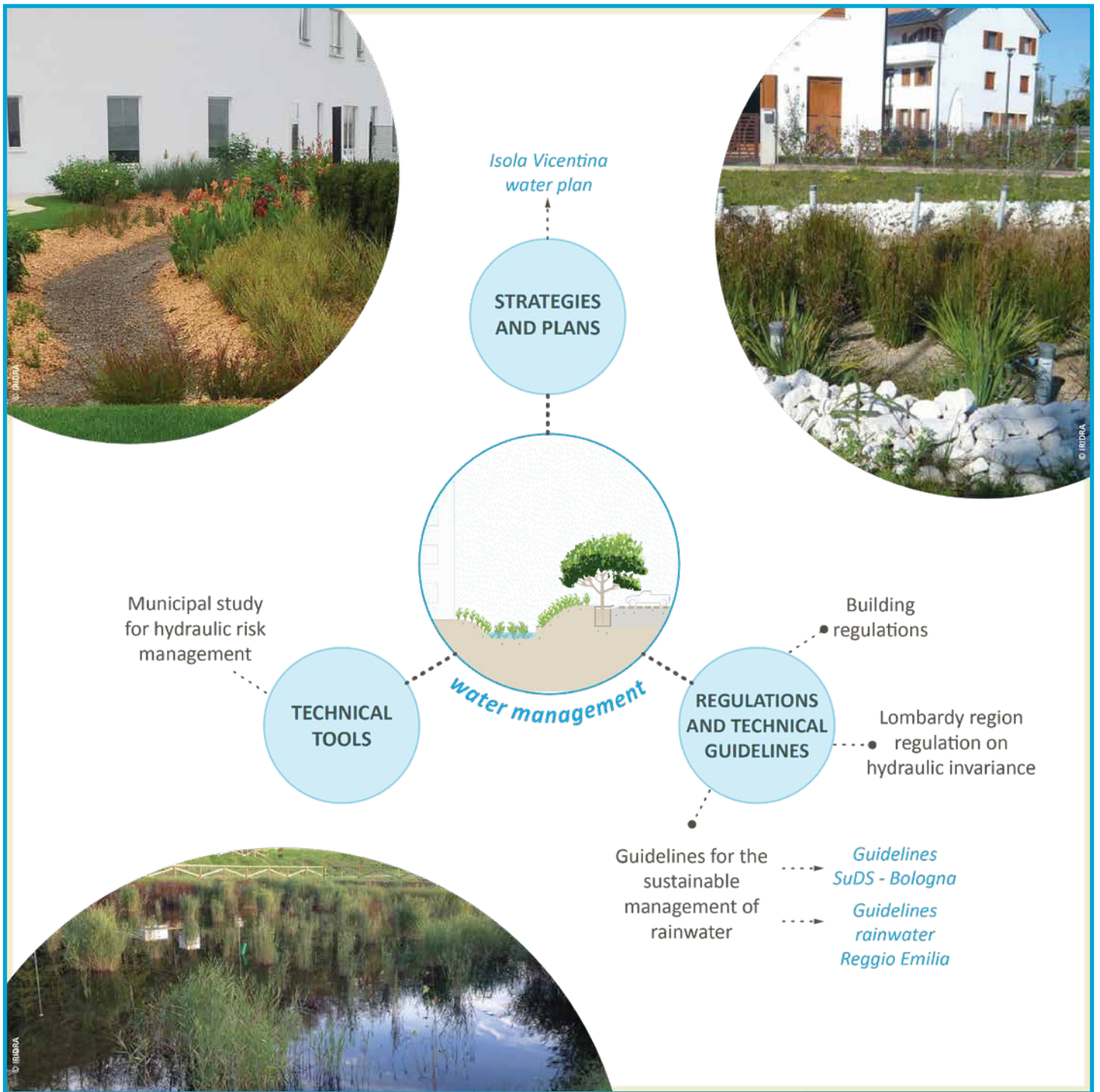


Regulations and technical guidelines



Public-private agreements.









Nature-Based Solutions feasibility within urban areas: the case of Parabiago and Buccinasco feasibility studies

PARABIAGO FEASIBILITY STUDY

The feasibility study conducted for the municipality of Parabiago about NBS implementation concerns a service road in an industrial area that needs to go through maintenance and restoration. The whole area is currently asphalt paved and includes 7,300 m² of road surface, 2,700 m² of parking areas on both sides of the road, 3,400 m² of sidewalks and a few hundred m² of green spaces.

The study is aimed at comparing different technical solutions to improve the stormwater management of the site, in the key of climate change adaptation in two scenarios: one that just reduces the stormwater runoff and another one that completely avoids runoff by storing stormwater in underground tanks.



Figure 1. Aerial photo of the area of intervention in Via Lombardia, City of Parabiago. Retrieved from Google

The alternatives that have been analysed by the study are the following:

Alt.0.1: Restore the asphalt paving.

Alt.0.2: Restore the asphalt paving + stormwater storage tanks to avoid stormwater runoff.

Alt.1.1: Use permeable pavement for the parking area to reduce stormwater runoff.

Alt.1.2: Use permeable pavement for the parking area + stormwater storage tanks to avoid stormwater runoff.

Alt. 2.1: Equip the whole area with infiltration trenches to reduce stormwater runoff.

Alt. 2.2: Equip the whole area with infiltration trenches + stormwater storage tanks to avoid stormwater runoff.

Alt. 3.1: Equip the whole area with bioretention areas to reduce stormwater runoff.

Alt. 3.2: Equip the whole area with bioretention areas+ stormwater storage tanks to avoid stormwater runoff.

Criteria	Evaluation matrix Scenario 1			
	Alternatives			
	A0.1	A1.1	A2.1	A3.1
Air quality	0.00	0.00	0.00	1.00
Urban renewal	0.00	0.00	0.00	1.00
Biodiversity	0.00	0.00	0.00	1.00
CO2 emissions and sequestration	0.00	1.00	1.00	0.99
Environmental education	0.00	0.33	0.33	1.00
Health and wellbeing	0.00	0.00	0.00	1.00
Wastewater	0.00	1.00	0.99	0.99
Groundwater recharge	0.00	0.96	1.00	1.00
Construction costs	1.00	0.00	0.73	0.54
Management costs	0.57	0.54	0.58	0.56

Criteria	Evaluation matrix Scenario 2			
	Alternatives			
	A0.2	A1.2	A2.2	A3.2
Air quality	0.00	0.00	0.00	1.00
Urban renewal	0.00	0.00	0.00	1.00
Biodiversity	0.00	0.00	0.00	1.00
CO2 emissions and sequestration	0.00	0.42	0.49	1.00
Environmental education	0.00	0.33	0.33	1.00
Health and wellbeing	0.00	0.00	0.00	1.00
Wastewater	0.00	0.85	1.00	0.95
Groundwater recharge	0.00	0.83	1.00	0.95
Construction costs	0.11	0.00	1.00	0.59
Management costs	0.57	0.54	0.58	0.55

Figure 2. Evaluation matrix for the different alternatives in Scenario 1 (left) and 2 (right) with color scale to highlight the performance of the alternatives for the different criteria: red for minimum performance (0) to green for maximum performance (1)

For each alternative, an estimation of the construction and management costs and of the main benefits (in term of ecosystem services) provided, has been done applying a Multi Criteria Analysis (MCA) approach. The following benefits have been considered:

- Air quality;
- Urban landscape;
- Biodiversity;
- CO₂ emissions and storage;
- Awareness and education;
- Health and wellbeing;
- Wastewater;
- Aquifer recharge.

The relative importance of the costs/benefits (used as evaluation criteria in the MCA) has been assigned by a panel of experts. For the estimation of the ecosystem services the software B£ST (Benefits EStimation Tool)⁴ valuing the benefits of blue-green infrastructure, developed by UK CIRIA, has been used.

The alternatives that do not include stormwater storage tanks show realization costs ranging between 395,000 € (Alt.0.1) and 500,000 € (Alt. 1.1), while the one that envisages stormwater tanks ranges between 900,000 € (Alt.2.2) and 1,370,000 € (Alt.1.2).

The results of the evaluation showed that in both scenarios (the one that reduce runoff and the second that completely avoid any runoff) the best performing alternative is the alternative 3 (Equipping the whole area with bioretention areas) that offers several other benefits in front of a negligible cost increase.



Figure 3. Rendering of the chosen solution (Alternative 3, bioretention areas) in the project scenario, in rainy weather (left) and dry weather (right)

⁴www.susdrain.org/resources/best.html

BUCCINASCO FEASIBILITY STUDY

The feasibility study conducted for Buccinasco concerns the possible solution of an existing problem of water pollution, due to the wastewater discharged by a Combined Sewer Overflow in a nearby water course.

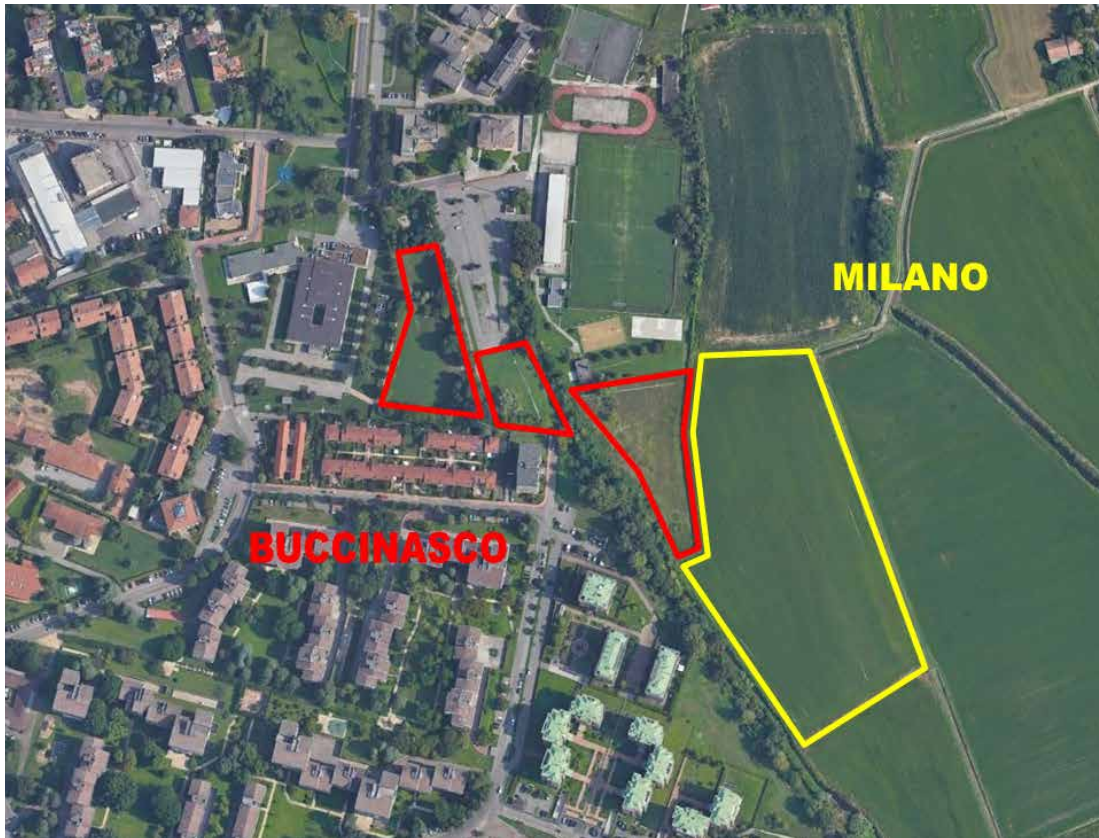


Figure 4. Area on the border between the city of Buccinasco and the city of Milan. Retrieved from Google Earth.

The alternatives developed consider 3 grey infrastructures (Alt.1.1, 1.2, 1.3) and 3 green infrastructures (Alt. 2.1, 2.2, 2.3), as follows:

- Alt.1.1:** Static primary sedimentation tanks and discharge to the stream.
Alt.1.2: First flush tank (small) and pumping back to the sewage after the rain event.
Alt.1.3: First flush tank (big) and pumping back to the sewage after the rain event.
- Alt. 2.1:** Single stage reed bed (French system) and discharge to the stream.
Alt. 2.2: Two stages (reed bed + free water wetland) natural treatment and discharge to the stream.
Alt. 2.3: Two stages (reed bed + free water wetland) natural treatment and discharge to the stream as part of a new urban park.

	Evaluation matrix					
	A1 – Gray infrastructure			A2 – Green infrastructure		
	A1.1	A1.2	A1.3	A2.1	A2.2	A2.3
Air quality	0.00	0.00	0.00	0.00	0.00	1.00
Biodiversity	0.00	0.00	0.00	0.37	1.00	1.00
CO2 emissions and sequestration	0.10	0.05	0.00	0.51	1.00	0.71
Environmental education	0.00	0.00	0.00	0.17	0.33	1.00
Water quality	0.00	0.25	1.00	1.00	1.00	1.00
Health and wellbeing	0.00	0.00	0.00	0.00	0.00	1.00
Usage	0.00	0.00	0.00	0.00	0.00	1.00
Wastewater	1.00	0.00	0.00	1.00	1.00	1.00
Administrative issues	1.00	1.00	1.00	0.00	0.00	0.00
Construction costs	1.00	0.76	0.20	0.49	0.37	0.00
Management costs	0.91	1.00	0.97	0.91	0.89	0.00

Figure 5. Evaluation matrix for the different with color scale to highlight the performance of the alternatives for the different criteria: red for minimum performance (0) to green for maximum performance (1).

As for the Parabiago feasibility study, also in this case, for each alternative, an estimation of the construction and management costs and of the main benefits (in term of ecosystem services) provided, has been done applying a MCA approach. The following benefits have been considered:

- Biodiversity;
- CO₂ emissions and storage;
- Awareness and education;
- Water quality;
- Health and wellbeing;
- Recreation;
- Wastewater;
- Administrative burden;
- Construction costs;
- Management costs.

The relative importance of the costs/benefits (used as evaluation criteria in the MCA) has been assigned by a panel of experts. For the estimation of the ecosystem services the software B£ST (Benefits EStimation Tool) – valuing the benefits of blue-green infrastructure, developed by UK CIRIA, has been used.

Construction costs range roughly between 300,000 € (Alt.1.1) and 1,200,000 € (Alt.2.3); however, considering all the evaluation criteria, Alt.2.3 was largely the most performing one: on the normalized scale 0 to 1, Alt.2.3 (Two stages - reed bed + free water wetland - natural treatment and discharge to the stream as part of a new urban park) scores 0.64, while the “grey infrastructure” alternatives ranges between 0.35 and 0.40.

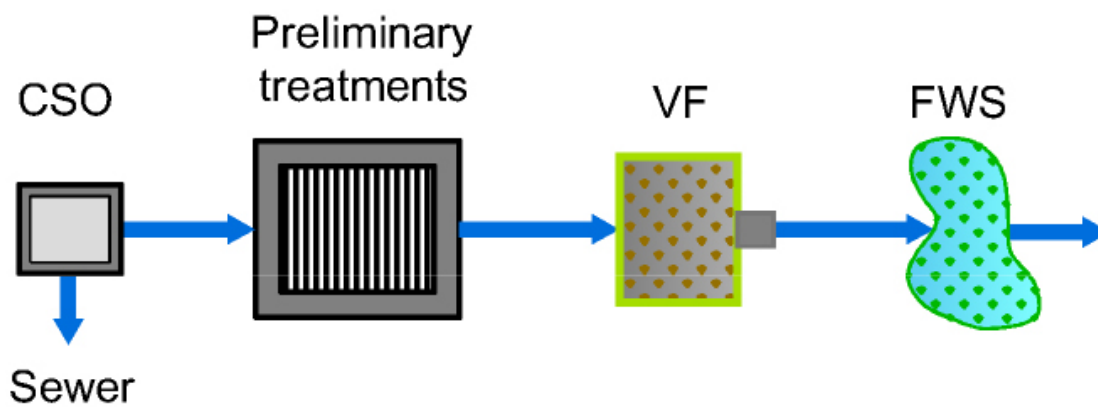


Figure 6. Vertical Flow Constructed Wetlands (VF) + Free Water Surface Flow Constructed Wetlands (FWS)

Pilot Nature-Based Solutions: the case of Solaro and Masate

As part of the LIFE Metro Adapt project two pilot interventions for sustainable water management have been carried out in the territories of Solaro and Masate aimed at contrasting the high hydraulic risk to which the metropolitan area of Milan is subject, due to a growing urban expansion.

MASATE (MILAN)

Masate is a town of about 3.5 thousand inhabitants located in the north-east part of the Metropolitan City of Milan. Over the last ten years, it has seen an abrupt increase of its population, which has augmented of 35% in ten years from 2001. This growth tendency has led to the need of new constructions; thus, it increased the anthropogenic impact on soil consumption, which made it a perfect field for LIFE Metro Adapt experimentation on NBS for meteoric water draining.

The realisation includes the disconnection of grey water drainage from the sewerage network serving a parking and a local road (blue circles in the figure below) and the collection of rainwater into a dedicated network, being sent to a retention basin, located in a surrounding green area (green circle in the figure), then partially treated and discharged into a local water body.



The choice for this type of realization is motivated by the fact that the local geological nature of the soil, characterized by a poor permeability, does not allow to entrust the natural drainage for relieving the area from rainwater. In this sense, in February 2020 two Lefranc tests have been realized in order to estimate the permeability, which resulted of about $1,09 \times 10^{-6}$ m/s between 1,5 and 2 m of depth, and of about $4,37 \times 10^{-6}$ between 3,5 and 4 m, showing a limited infiltration capacity. Moreover, from the internal CAP database, it was possible to observe that in that specific area the aquifer is located at only 12,5 meters of depth. For these reasons, the choice of the realization went for a retention basin followed by discharge in a local water body.

The key of the realization is the construction of a new manhole collecting the two flows of rainwater, one coming from the parking area and the other from the local portion of via Circonvallazione, by at the same time disconnecting this flows from the sewerage.

The new manhole is itself connected to a retention basin located in a neighboring green area: the basin is preceded by two de-oiling artifacts, to avoid any soil infiltration by oils/hydrocarbons, and which can be easily maintained. The retention basin has a capacity of about 90 m^3 and interests an area of about 400 m^2 , with lateral slopes of 30% and a gravel trench to avoid any superficial water stagnation.



SOLARO (MILAN)

Solaro is a town of about 15 thousand inhabitants located in the north-west part of the Metropolitan City of Milan. It neighbors on the North the municipality of Ceriano Laghetto, on the east the municipalities of Bovisio M. and Limbiate, on the South the municipality of Cesate and on the East the municipality of Saronno.

The demonstrative NBS-based realization in the Solaro municipality has been focused on the upgrade of a runoff draining system located in a public parking: in this context, the draining has been disconnected from the sewer system and replaced with the new sustainable solutions. The disconnection benefits the local sewer system, lowering the dilution effect coming from the mixing with meteoric waters, thus removing one source of the so-called "parasite water", that are overcharging the sewer network.

The concept of this realization is in line with recent local regional and municipal regulations, that are, for example, prescribing those new buildings should be equipped with independent meteoric water draining systems, where the soil has an adapted degree of permeability.

After analyzing all the available information, it was decided to define the realization as it follows. Two separate intervention zones were identified, as shown in the following pictures.



Zone 1 is located in the south-east portion of the parking, at its end, and has a surface of 135 m². The existing meteoric water draining pipe has been separated into two sub-pipes, each one connected with first a sand and oil removal system, and then with three percolation shafts, of 3.5 m of height. The whole surface was surrounded with a bioretention area and a trench drain. The connection between the meteoric water drain network and the sewer network, which is currently at the bottom of Zone 1.

Zone 2 is located in the middle of the parking. The existing drainage network was intercepted, and the flow distributed to two parallel systems, comprising a first sand and oil removal, and then three percolation shafts each. In this same Zone, at the correspondence with the entrance of the parking, a rain garden composed of 4 draining flower beds will also be implanted. Preliminary section of sand and oil removal are needed to avoid any potential infiltration of hydrocarbon traces (coming from fuel or motor oil residues) in the soil.



Participatory methodologies to raise awareness at the local and international level

The LIFE Metro Adapt Project working group acknowledged “participation” as a strategic approach for the involvement of local, supra-local and international territorial players operating in the involved area. **Participation** is a crucial element to foster knowledge sharing, boost dialogue among multi-sectoral stakeholders, listening to requests, evaluating proposals and identifying the most effective measures for climate change adaptation in a specific territory.

With the aim of maximizing the impact of the project generated knowledge and achieved results, the LIFE Metro Adapt Project has adopted a participatory approach throughout the whole project duration, implementing activities – both at the national and international level - that have been articulated around two main axes:

- On the one hand, the Project promoted activities aimed at increasing the level of knowledge and analytical skills of technicians, policymakers, and key stakeholders in the water management and urban planning sector, developing and making available databases and maps with adequate details, able to highlight the causes, effects and possible areas in which to develop solutions capable of reducing the UHI effect and improving urban water flow.
- On the other hand, a structured communication and information process has been boosted, aimed at involving subjects, local entities and the whole community thanks to public initiatives and awareness raising events on the issue of climate change adaptation.

Both axes have been crucial for identifying ideas, projects, territorial needs, and expectations and to actively involve the community, by boosting a co-creation process which led to the creation of a multi-stakeholder network that through the creation of synergies and best practices exchange is multiplying the project impact, by boosting its transferability and replicability at the national and international levels.

Beyond the technical tables, already explained extensively in the initial chapters, the project has adopted different tools with the final aim of involving national and international stakeholders in the project activities and disseminating the generated knowledge. In order to reach a wider audience, the project has worked on different levels by organizing initiatives directed to diverse target groups: i) experts and organizations working in the environmental field; ii) local and regional authorities all over Europe; iii) representative of the private sector; iv) citizens; v) children and students, among others. In the following sections, some examples of implemented tools and participatory methodologies will be outlined.



The Metro-Theatre: Art as a powerful tool to raise awareness

The **Metro-theatre** is a caravan of theatrical performances dedicated to explain the risks associated with climate change and the need to regenerate urban areas with the view to adapting to increasingly extreme phenomena. Through the collaboration with the theatre company ArditoDesio, the theatre show **"Pale Blue Dot show"**, a production by the Jet Propulsion Theatre has been performed all over the Metropolitan Area of Milan and internationally, spreading the message about climate change through theatre and art. This incredible initiative aims to explain the wide public risks associated with climate change (e.g. extreme rainfall, flooding, temperature anomalies, etc.) and the ever-present need to regenerate urban areas that are increasingly affected by the need to create the necessary measures to prevent the most extreme phenomena. This is an opportunity to re-launch and raise awareness on this topic and to present the project to the local community. The show aims to question us citizens on the need to have to protect our planet, and wonders if we are really ready to do so.

The Metro-theatre initiative has been brought also to schools of the Milan Metropolitan Area, with the show "The Trees Dance" by the ArditoDesio Company. The story tells of the woodcutter Pinot who is sent into the heart of an ancient forest with an arduous task: to cut down the majestic tree Valhalla and bring it to the village for an important celebration. But Valhalla will prove to be a tough nut to crack and the great tree, in addition to revealing wonderful and surprising secrets of the forest, will push Pinot to reflect on the meaning of life and the importance of always deciding for yourself. A journey of education and knowledge that will end in a delicate embrace between man and nature, also in relation to the ongoing climate emergency.

THE PALE BLUE DOT

"Pale Blue Dot" is a compelling and "harsh" show that reminds us all of our responsibilities towards the environment, stressing that the time at our disposal to change the way we conceive and exploit the world is less and less. The story tells of the probe Voyager 1 that is mixed with that of its creator suicide, that of his dreamer son and that of the planet Earth. The artificial satellite gradually moves away from the solar system and everything seems to become paler and clearer as well as the Earth, the pale blue dot, in this case the Earth will be the subject to be protected as the most precious thing in the world. What will happen?

Just when all seems lost, an event that changes the social structure and transforms the whole scene. However, this uncompromising revolution is necessary. Everything will be documented and sent to Voyager 1 with the hope of keeping some relic of our civilization.

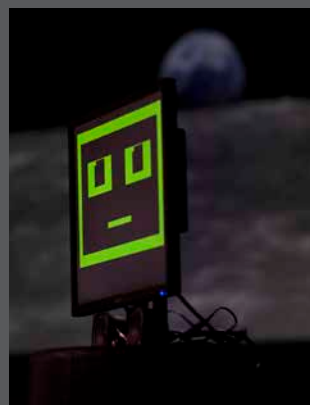


Photo Credit:
Monica Condini



The play is by and with Andrea Brunello. Directed by Christian Di Domenico.
Music by Enrico Merlin. The trailer of the show is available here: <https://vimeo.com/126845835>

Thematic seminars: climate emergency and climate change adaptation in urban areas

With the aim of boosting participation of the local community and to foster citizens' appropriation of the project objectives, the LIFE Metro Adapt project has promoted moments of in-depth study on the topic of climate emergency, the adaptive potential of cities and metropolitan areas and on the development of appropriate design strategies and the crucial role of NBS for territorial resilience to climate change. A wide variety of seminars (both in presence and online) has been promoted throughout the project duration, involving a high number of interested citizens and contributing to increase the awareness around climate change. In the following paragraphs, some examples are illustrated.

TITLE OF THE WEBINAR:

"How to change communication about climate change in metropolitan areas".

MAIN TOPIC OF DISCUSSION:

The evening was presented by **Cinzia Davoli** from the Metropolitan City of Milan and coordinator of the Metro Adapt project and **Lorenzo Baio** from Legambiente Lombardia who briefly summarised the main themes and objectives of the Metro Adapt project, co-financed by the EU LIFE Programme. Afterwards, **Lorenzo Cecchi**, president of Legambiente Firenze, moderated two interesting presentations. The first was given by **Luca Lombroso**, meteorologist and scientific popularizer, who described the difficulties and history of communicating climate change issues to the general public, suggesting some new methods. The second, held by **Francesco Alberti**, Professor of Urban Planning at the University of Florence, sought to convey the concept that in addition to communication to the general public, communication to administrators and technicians is strategic. They must be led to overcome the current vision restricted to bureaucracy alone, which must change and expand.

TITLE OF THE WEBINAR: *"Metropolitan cities facing the climate emergency. Green solutions that change the urban landscape".*

MAIN TOPIC OF DISCUSSION:

The evening included a brief introduction by **Marzio Marzorati** of Legambiente Lombardia, who summarised the objectives of the LIFE Metro Adapt project. This was followed by three presentations by experts who have been collaborating with Legambiente for many years in various capacities: **Giulio Conte**, hydrobiologist and technical director of AmbienteItalia, who in addition to presenting the guidelines on NBS measures drawn up for the Metroadapt project, talked about the feasibility studies on sustainable urban drainage carried out for Parabiago and Buccinasco and the pilot interventions in Solaro and Masate. **Lidia Castagnoli** from Legambiente Emilia-Romagna and contact person for the SOS for LIFE project. She told about the experience of the LIFE SOS4Soil project and the tools used by the technical actors. In addition, he focused on the depaving interventions carried out in Forlì, Carpi and San Lazzaro. **Lorenzo Nofroni**, on the other hand, described three experiences in the Florence area with a different slant, a hybrid between social and ecological objectives. In other words, how to create ecological quality through participatory redevelopment projects. Finally, he described the new "paesaggi comuni" call for proposals issued by the Florence City Council, which encourages participatory projects for the reconfiguration of public spaces.

TITLE OF THE SEMINAR:

"Cities are adapting to the changing climate: technical strategies and lifestyles"

MAIN TOPIC OF DISCUSSION: The seminar, which took place in an informal and participatory atmosphere, analyzed and compared the experience of the city of Milan with the practices of other international cities, as told by **Piero Pelizzaro** – Chief Resilience Officer of the City of Milan. **Lorenzo Bono**, representative of AmbienteItalia, illustrated the technical and urban planning tools able to modify the building practices in favor of choices that go in the direction of climate change adaptation. **Marco Callerio**, representative of Cap Holding, brought concrete examples of ongoing interventions and technical solutions capable of increasing cities resilience to climate change. **Andrea Brunello** from the theatre company ArditoDesio and **Barbara Meggetto**, president of Legambiente Lombardia, recalled the importance of individual behavior, that can trigger deep changes towards sustainability at a global level. The round table was chaired by **Pietro Mezzi** – Delegate Councilor for the territory and the environment of the Metropolitan City of Milan, tha in recent months, is updating its Territorial Plan also in terms of adaptation to Climate Change.

**Photo contests:
engaging citizens in the fight against climate change**



In order to assess the awareness of citizens involved in previous activities, the tool of the **photo contest** has been used. The LIFE Metro Adapt project has launched the photo contest "PhotoAdapt – The impacts of climate change in the Metropolitan City of Milan" with the aim of promoting and generating knowledge about the climate change impacts in the territory of the Metropolitan City of Milan, raising awareness about the need for urgent actions to address them.

The title of the photo contest invites us to reflect, in particular, on the impact of our lifestyle on the environment, on other species, but also on the most vulnerable communities, victims of the growing inequalities caused by the economy and human activity. Citizens have been invited to share photos highlighting the consequences of climate change on the territory, both from an environmental and social point of view .



Federica Aggio



Laura Cardacino



Arianna Bazzocchi



Jacopo Bertin



Jacopo Bertin



Franco Beccari



Marco Betti



Ginevra Carniletto



Daniele Passoni



Immacolata Carmicino



Ginevra Carniletto



Marco Betti



Federica Aggio



Stefania Lazzaro



Fabrizio Stefani



Laura Zamprogno



Immacolata Carmicino



Gabriella Porta



Stefania Lazzaro



Fabrizio Stefani



Gabriella Porta



Laura Zamprogno



Laura Cardacino



RobertoVisigalli



RobertoVisigalli

Best practices exchange: International webinars

Throughout the project, the networking activity with European metropolitan cities, municipalities and international CSOs whose thematic is in line with Metro Adapt focus has been central. With the aim of maximizing the impact of the project dissemination activities, transferring the project generated knowledge and achieved results, the Project has organized several dissemination initiatives at the international level, involving a wide range of stakeholders and strengthening linkages with international networks and platforms, spreading the project mission and fostering a high level exchange of knowledge. The Project has joined international spaces of dialogue such as the European Week of Regions and Cities, the European Green Week and global festivals as the "Nature of Cities Festival", supporting the creation of a network that could enhance the dissemination of good practices and the maximization of results' replication.

The first webinar was organized in the framework of the **18th European Week of Regions and Cities**. The webinar **"Adaptation of European metropolitan areas to climate change"** analyzed the key role of European metropolitan cities in defining a climate change adaptation strategy at the local level, based on good practices developed by CMM and the Barcelona Metropolitan Area.

The second webinar was organized in the framework of the Nature of Cities Festival. Starting from the experience of the Metro Adapt project, the webinar **"Nature Based Solutions as a means to boost urban climate change adaptation"** created a space of dialogue among the key stakeholders which can be potentially involved in the implementation of sustainable strategies to limit the impact of climate change. In the first part of the workshop the speakers tackled the climate change issue in relation with the experience of the Metro Adapt project in the Metropolitan City of Milan; in the second part of the session, a space of dialogue between participants was created, about implementing sustainable strategies to limit the impact of climate change.

The third webinar **"Zero pollution challenge and Nature-Based Solutions: The leading role of metropolitan areas and EU financial instruments"** was organized within the European Green Week 2021 tackling the issue of urban pollution through an interactive reflection around two main questions: i) Among the different mitigation measures, which are the benefits and challenges of NBS? ii) Which is the strategic role of metropolitan areas as leaders of territorial environmental governance?



Zero pollution challenge and Nature-Based Solutions: The leading role of metropolitan areas and EU financial instruments

4th June, 2021 | 10.30 A.M.-12.00 P.M.

#EUGreenWeek
2021 PARTNER EVENT

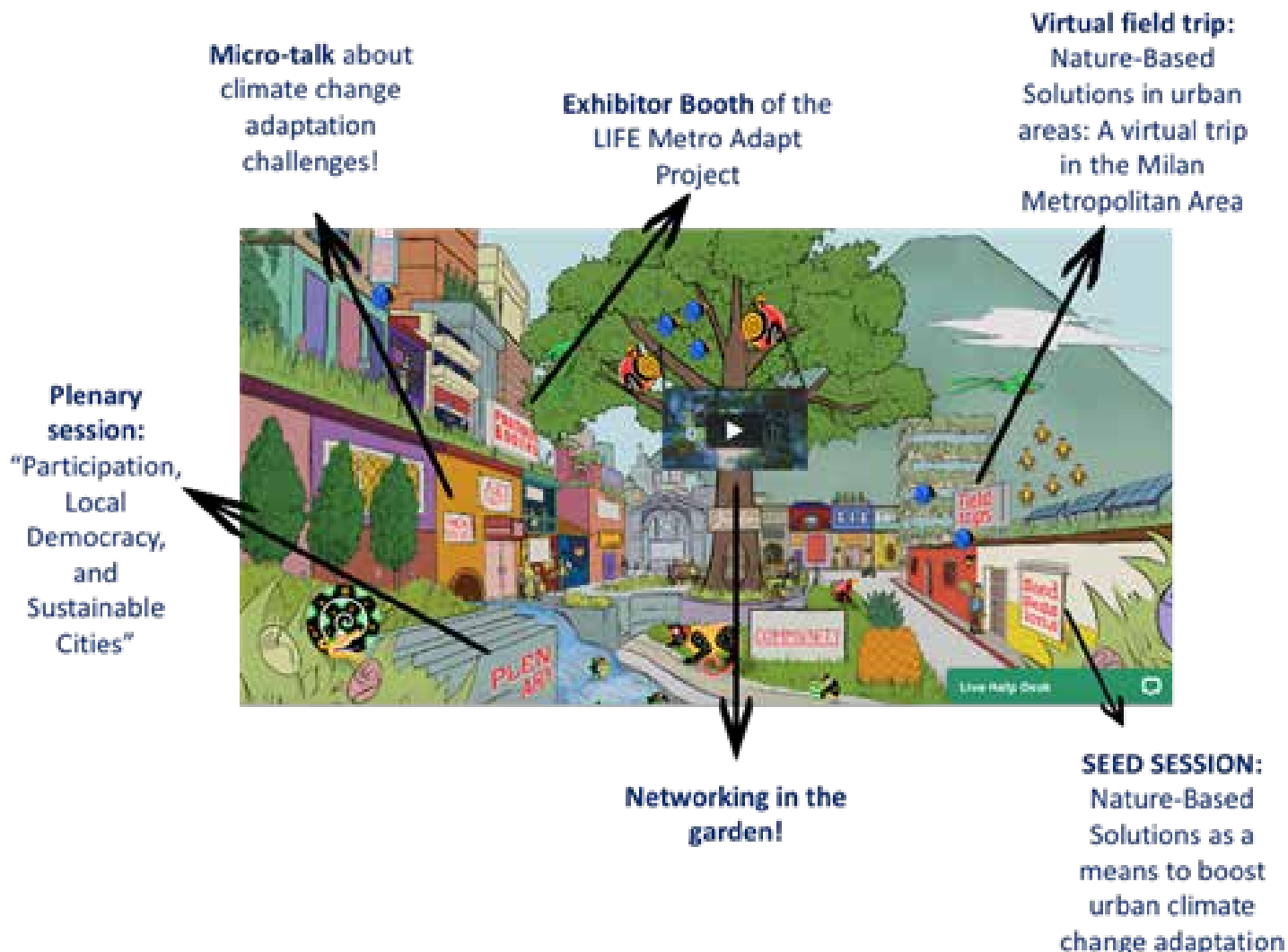


International events: Creating a network at the global level

Despite the Covid-19 pandemic, the first Metro Adapt international event has been organized online within the **“Nature of Cities Festival - Better Cities for Nature and All People”** a virtual festival that took place from the 22nd to the 25th of February. The 5-days event focused on facilitating transdisciplinary dialogue, small group workshops, arts engagement, and fostering a collaborative spirit around solutions for our urban futures. More than **2000 participants** around the world joined the sessions and visited the imagined city created by The Nature of Cities. The Metro Adapt project joined the international event as one of the main co-organizers, proposing a wide variety of activities and sessions:

- The workshop **“Nature-Based Solutions as a means to boost urban climate change adaptation”**, which took place on the 23rd of February.
- The virtual field trip **“Nature-Based Solutions in urban areas: A virtual trip in the Milan Metropolitan Area”**, which took place on the 24th of February.
- The conversation in the plenary session **“Participation, Local Democracy, and Sustainable Cities”** between Antonella Valmorbida, ALDA’s Secretary General, and Mary Rowe, President and CEO of the Canadian Urban Institute, which took place on the 24th of February,
- The workshop **“Covenant of Mayors: The Sustainable Energy and Climate Action Plan in Metropolitan Areas”**, which took place on the 25th of February.
- The mutual learning **“Pale Blue Dot and the Metro-Theatre: Art as a powerful tool to raise awareness”**, which took place on the 25th of February.

Furthermore, participants had the possibility to interact with the project partners and to discover more information about the Project results within the **LIFE Metro Adapt exhibitor booth** and listening to the **Metro Adapt Micro-Talk**.



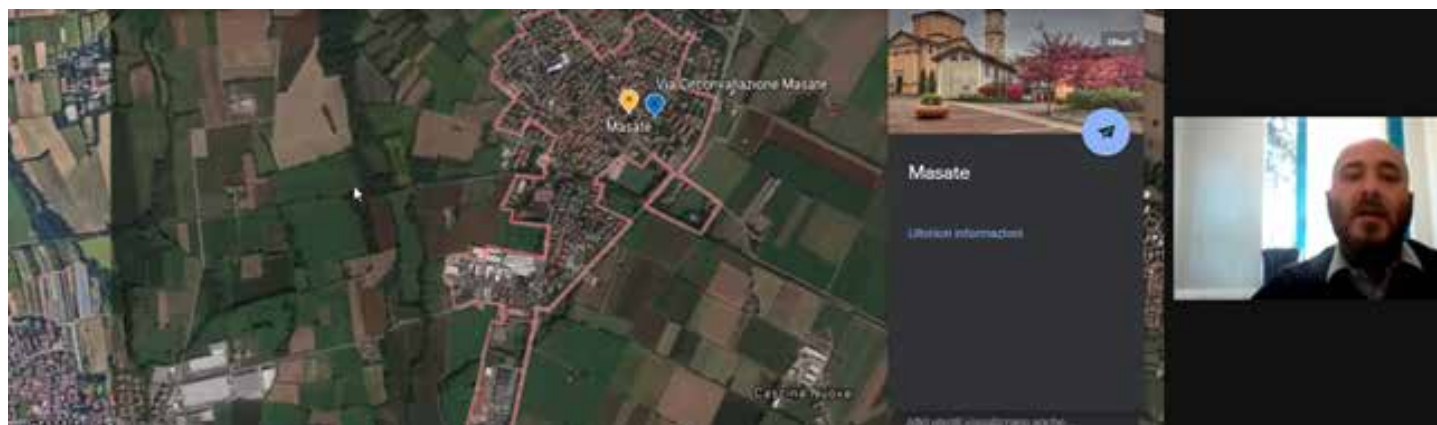
Nature-based solutions in urban areas: a virtual trip in the milan metropolitan area

Within the Nature of Cities Festival, the LIFE Metro Adapt project organized a virtual fieldtrip to give participants the chance to travel 360° inside the project using a google earth map and video pills, with a focus on the pilot interventions implemented in Masate and Solaro municipalities. The Metropolitan Area of Milan is prone to flood risk, due to the expected increase of the the Olona and Seveso rivers and to the high urbanization level. In an attempt to gain an in-depth knowledge of the phenomenon and to reduce its impact, the EU funded LIFE Metro Adapt project analyzed the hydraulic risk of the area taking into account the rainwater retention capacity of the soil, based on the soil use/cover and pedological soil characteristics.

The **virtual field trip** showed the two interventions implemented by the project in Masate and Solaro, explaining their main features and benefits both from a socio-economic and environmental point of view. The main objective of the virtual field trip was to stress the importance of adopting Nature-Based Solutions in highly urbanized areas to increase territorial resilience to extreme weather phenomena such as heavy rainfalls or intense heatwaves. By showing the path that led to the implementation of a rainwater retention system in the municipalities of Masate and Solaro, the session wished to boost the replicability of such measures in urban areas by detailing their scale of application (depending on the kind of NBS and the territorial context), the challenges, the socio-economic and environmental benefits. **Marco Bernardi**, project manager of CAP Holding S.p.A. guided the participants in a trip through the two implemented Nature Based Solutions.

The session represented the opportunity to launch the two videos that have been realized about the interventions:

1. **Nature-Based Solution in Masate:** The objective is to convey and dispose of wastewater from a parking lot and a portion of the provincial road in a special retention system.
2. **Nature-Based Solution in Solaro:** The objective is to reduce rainwater's contribution to the sewage system by a special drainage system in a public parking lot, that has been developed in two different areas.



The life metro adapt project within the all4climate Italy2021 initiative

All4Climate – Italy 2021 brings together all the events dedicated to the fight against climate change that will take place in Italy this year. The aim is to make 2021 a fundamental year for climate ambition. Launched by the **Italian Ministry of Ecological Transition** in collaboration with the World Bank Group's **Connect4Climate** and with the participation of the Lombardy Region and the Municipality of Milan, All4Climate aims to promote an active and constructive dialogue on the challenges of the climate crisis and encourage the achievement of the objectives of the Paris Agreement. **All-4Climate** represents an opportunity for all those involved in the **fight against climate change** to make a concrete contribution to the debate ahead of the **Pre-COP26** hosted in Milan in September and the **COP26** hosted by the UK in November.

To present its final results, the LIFE METRO ADAPT project will participate in the debate **from the 21st to the 28th of September 2021** with the multi-days event entitled:

“Climate change adaptation strategies and measures in the Metropolitan City of Milan”.

The event is the result of the project **Metro Adapt – Strategies and Measures for Climate Change Adaptation in the Metropolitan City of Milan**, which aims to promote the creation of a solid governance on climate change that is common to all local authorities and to produce the tools that allow them to implement efficient adaptation measures. It will alternate knowledge exchange initiatives with national and international experts with moments of entertainment and guided visits around the territory of the project implementation, with the final objective of bringing the topic of climate change and climate change adaptation strategies closer to public decision makers, technicians, municipalities, citizens, young people and students.

