Chapter 45
Urban Sustainable Development in the Mediterranean Area: The Case of Sestri Ponente, Genoa

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Abstract In November 2014 a green *façade* was built in the Sestri Ponente district in Genoa, Italy, on an office building owned by the Istituto Nazionale di Previdenza Sociale (National Institute of Social Insurance). This area, which is characterized by a relatively high population density, faces important environmental issues related to, for example, air pollution, stormwater management, and the urban heat island effect. The Department of Sciences for Architecture at the University of Genoa (Italy) is conducting monitoring activity to evaluate the effectiveness of the green *façade* with regard to summer cooling, winter heating – in collaboration with Research on the Energy System – air quality improvement, and economic and environmental sustainability. Starting from this first pilot project a question arises: what would be the effect of vegetation at the district scale? This article discusses the potentialities for urban sustainable development of the integration of green infrastructure. Simulations carried out with ENVI-Met software demonstrate the potentialities of different amounts of vegetation for urban heat island mitigation. In addition, the possible stormwater runoff reduction was calculated. Such calculations are based on urban design projects developed for the area to evaluate the possible improvement to environmental quality owing to the integration of green infrastructure.

1 Step One: A Green Façade

In November 2014 the first green *façade* was built in the city of Genoa, Italy, on the south *façade* of an office building owned by the Istituto Nazionale di Previdenza Sociale (National Institute of Social Insurance) (INPS) on Ciro Menotti Street, Sestri Ponente district (Fig. 45.1). The project was developed thanks to a

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Fig. 45.1 South façade of INPS building in Genoa Sestri Ponente

collaborative effort between the technical director Enrica Cattaneo and the authors of this chapter. This collaboration between INPS and the Department of Sciences for Architecture at the University of Genoa allows for the setup of monitoring activities that involve Research on the Energy System (RSE SpA, GSE group), Regional Environment Protection Agency of Liguria region (ARPA Liguria), and Prof. Marc Ottelé of the Delft University of Technology (TU-Delft) regarding air quality, energy performance, and citizens' social perceptions.

The commitment to reduce by 3 % per year the energy demand of public buildings (by Law D. Lgs. 102/2014, art. 5) induced INPS Liguria to retrofit some buildings; European funds also made it possible. The Ciro Menotti office building was built in the 1930s with reinforced concrete structure and a light brick envelope (no insulation material). The Sestri Ponente area, which is characterized by a relatively high population density (13,000/km^2), faces important environmental issues related to, for example, air pollution, stormwater management, and the urban heat island effect, owing to urban morphology, vehicular traffic, and lack of green spaces. In addition, with the aim of reducing these environmental imbalances, a green *façade* was built, and monitoring activities to qualify the effects of vegetation on air quality improvement and on microclimate are under development.

The benefits of vegetation in urban areas involve a wide range of scales; some have effects only if a large surface in the same area is greened (with clear results on neighbourhoods or cities), whereas others are directly related to the building microclimate. The benefits on a larger scale are mainly related to improvements in air quality, an increase in biodiversity, and mitigation of the urban heat island effect [1]. Green *façades*, roofs, or a simple placement of trees and shrubs allow for improving the building envelope efficiency, thermal comfort, and visual, aesthetic, and social aspects [2].

As demonstrated by recent studies [3,4], air quality improvements due to vegetation are mainly a result of the absorption of fine dust particles, or particulate matter (PM) and the uptake of gaseous pollutants such as CO_2, NO_2, and SO_2. Carbon dioxide is used by plants for photosynthesis, leading to the creation of oxygen and biomass; in addition, nitrogen and sulphur dioxides are converted into nitrates and sulphates in the plant tissue. The PM, especially the smaller fractions (<10 μm), adhere mainly to the outside of plant parts [3], so vegetation is a perfect anchor for airborne particles at different heights. Dust particles smaller than 2.5 μm are relevant mainly in dense urban areas because they can be inhaled deeply into the respiratory system and cause health issues and damage to human beings [5]. Baik et al. [6] evaluated the positive effects, in terms of air quality improvement, of green roofs by means of a computational fluid dynamics (CFD) model. The results show that vegetation cools the air, improving airflow in urban canyons and allowing a reduction of air pollutants.

Finally, the effects of vegetation in terms of mean radiant and air temperature reduction can be considered [7]. Though trees with wide foliage can provide significant benefits, because of the lack of space in dense urban environments, exploiting building surfaces through the use of green *façades* and roofs can be an interesting strategy.

2 Study Area

Following installation of the green *façade* (Fig. 45.2), the authors considered the possibility of starting a greening process in the area, i.e., finding other possibilities for integrating vegetation. Urban greening should be conceived of as considering different characteristics that make it possible to improve environmental conditions related to air quality, mitigation of the urban heat island effect, and urban environmental aesthetics [8].

The area considered in this study is located in the Sestri Ponente district. This area, which has a relatively high population density, is characterized by a rigid road network with perpendicular paths and by a lack of green areas (Fig. 45.3). The main axis is the aforementioned Ciro Menotti Street, where the green *façade* was installed. The majority of the buildings date back to the late ninth and early tenth centuries. Among the retrofitting measures envisioned, the reconversion of the Sestri Ponente port may be mentioned. This is an industrial port with several defunct buildings and areas, which are not suitable for the current needs of the naval industry.

Fig. 45.2 South façade of INPS building in Genoa Sestri Ponente, June 2015

Fig. 45.3 Area around INPS building in Genoa Sestri Ponente

In 2014 the Piano Ubanistico Comunale (municipality urban plan) was approved. The initiatives expected to be carried out in the area considered are as follows:

– Improvement of the boatyard area, including parts of it into areas more suitable for urban life;
– Requalification of the waterfront and the railroad and train station to favour a connection with the city centre.

3 Vegetation and Urban Regeneration

For the implementation of the Piano Urbanistico and for the improvement of the environmental quality of the district, vegetation can play an important role.

The effects of green areas on microclimate and comfort can be evaluated thanks to the use of environmental modelling. This was conceived with the aim of understanding many current environmental problems; it makes it possible to evaluate the effects of zoning changes (use of territory) on meteorological parameters and on the consequences for quality of life through microclimate models such as ENVI-met is a three-dimensional microclimate model designed to simulate the surface-plant-air interactions in urban environment [7].

ENVI-met models have been used in several studies to evaluate the effects of the characteristics of cities on the microclimate. Krüger et al. [9] observed and estimated relations between urban morphology and changes to microclimate and air quality within a city centre; Fahmy et al. [10] studied the leaf area index (LAI) using an ENVI-met plant database as a platform for a foliage modelling parameter, the leaf area density (LAD). Ali-Toudert and Mayer [11] analyse outdoor thermal comfort on the design of an urban street using the three-dimensional microclimate model made by ENVI-met; they found that vertical profiles and different street orientations have a moderate impact on the air temperature and a strong effect on the heat gained by a human body: the larger the openness of the canyon to the sky, the higher the heat stress. For canyons with a smaller sky view, the orientation is also decisive: east–west (E–W) canyons are the most stressful, and deviating from this orientation ameliorates their thermal conditions. Yang et al. [12] compared field measurements of the thermal behaviour of different types of ground surface and the data obtained with an ENVI-met model. The results show that the ENVI-met model is capable of reasonably modelling the diurnal thermal behaviour of different ground surfaces and their effects on local air temperature and humidity.

An area of approximately 800 m $\times$ 800 m was considered in this study. Climatic data recorded within the city centre were used (available to the public on the regions' Web sites: http://www.cartografiarl.regione.liguria.it/).

Simulations using the ENVI-met software were carried out for the current situation, highlighting overheating problems in the port area, i.e., where there is no vegetation and all surfaces are artificial (e.g., asphalt roads, concrete) (Fig. 45.4).

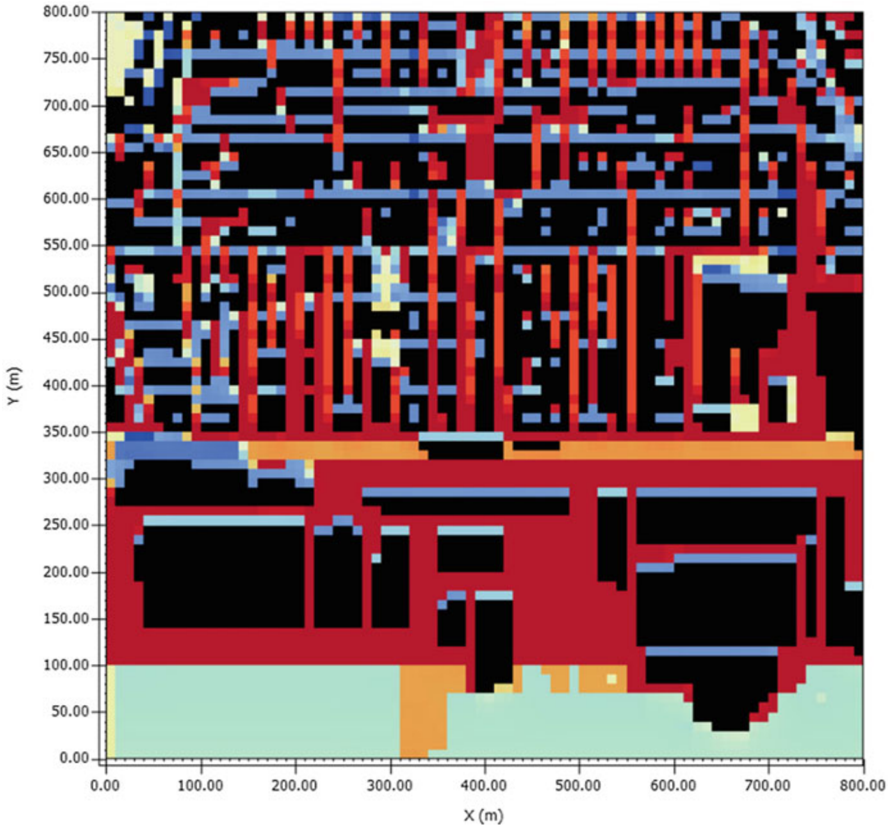

Fig. 45.4 Simulation of superficial temperatures in October, from 22 °C (*blue*) to 35 °C (*red*)

In such areas, despite the presence of water, high mean radiant and air temperatures, and PMV[1] values can be recorded, resulting in discomfort for people. For this reason, the area was selected as the site of development of a project for the integration of vegetation, in compliance with the urban plan, designed for the improvement of environmental quality.

[1] The predicted mean vote (PMV) is a comfort index defined by Fanger in 1970 and mentioned in ISO 7730:2006 ("Ergonomics of the thermal environment—Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria"). PMV takes into account several parameters (e.g., air temperature, mean radiant temperature, wind speed); positive values indicate hot-warm, while negative values cold. According to ISO 7730:2006, PMV values between +0.5 and −0.5 correspond to comfortable thermal conditions.

4 A Master's Thesis for a Retrofitting Project

With the aim of evaluating the effect of greening solutions on the environmental quality of an area, a master's thesis was developed. The requalification strategies assumed include the installation of green roofs and vertical greening systems, green areas on the ground and the replacement of paved surfaces with permeable surfaces.

The design project was based on a gradual implementation strategy, through a step-by-step greening process. The design choices were based on simulation results: situations highlight the most problematic areas with regard to microclimatic conditions (i.e., western area). Vertical greening systems were assumed to be integrated in the narrowest streets, where trees cannot be planted owing to a lack of space. All flat roofs were assumed to be green with intensive or extensive solutions, considering the type of roof structure.

The plant species chosen, *Citrus aurantium* and *Acer*, tolerate air pollution and atmospheric agents and have basic maintenance needs. In general, the plant species choice plays an important role in restoring ecological imbalances of urban areas since vegetation can provide ecosystem services [13]. For this reason native or naturalized plants should be integrated to allow urban parks to have a key role in improving the environmental quality of a district.

Since most of the area (82 %) is characterized by impervious surfaces (asphalt road and buildings), water management problems often arise, with flooding a consequence (even with just an ordinary storm when the sewer system is overloaded). For this reason, where possible, rain gardens for stormwater runoff reduction [14] are assumed. Green roofs can contribute as well [15] and streets can be converted into permeable surfaces to slow down the flow of water that goes directly through the drainage system into rivers.

To verify the effects of the design choices on mean radiant temperature and air temperature (at 1.6 m from ground level) simulations with ENVI-met software were carried out. Such simulations show a temperature reduction due to vegetation also in the most problematic area (Fig. 45.5).

5 Conclusions

A progressive greening, according to the design project (unfortunately just a teaching simulation), could lead to an improvement in air quality that is currently difficult to quantify. Some other evaluations were done with regard to urban heat island effect mitigation and runoff reduction.

While air temperature cannot be significantly reduced without large trees, the design choices assumed allow for a relevant reduction in mean radiant temperatures, which plays a key role in improving summer comfort conditions (Fig. 45.5).

Considering the final step of the assumed greening process, i.e., when all the roofs are green (115,061 m^2) and more than 20,000 m^2 of asphalt surfaces have

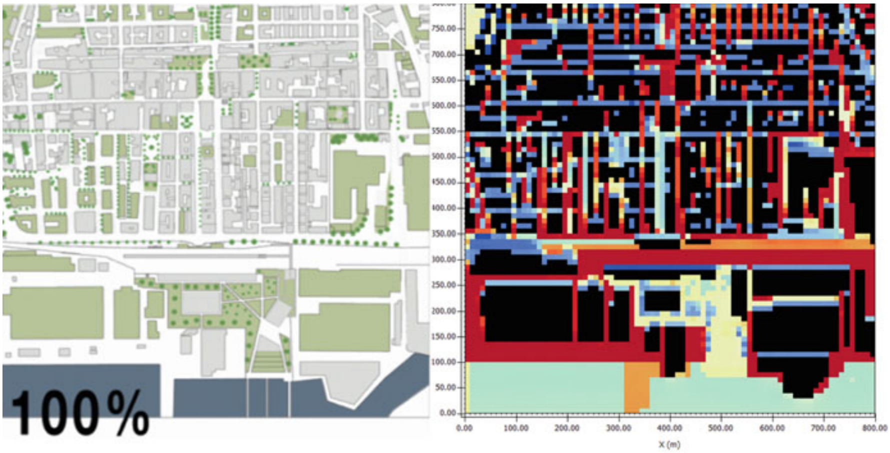

Fig. 45.5 Simulation of superficial temperatures in October with greening project completed

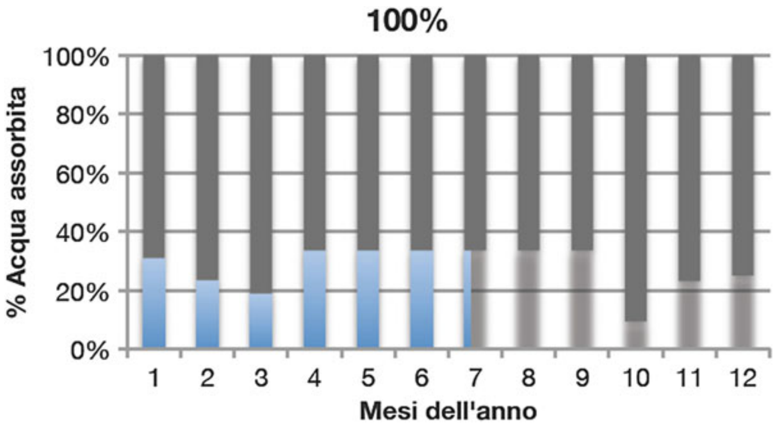

Fig. 45.6 Percentage of rainfall adsorbed with greening project completed

been converted into permeable surfaces, a reduction in stormwater runoff within a range of 10 % (during fall) to 30 % was calculated (Fig. 45.6) depending on the rainfall.

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