CITIES FOR PEOPLE
THE EXPERIENCE OF REBUS LABORATORIES FOR MITIGATION AND ADAPTATION TO CLIMATE CHANGE

Today, almost 70 percent of Italy's population lives in urban areas, in small, medium, and large cities. This percent is growing and with it the expansion of urbanized areas.
All urban areas, both big and small, are vulnerable to the effects of climate change, even if the degree of vulnerability can differ greatly between cities and within a city. The climate has become the most decisive factor of change on a global and local scale, and cities are at the center of the challenge that this change entails, for two reasons:

- first, they are responsible for 75 percent of gas emissions on a global scale due to human activity (mobility, residency and industrial activity);
- and second, climate change has an enormous impact on them, causing problems, such as heat waves, periods of heavy rains that have become more frequent and last longer, drought, and other extreme weather patterns.

In the fight against climate change, the goal on a local level is to make cities 'climate-proof.' Therefore, we must intervene to reduce heat stress and control the effects of heavy rains, which can sometimes add to situations of critical status in urban areas, like in the cases of the urban heat island phenomenon and inadequate urban drainage systems. This means reducing the factors that negatively affect the quality of life, health, and safety of the people, the indoor comfort of homes and work environments, and productivity.
Since 2015, the Emilia-Romagna region has run training sessions and experimental labs on the effects of climate change on cities, with a focus on the public open spaces of cities as the physical contexts where mitigation and adaptation measures can be set. The approach to this topic is necessarily multidisciplinary and requires the expertise of architects, urban planners, landscape designers, agronomists, transporters, hydraulic engineers, and so on. With all these different disciplines and perspectives, we have tackled the topic of urban regeneration starting from public spaces. We did this by testing more careful choices of mineral materials, but even more so testing nature-based solutions for both the mitigation and adaptation of climate change.

THE EXHIBITION

'Climate proof cities' are also 'Cities for people' - to borrow Jan Gehl's expression - because most measures, surely the more efficient ones for mitigation and adaptation, are measures based on the reintroduction of nature into urban areas, which makes cities more healthy, beautiful, comfortable, livable, vital, and attractive. With this exhibition, we aim to illustrate the problems that climate change can cause in urban environments, suggest possible solutions, pulling from the best practices selected mainly in European experiments, and share the results of the experimental projects done during the training program and design labs of REBUS [*REnovation of public Buildings and Urban Spaces*].
The first section of the exhibition (in red) is dedicated to the illustration of extreme climate phenomena and their impact on urban areas with a particular emphasis on the consequences for the health and safety of city dwellers.
The second and third sections of the exhibition (in green and blue) look at the most efficient solutions for improving the urban microclimate, namely the urban green infrastructure, the planning of outdoor comfort to provide livability and quality in public spaces, and the blue infrastructure for sustainable management of the urban rainwater.
The fourth section of the exhibition is dedicated to illustrating urban regeneration projects in six neighborhoods in the cities of Parma, Modena, Rimini, Ferrara, Ravenna, and San Lazzaro di Savena (BO) - each has its own color - that participated in the REBUS design labs during the four editions held between 2015 and 2017, testing the methods and tools of the 'Regenerate the city with nature' Guide and evaluating the effectiveness of proposed projects from a climatic and environmental point of view through the use of simulation models.

CITIES FOR PEOPLE

Regione Emilia-Romagna

REBUS®
LABORATORIO SULLA RIGENERAZIONE URBANA E LO SPAZIO PUBBLICO PER L'ADATTAMENTO E LA MITIGAZIONE AI CAMBIAMENTI CLIMATICI

EMILIA ROMAGNA anci

Ibimet
Istituto di Biometeorologia
Consiglio Nazionale delle Ricerche

PROAMBIENTE

POLITECNICO MILANO 1863
DIPARTIMENTO DI ARCHITETTURA E STUDI URBANI

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HEAT WAVES AND HEAVY RAINS
EXTREME WEATHER PATTERNS GET MORE FREQUENT AND LAST LONGER

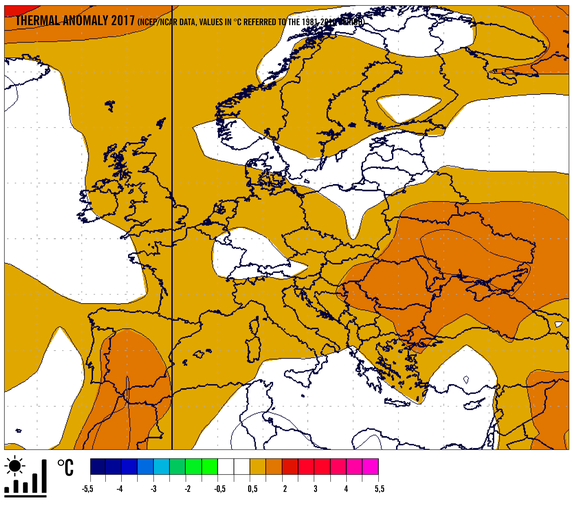
A HEAT WAVE occurs when the temperature reaches higher than the 90th percentile of the weather standards of the season for at least six consecutive days.
Temperatures above 40°C, high humidity, drought, fires, and blackouts due to energy overload are the effects that have increasingly afflicted our cities in the summer over the past 10 years.
In August 2003, in Europe, especially in France and Italy, 35,000 people, particularly elderly, died due to the heat.

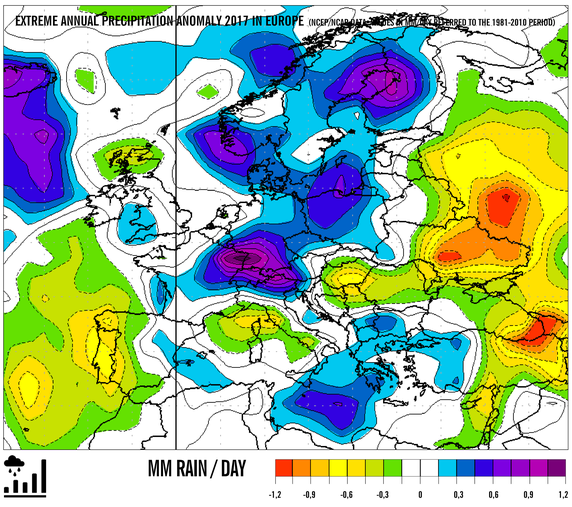
HEAVY RAINS - commonly called 'cloudbursts' - are ENHANCED PRECIPITATION and are included among the large-scale phenomena caused by global climate change.
The effects consist of an impressive variation in the capacity of the rain, through a small number of events, but increasingly intense for each. The impact is particularly dangerous for the impressive amount of water that they can release on urban areas, which are already intrinsically vulnerable, especially those that are intensely paved and sealed.

A CHANGING CLIMATE / RISING TEMPS CONTINUE WITHOUT STOPPING
The general discussion of what happened in 2017 confirms the trends that had already been seen in almost all previous years: global warming shows no sign of stopping, especially in the Northern Hemisphere.

Regarding the anomaly of 2017 as a whole in Europe, the map to the left below portrays the situation well. Practically all of Europe experienced a positive anomaly, with a value of more than 1°C in high altitudes, in the southeast region and on the Iberian peninsula, and few areas had anomalies less than 0.5°C.

It is interesting to note that there is a good correlation between this and the precipitation. From the following map, we can in fact see how the areas with above-average precipitation levels – those in central Europe and, to a lesser extent, in northern Europe and the eastern Mediterranean – are also those with the lowest thermal anomalies. This is due to a lack of sunshine and the conditions of soil humidity. As noted, a single severe thunderstorm can release tens of millimeters of rain in a short period without compensating for previous months of drought (climalteranti.it).



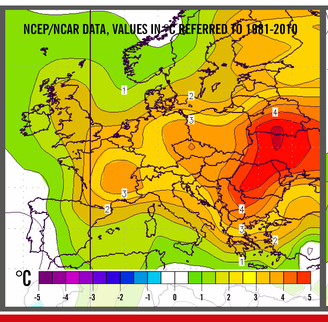


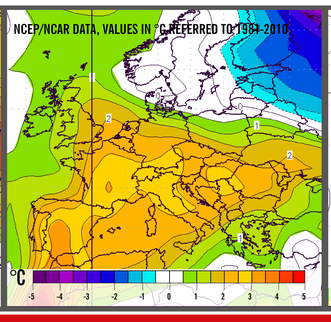
march 2017
THERMAL ANOMALY +1°C/+2,5°C
Northern Italy, and in particular the Northwest, showed anomalies higher than +2.5°C, while in Sicily they reached +1 °C. A positive anomaly involved virtually the whole of Europe (climalteranti.it).

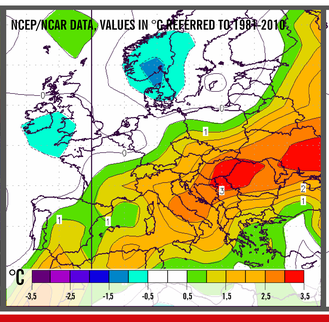
june 2017
THERMAL ANOMALY +2°C/+2,08°C
The major anomaly was recorded in June, with +2.08°C; as we can see in the image below, it involved practically the entire national territory, with Norther and Central Italy, in addition to France and the Iberian Peninsula, included in the 2°C isotherm, and with values only slightly lower than the South of Italy (climalteranti.it).

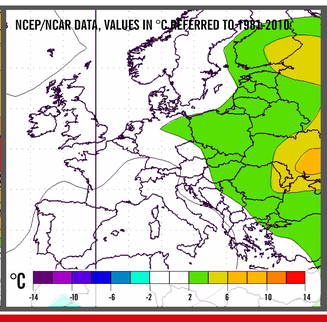
august 2017
THERMAL ANOMALY +2°C/+3°C
In August, Central Italy recorded an anomaly of more than +3°C, while the rest of the territory shows values higher than +2°C; only the islands and the Alps have values lower then +1°C (climalteranti.it).

december 2017
THERMAL ANOMALY - 0,53°C
In December, the whole national territory recorded a negative anomaly of -0.53°C. Also in this case, we can notice that, in addition to the very positive anomalies at high latitudes, the higher values in Eastern Europe rise up to +4°C (climalteranti.it).









CLIMATE CHANGE

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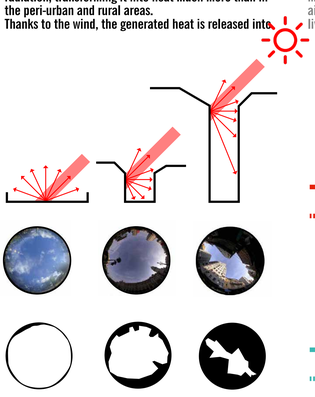
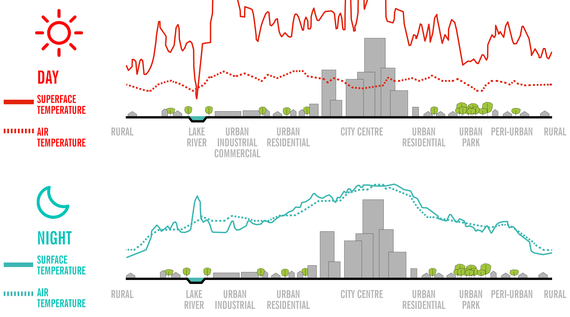
INTERACTION BETWEEN URBAN CLIMATE AND CITY

URBAN AREAS ABSORB SOLAR RADIATION AND TRAP HEAT AND POLLUTION

The term 'urban heat island' represents a complex system of energy exchange between the surface of the built environment and the atmosphere. The city is configured as a complex system of interactions on different levels of time and space and behaves like a type of macro-organism that pulses and breathes to the rhythm of the diurnal cycle of absorbed solar radiation. The study of different interactions between the urban climate and the built environment is, therefore, fundamental because the city, in terms of the relationship between buildings and open spaces, permeable and impermeable surfaces, and in terms of the characteristics of the materials it is composed of, influences the formation of a local climate to which the population is subjected, determining conditions of comfort or discomfort. There is also **higher energy consumption** associated with urban heat islands **due to the air conditioning of buildings**, which releases even more heat to the outside, and the formation of photochemical smog, which is the most common form of pollution in urban areas. This pollution forms especially in the summer with the high temperatures and high solar radiation. **The thermal properties and morphological characteristics of the built environment, along with the local climate conditions, strongly affect the concentration of atmospheric pollutants, so much so that the consequences on health cause dangerous situations for the most vulnerable populations (children, elderly, and sick people).**

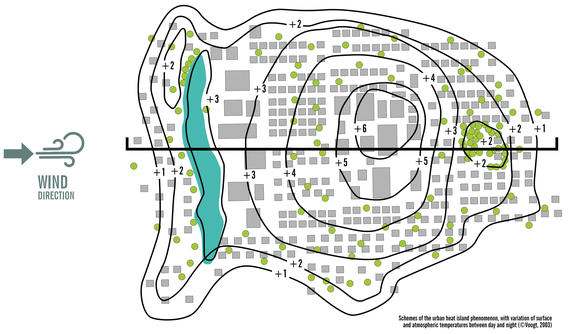
URBAN AREAS AND HEAT DAY AND NIGHT
Urban areas generally have dark surfaces and little vegetation; therefore, they tend to absorb a lot of solar radiation, transforming it into heat much more than in the peri-urban and rural areas.
Thanks to the wind, the generated heat is released into the air. But in the denser areas and/or those in which the wind is modest or absent – like in the Po River Valley – the heat disperses less and as it accumulates, makes the temperature on surfaces and that of the air rise, causing discomfort and making the city less livable during both the day and the night.





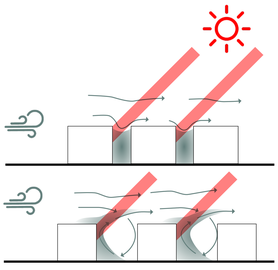
The ***SKY VIEW FACTOR*** is the part of the sky that's visible in a certain place and is determined by the urban morphology drawn by the physical borders of the urban space:
- vertically, by the surfaces of the buildings that face it;
- horizontally, by the ground and sky.

From photos taken with a fish-eye lens and from the corresponding sections, we can deduce that **the greater the visible sky is, the greater the quantity of solar radiation that can enter the urban space during the day, and the greater the chance of it dispersing into the environment during the night**.
The resurfaced radiation that remains 'trapped' between buildings is the highest cause of increasing average temperatures in cities, establishing a more or less intense heat island effect (V. Dessì).

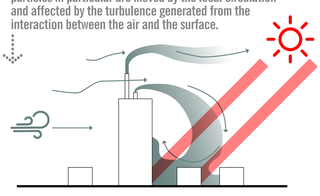


Schemes of the urban heat island phenomenon, with variation of surface and atmospheric temperatures between day and night (©Voogt, 2002)

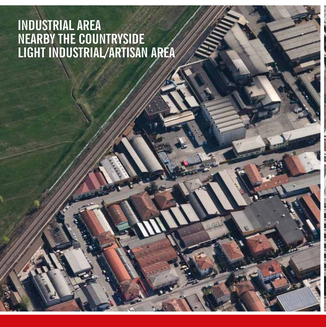
This phenomenon therefore means that – at equal temperatures – as you move from rural and suburban areas towards city centers a difference in temperature can be upwards of 5°C or 6°C.
The only points of discontinuity and cooling in urban heat islands are found in its **parks** or by **encroaching flows of water**, where present.
Between these and the city center, there can be up to 2 or 3°C difference in temperature, and it is for these reasons that parks and river walks or lakesides are important areas for the wellbeing of the people who reside in cities.

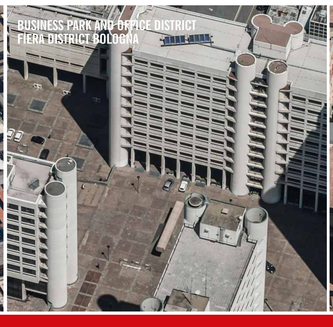


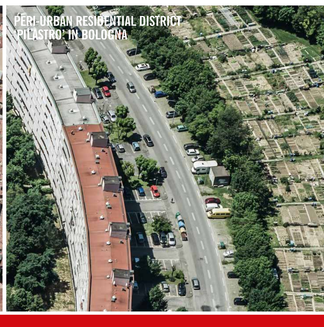
POLLUTION AND THE CLIMATE
The urban environment is the place where the effects of the microclimate and the behavior of pollutants are perfectly paired together. The pollutants emitted from human activity are subject to being moved and deposited and, therefore, are strongly influenced by the anemological movements of the surrounding environment. We can assume that the gases and small particles in particular are moved by the local circulation and affected by the turbulence generated from the interaction between the air and the surface.



This interaction can be mechanical, caused by the roughness of the surface, which slows the flow of air touching the surface, or thermal, from the exchange of heat, again with the surfaces that the flow touches. **Therefore, the microclimate and the behavior of the pollutants also depend on the special organization of the city and on the thermal properties of the built environment (T. Georgiadis).**







URBAN HEAT ISLAND

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HEALTH RISKS AND THE THERMAL DISCOMFORT FOR PEOPLE DURING HEAT WAVES

HEAT WAVES IN CITIES CAN BE *DEADLY*

The heat wave is an exogenous problem to the urban system. However, when this anomalous phenomenon occurs in man-made environments, the effects of the urban heat island, typical of densely built cities, combined with those of the heat wave, can lead to extremely high temperatures that can last for several days. The materials of the built environment hold such high quantities of energy that are released during the night and thus cause the people physiological stress that can last without pause for days on end. This means, in general, a rise in the sleep disorders of the urban population (with a subsequent decrease in productivity).

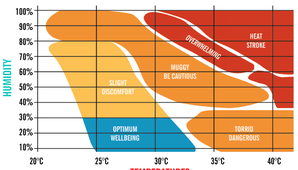
But in the more vulnerable subgroups of the population, such as the elderly (over 65) and those suffering from chronic illnesses, especially those with cardiovascular and respiratory diseases, the consequences are much more severe. If we consider that, in the case of heat waves, the right conditions for the maximization of photochemical pollution are also created in cities, the health impact on weaker subjects is even more relevant. It is evident that to reduce the occurrence of heat waves, we must act on a global scale; however, on the local level, it is possible to work on mitigation and adaptation to reduce a considerable part of the adverse effects on the population.

INDEX OF BIOCLIMATIC WELLBEING
The index of bioclimatic wellbeing is defined as a statistical process that correlates micro-meteorological parameters with people's perceived sensation of wellbeing or physiological discomfort.
A large variety of bioclimatic indices exists.

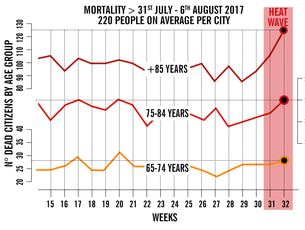
One of the most used is the Temperature-Humidity Index (THI). The physiological comfort is thus a state of equilibrium between the individual and the surrounding environment, between entering and exiting energy.
A parameterization in particular found a vast application in the numeric models of these phenomena.

The PMV (Predicted Mean Vote) is a numeric value on a scale from -3 (too-cold sensation index) to +3 (too-hot sensation index), where zero represents the thermal state of wellbeing.
WHO RISKS THE MOST? Elderly, newborns, children, pregnant women, those suffering from chronic illness (cardiovascular, diabetes, kidney failure, Parkinson's disease, etc.), mental illness, individuals (even young people) who do physical exercise or intense labor outdoors, and people in disadvantaged socio-economic and living situations.

CLASSES OF COMFORT/DISCOMFORT The human body exchanges heat with the outside environment, and its thermal state is determined by the relationship between the air temperature, the wind speed, the mean radiant temperature, and relative humidity. Two values related to the subject then contribute to this: the activity carried out and the thermal resistance of the clothing.

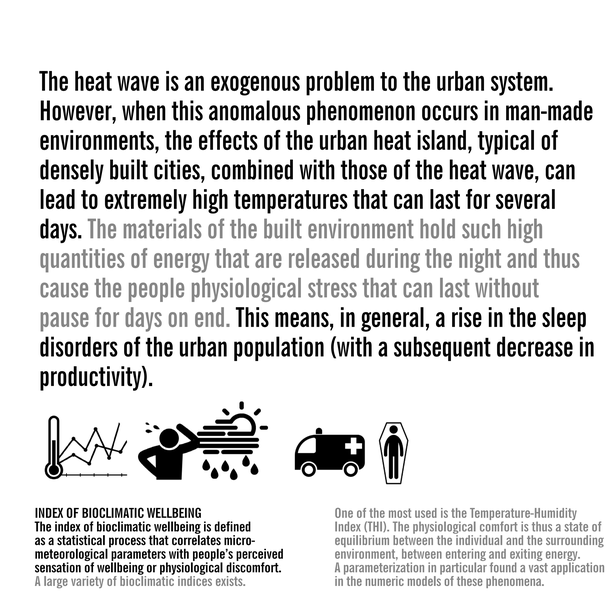


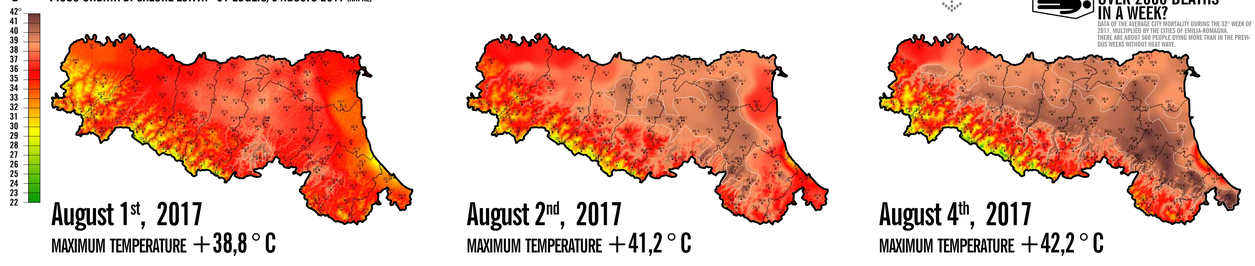
ANOMALOUS HEAT WAVE, BEGINNING OF AUGUST 2017
The heat wave in the 32nd week of 2017 was the worst of the year. The SISMG or the Italian System for Monitoring Mortality, which reports the average number of citizen deaths, registered 35 more deaths than were expected on August 6, 2017, for each city.



AUGUST 1, 2017. Emilia-Romagna was one of the hardest-hit regions, where temperatures between 35°C and 38.2°C were registered in the areas and cities of the Po River Valley.
AUGUST 2, 2017. Central Emilia registered maximum temperatures between 38°C and 41°C across all the cities and urban and peri-urban areas that connect Reggio Emilia, Modena, Bologna, Imola, and Faenza.
AUGUST 4, 2017. The areas with temperatures between +39°C and +42°C consist of a wide buffer between the cities and provinces of the via Emilia, between Parma and Cesena and onward to Ferrara and the hinterland area of Rimini, to the Ferrara plains towards the Po, and to the valley floors towards the Apennines.

OVER 2000 DEATHS IN A WEEK?
DATA OF THE AVERAGE CITY MORTALITY DURING THE 32° WEEK OF 2017, MULTIPLIED BY THE CITIES OF EMILIA-ROMAGNA. THERE ARE ABOUT 500 PEOPLE DYING MORE THAN IN THE PREVIOUS WEEKS WITHOUT HEAT WAVE.





HEAT WAVE

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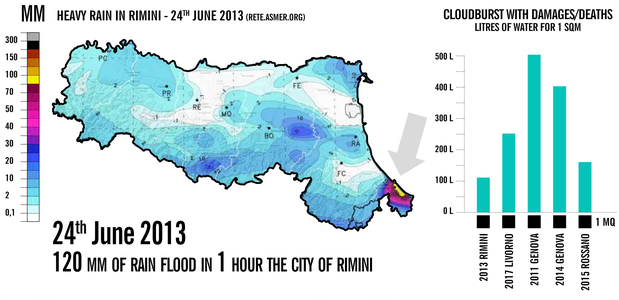
INTERACTIONS BETWEEN CITIES AND STORMS
HIGHLY IMPERVIOUS URBAN AREAS ARE VULNERABLE

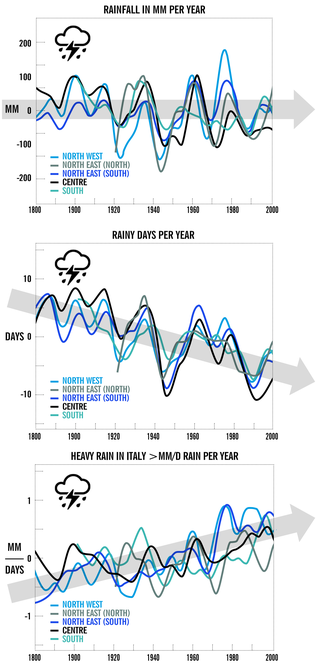
Many stress factors contribute to making THE URBAN ENVIRONMENT HIGHLY VULNERABLE TO HEAVY RAINS.
The water system within a city is complex, and the water cycle can be put under intense pressure from the climate conditions. The increase in intensity of precipitation on paved surfaces can in fact be greater than the capacity of the drainage system. The quality and quantity of the water in urban environments is in fact increasingly compromised by the increase in droughts and floods due to heavy rains.
These two events together require innovative solutions to improve the water management systems at different levels of intervention.

- First, on an inter-municipal and interregional level, by supporting the adoption of agreements on the management of resources and networks and financing climate adaptation plans.
- And second, on a local level, by developing, especially in existing urban contexts, smart design solutions that can create permeable surfaces, green and wooded areas, de-paving actions, and sustainable urban drainage techniques, such as retention basins, temporary floodable basins, floodable ditches, water squares, rain gardens, and green parking lots.

HEAVY RAIN AND CLIMATE CHANGE
Numerous scientific studies reveal a link between global warming and a rise in extreme rain.
The Intergovernmental Pal on Climate Change (IPCC), already in its Fourth Assessment Report from 2007, declared that it was 'very likely that events of extreme heat, heat waves, and heavy rain will continue to be more frequent.'Likewise, the Weather Extremes in a Changing Climate (WMO) report from 2011 claimed that 'even if it is impossible to say whether a single weather or climate event was caused by climate change, it must be expected that the width, frequency, and duration of extreme events will most likely change, while Earth's atmosphere will be warmed by higher concentrations of greenhouse gases.' Again the IPCC, in the 2007 Fourth Assessment Report indicated that an increase in the destructive potential of hurricanes has been found since 1970.

The report writes that '**an increase in extreme events emerges, which can be explained fully by climate change**' (www.climalteranti.it).





HEAVY RAIN IN ITALY
An increase in the intensity of precipitation has also been found in Italy. As is evidenced in the following graphs (published in 2006 on *Trends of the daily intensity of precipitation in Italy and teleconnections* edited by M. Brunetti, M. Maugeri, and T. Nanni), **the entire Italian territory has shown a strong decrease in the number of days with little rain, while the frequency of those with heavy rain has increased, especially in certain areas of northern Italy**.
This data presents various results:

- **the total amount of rainfall is almost unchanged;**
- **the number of rainy days is decreasing while the dry days are increasing;**
- **the intensity and duration of rainy patterns is increasing.**

Information gathered from local news sources published just before some notable and recent rainy events that were particularly intense reveals how cities and urban Italian areas, from north to south, have been afflicted by enhanced precipitation, with huge damage to **residential properties, commercial and industrial activities, and public spaces, but also, in some case, with significant human loss**. The damage caused by frequent episodes of flooding from the heavy rain or flooded rivers is attributable to previous damage to the transportation and other infrastructure systems and economic activities, **but ever more frequently, also includes human loss.**

PLUVIOMETRY
The quantity of fallen rain is measured in millimeters and indicates the volume of fallen water on a certain surface. The measure in millimeters corresponds to the rain gauge's height.
A millimeter of accumulation is equal to a liter of fallen water on one square meter of surface.
For example, to say that 20 mm of rain has fallen in a certain place means that 20 liters of rain have fallen on every one square meter of that place. Therefore, 120, 160, 250, 395, and 500 mm of water means that 120, 160, 250, 395, and 500 liters of water have fallen on each square meter of that city. These are the water quantities recorded in several Italian cities afflicted by intense downpours, especially in the summer and beginning of autumn.

HEAVY RAIN

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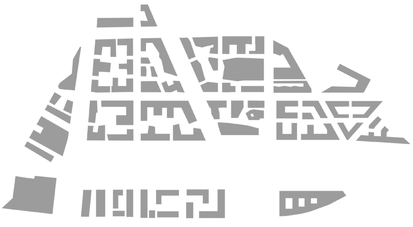
CITIES AND URBAN SHAPE

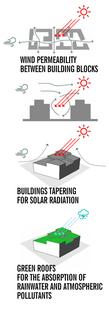
THE RELATIONSHIP BETWEEN CLIMATE AND URBAN AREAS AND THE ROLE OF GREEN AND BLUE INFRASTRUCTURE

The city responds better to phenomena of climate change and atmospheric pollution if it has eco-environmental infrastructure, systems of sustainable transportation, networks for public transportation, and bike and pedestrian mobility. It is possible to plan settlements in a way that manages the phenomena of climate change *in situ* when regenerating neighborhoods and abandoned areas or building new expansion.
The more the **open spaces of the city** are physically integrated into the project of the urban fabric, the more they can carry out social and recreational functions and contribute to mitigation and adaptation to the climate.
The compact **urban fabric** must not obstruct the wind that's necessary for mitigating summer temperatures in the city. If conceived with irradiation and wind direction in mind, making sure to favor wind that provides necessary cooling in the summer - and obstructs wind in the winter - the building fabric will allow the heat to more easily disperse in the hot seasons while containing energy consumption for cooling.
Green and blue infrastructure must be integrated into the urban fabric that grows and regenerates itself, making sure to guarantee as much as possible the proximity of shade and evapotranspiration created by large quantities of plants, obtaining thus a decrease in summer temperatures, a higher absorption of pollutants, and a reduction of the flow of urban water, thanks to the 'sponge' effect of permeable land.

ECO-DISTRICTS IMAGINED FOR THE CLIMATE / THE CASE STUDY OF EX RENAULT FACTORY IN BOULOGNE BILLANCOURT
The eco-district of Boulogne-Billancourt is an example of a neglected urban area regenerated with climate issues in mind. Its elements create guiding principles for urban areas that can tackle climate adaptation and mitigation of climate change.

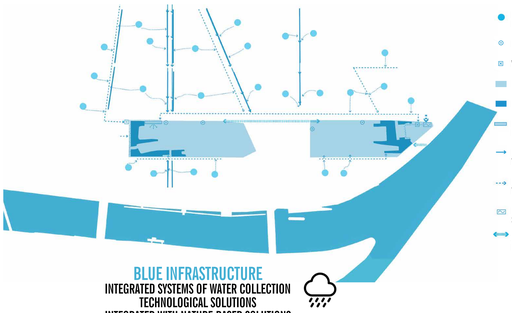
The neighborhood was imagined starting from green and blue infrastructure. A big urban park in the center of the neighborhood is the recreational space for community coexistence and also serves as a drainage basin when it rains and a cool space for the whole neighborhood during heat waves. All the streets have rows of trees with continuous and contiguous foliage, at the base of which are rain gardens that collect the water runoff from the blocks and carry it to the park where it combines with the water of the basin and the groundwater. The imprint on the ground of the blocks and buildings, although compact, is permeable and alternates with open spaces that have mineral and green surfaces. These surfaces are used by the people, thanks to various public and semi-public courtyards and spaces, and are permeable for the rain. The buildings have layouts in which the continuous facades are divided up and the section is tapered to guarantee permeability for currents and breezes, which favors wind circulation and cooling of the urban environment. Plant coverings are present at the top of the buildings, which helps to obstruct pollutants and release rainwater slowly.
The urban fabric gets thinner in the central area.





URBAN FABRIC
DESIGNED FOR PLOTS PERMEABLE TO SOLAR RADIATION AND TO THE WINDS, AND WITH AMPLE PUBLIC SPACES

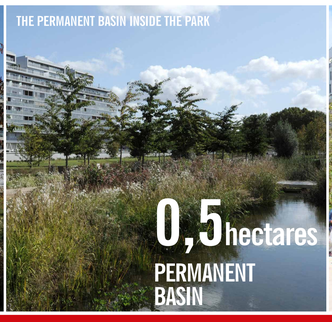
GREEN INFRASTRUCTURE
CONNECTION TO PUBLIC AND PRIVATE GREEN SPACE
PLENTY OF PLANTS AND ROWS OF TREES
WITH CONTINUOUS AND CONTIGUOUS FOLIAGE
AND PERMEABLE GROUND VEGETATION



BLUE INFRASTRUCTURE
INTEGRATED SYSTEMS OF WATER COLLECTION
TECHNOLOGICAL SOLUTIONS
INTEGRATED WITH NATURE-BASED SOLUTIONS

65 hectares
OF TRANSFORMATION

(original redrafting from Parc Du Trapeze Eco-district
Plan and projects by Chavannes, Laverne, Agence Ter, Setec TPI and Biotope)



URBAN MORPHOLOGY AND CLIMATE CHANGE

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INFLUENCE AND EFFECTS ON MICROCLIMATE
THE MATERIALS OF THE CITY AFFECT THE URBAN COMFORT IN PUBLIC SPACES

THE MINERAL AND GREEN MATERIALS OF THE URBAN ENVIRONMENT have different behaviors according to the absorption and reflection of incident solar radiation, making the amount of available radiation more or less high (absorbed or utilized). The choice of more appropriate mineral materials and the use of trees and vegetation can therefore significantly improve the urban microclimate.

THERMAL INERTIA is a material's ability, whether it's mineral or green, smooth or rough, to adjust over time the release of the radiant energy that was absorbed as heat flow, a cyclical process that follows the daily trend and that influences the conditions of wellbeing in the urban environment that are perceived by the people, especially for the weaker groups of the population.

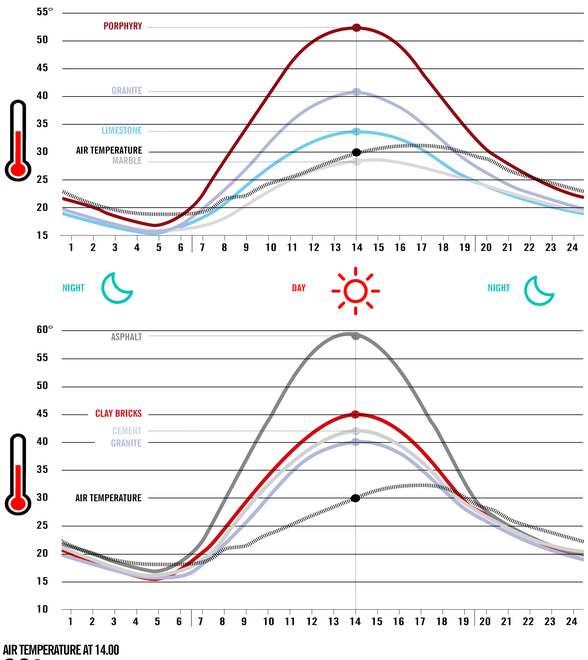
ALBEDO is the amount of reflected energy in relation to incident radiation. The higher the albedo is, the lower the amount of energy a body stores, and thus, the lower its surface temperature.

EMISSIVITY is the ability to emit energy as radiation (with regards to a black body). The higher the emissivity is, the greater the quantity of energy that the body can release as heat, avoiding an increase in surface temperature.

CONTAINING AND HINDERING HEAT ISLANDS
MINERAL AND GREEN MATERIALS
The fluctuation in material temperature due to their specific color and texture, present patterns determined largely by the albedo.
It is evident that **the higher the albedo is, the lower the surface temperature of the material is**. For example, clear and smooth mineral and green materials absorb little solar radiation and their surface temperatures remain lower or little higher than that of the air, even during the hours in which there is a high incidence of solar radiation or air temperature.

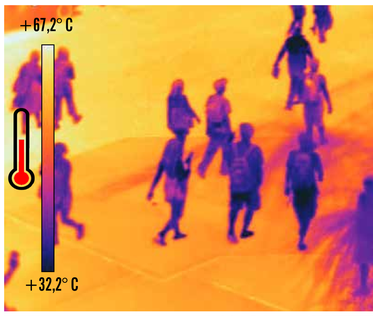
The materials that have temperatures similar to the air temperature behave as if they were in the shade. The choice, variety, and variation of materials thus affect the surface temperatures of the urban space and the increase or reduction of the heat island and the wellbeing of people.

It is essential to favor the following: using materials with a higher albedo, especially in pathways and spaces for pedestrians; placing mineral materials next to green ones and trees, which provide shade, and next to water, which exchanges energy by lowering surface temperatures (V. Dessì).



The surface temperature value of pavements of different stone materials and external air temperature. Being equal to the external air temperature (+30°C at 14:00), porphyry has a much higher surface temperature than marble (+25°C), limestone (+20°C), and granite (+12-15°C).

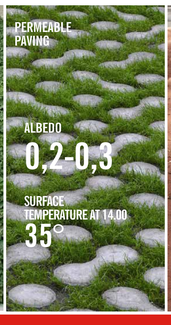
Being equal to the external air temperature (+30°C at 14:00), the surface temperature values of pavements of an urban space in which the presence of buildings is irrelevant (the center of a very big square or a space without surrounding buildings) vary as the materials and their relative albedo vary.
Asphalt has a rather high surface temperature compared to other materials (up to +30°C).

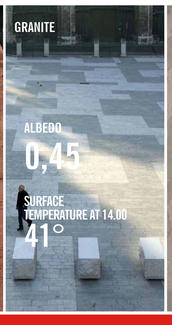


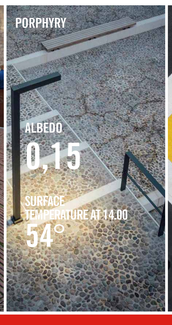
The corner of a square and street in Phoenix, Arizona. The urban space is made with a variety of conventional materials that reach high temperatures in the summer - up to 67°C - as is seen in the thermography above (© EPA, 2005 www.epa.gov).
For the people, walking or resting at length in places where the materials have such high temperatures is not only uncomfortable, but is also dangerous, especially for the weaker groups of the population (the elderly, sick, and children).

The relationship between air temperature (+30°C) and the surface temperature of some materials. Green materials behave better than the mineral ones thanks to evapotranspiration. Marble, granite, creek pebbles, cement, and clay bricks behave better than asphalt or porphyry.

AIR TEMPERATURE AT 14.00
30°







MATERIALS OF THE CITY AND CLIMATE

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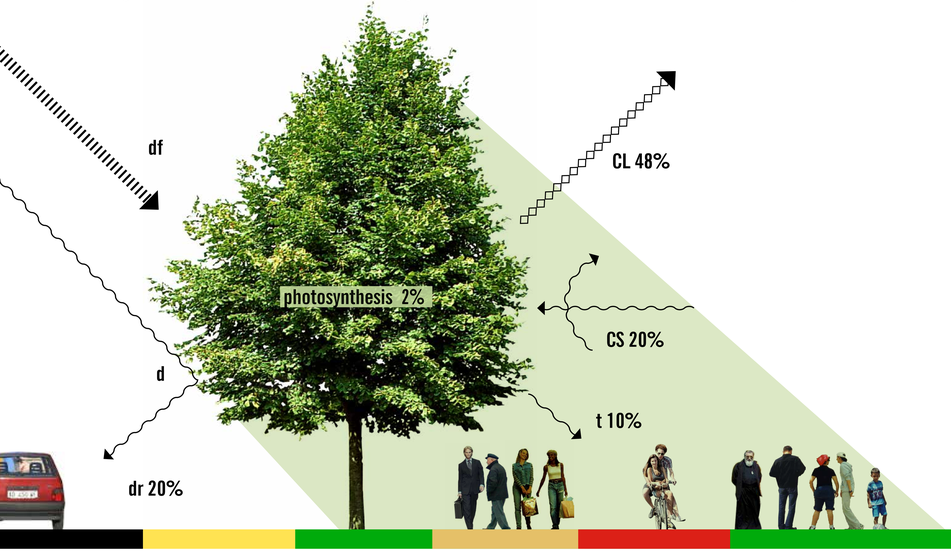
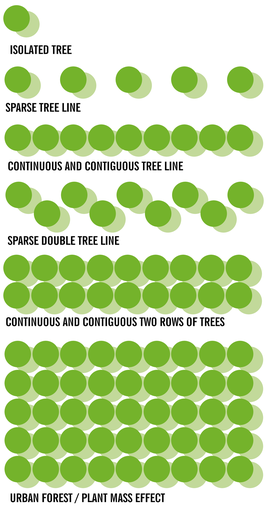
TREES
SHADING AND EVAPOTRANSPIRATION FOR URBAN COMFORT

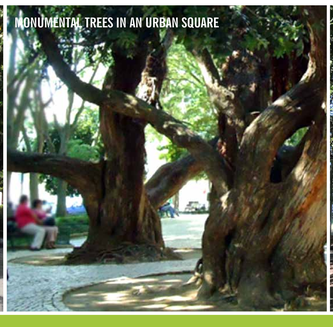
Trees create 'bubbles of shade' in which the level of thermal comfort is greater. This bubble can be rather wide and intense depending on the height and shape of the type of plant and the shape and density of the leaves. The foliage additionally intercepts the solar radiation, causing the shaded built surfaces to have a lower radiant temperature than that of surfaces exposed to direct radiation. **The effectiveness of a mass of vegetation's cooling ability is generated by the sum of the effect of evapotranspiration and shading and is proportional to the continuity of the former and contiguity of the latter.** The same number of trees has a greater thermo-regulating effectiveness the smaller the distance between them, compatible with the required space for growth and depending on the species and variety. Therefore, **depending on the urban morphology, the trees can be present singularly, in rows (single, double, groups or mixed) or as masses of vegetation.**

LOWERING THE TEMPERATURES / EVAPOTRANSPIRATION OF TREES AND PLANTING IN URBAN SPACE
Plants use a minimal part of solar radiation (RS) for photosynthesis (2%), but reflect about 20% back (dr) and transmit 10% (t) to the ground, re-emitting 20% as 'sensible heat' (CS) and 48% as 'latent heat' (CL) through a natural mechanism that lowers air temperature: evapotranspiration (the emission of water vapor).
One plant provides the necessary oxygen for the life of 10 people. The benefits that draw an individual that walks protected by the trees are numerous: direct shade, lower air temperatures, and the fact that people 'exchange' heat with an element that has a lower temperature (the foliage of the tree or the shaded walls of buildings).
Along the pathways, rows are generally used, while in squares, gardens, and parking lots, both rows (even double) and masses of vegetation are used, which create a forest effect.
The overall use and planting of trees in its different forms provides continuity to the green infrastructure of the city. When arranging the trees, we must keep in mind that the size of the tree's crown radius which will be half of the planting pattern in order to prevent that the growth of a tree's foliage interferes with that of another.





(original redrafting from G. Scudo, De la Torre, M. José)



URBAN GREEN INFRASTRUCTURE

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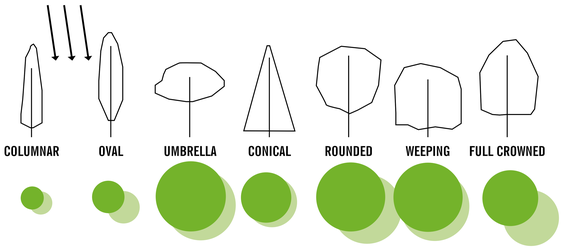
TREES

TREE SIZE AND CROWN FORM FOR LIVABILITY OF PUBLIC SPACES AND WELLBEING OF THE PEOPLE

The crown form and size are important characteristics in choosing the best tree for an urban context. These two elements define the size and shape of the shadow, or the main requirements that a space must have to allow activities to take place in adequate environmental conditions.
Once established, it is possible to choose the plants according to the location, climate, color variation, hardiness, and urban context.
Choosing plant species in terms of their shape can determine the thermal effects of the green space. However, the determining element in the choice of tree species remains the potential for survival and growth, depending on the space available for the roots and foliage.

LOWERING TEMPERATURES / SIZE AND CROWN FORM OF TREES
The choice of tree species derives from the **union between the shape of the urban space and the morphological characteristics of the plants**, which includes size, crown form, foliage color and their seasonal variation, and the presence of flowers and fruits. In heavily trafficked areas, the trees and shrubs must guarantee shade for the pedestrian spaces, such as sidewalks and squares, and for the buildings, at least in the hottest part of the day and for façades that are more exposed to solar radiation.
Along the streets, beyond providing shade, trees and plants also help to mitigate pollutants.

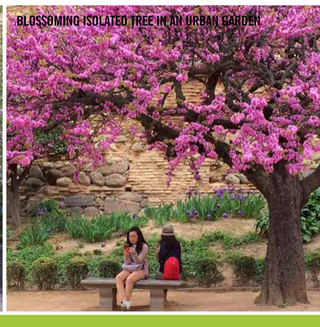


(REBUS' original drawings)


TWO ROWS OF TREES AT THE ENTRANCE OF AN URBAN PARK


LARGE ISOLATED TREE IN AN URBAN SQUARE


GROUP OF BLOSSOMING TREES IN AN URBAN SQUARE


BLOSSOMING ISOLATED TREE IN AN URBAN GARDEN

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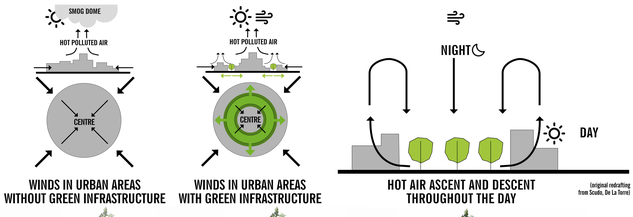
TREES
ENHANCING WIND AND BREEZES TO COOL THE URBAN ENVIRONMENT

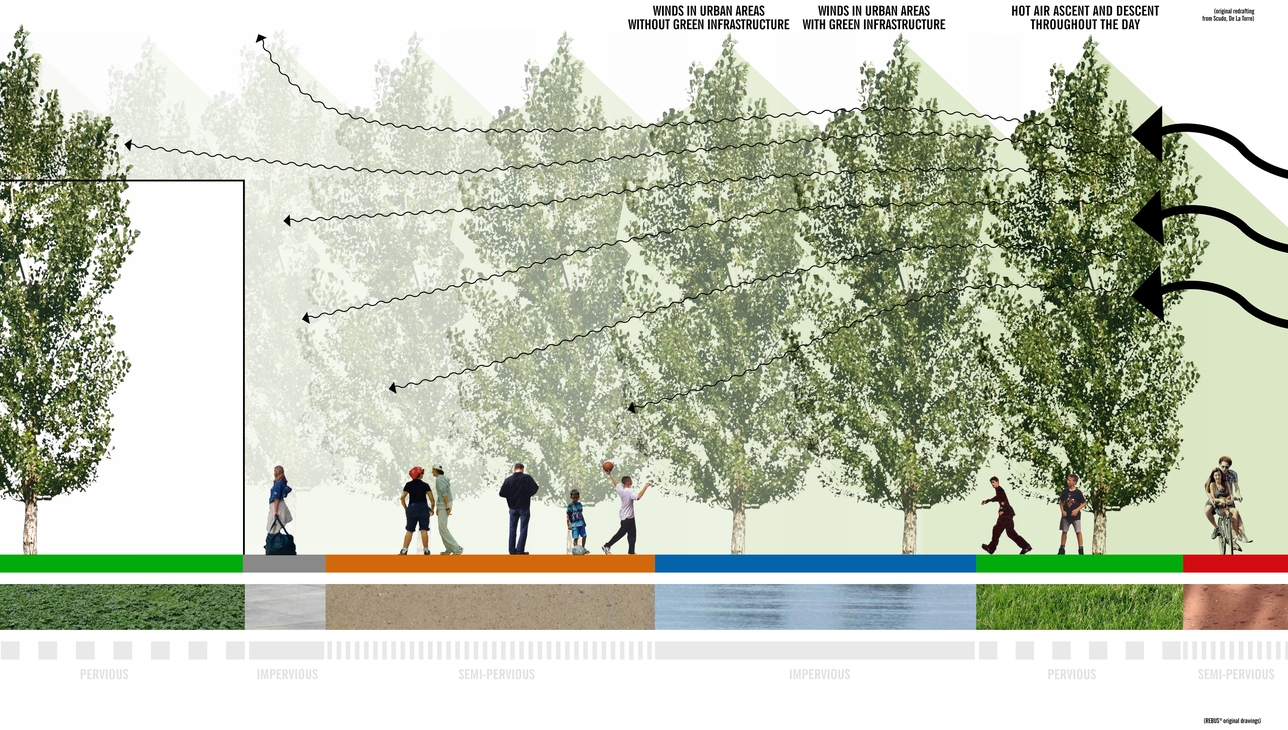
Green infrastructure, especially concentric and widespread ones, lower the air temperature by activating an urban breeze that moves from the foliage to the built environment. The general effect that derives from the energy exchange is the moderation of the microclimate thanks to the formation of thermal winds generated by the massive and continuous presence of trees. The trees affect the microclimate in various ways:

- channeling, redirecting, and enhancing currents and breezes to mitigate the summer heat (rows);
- increasing the currents and breezes along rivers and channels in urban environments (rows, grouped) and in open spaces where water surfaces are present (grouped);
- blocking wind (isolated trees, rows, and masses of vegetation) in the winter;
- filtering currents and absorbing atmospheric pollutants keeping them away from the urban environment.

INFLUENCING THE THERMAL STATE/ THE WIND AND TREES
In built urban structures, in windless weather conditions, **the heat island establishes an external-internal breeze that amasses pollution, which doesn't allow heat to be dispersed and fosters the concentration of pollutants.**

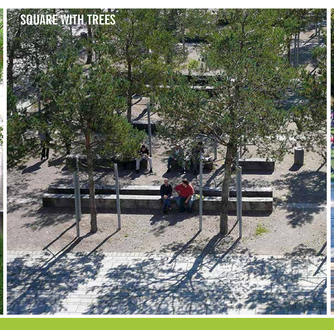
Green urban structures, especially concentric and widespread ones, lower the air temperature, activating the urban breeze that moves from the green areas to the built environment. The general effect that derives from the energy exchange is the **moderation of the microclimate** thanks to the formation of thermal wind generated by the massive presence of trees.

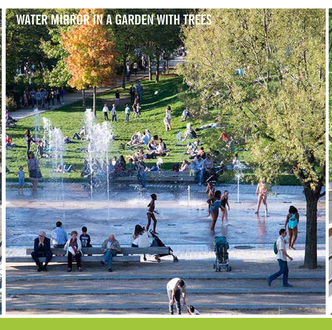


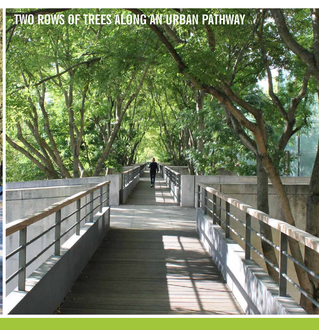


(REBUS' original drawings)


URBAN FOREST INSIDE A RESIDENTIAL COURTYARD


SQUARE WITH TREES


WATER MIRROR IN A GARDEN WITH TREES


TWO ROWS OF TREES ALONG AN URBAN PATHWAY

URBAN GREEN INFRASTRUCTURE

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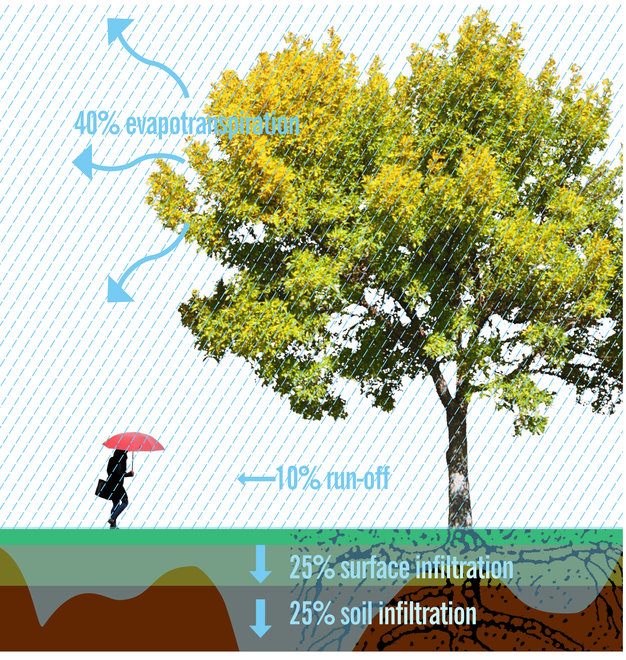
TREES
REDUCING RAINWATER RUN-OFF IN URBAN ENVIRONMENTS

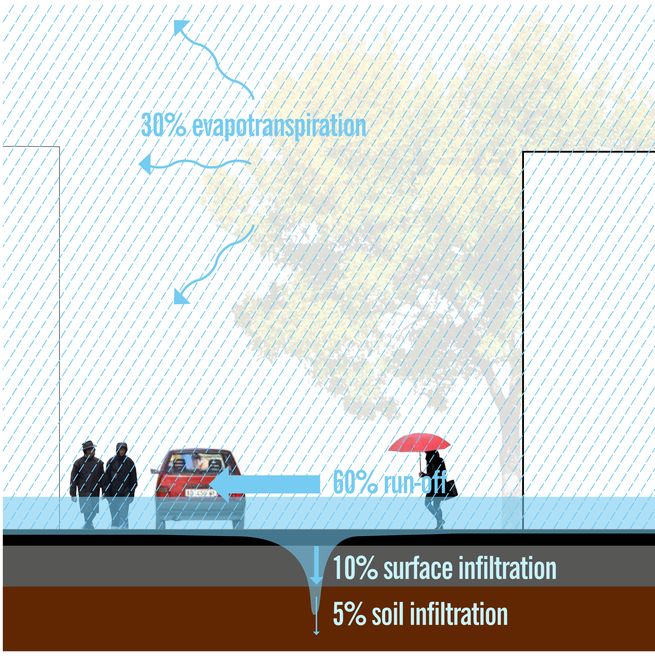
Many urban areas experience critical water system conditions. Often, the state of the system for collecting rainwater is not adequate for managing surface drainage following rainy events that are not even that intense. The percentage of sealed surfaces in cities is extremely high. There is an insufficient availability of green, permeable, and vegetated areas in densely built cities; the public spaces such as squares, parking lots, and sidewalks are almost always sealed, as are many nearby areas and private buildings.

The management of run-off in urban environments when there is intense and long-lasting rain can reveal itself to be problematic. Given the speed of delivery, the collection system goes quickly into crisis, causing flooding with huge environmental, social, and economic losses. **The 'sponge' function is missing, something that soil and vegetation could provide and which would reduce run-off and slowly return water to the collecting system, allowing it to enter into both deep and surface groundwater, and enabling evaporation and evapotranspiration through the trees.**

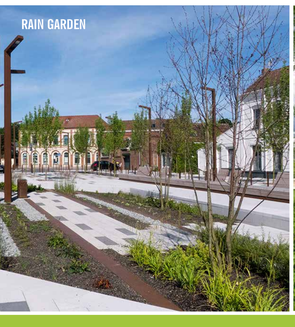
URBAN RUN-OFF / SUSTAINABLE MANAGEMENT OF URBAN RAINWATER
Urban run-off (surface flow) **is the portion of rainwater** (up to 90%) **that flows along the impermeable surfaces of the city** (roofs, streets, parking lots, etc.) **and more quickly reaches the drainage network without being filtered and retained by the soil.**
As a result of climate change as well, the management of run-off in urban environments is a problem that has severe consequences for the economy, environment, and safety of the people. Starting in the 90s, people began to promote a set of practices related to **Sustainable Urban Drainage Systems (SUDS)** that propose solutions for managing rainwater in situ by rethinking public spaces and multifunctional green areas.

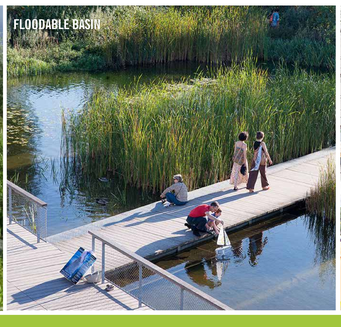
The solutions can be referred to two fundamental strategies:
- **slowing the flow of water;;**
- **temporarily storing water in systems, such as basins, pools, and flooding areas and then restoring it in a controlled way to the drainage network.**





(REBUS® figure)





SUSTAINABLE URBAN DRAINAGE SYSTEMS

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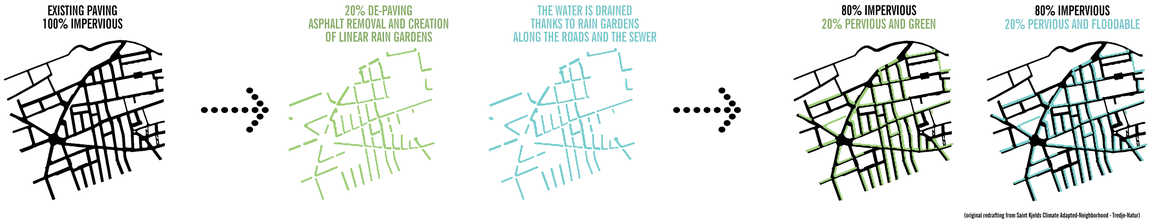
URBAN RESILIENCE
RESTORING SOILS PERMEABILITY IN URBAN ENVIRONMENTS

The high percentage of paved surfaces of the built city has a considerable impact on the urban microclimate, indoor and outdoor comfort, and the water safety of urban areas. The necessity of promoting, where possible, de-sealing and de-paving actions derives from the consideration that the permeable land that remains in urban environments is residual and that paving isn't always done out of necessity.
Public urban space and urban regeneration of neglected areas can offer numerous opportunities to integrate nature-based solutions and systems of sustainable urban drainage. In some cases, the solutions simply entail remodeling the natural components (morphology, soil, vegetation), taking de-sealing and de-paving actions; and in others, we have more complex water solutions depending on the specific characteristics of the site, the intended function of the interested areas, and the social usage objectives that are placed there.

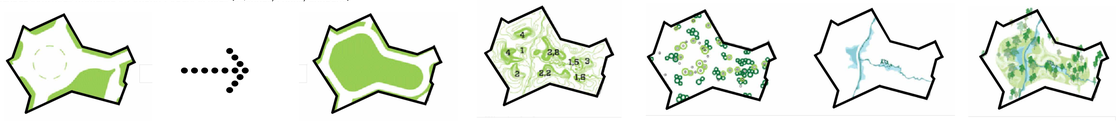
SUSTAINABLE MANAGEMENT OF URBAN RAINWATER / THE PRINCIPLE OF WATER INVARIANCE
In urban areas, there are wide asphalted spaces used only some days of the week and/or for a few hours of the day. If these spaces were reimagined and redesigned, replacing the asphalt with permeable and vegetated surfaces, they could help make the city more welcoming and livable. Urban land could thus collect and filter rainwater, help to reduce small particles and pollution, and hinder the creation of the heat island phenomenon.
The more suitable open spaces for promoting de-paving actions are parking lots, squares, and the foot paths along the streets of urban areas that were made with little attention to the quality and environmental characteristics of the public space (artisan and industrial areas and residential areas).
In these contexts, we could identify portions of asphalted areas that, if made permeable again, could become small gardens, usable by people, and/or drainage filters along the curb.

INCREASE OF PERVIOUS SURFACES ON PUBLIC ROADS (DISTRICT)



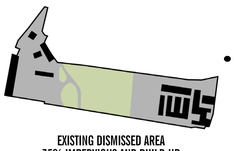
(original redrafting from Saint Kjelds Climate Adapted-Neighborhood - Tredje-Natur)

PERMEABLE SURFACES INCREASE ON URBAN PUBLIC SPACES (SQUARES, PARKS, GARDENS)



(original redrafting from Saint Kjelds Climate Adapted-Neighborhood - Tredje-Natur)

REGENERATION OF DISMISSED AREAS

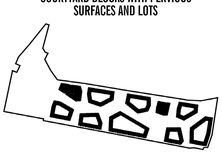


EXISTING DISMISSED AREA
75% IMPERVIOUS AND BUILD-UP
25% SEMI-PERVIOUS ABANDONED SURFACES
COLONIZED BY PIONEER VEGETATION

CREATION OF ECO-DISTRICTS

PROJECT SITE
60% PERMEABLE PUBLIC SPACES
40% BUILT-UP AREAS

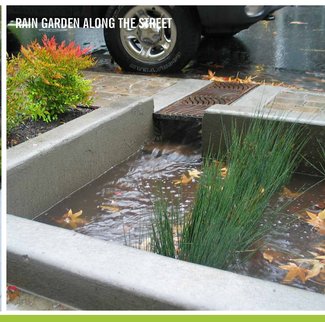
COURTYARD BLOCKS WITH PERVIOUS SURFACES AND LOTS



GREEN INFRASTRUCTURE INTEGRATED WITH THE CONTEXT
CONNECTING PUBLIC AND PRIVATE AREAS

BLU INFRASTRUCTURE INTEGRATED WITH THE CONTEXT
RAINWATERS CONNECTION AND DISPOSAL

(original redrafting from Bryggens Bastion Amager Eco-district - Tredje-Natur)



SUSTAINABLE URBAN DRAINAGE SYSTEMS

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NATURAL INFILTRATION OF RAIN AND STORAGE OF URBAN RAINWATER *SPONGE-CITIES* AND NATURE-BASED SOLUTIONS

Starting in the 90s, people began to promote a set of practices related to **Sustainable Urban Drainage Systems (SUDS) that proposes solutions for managing rainwater *in situ***, reducing water volume in drainage systems, and avoiding burdening the system, which would all make the water cycle more sustainable.

The solutions are attributable to the following strategies:

1. slowing run-off;
2. favoring soil infiltration;
3. providing temporary water detention systems;
4. restoring water to the network in a controlled way;
5. providing storage systems;
6. reusing stored water (for green area management).

Some solutions are applicable to public and private spaces: retention and infiltration basins; flooding ditches or *noue paysagère* (wide, shallow channels with weakly sloping sides); partially and temporarily flooding public urban spaces (rain gardens, green parking lots, water squares); private spaces with gardens or green roofs. The city offers many opportunities to implent such solutions.

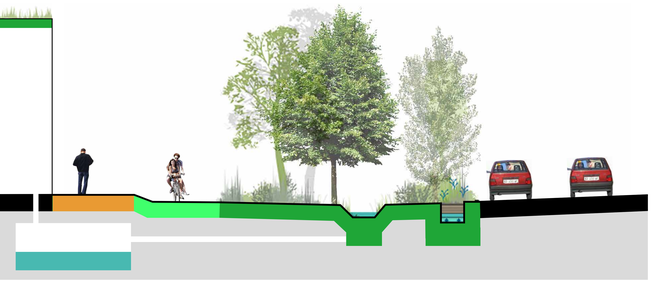
SUSTAINABLE MANAGEMENT OF URBAN RAINWATER / THE PRINCIPLE OF WATER INVARIANCE

Sustainable management of rainwater foresees the fulfillment *in situ* of the **principle of water invariance** through:

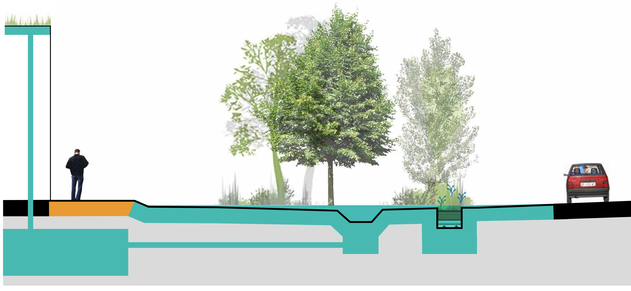
- the conservation or restoration of permeable areas through de-sealing actions;
- the containment of run-off to limit flooding risks;
- the restoration of the soil's natural function of filtering to reduce water pollution and help refill groundwater by infiltration.

All these objectives must be matched with the following aspects:

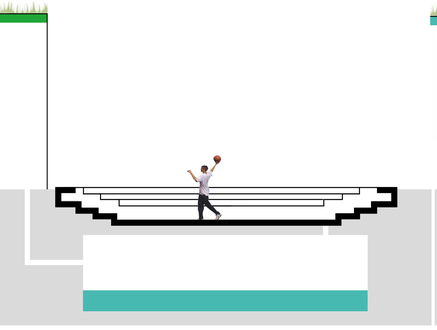
- the type of run-off surface;
- the presence of pollutants;
- the presence or lack thereof of water collection systems of the first rain for industrial areas and parking lots,
- soil characteristics and aquifer vulnerability, and in a special way for protected zones for groundwater restoration.



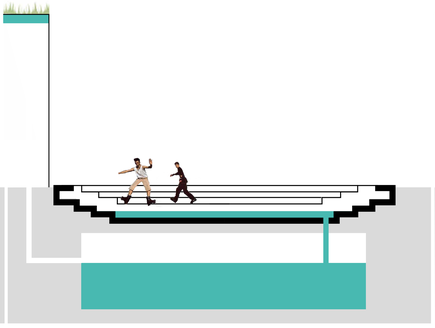
DETENTION BASIN WITH VARIABLE SECTION IN NORMAL CONDITIONS



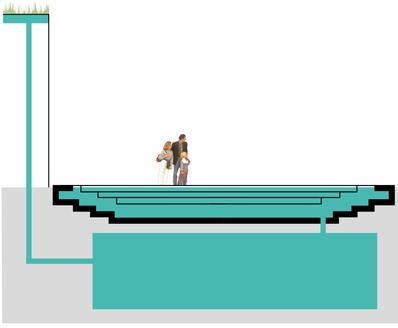
IMMEDIATELY AFTER A CLOUDBURST



WATER SQUARE WITH VARIABLE SECTION IN NORMAL CONDITIONS



IMMEDIATELY AFTER HEAVY RAIN

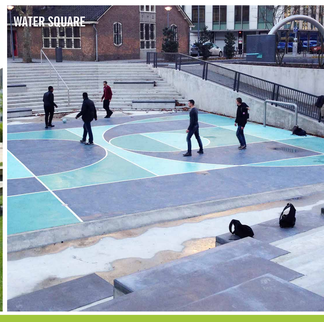


IMMEDIATELY AFTER A CLOUDBURST

FLAT GREEN ROOF

FLOODABLE PARK

DETENTION BASIN



WATER SQUARE

SUSTAINABLE URBAN DRAINAGE SYSTEMS

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THE CITY AS A MEETING PLACE
LIVABILITY AND ATTRACTIVENESS OF PUBLIC SPACES CAN BE DESIGNED

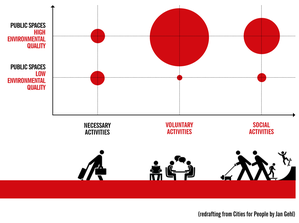
People feel good in a public place if they feel safe, have conditions of comfort and wellbeing, both physical and psychological, and if they have the possibility to share moments socially and experiences that stimulate and renew their feeling of belonging.

Feeling good in an urban space is a need that can be satisfied and designed in this way and that depends on the environmental quality perceived by the people, in terms of livability and vitality. At the same time, in urban spaces, climate adaptation and mitigation measures can be created.

To obtain this, the approach that's more correct for designing public spaces — roads, squares, parks, and gardens — must pay attention to the variables tied to social relations and safety, as well as environmental and climate variables.
Some of the most important elements that must be taken into consideration for **outdoor comfort** are the morphology of the space, the mineral and green materials, the presence of water, trees, coverings, and seating. **Overall, these elements have a fundamental role in providing shade, reducing surface temperatures, and attracting users.**

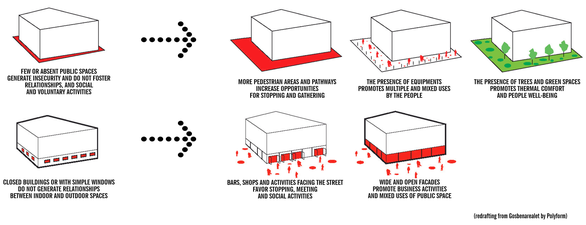
PUBLIC SPACES FOR PEOPLE / MULTIFUNCTIONAL, LIVABLE, VITAL, A PLACE THAT CREATES BELONGING
An urban space can be characterized by seasonal, daily, and weekly rhythms for the flow of different people and things, making it multifunctional. It is therefore a versatile and flexible space that is modified and modifies the elements within it, according to the environmental, usage and safety needs.
The multifunctional space additionally welcomes a mix of users who make it vital at every time of the day and throughout the year and help to initiate other flows and the presence of other people and activities.
LIVABILITY is a characteristic that has to do with the perception and awareness that an individual has of the elements of the space. It is therefore a reality mediated by the mind (Bosselmann, 2008) subject to subjective interpretation of some aspects, but also tied to objective urban quality of the space, such as street and square accessibility, bike and pedestrian mobility, environmental comfort of open spaces, and increasingly the presence of natural elements, such as greenery, water, shade elements, and primary or secondary seating.
VITALITY is what makes a city alive, vivacious (Jacobs, 1969), and densely inhabited, with the presence of different types of inhabitants, pedestrian spaces, stores, and services. It is measured by looking at factors, such as building density, the number of commercial activities, and the presence of individuals that carry out volunteer and social activities, in addition to those that are necessary.
A **FEELING OF BELONGING** is the perception of the space that the inhabitants have for that place.
It is about the attachment and identification of the place, which go beyond its specific physical configuration. It is a bond that holds an emotional investment (Hiss, 1990).

THE ENVIRONMENTAL QUALITY INFLUENCES THE USE OF PUBLIC SPACES



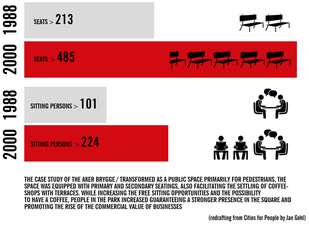
(redrafting from Cities for People by Jan Gehl)

THE GREATER THE QUANTITY AND THE ENVIRONMENTAL QUALITY OF THE PUBLIC SPACE IS THE MORE ARE THE SOCIAL AND VOLUNTARY ACTIVITIES OF THE PEOPLE



(redrafting from Gesbenaroalet by Polyform)

WHEN THE SITTING OPPORTUNITIES ARE DOUBLING PEOPLE GATHERING IN THE AREA ARE INCREASING

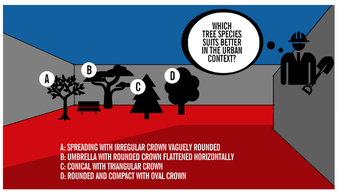


THE CASE STUDY OF THE AKER BRYGGE / TRANSFORMED AS A PUBLIC SPACE PRIMARILY FOR PEDESTRIANS, THE SPACE WAS EQUIPPED WITH PRIMARY AND SECONDARY SEATINGS, ALSO FACILITATING THE SETTLING OF COFFEE-SHOPS WITH TERRACES. WHILE INCREASING THE FREE SITTING OPPORTUNITIES AND THE POSSIBILITY TO HAVE A COFFEE, PEOPLE IN THE PARK INCREASED GUARANTEEING A STRONGER PRESENCE IN THE SQUARE AND PROMOTING THE RISE OF THE COMMERCIAL VALUE OF BUSINESSES

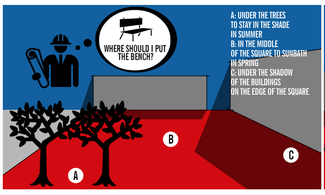
(redrafting from Cities for People by Jan Gehl)

Which elements foster the wellbeing of the people?
4 REBUS® ON PUBLIC SPACE AND JUST AS MANY POSSIBLE SOLUTIONS (OPEN)

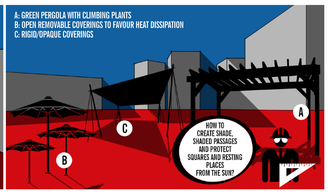
(REBUS® original drawings)



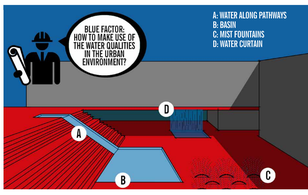
WHICH SPECIES ARE BEST FOR AN URBAN CONTEXT?
The trees must be chosen based on their role, the space that they occupy and their crown form, which is different for each tree species.
The tree size and crown form requirements are fundamental in designing urban space and, once established, it is possible to choose the plants based on location, climate, color variation, indigenousness, and context.



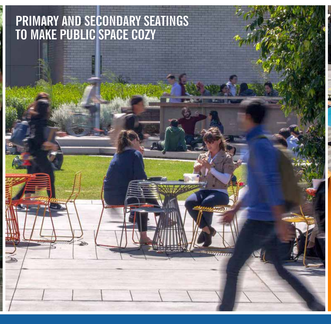
WHERE SHOULD I PUT THE BENCH?
WHY IS 'SITABILITY' IMPORTANT IN PUBLIC SPACE?
The 'sitability' of a place measures the number of opportunities to sit that are present in urban space, which are divided into primary seating (benches and chairs) and secondary seating (walls and stairs). The seating must offer people the opportunity to choose different conditions (sun or shade) according to the season.

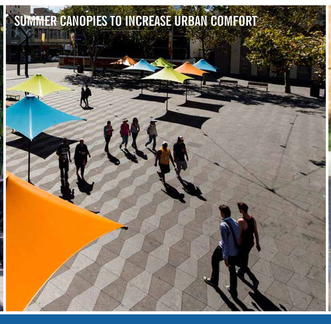


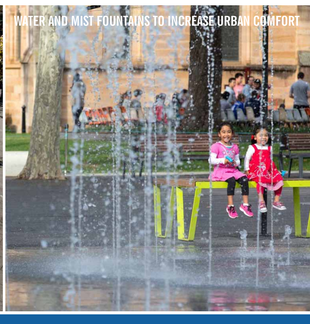
HOW CAN I CREATE SHADED AREAS? HOW CAN I PROTECT SQUARES AND REST AREAS FROM THE SUN?
Pergolas, marquees, urban shade structures and canopies can protect the public space from solar radiation by modifying the energy flow based on the type of covering. Removable shade structures adapt better than fixed ones to the climate and seasonal needs of the space.



HOW CAN I TAKE ADVANTAGE OF WATER QUALITIES IN PUBLIC SPACES?
The presence of water in an urban space has a double contribution for thermal comfort: psychological effect and the perception of relief from the heat and improving the microclimate. From far away, the water seems to offer the feeling of relief, making the space attractive. Close up, water improves the microclimate. When it comes into contact with the air, it exchanges energy and takes away heat from the environment where people hang out.







LIVABILITY OF PUBLIC SPACE

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THE DESIGN QUALITY OF PUBLIC SPACES AND GREEN URBAN INFRASTRUCTURE
EVALUATING ENVIRONMENTAL AND ECONOMIC BENEFITS

In the experience of REBUS® we have been able to verify that the most effective (and inexpensive) measures in fighting the effects of climate change in cities are the Nature-Based Solutions - green and blue infrastructure - which are unique for being **win-win measures.**

Such measures are in fact able to contemporarily mitigate and adapt to climate change, generating urban quality, comfort, livability, and economic benefits for the existing city. The eco-environmental aspects for supplying the urban environment with these features (environmental, energy, climate and microclimate, social, and economic) must be conceived and adequately designed with transdisciplinary knowledge.

These ecosystem services can also be measured through software – many of which are open-source – which allows us to 'check' the effectiveness of a project by evaluating the effects in terms of the microclimate and environmental and economic benefits.

WHY WE USE ENVIMET®
ENVIMET® s an environmental and microclimate simulation model that works on the urban scale. Through thermofluidodynamic equations, the software allows us to reproduce the behavior of a three-dimensional climactic model.
The model allows us to evaluate the condition and performance of the microclimate from the perspective of the people, taking into consideration both the urban morphology of an area and the materials (mineral and green) used, both in the current state of things and in relation to the project itself.
This allows us to test the effectiveness of the proposed solutions and improve their performance.

WHY WE USE ITREE®
ITREE® is software from the USDA Forest Service that calculates the ecosystem services of the trees supplied in a city. The software of the iTree suite is open-source and various European cities use them, thanks to volunteer citizens and schools, to make the benefits of trees known and to promote responsible behaviors.

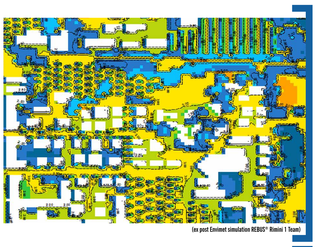
WHY WE USE BENEFITS®
BENEFITS® is a calculation sheet invented during the REBUS® workshops and started from QUALIVIVA tree data sheets of the Ministry for Agriculture, Food and Forests. BENEFITS® estimates the quantity of polluting substances extracted by the tree from the environment in the phases of planting and maturity of the species.

ENVIMET® DATA INPUT COMFORT OF URBAN AREA

- LOCAL CLIMATE
- NEAREST WEATHER STATION
- DAY AND TIME OF SIMULATION
- ALBEDO OF MINERAL AND GREEN MATERIALS
- EX ANTE 3D MODEL OF THE STUDY AREA
- TRANSFORMATION PROJECT OF THE AREA
- EX POST 3D MODEL OF THE STUDY AREA

These data provide the main parameters to simulate the climatic conditions and the outdoor comfort of a study area before and after the project.

(REBUS® project Rimini 1 Team)



(ex post Envimet simulation REBUS® Rimini 1 Team)

ENVIMET® DATA OUTPUT COMFORT OF URBAN AREA

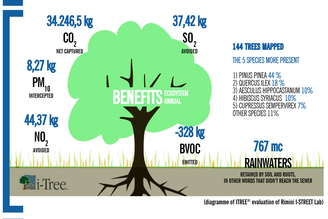
The software simulates outdoor comfort by comparing the state of the art of an area with the effects produced by a public spaces project by evaluating different parameters

- WIND SPEED
- INCREASE OR DECREASE OF THE AVERAGE SPEED AND PRESENCE OF TURBULENCES OR ' VENTURI EFFECT '
- SPECIFIC HUMIDITY
- DRIER OR MORE HUMID AREA
- AIR TEMPERATIRE
- BENEFITS IN RELATION TO HEAT ISLAND
- PMV INDEX
- OUTDOOR COMFORT IMPROVEMENT

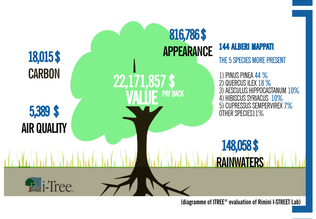
I-TREE® DATA INPUT PLANTING PATTERN

- SPECIES
- TRUNK CIRCUMFERENCE AND TREE HEIGHT
- CROWN PROJECTION AREA (SIZE OF THE CROWN PROJECTION ON THE GROUND)
- GEOGRAPHICAL COORDINATES OF EACH TREE INSIDE THE STUDY AREA
- HEALTH STATUS

These data provide the main parameters to define the ecosystem structure, the leaf area index (LAI) and all other variables necessary to characterize the ecosystem services.



(diagramme of ITREE® evaluation of Rimini I-STREET Lab)



(diagramme of ITREE® evaluation of Rimini I-STREET Lab)

I-TREE® DATA OUTPUT PLANTING PATTERN

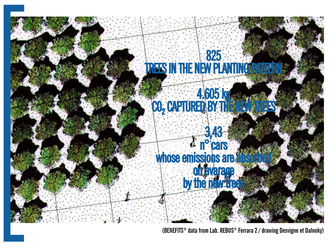
The role of vegetation in reducing local air pollution and avoided costs due to the economic value of ecosystem services

- ENVIRONMENTAL BENEFITS FROM THE DIFFERENT TYPES OF PLANTS (CONIFERS, BROADLEAF, EVERGREEN)
- O_3 REMOVAL INDEX
- $PM_{2.5}$ REMOVAL INDEX
- CO_2 REMOVAL INDEX
- NO_2 REMOVAL INDEX
- SO_2 REMOVAL INDEX
- ECONOMIC BENEFITS
- ESTIMATION OF THE ECONOMIC VALUE OF ECOSYSTEM SERVICES IN TERMS OF AVOIDED COSTS

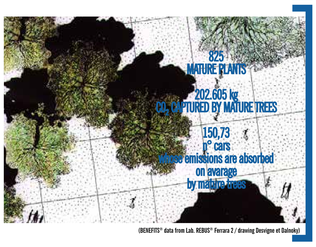
BENEFITS®DATA INPUT PLANTING PATTERN

- LATIN NAME
- COMMON NAME
- FAMILY
- GENUS
- NUMBER OF PLANTED TREES
- QUALIVIVA DATA OF TREE SPECIES

These data essentially provide the contribution of the pollutants reduction of an arboreal planting, both at the early and mature stage.



(BENEFITS® data from Lab. REBUS® Ferrara 2 / drawing Desvigne et Dalnoky)



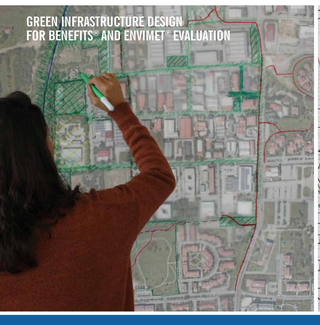
(BENEFITS® data from Lab. REBUS® Ferrara 2 / drawing Desvigne et Dalnoky)

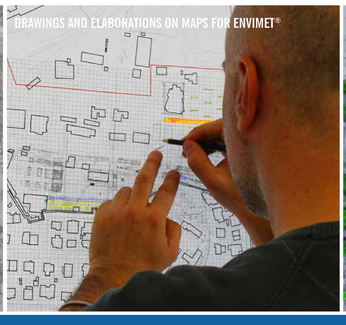
BENEFITS®DATA OUTPUT PLANTING PATTERN

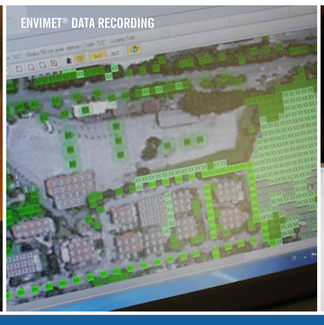
The role of vegetation in reducing local air pollution

- CO_2 STORED (KG)
- CO_2 ABSORBED (KG/Y)
- REDUCTION OF O_3 (KG/Y)
- REDUCTION OF NO_2 (KG/Y)
- REDUCTION OF SO_2 (KG/Y)
- REDUCTION OF PM_{10} (KG/Y)
- CO_2 REDUCTION REPRESENTED IN TERMS OF THE NUMBER OF CARS WHOSE CO_2 ANNUALLY EMITTED IS SUBTRACTED FROM THE ENVIRONMENT THANKS TO THE PLANTS

120 g CO_2/km are the emissions to be complied according to Kyoto protocol provisions







ECOSYSTEM SERVICES AND URBAN COMFORT EVALUATION

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MICRO-SCALE PROJECTS
VERIFICATION CHECKLIST

The REBUS® project checklist was conceived as a guiding instrument of self-evaluation, which the technicians working for public local administrations and the designers can use to verify the requirements for livability and comfort of a public space being designed.
This tool is meant to accompany an ongoing design of public space on an urban micro-scale, to rethink squares, multimodal roads, parks, gardens, and small open spaces, putting the responsible figures of the project in the position to evaluate adaptation measures and adapt it for the definitive and executive project.

WHY WE USE THE REBUS® CHECKLIST
The REBUS® checklist is made for the requirements and objectives, through ten guiding principles and 30 different questions.
The more that the public space under evaluation has been conceived taking into account the issues and questions posed by the checklist, the more it will respond to the criteria of livability, comfort, and resilience, although the application to different contexts must be evaluated case by case.
In particular, remember that the plants are the ones to carry out the most effective actions of mitigation and that the presence of trees, shade, and permeable surfaces is necessary to design public space for the wellbeing of the people.

1. THE PUBLIC SPACE IN RELATION TO THE URBAN CONTEXT

- Was an analysis of the urban context in which the space is situated carried out?
- Were the flows and function of the people at the edge and within the area analyzed?
- Does the project improve the environmental quality of the public space and its surroundings?
- Does the designed space have different functions that attract different types of people and volunteer and social activities, or those that aren't necessities?
- Does the space connect bike and pedestrian paths and areas and to public transportation?
- In the public space, or at its edges, is it possible to have comfortable thermal conditions?
- Does the public space function in a way that mitigates climate change?

2. COMPLEXITY AND MULTIFUNCTIONALITY OF PUBLIC SPACE

- Does it have a size that's capable of making people feel safe and/or in a pleasant context?
- Is it complex from the visual and perceptual point of view?
- Does it foster different uses? If yes, does it have differentiated spaces and adequate equipment?

3. BORDER OF THE SPACE, FUNCTIONS OF THE EDGES AND MATERIALS

- Are the pavements and used land distinguished based on use?
- Are the borders defined and noticeable?
- Are the edges of the space welcoming and do they tempt people to stop there?
- Have the materials been chosen with the impact on environmental comfort in mind?

4. ACCESSIBILITY

- Is the space accessible to everyone?
- Does it foster and help crossing?

5. SITABILITY' AND EQUIPMENT

- Does it encourage people to sit?
- Does it encourage socialization (and privacy) for seated people?
- Is there primary and secondary seating and street furniture/equipment for those who use the space?

6. TREES, VEGETATION AND NATURE-BASED SOLUTIONS

- Are there trees and vegetation in the project on public space?
- Are the trees and vegetation separated in the space?
- Were they chosen based on the function they serve?
- Do the trees and vegetation have space to grow and develop?
- Do they encourage people to rest there?
- Were they chosen to mitigate pollution and the urban heat island?
- Are permeable surfaces and soils for sustainable urban drainage systems included?

7. WATER

- Was the use of water as an element of public space taken into consideration?

8. SERVICES AND PERMANENT ACTIVITIES

- Does the space hold and face services and activities?

9. TEMPORARY USES

- Does the space encourage use, events and temporary exhibitions?

10. MAINTENANCE

- Does the project include materials, solutions, systems, and vegetation of low maintenance?
- Does the project include solutions and materials resistant to vandalism?
- Were the plan and the usual maintenance costs conceived as an integral part of the project?

PUBLIC SPACES AND ECO-DISTRICTS PROJECTS
STRATEGIES, CRITERIA, CALLS

The REBUS® criteria for the construction of calls for tender on urban regeneration are thought of as guiding tools to support local administrations, to guide the design of eco-districts and public urban spaces, keeping in mind the issues of climate change and measures for mitigation and adaptation. These criteria are devised especially for complex regeneration interventions at the urban scale, such as the renovation of abandoned areas and brownfield and retrofitting of public open spaces. In these contexts, the strategy for urban and environmental quality should be the reference for each intervention, which could be implemented for individual parts and in phases, with a strong public oversight of the transformations.

WHY WE USE REBUS® CRITERIA
The REBUS® criteria tackle the issues of urban regeneration and social innovation along with climate issues, posing the public space as a guiding element of the process of urban transformation.
'Climate-proof cities' are 'cities for people' in which the measures that are most effective for adaptation and mitigation - based on the reintroduction of nature in urban areas - are also those that make a city more healthy, beautiful, comfortable, livable, vital, and attractive and in which it is more convenient to invest in a public and private long-term vision.
Dealing with the climate means dealing with the regeneration of the city and the improvement of its resilience.

STRATEGY FOR THE URBAN AND ECO-ENVIRONMENTAL QUALITY FOR PLANNING ECO-DISTRICTS AND/OR WIDESPREAD INTERVENTIONS IN PUBLIC SPACES

The 'strategy for the urban and eco-environmental quality' establishes the basic necessities and performance requirements of the built environment and land equipments, with particular reference to the issues and objective of the mitigation and adaptation to climate change established on a national and European level and by receiving the directions of the sectorial planning.
The strategy is carried out through the creation of public space with high urban, environmental, and social quality and through eco-districts.
'Eco-districts' are urban environments that have been regenerated and redeveloped according to principles of sustainable development, from an urban, environmental, climate, social, and economic standpoint.
'Widespread intervention' means a series of actions and projects in public spaces that might involve the restoration and reuse of public and private real estate. Such interventions must be able to operate in an urban area or neighborhood, globally improving its livability and attraction according to the principles of sustainable development from an urban, environment, climate, social, and economic standpoint.

NTERDISCIPLINARITY OF PROFESSIONAL TEAMS AND EVALUATION CRITERIA

The project must have an interdisciplinary approach and involve professionals and experts from various sectors in elaborating a project with with high urban comfort and resilience to climate change.

1. QUALITY OF THE STRATEGIC PROPOSAL AND URBAN AND FUNCTIONAL LAYOUT

Evaluating the guiding idea of the project of urban regeneration.
Adequacy of the chosen strategy for intervening in problems of the area.
Quality of the urban project and urban master plan from the functional point of view, keeping in mind the historical, settlement, environmental, and socio-economic specifics.
Presence of a public-private strategy of urban regeneration.
Effectiveness of the implementation phases of the strategic proposal.

2. EFFECTIVENESS OF THE URBAN PROJECT FROM A CLIMATE POINT OF VIEW

Evaluation of ENVI-MET simulation results in terms of capability of lowering temperatures.
Thermoigrometric comfort of the neighborhood and at the urban micro-scale.
Ventilation.
The use of water and the restoration and soil permeability as elements of mitigation.

3. QUALITY OF GREEN URBAN INFRASTRUCTURE

Evaluating the guiding idea of the project of the green infrastructure and adequacy of the strategies chosen for intervening in problems of the area.
Landscape value of the project in relation to the space and its evolution over time and across seasons.
Choice of plants for absorbing pollutants and heat and capturing fine particles.

4. EFFECTIVENESS OF NBS AND SUDS

Evaluation of the guiding idea of the project of blue infrastructure and the adequacy of the strategies chosen for intervening in problems of the area.
Landscape value of blue infrastructure project.
Multifunctionality of the adopted solutions.
Reduction of urban run-off.
Effectiveness of the adopted measures on an urban and micro-scale.

5. QUALITY, LIVABILITY, AND URBAN COMFORT OF PUBLIC SPACES

Evaluation of the interventions in public spaces in relation to the urban context and issues of the specific neighborhood.
Livability and attraction of the planned public spaces.
Adequacy and effectiveness of mineral and green materials chosen to improve the microclimate and the wellbeing of the people.
Accessibility, walkability, and usability of the neighborhood and presence of sustainable mobility systems.

6. INVOLVEMENT OF THE LOCAL COMMUNITY IN THE DEVELOPMENT OF THE PROJECT

Quality of the participation process in the different design phases; development and implementation of the urban project.
Actions of active involvement of local community regarding bottom-up actions on issues of climate change and the care for public spaces.
Actions of information and expected monitoring activities.

7. CONSISTENCY AND INTEGRATION BETWEEN THE DIFFERENT QUALITY CRITERIA

Evaluation of the consistency and integration between interventions included and pursuing the general objectives stated previously.

QUALITY AND LIVABILITY OF PUBLIC SPACE

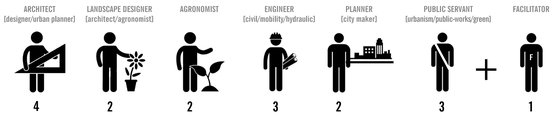
REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

THE REBUS® OF PUBLIC SPACES
A TRAINING PROGRAM FOR PLANNING CITIES IN THE AGE OF CLIMATE CHANGE

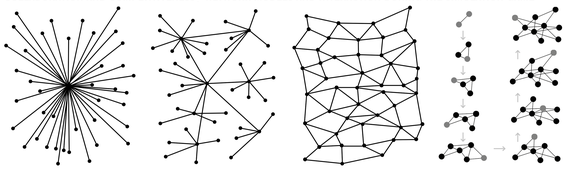
REBUS® REnovation of public Buildings and Urban Spaces is a training program and **design lab on urban regeneration for climate mitigation and adaptation**.
It is carried out through a **simulation game**. It includes classroom lessons, surveying, debriefing moments, and final workshops for a total of 40 educational hours.
The focus of the experimental lab is on **public spaces as strategic locations in the planning and designing of the necessary equipment of a climate-proof city**.
REBUS® cities: Modena, Parma and Rimini (2015); Ferrara, Ravenna and San Lazzaro di Savena (2017). **For each city, interdisciplinary teams competed by developing a planning proposal based on a made-up law and call for tender.**

From the first to the fourth edition, the content and written requests within the law and call for tender have grown in number and complexity, arriving at the definition of criteria for the planning of eco-districts and public spaces that mitigate and adapt to climate change.
In less than three days, each team developed urban regeneration strategies and projects to improve the quality of public spaces, rethinking the use of green space, the management of the urban water system, mineral and green materials, and the equipment that can make public spaces more resilient, comfortable, attractive, and livable. During the labs, the efficiency of the projects in terms of comfort and thermal mitigation as well as the environmental benefits of green infrastructure were evaluated.

COMPOSITION OF REBUS® TEAMS



COLLABORATION AND COMPETITIVENESS / NETWORK MODELS AND INTERACTION DURING THE SIMULATION-GAME



CENTRALIZED NETWORK
All the nodes are connected in a hierarchical way to a single central node on which all links depend.
This network is not collaborative. It has a high level of competitiveness and can be efficient but is weak because it is supported by the existence of a single node. If it were to fail short, it would kill the network itself (©P.Baran, 1964)

DE-CENTRALIZED NETWORK
The nodes are grouped into subgroups connected to a main node, which in turn depends on a central one.
This network has a good level of collaboration and competition, however the links between the main nodes are weak, and if one fell short, it would entirely lose a significant part of it.
(©P.Baran, 1964)

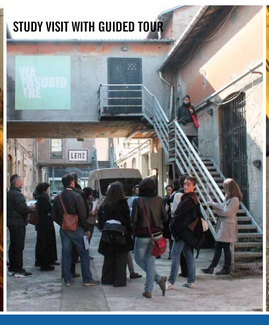
DISTRIBUTED NETWORK
The nodes are grouped into a mesh of three nodes, which facilitates a high level of connections within the network and makes the nodes that might lose connection largely stable since they have two other connections.
This network has a high level of collaboration and competition, but lacks hierarchy and, in certain cases, efficiency.
(©P.Baran, 1964)

SIMULATION GROWTH OF COMPETITIVE AND COLLABORATIVE DISTRIBUTED NETWORK
The growth of the network implies a competitive behavior between the nodes that form it. Every new node, before connecting, evaluates and chooses the node that offers the most. Between two nodes with an equal number of connections prevails over the more competitive one, while when equally competitive, the longer existing node prevails.
(©Barabási, Bonabeau, 2003)

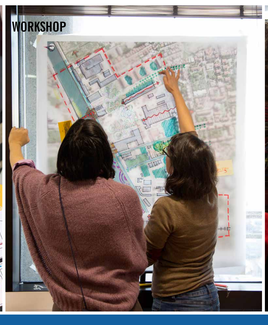
REBUS® INSTRUMENTS

REBUS® JURY COMPOSITION


LECTURE


STUDY VISIT WITH GUIDED TOUR

STUDY VISIT WITH GUIDED TOUR


WORKSHOP


WORKSHOP

SIMULATION-GAME AND URBAN REGENERATION

REBUS Lab
Emilia-Romagna Region
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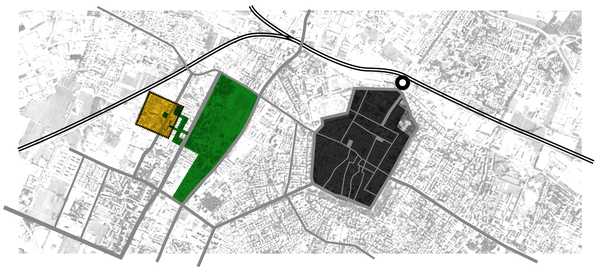
ARTISAN AND MANUFACTURING DISTRICT OF THE SECOND POSTWAR PERIOD / STUDY AREA AND DESIGN OBJECTIVES

The Artisan Village is a **manufacturing district** located in the first outskirts the city that was **built during the postwar period of World War II**. **Small and medium-sized craft activities** were established there, particularly focused on the **mechanical supply chain**. There is also a foundry and the manufacturing headquarters of Figurine Panini. The area is composed of **buildings organized by roads in a grid system**. An experimental urban plan that aims to involve the private enterprises is underway to improve the comfort of the area and the energy efficiency of the building heritage. **The road network is not characterized by soil permeability or significant sections of vegetation**, except for at the entrances to some larger factories or private homes with a warehouse annex.
Viale Po, a two-lane thoroughfare that divides the manufacturing district from the residential area, has all the main services. **The road section varies, with parking, green areas, and cycle and pedestrian paths.**
Within the district, we find mostly **anonymous warehouses with little building value** and some **homes with connected laboratories**. Most of the buildings are in need of maintenance.
The internal roads have continuous parking sections on one or two sides; the streets are paved in asphalt and often missing sidewalks. Green areas are nearly nonexistent, except for the private green spaces of the residential buildings near Ferrari Park and along Viale Po. **The green areas within the district, on the other hand, are found near entrances and the private yards of the artisan warehouses.**



1 VIALE PO
2 UNUSED PUBLIC GREEN AREA
3 COMMUNITY GARDEN
4 ENZO FERRARI PARK
5 FIGURINE PANINI
6 PARKING AREA ALONG VIALE PO
7 FOUNDRY
8 RAILWAY
9 MALL / SHOPPING CENTRE
10 VIA BIONDO
11 VIA DELLA CHIESA
12 VIA NOBILI
13 VIA BRUINI
14 VIALE DELL'AUTODROMO

STUDY AREA
CITY CENTRE
URBAN PARK
STATION
ROAD NETWORK
RAILWAY

SIMULATION AREA
PROJECT SITE / AREA OF INTEREST
PUBLIC MOBILITY ROUTE (BUS)
BIKE NETWORK

ENVI-MET SIMULATIONS

A study of the thermal comfort of the area has been prepared using the SPACE modules from ENVI-MET, a holistic three-dimensional non-hydrostatic software that allows one to model the physical and microclimatic behavior of the buildings and open spaces, with applications for urban planning, climate adaptation, comfort, and the health of the people.

The software allows one to analyze the urban comfort of a certain area linking data that has been extrapolated from a climate analysis of the place with the topographical study of the spaces (which includes the buildings, vegetation, and land-use).

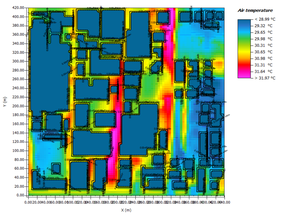
The output results of the ex-ante status are compared to the thermal comfort of the ex-post status, which takes the different design choices into consideration.

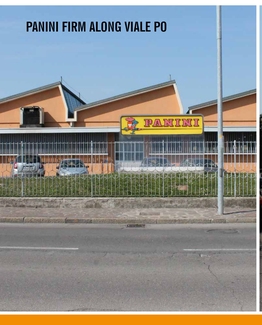
The area of Modena represents a very complex case for the project and simulation: the urban fabric is in fact made up of more than 80 percent built areas. Excluding roads, there are few public and open spaces of significant size where it is possible to intervene. Additionally, the presence of numerous trees in the park included in the study area caused the calculations to crash many times.

AIR TEMPERATURE / 23.07.2013 - H 11:00

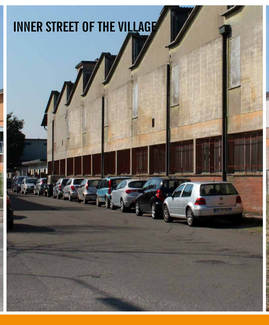
The isolines allow one to understand the distribution of the air temperature in °C, in the open spaces and near buildings, a value that affects the direct thermal exchange between the human body and the environment.

The current status of the Modena area displays temperature distribution that is distinct for the open areas, roads, and squares, with values largely between 30°C and 32°C, and building temperatures below 28°C.





PANINI FIRM ALONG VIALE PO


INNER STREET OF THE VILLAGE


UNUSED GREEN AREA


VIA NOBILI


VIALE EMILIO PO

MODENA ARTISAN VILLAGE

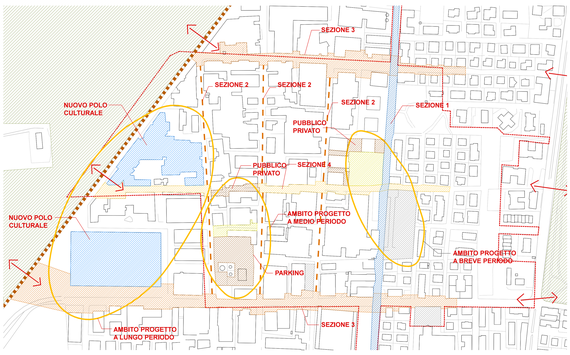
STUDY AREA

REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

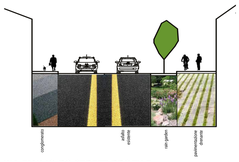
NEW URBAN CONNECTIONS AND SOCIAL INNOVATION IN THE ARTISAN VILLAGE

INNOVATION LEAVES ITS MARK

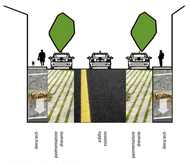
The proposal is focused on the **extension of the perimeter of the proposed area to include again two strategic areas for environmental comfort (the green area east of the railway and Ferrari Park)**, which is the objective of future transformation/ delocalization of the industries that are inconsistent with the urban context and near the abandoned railway line.
Assuming a reunification of the Village with its context, **investments were made on the connections to the abandoned railway and the Ferrari Urban Park**. The regeneration of the area intends to identify a series of new polarities and/or the enhancement of existing ones to create a network and reconnect the various fragments of the artisan district. Consequently, the project plans to overturn the current hierarchy (north/south) **by enhancing new east/west connectivity, functional to the connection of the identified poles**.
The implementation of areas for parking is also called for, which would serve to rationalize spontaneous stops along the main routes by proposing an area with around 90 parking spots.
The interventions are concentrated in precise areas and along some roads with the creation of equipped public spaces, the use of permeable paving, and the creation of tree-lined parking areas and rain gardens along curbs in order to create pervious surfaces and plant new trees.
The solutions for improving urban comfort also call for **work on private buildings, using cool and green roofs and walls by drawing from public funds that encourage their use**.



MASTERPLAN

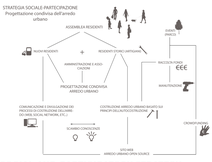


VIA EMILIO PO STREET PROFILE



INNER STREET PROFILE

PUBLIC SPACES AND GREEN STRATEGY

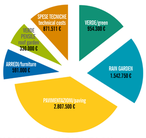


SOCIAL AND PARTICIPATORY STRATEGY

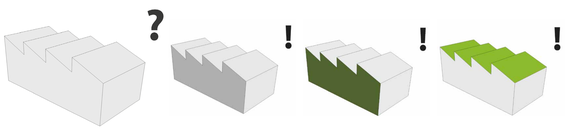
SIDE STREET PROFILE

CONNECT to the macroscale
HIERARCHIZING the viability
POLARIZE urban fabric
RECOMPOSING urban fragments
EQUIP areas for parking
CONTAMINATE uses

REUSE STRATEGIES



ECONOMIC-FINANCIAL PLAN

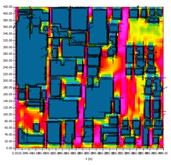


INTERVENTION STRATEGY FOR PRIVATE BUILDINGS: COLOURS AND GRAFFITI, GREEN WALLS, GREEN/COOL ROOFS

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

The ex-ante map shows uniform values between 0.5 m/s and 1.05 m/s 'calm wind.
The design solution shows a small variation exclusively near two open spaces where the wind speed arrives to 0.6 m/s, while episodes of still air and localized turbulence persist.

EX ANTE



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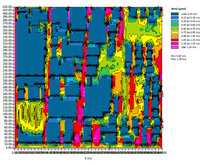
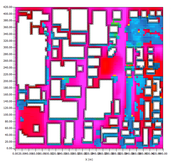


ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

The PMV index expresses the opinion of individuals on thermal comfort in a given microclimatic condition. The ex-ante map presents a tragic situation, with an average index greater than 3.2 'very, very hot.'
The map of the project shows a slight localized improvement that does not allow mitigation of the heat island effect in the district.

EX ANTE



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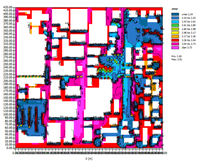

TEAM MODENA 1 / Christian Abate - agronomist, Luca Biancucci - urban planner, Alfredo Borghi - architect, Claudia Dall'Olio - Regione Emilia-Romagna public officer, Irene Esposito - landscape architect, Andrea Franceschi - architect, Giulia Gatta - landscape architect, Federico La Piccirella - engineer, Martina Lucchi - landscape designer, Maria Angela Mirri - agronomist, Roberta Palumbo - architect, Elena Pellegrini - architect, Paolo Piazza - engineer, Andrea Reggianini - Municipality of Modena public officer, Catia Rizzo - Municipality of Modena public officer, Melissa Semeraro - engineer.

MODENA ARTISAN VILLAGE / 1

PROJECT STUDY AREA

REBUS Lab
Emilia-Romagna Region
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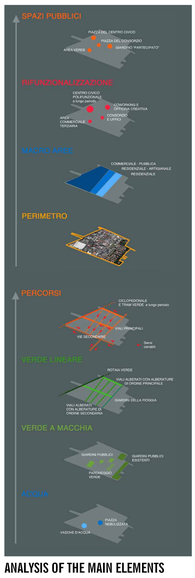
THE RENOVATION OF THE ARTISAN DISTRICT
IDENTITY, URBAN QUALITY, AND PARTICIPATION
ARTISAN VILLAGE, ALIVE VILLAGE

The project aims to **revitalize and regenerate the urban fabric of the Village through innovative environmental actions that will help increase the degree of resilience of the area and the addition of new functions, centrality, attractive poles, meeting places, and services for the community** in order to strengthen the identity and livability of the district.
Different parts of the road system become links between the Ferrari Park and the area beyond the old railway, passing through the Village and **connecting the attractive elements**. From a strategic perspective, the project intervenes in order to **open and revitalize the places, adding new functions, creating new public spaces, and activating participative processes**. It will also reorganize the space by **redefining road systems, space, and functions**; **connect the district by creating spaces for slow mobility**; and **restore the spirit of its places through actions that reuse neglected space and with the introduction of elements for the recovery of environmental resources added to the network**.
The **transformation of some roads from two lanes to one way allows for the addition of rows of trees** that have a columnar habit, deciduous leaves, easy maintenance, and the ability to absorb pollutants. To combat the consequences of heavy rain, along via Emilio Po there will be **linear rain gardens as initial flooding zones to slow and regulate the water run-off**.
In the squares, newly created central locations, **the use of water as an outdoor summer cooling element is planned with the use of mist fountains and spouts that spray onto water mirrors**.



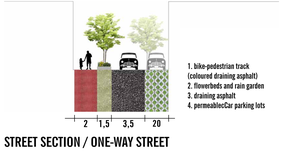
ANALYSIS OF THE MAIN ELEMENTS


MASTERPLAN

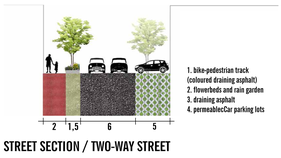

ONE -WAY INNER ROAD, NEW MOBILITY AND URBAN LANDSCAPE


PERSPECTIVE VIEW OF THE INTERVENTIONS ON THE WALLS AND ROOFS OF THE PRIVATE BUILDINGS

PARTICIPATION, STRATEGIES AND WAYS TO INVOLVE THE DISTRICT



STREET SECTION / ONE-WAY STREET



STREET SECTION / TWO-WAY STREET

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

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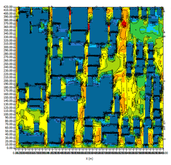
EX ANTE



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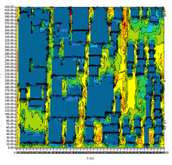

ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

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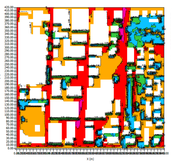

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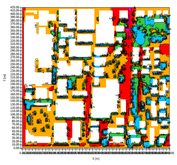

SQUADRA MODENA 2 / Roberto Bacchilega - landscape architect, Elvira Laura Bandini - landscape architect, Alessandro Bettio - urban designer, Cinzia Compagnone - architect, Claudia Guastadini - architect, Giulia Lucchi - public officer Municipality of Modena, Silvia Manelli - urban planner, Francesco Michele Masera - engineer, Patrizia Melotti - Emilia-Romagna Regione public officer, Sara Navacchia - architect, Roberta Paglioli - designer, Angela Santangelo - urban designer, Giuseppe Satta - architect, Daniela Stagni - agronomist, Valeria Zorzin - agronomist.

MODENA
ARTISAN
VILLAGE / 2

PROJECT
STUDY AREA

REBUS Lab
Emilia-Romagna Region
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THE MANUFACTURING FABRIC OF THE SAN LEONARDO DISTRICT / STUDY AREA AND DESIGN OBJECTIVES

The area is characterized by a pattern of early industrial expansion, which was made easier by its proximity to the railway. In the postwar era, the district experienced a period of huge expansion with a urbanisation that developed without any actual organized oversight in the area around the train station and along Via Trento, the main road and extension of the central Via Garibaldi.
The more emblematic buildings have been preserved and are still the subject of possible re-functioning and recovery today. New buildings and urban functions have substituted other neglected areas in order to regenerate and revitalize the district.
The current context, characterized by a strong social and multiethnic trait, is made up of a disorganized urban fabric in which small homes prevail beside the strong presence of small industries and artisanal and commercial activities.
The open spaces include roads, small under-used green spaces, parking, and private lots. These areas are disaggregated and display very different formal, functional, and plant-related qualities. It is necessary to plan the reconnection of the public spaces taking into account the multiethnic community, the needs of the spaces called to cultural production, artisan activity, worker residence, and new housing.
Within the district, the open green spaces are situated mostly in the northern part, beside the private space of worker homes. The main green spaces are beside the entrance to the bike path, near the elderly center and in the lots where social housing is planned.

1 VIALE TRENTO
2 TRAIN STATION
3 EX-MANZINI PLANT - WORKOUT PASUBIO
4 PASUBIO RESIDENCE - MBM ARCHITECTS
5 SCEDED - LENZ/CID
6 UNDERGROUND PARKING AREA / GREEN SPACE
7 ELDERLY CENTER AND GREE AREA
8 PARKING - SOCIAL HOUSING (PLANNED)
9 PARKING - COMMERCIAL CENTER (PLANNED)
10 SOCIAL HOUSING (PLANNED)
11 VIA GARIBALDI
12 VIA RASTELLI
13 VIA PASUBIO

STUDY AREA
CITY CENTER
URBAN PARK
TRAIN STATION
ROAD NETWORK
RAILWAY
PARMA TORRENT

SIMULATION AREA
PROJECT SITE / AREA OF INTEREST
PUBLIC MOBILITY ROUTE (BUS)
BIKE NETWORK

ENVI-MET SIMULATIONS

A study of the thermal comfort of the area has been prepared using the SPACE modules from ENVI-MET, a holistic three-dimensional non-hydrostatic software that allows one to model the physical and microclimatic behavior of the buildings and open spaces, with applications for urban planning, climate adaptation, comfort, and the health of the people.

The software allows one to analyze the urban comfort of a certain area linking data that has been extrapolated from a climate analysis of the place with the topographical study of the spaces (which includes the buildings, vegetation, and land-use).

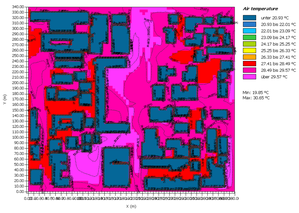
The output results of the ex-ante status are compared to the thermal comfort of the ex-post status, which takes the different design choices into consideration.

In the area of Parma, there are various large abandoned artisan and industrial buildings with historically significant architectural characteristics. They alternate with open spaces, which are connected by pedestrian areas with a nearly equal ratio of space between built areas and open space.

AIR TEMPERATURE / 23.07.2013 - H 11:00

The isolines allow one to understand the distribution of the air temperature in °C, in the open spaces and near buildings, a value that affects the direct thermal exchange between the human body and the environment.

The map of thermal comfort of the current state shows that the values are between 20°C near the buildings and 30°C in most open spaces.



GREEN AREA BEHIND EX-MANZINI

RESIDENTIAL BUILDING IN VIA PASUBIO

VIA RASTELLI

SCEDED - LENZ/CID

VIA PASUBIO

PARMA PASUBIO DISTRICT

STUDY AREA

REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

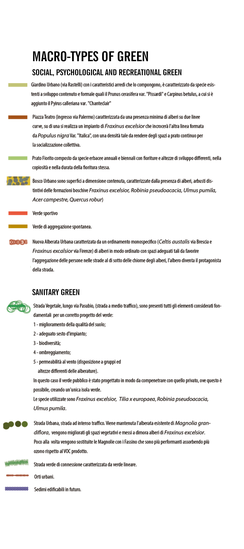
NEW URBAN LANDSCAPES FOR MULTIFUNCTIONAL AND TREE-LINED PUBLIC SPACES

LET'S TAKE BACK THE ROAD

The project aims to **reintroduce residents to the social aspect of the street**, improving the microclimatic comfort of roads and squares, **developing a network of slow mobility, and creating welcoming and attractive open spaces**. The transformations underway have deprived the districts of its **historical identity**, increasing its critical status. Therefore, a coordinated intervention system was devised to improve the social relations and the sense of belonging of the area by defining a '**layout of potential functions**' within the district space, which would guide design choices. These include the **(re)qualification of existing open space**, the **creation of connections between open space and attractive buildings**, actions aimed at allowing the temporary use of private areas waiting to be built, and **redefining the mobility hierarchy and roles**.

The qualification of the public spaces and improvement of the residents wellbeing will be pursued through the use of green, in the following adaptations: **GREEN ROAD**, a linear park along Via Pasubio equipped with rest and recreation spots and various species that attract melliferous entomofauna; **PASUBIO EDEN**, an urban garden composed of a sequence of squares, green areas, and built elements; **STREET BRIDGES**, connections between the district, Via Trento, and the Train Station; **ENTRANCE DOOR**, entrance to the area characterized by a green wall placed against the track ballast, which emphasizes the main access to the pavilion; **COMMERCIAL PATH** on Via Trento, which, redeveloped as a one-way road exiting from the city, allows the project to integrate the greenery and expand the pedestrian space.

GREEN INFRASTRUCTURE PROJECT



STRATEGIC ACTIONS

NEW MOBILITY NETWORK

IMPLEMENTATION PLAN IN FORCE

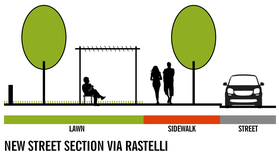
VARIATION PROPOSAL

A: "EX-MANZINI SQUARE"
Private space with public use, with green scenery and socializing spaces.

B: "URBAN SQUARE"
Space for meeting and commercial relations connected to "Piazza Teatro / Theatre Square" behind Lenz, until "Giardino Condiviso/ Shared Garden" and past Via Rastelli until the urban green area.

C: "THE MEADOW"
Areas currently not used, thus requiring construction only to close off Via Rastelli, guaranteeing and improving permeability for wind.

D: RECREATIONAL AND SPORT ACTIVITIES
Construction on the upper part of the lot to allow the creation of green scenery overlooking "green road."



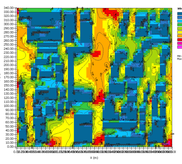
NEW STREET SECTION VIA RASTELLI

NEW STREET SECTION VIA PALERMO

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

The ex-ante map shows average values greater than 1.10 m/s 'light breeze,' with localized turbulence and episodes of Venturi effect, in the main square.
The design solution is very effective: it can homogenize and improve the changing wind, eliminating peak areas and conditions of obvious discomfort.

EX ANTE



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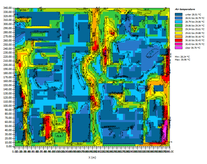
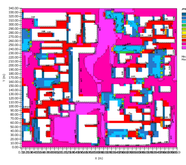


ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

The PMV index expresses the opinion of individuals on thermal comfort in a given microclimatic condition. The ex-ante map presents a homogenous situation, with values greater than 3.5 'very, very hot.'
The project map shows a widespread improvement and a greater variability of values that move from 'hot' to 'slightly hot.'

EX ANTE



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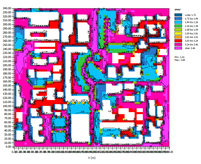


TEAM PARMA 1 / Costanza Barbieri - Parma Municipality public officer, Luca Boccacci - architect, Giulia Ceribelli - landscape designer, Giulia D'Ambrosio - architect, Francesco Fulvi - engineer, Roberto Guizzardi - engineer, Elena Lazzari - urban planner, Christian Manfrini - architect, Martina Mazzali - architect, Pier Vittorio Miola - agronomist, Barbara Negroni - agronomist, Vanessa Passalacqua - architect, Bianca Pelizza - Parma Municipality public officer, Paolo Pinto - engineer, Laura Punzo - Emilia-Romagna Regione public officer, Luca Vandini - landscape designer.

PARMA PASUBIO DISTRICT / 1

PROJECT STUDY AREA

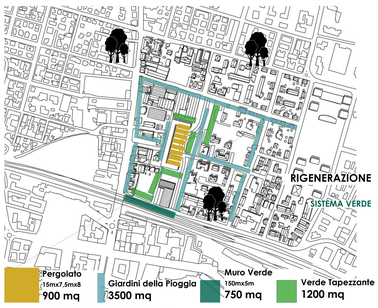
REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

GREEN AND BLUE INFRASTRUCTURE AND ECOLOGY FOR THE LIVABILITY OF THE DISTRICT

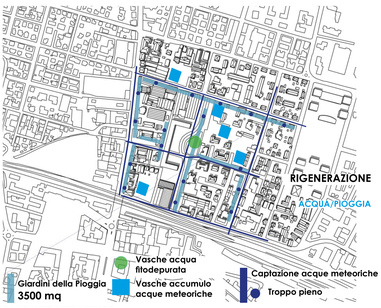
PARMA *POLIS* PROJECT

The proposal aims to **regenerate the district starting with the re-use, re-functioning, and recovery of large buildings that characterize the backbone of the area**.
The implied objective is to **regenerate the site, putting people that live there at the center of the process and guaranteeing integration between different cultures, generations, and social classes** by redefining the present functions and the maintenance of the infrastructure of public spaces and greenery to **increase urban resilience and open areas livability**.
Therefore the green infrastructure is a fundamental element for reconnecting the three functional poles of the district and the district itself with the surrounding urban areas.
The revitalization of the area is considered feasible by renegotiating the Urban Renovation Program (PRU) to obtain additional vacant lots compared to the plan's expectations in order to improve urban comfort, the microclimate, and the general livability and sociability of the district. In particular, the proposal decreases the building capacity and relocates the commercial areas.
The main action of the urban regeneration is the **increase of vegetation for improving thermal-igrometric comfort and reducing fine particles**, avoiding, however, plants that release VOCs and OFP.
The project will implement a de-sealing action to create floodable ditches for rainwater collection, with hygrophilous plants that can resist dry summers.

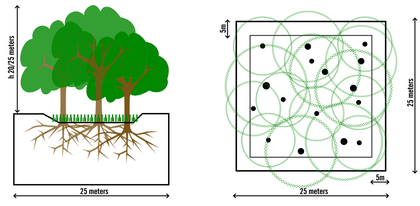
GREEN INFRASTRUCTURE



GREEN AND BLUE INFRASTRUCTURE



BLUE INFRASTRUCTURE



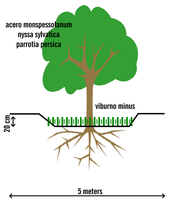
GREEN MASS BOX WITH HIGH URBAN AND ENVIRONMENTAL REGENERATION

GREEN MASS BOX
25X25METERS
GROSS FLOOR AREA 405QM

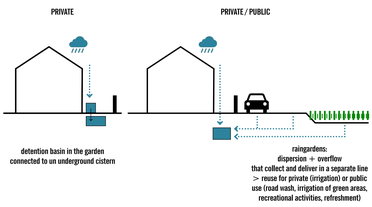
LAYOUT 3 METERS 3X3
16 LARGE TREES

LARGE TREES:
- quercus robur (English oak)
- fraxinus angustifolia
- quercus rubra (red oak)
- quercus palustris
- poplar
- salix

SHRUBS:
- salix purpurea nana
- cornus stolonifera 'flaviramina'



SINGLE TREE BOX



RAINWATER TREATMENT

REGENERATION STRATEGY AND PROPOSAL TO CHANGE ONGOING URBAN INSTRUMENTS

The revitalization of the area is made feasible by renegotiating the Urban Renovation Program with the private stakeholder.
The current situation of the area proves that the plan did not respond well to the needs of the district. Therefore, taking advantage of the economic crisis that blocked the housing market and thus construction, as well as the fact that the plan expired and was not entirely implemented, we can consider initiating *ad hoc* procedures that deal with the current critical situation.
The renegotiation of the Urban Renovation Program with the developer is meant to obtain additional vacant lots compared to the plan's expectations in order to allocate more public space where to improve urban comfort, the microclimate, and general livability and sociability of the district.
proposal summary:
- decrease construction capacity of the plan;
-reduce social housing quota;
-modify parking areas;
-confirm permitted uses;
- redistribute functions in unused existing buildings.

AXIS: FUNCTIONS TO BE REACTIVATED

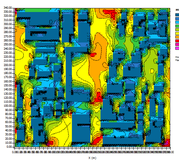

PUBLIC AND PRIVATE GREEN


FUNCTIONS, GREEN AND CONNECTIONS

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

The ex-ante map shows average values greater than 1.10 m/s 'light breeze,' with localized turbulence and episodes of Venturi effect, in the main square.
The plan shows a more homogenous distribution of wind speed that favors the creation of a north-south wind corridor, eliminating conditions of obvious discomfort.

EX ANTE



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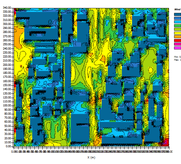
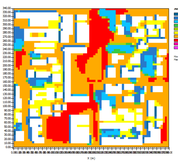


ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

The PMV index expresses the opinion of individuals on thermal comfort in a given microclimatic condition.
The ex-ante map presents a homogenous situation, with values greater than 3.5 'very, very hot.'
In the project, the average index stays equal to 3 'very hot,' except for the square where there is a notable improvement to 1.8 'hot.'

EX ANTE



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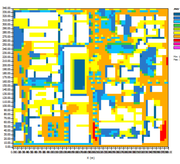


Team Parma 2 / Giulia Angelelli - Emilia-Romagna Region offices, Maria Teresa Araldi - architect, Rodolfo Bonora - agronomist, Laura Cevenini - agronomist, Nicoletta Congiu - architect, Lorenzo Bergamini - designer, Germana De Michelis - urban designer, Luca Filippi - architect, Valentina Guagliardi - architect, Maria Grazia Lenato - architect, Caterina Michelini - landscape architect, Enrico Reatti - engineer, Giulia Reatti - architect, Daniela Rossi - officer Municipality of Parma, Patrizia Rota - urban planner, Silvia Settimj - architect, Natascia Tassinari - landscape architect.

PARMA PASUBIO DISTRICT / 2

PROJECT STUDY AREA

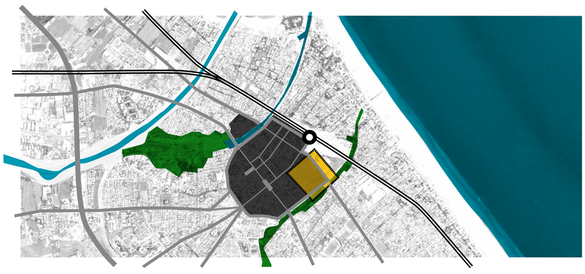
REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

LARGE MARKETS AND PARKING AREAS OF THE HISTORICAL CENTER / STUDY AREA AND DESIGN OBJECTIVES

The market areas are located southeast of the historical center of Rimini, inside and up to the city walls, between the Roman amphitheater, the Malatesta temple, the covered market, and Ausa Park. They are easily reached from the station; from the operational transportation center of the local population (START); from the bike and pedestrian path that connects the historical center to the seaside; from the parking lots of DLF (the Railway Recreational Club) and the Settebello Cinema; from Via Roma, the main thoroughfare that passes by the historical center carrying traffic along the coast; and from the highway toll of Rimini South. **Parking lots serving downtown contain 756 parking spots and will become 1,000 as soon as expansion of the train station parking is completed.**

The current grounds of Piazza Gramsci belong to the state and are being used by the City, which started the process of acquisition some time ago; a public parking lot was created on the site, and recently the **weekly market** was moved there in light of the construction work on Teatro Galli and restoration of Piazza Malatesta.

The open spaces are essentially three urban plots for parking, large asphalted surfaces encircling the roman theater. In addition, there are inner roads that connect the district, characterized by **small houses from the turn of the century** that extend up to the ancient riverbed. **The green spaces are located mainly in the southern part, beside Ausa Park and the roman amphitheater and around the school grounds, the yards of historical homes, and Viale Roma.**



1 PIAZZA GRAMSCI - PARKING AREA
2 EX-PADANE PARKING AREA
3 DLF (RAILWAY RECREATIONAL CLUB) PARKING AREA
4 PARKING AREA CINEMA SETTEBELLO
5 VIALE ROMA
6 SWISS NURSERY - ROMAN AMPHITHEATER ARCHAEOLOGICAL SITE
7 PANZINI SCHOOL
8 SANTA RITA CHURCH
9 AUSA LINEAR PARK
10 COVERED MARKET
11 MALATESTA TEMPLE
12 ARCH OF AUGUSTUS
13 TRAIN STATION

STUDY AREA
CITY CENTER
URBAN PARK
TRAIN STATION
ROAD NETWORK
RAILWAY
MARECCHIA RIVER
ADRIATIC SEA

SIMULATION AREA
PROJECT SITE / AREA OF INTEREST
PUBLIC MOBILITY ROUTE (BUS)
ARCHAEOLOGICAL SITE
CITY-SEASIDE BIKE NETWORK

ENVI-MET SIMULATIONS

A study of the thermal comfort of the area has been prepared using the SPACE modules from ENVI-MET, a holistic three-dimensional non-hydrostatic software that allows one to model the physical and microclimatic behavior of the buildings and open spaces, with applications for urban planning, climate adaptation, comfort, and the health of the people.

The software allows one to analyze the urban comfort of a certain area linking data that has been extrapolated from a climate analysis of the place with the topographical study of the spaces (which includes the buildings, vegetation, and land-use).

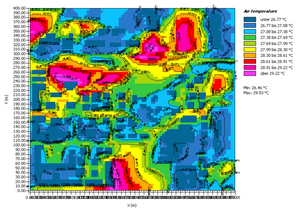
The output results of the ex-ante status are compared to the thermal comfort of the ex-post status, which takes the different design choices into consideration.

In the area of Rimini, there are open spaces of considerable size designated to squares and asphalted parking, and they contain few trees. The built environment is characterized by an urban fabric of two- or three-story houses that are typical of the garden city. Some large buildings are also present (schools, cinemas, and churches).

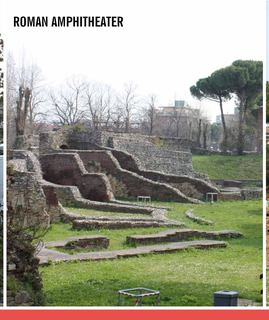
AIR TEMPERATURE / 23.07.2013 - H 11:00

The isolines allow one to understand the distribution of the air temperature in °C, in the open spaces and near buildings, a value that affects the direct thermal exchange between the human body and the environment.

The ex-ante map of thermal comfort shows that the values are between 26°C and 30°C in most open areas, with largely varying values and 'pockets of hot air.' The areas of greater discomfort in which the discomfort of the people is high due to excessive heat, are in Piazza Gramsci and the parking lots of the ex Padane and Settebello Cinema.




THE MARKET IN PIAZZA GRAMSCI - SANTA RITA


ROMAN AMPHITHEATER


AUSA LINEAR PARK


DLF (RAILWAY RECREATIONAL CLUB) PARKING


EX-PADANE PARKING AREA

RIMINI CITY CENTER

STUDY AREA

REBUS Lab
Emilia-Romagna Region
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LIVABLE PUBLIC SPACE AND URBAN GREEN INFRASTRUCTURE

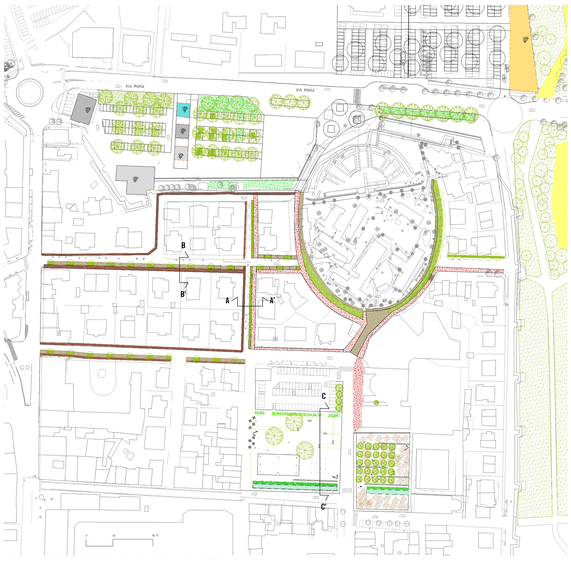
THE FOUR Ps OF URBAN COMFORT

Public spaces and urban comfort are at the center of the regeneration project of the large market areas, as well as the enhancement of historical and identity symbols of this portion of city center: the amphitheater, the walls, the port, and the decumano road. **The public city guides the transformation starting with four themes and locations, reimagined to be people-friendly and for the wellbeing of residents**; PORTA (door), PIAZZA (square); PARCO (park), and PERCORSI (paths).

1. **The creation of an entryway – PORTA** - to the historical city is structured by: the design of the railway area/Settebello as intermodal public and private access with cultural and commercial functions, the design of the ex-Padane area as a multifunctional space with permanent and temporary (market) activities, the improvement of connections between various places, and the reunification of spaces through green paths.

2. **PIAZZA Gramsci will become a multifunctional space for itinerant trade, with both recreational activities for educational services**, and a function of urban square that offers the possibility of economic and social development and contributes to the renovation of pedestrian paths. **The pedestrianization and elimination of parking is possible with the expansion of the railway/ Settebello area.**

3. **PARCO will be completed through a system of linear green spaces along the Ausa River**. 4. **PERCORSI paths foster relations between identified strategic locations, through bike and pedestrian ways conveniently protected by natural elements**.

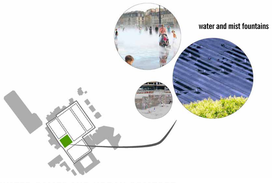


ENHANCEMENT OF PUBLIC SPACES AND GREEN STRATEGY

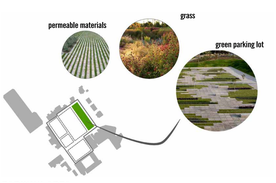
PIAZZA GRAMSCI: EXISTING SITUATION AND DESIGN STRATEGIES

THE REGENERATION OF PIAZZA SANTA RITA

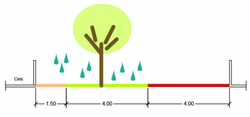
THE (UN)COVERED MARKET



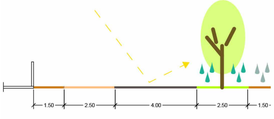
WATER GAMES AND URBAN COMFORT



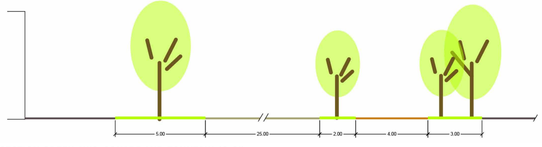
PARKING AREA



SECTION HYSTORICAL PATHWAY (A-A')



SECTION RESIDENTIAL PATHWAY (B-B')

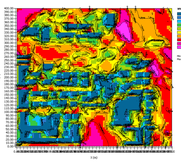


SECTION GREEN AXIS, SQUARE AND FOUNTAIN (C-C')

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

The ex-ante map shows values between 0.2 m/s 'almost still air' and 1.6 m/s 'light breeze,' except rare cases of turbulence near buildings.
The results of the project show a different distribution and greater concentration of wind speed in the areas to the northeast, where green areas and trees are planned.

EX ANTE



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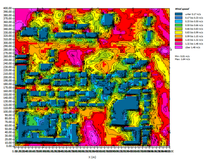
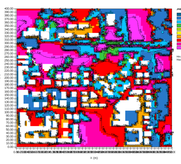


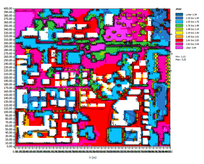
ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

The PMV index expresses the opinion of individuals regarding thermal comfort in a given microclimatic condition.
The map of the project shows an improvement for the ex-Padane area and the DLF parking where it moves from 'very, very hot' to 'slightly hot.

EX ANTE



EX POST



SQUADRA RIMINI 1 / Giuseppe Anastasi - landscape designer, Sara Angelini - landscape designer, Monica Margherita Assunto - officer Municipality of Rimini, Daniela Brighi - engineer, Cecilia Carattoni - architect, Eva Cerri - engineer, Marialuisa Cipriani - landscape architect, Luca Cruciat - architect, Chiara Dal Piaz - officer Municipality of Rimini, Annamaria Fabbri - engineer, Francesca Gennari - engineer, Claudio Masini - architect, Barbara Nerozzi - Emilia-Romagna Region public officer, Giovanni Poletti - agronomist, Alessandro Pracucci - architect, Chiara Semprini Cesari - architect.

RIMINI CITY CENTER / 1

PROJECT STUDY AREA

REBUS Lab
Emilia-Romagna Region
bit.ly/rebus-laboratorio

THE HISTORICAL CITY BETWEEN IDENTITY AND URBAN RESILIENCE

RES: RIMINI ENVIROMENTAL STRATEGY

The design strategy is based on re-naturalization of the urban environment, enhancement of historical and cultural identity of the city center, resilience of the district system, restitution of public spaces to the community and participation as a paradigm for the construction of the project, and management of collective works.
The specific objectives are declined on the issues of **environmental, social and economic sustainability**.
The reduction of parking spaces and creation of underground parking helps **expand the public space, the network of bike and pedestrian paths, and commercial spaces**, with the introduction of new equipped and shaded rest areas.
The project studies every detail of the integrated solutions of urban green space and water treatment to improve the resilience of the district to extreme weather. There will be **detention basins, rain gardens, and a rainwater collection system made with drainage modules for trees**, connected to the sewage system in order to carry the excess drainage to the detention basins. Additional proposed actions includes green barriers to contain sound and purify the air, removal of coniferous trees to be replaced with broad-leaved trees, thus **creating new green infrastructure by replacing the tree lanes with an east-west orientation, towards the dominant winds** to mitigate the Venturi effect. The use of partially permeable materials is preferred and de-paving and permeable surface expansion operations are planned.

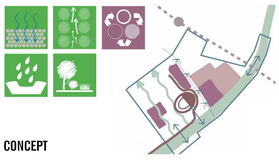
MASTER PLAN AND STRATEGY FOR PUBLIC SPACES REGENERATION

SCHEME OF GREEN AND WIND SYSTEM

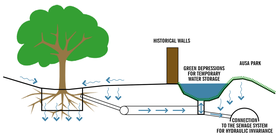
WATER NETWORK SCHEME

PROJECT FOR PIAZZA GRAMSCI

PROJECT FOR PIAZZA EX-PADANE



CONCEPT

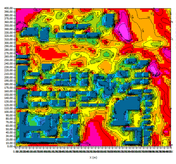


DRAINAGE MODULE FOR TREES

ENVI-MET SIMULATION / WIND SPEED / 23.07.2013 - H 11:00

The ex-ante map shows values between 0.2 m/s 'almost still air' and 1.6 m/s 'light breeze,' except rare cases of turbulence near buildings.
The design solution displays a distribution that is lower than the current state and more homogenous, with a reduction of the wind speed by around 0.5 m/s in open spaces.

EX ANTE



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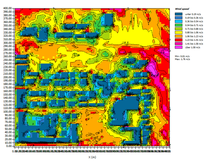
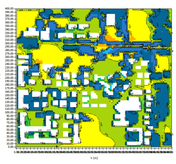


ENVI-MET SIMULATION / PMV (PREDICTED MEAN VOTE) / 23.07.2013 - H 11:00

The PMV index expresses the opinion of individuals regarding thermal comfort in a given microclimatic condition.
The design solution displays a distribution that is lower than the current state and more homogenous, with a reduction of the wind speed by around 0.5 m/s in open spaces.

EX ANTE



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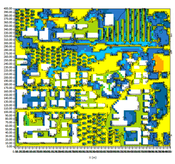

TEAM RIMINI 2 / Nicola Bastianelli - Municipality of Rimini public servant, Adriano Bergamaschi - Emilia-Romagna Region public servant, Cinzia Casadei - urban designer, Natascia Casadei - urban planner, Enrico Di Felice - agronomist, Nicoletta Franchini - architect, Paolo Gueltrini - agronomist, Ilaria Guidalotti - engineer, Davide Lupini - architect, Marco Marcucci - architect, Nicolina Masiello - landscape designer, Claudia Morri - landscape designer, Nedo Pivi - architect, Cecilia Rendina - architect, Giorgio Roffi - designer, Claudia Trevisan - urban designer.

RIMINI CITY CENTER / 2

PROJECT STUDY AREA

REBUS Lab
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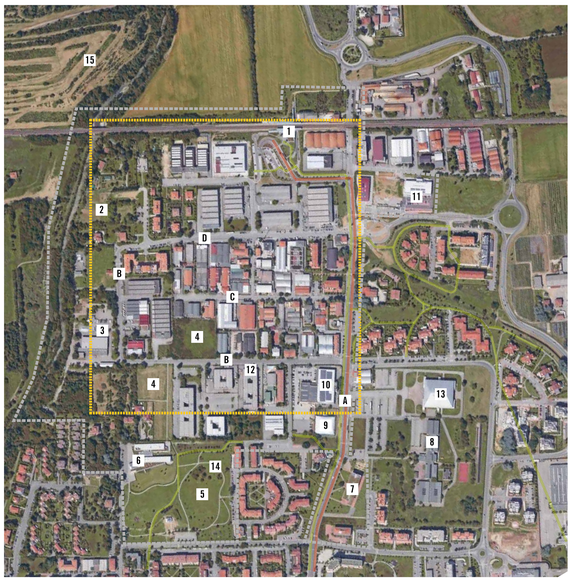
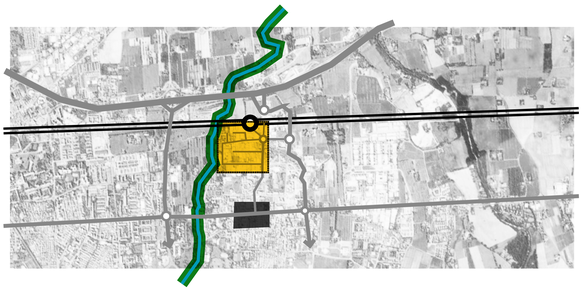
LIGHT INDUSTRIAL DISTRICT OF VIA CASELLE AND VIA SPERANZA / STUDY AREA AND DESIGN OBJECTIVES

The light industrial area of via Caselle-Speranza was **built in the 60s and 70s with varied functions of production and residence and neglected buildings**. The district, part of the regeneration sites of the City Urban Plan, **lacks of facilities** and is characterized by **an urban fabric structured in a grid system where public space coincides substantially with the roads**.
The area is characterized by **a compact built environment inserted into a standard geometric grid that follows the structure of the land properties**. The result is an **extremely fragmented morphological and land ownership structure**, started with the intention to optimize the space where to establish light industrial and handcrafted activities.
The artisan warehouses, many of which are abandoned, present a good state of preservation but **poor architectural quality**. Because of its strategic position, the presence of unused buildings, and its vicinity to the future Alce Nero Campus, **the ex-artisan area lends itself to both reuse experiments** (in terms of environmental sustainability and energy saving through the reconversion of neglected buildings) **and as a location that could welcome varying degrees of construction potential, as well as experimental social and economic innovation** (temporary uses, creative industries, co-working, artist-in-residence programmes and lofts).
Vegetation, or more generally the surfaces intended for greenery, is extremely poor, except for the areas undergoing renovation projects with land-use transformations from commercial to residential.





1 TRAIN STATION
2 SAVENA RIVERSIDE AREA
3 ALCE NERO CAMPUS
4 VACANT AND WILD LAND
5 EUROPA PARK
6 SCHOOL COMPLEX
7 AUDIOVISUAL LIBRARY
8 'ITIS MAJORANA' TECHNICAL SCHOOL
9 BEACH ARENA
10 BOWLING
11 SUPERMARKET
12 GYM
13 'PALASAVENA' SPORT COMPLEX
14 'PRIMO SPORT 0246' PARK
15 'WASTE' MOUNTAIN

A VIA CASELLE
B VIA SPERANZA
C VIA COMMENDA
D VIA CA' RICCHI

STUDY AREA
CITY CENTER
RIVERSIDE PARK
TRAIN STATION
ROAD NETWORK
RAILWAY
SAVENA TORRENT

SIMULATION AREA
PROJECT SITE / AREA OF INTEREST
PUBLIC MOBILITY ROUTE (BUS)
BIKE NETWORK

ENVI-MET SIMULATIONS

A study of the thermal comfort of the area has been prepared using the SPACE modules from ENVI-MET, a holistic three-dimensional non-hydrostatic software that allows one to model the physical and microclimatic behavior of the buildings and open spaces, with applications for urban planning, climate adaptation, comfort, and the health of the people.

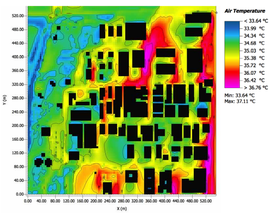
The software allows one to analyze the urban comfort of a certain area linking data that has been extrapolated from a climate analysis of the place with the topographical study of the spaces (which includes the buildings, vegetation, and land-use).

The output results of the ex-ante status are compared to the thermal comfort of the ex-post status, which takes the different design choices into consideration.

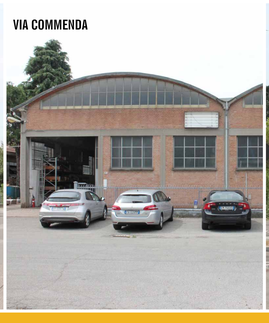
The area of San Lazzaro di Savena presents an extremely dense and compact urban fabric.
If the roads are excluded, there are few public and open spaces of considerable size (the waterproof surfaces make up around 90 percent of the local land); additionally, the presence of numerous trees in the green area along the Savena creek risked disturbing the calculations.

AIR TEMPERATURE / 24.06.2017 - H 14:00

The isolines allow one to understand the distribution of the air temperature in °C, in the open spaces and near buildings, a value that affects the direct thermal exchange between the human body and the environment.
The map shows that the temperature values are between 33°C and 37°C in most open area. The areas in fuchsia represent the areas with a higher temperature that can be considered 'pockets of hot air.'
The west zone has a lower temperature thanks to the 'cooling' effect of the vegetation and the Savena creek.




VIA SPERANZA


VIA COMMENDA


VIA CASELLE


GREEN AREA ALONG THE SAVENA TORRENT

DRIVERS AND NEW FUNCTIONS

SAN LAZZARO LIGHT INDUSTRIAL DISTRICT

STUDY AREA

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