5.3.5 Mitigation of and adaptation to UHI phenomena: the Padua case study

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Introduction

The test developed by the Veneto Region and by the working group of the IUAV University of Venice as part of the European project "UHI - *Development and application of mitigation and adaptation strategies and measures for counteracting the global Urban Heat Islands phenomenon*" is based on the territorial peculiarities of the Veneto region's lowlands, mostly characterized by small sized historical centers and the widespread settlements that have developed around them over the last forty years.

This urbanization occurred without strategies or rules as a summation of individual initiatives that amalgamated residential forms and functions with large thoroughfares, as well as production and commercial areas (Selicato, Rotondo, 2003).

In some ways, this process broke the environmental balance of the medieval towns (which were designed keeping in mind local microclimate regulation) often creating an artificial barrier around them, suffocating them, and contributing greatly to raise the amount of impermeable surfaces to the detriment of permeable ones. In recent years, the relationship between urban planning and architecture paid a price for the rigidity dictated by Local Strategic Plans conforming to homogeneous and repetitive rules rather than adapting to the peculiarities of the various land areas (Samonà, 1980). As a result, we are dealing with areas that are already rigid and intensely anthropized, with a paucity of characterizing settlements, whose development in the near future may be expected to involve mostly the transformation of the existing tissues. Our test focused on the connection between local climate, urban structure and the emergence of the urban heat island effect, with the purpose of providing land management guidelines for the near future (Musco *et. al.*, 2014). Within this framework, we singled out a section of Padua's metropolitan area for analysis and planning, with the intent of applying the results of our tests to the rest of Veneto's central area. Often, the cause for urban heat islands are specific factors (such as large paved areas), which are directly connected to widespread systemic factors (such as the nocturnal dispersion of the heat absorbed by peripheral urban tissues, or pollution from production areas, again located in the suburbs). Such a plurality of causes leads to studying heat islands from different points of view, which are both horizontal and vertical.

Oke's model (2006) approaches this phenomenon by analyzing different urban climate scales, where diverse climate events occur that influence each other:

- Horizontal scale: Microscale, Local scale and Mesoscale;
- Vertical scale (according to different UHI types): *Air* UHI (*Urban Canopy Layer* UCL, and *Urban Boundary Layer* UBL), *Surface* UHI, and *Subsurface* UHI.

The *Urban Boundary Layer* (UBL) encompasses the urban cover layer above the average height of buildings, whereas the *Urban Canopy Layer* (UCL), encompasses the urban cover layer below the average height of buildings. After considering the goals of our projects, namely to analyze the causes of this phenomenon at the microscale level with the intent of coming up with accurate mitigation measures, we proceeded by considering the heat island on the vertical scale encompassed between ground level and the average height of buildings, that is, in the *Urban Canopy Layer*.

This microscale level can help verify the relationship between urban form, roofing materials and UHI, with particular reference to the vegetative cover, soil permeability and albedo of materials. Within this context, the following factors influence microclimate at different urban scales in a significant way: orientation of buildings, surface covering, Sky View Factor (SVF), solar incidence, materials used, and shape of buildings. For example, where building facades are too close to each other, temperatures are affected by the SVF, i.e., they heat up more than other facades located on more open and ventilated roads (which are perhaps no more than thirty or forty yards away).

A recent study shows how urban microclimate affects the functions of buildings in terms of thermal performance, proving that urban form has an effect on the UHI phenomenon (Wong and Chen, 2009). Speaking specifically of Italian cities, heat islands are not caused by the anthropogenic heat produced by human activities, but rather by the heat stored by urban surfaces (buildings, roads, parking lots) during the day and then released gradually at night. This effect generates a nocturnal heat island, insofar as the heat released does not allow the city to cool down as much as the rural environments external to it.

The complexity of the UHI phenomenon is directly related to the relationship between city and atmosphere; urban climate and atmospheric climate affect and influence each other (Oke, 2006b).

Usually, the aspects that influence climate, generating an urban microclimate that is different from the climate of the atmosphere, (Shahmohamadi, 2012) are the following:

- amount of grass, permeable soil, trees, asphalt, and concrete;
- artificial heat released from buildings, air-conditioning systems, cars, and production areas;
- surface water storage and lamination in favor of underground canals and drains;
- air pollution;
- urban ventilation.

Urban heat islands arise from extensive anthropization, or rather, it could be said that the fewer the ecological properties of a city, the greater its heat island will be. It is no coincidence that this effect had already been observed by meteorologist Luke Howard for the first time in 1818, in London, at the height of that city's expansion. At the time, it was not identified as a heat island[1]; the term "island" was coined when isotherms were used to map the city. When air temperatures are mapped through isotherms, the city appears like an island compared to the surrounding rural areas, which are differentiated by lower temperatures. On these bases, we started our project by studying the different behaviors of the urban heat island of pilot experiment city Padua vis-à-vis its different urban contexts. We chose this area also taking into account our purpose of drafting an urban planning manual for the Veneto Region to be delivered to municipal administrations in order to support their future strategic choices in terms of mitigating the UHI phenomenon and adapting vulnerable urban areas to climate changes. Therefore, we picked this area for our study also because it conforms to the urban and spatial characteristics of other cities and areas of the Veneto region.

To conduct urban heat island effect analyses and surveys, we then went on to selecting five pilot areas in the municipality of Padua, based on their location with respect to a survey transect crossing the city along the north-west/ south-east axis and the intrinsic features of their settlement structure. These features are the following (Fig. 5.3.5.1):

Area 1, a dense urban area located inside the medieval historical center;
Area 2, a mixed-use area, ranging from a major river to a large parking lot;
Area 3, a “high density” residential area built in the 60/70s;
Area 4, a “low density” residential area, also built in the 60/70s, located in the first outer ring of the city and consisting of free-standing 1-2 storey buildings;
Area 5, a production area located outside the municipality of Padua.

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[1] The term “urban heat island” was coined in 1958 by Gordon Manley in an essay found in the *Quarterly Journal of the Royal Meteorology Society*

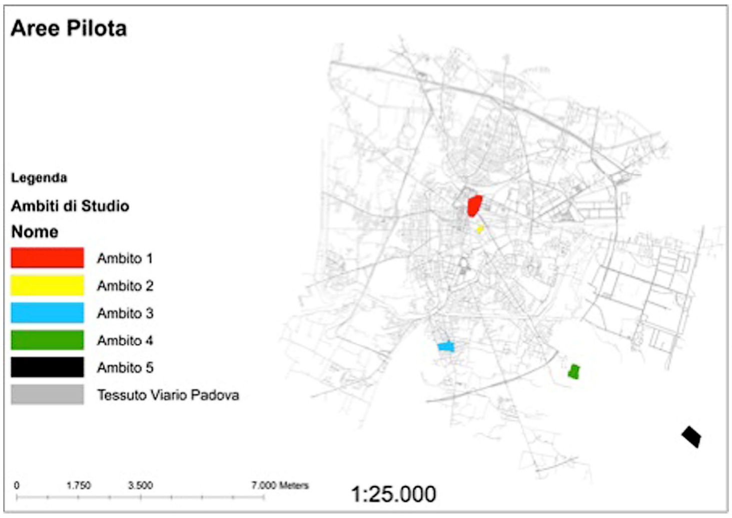

Fig. 5.3.5.1

Analysis methods: traditional surveys and remote sensing

The first part of our project concerned the implementation of an efficient urban heat island study method. We focused our attention right away on producing an urban planning manual that could be used by other municipal administrations. With this in mind, we sought to adopt simple but effective methods. An ideal process of analysis would require atmospheric temperature readings throughout the urban environment.

Temperature is an important descriptor of UHI behavior; unfortunately however, detectors often are not spread evenly through the urban environment. In Italian cities, the location of temperature and humidity detection devices is often organized around the monitoring of pollution rather than the microclimate. Due to this lack of information, it was not possible to build a homogenous framework capable of bringing out the causes of urban overheating for the various scales. In addition, some land management data usually available to public administrations do not consider the variables used to identify this phenomenon. As part of our project, the University of Padua research unit measured urban environment atmospheric heat, working to determine the heat island within the city by paying specific attention to the five selected areas described above (Fig. 5.3.5.2).

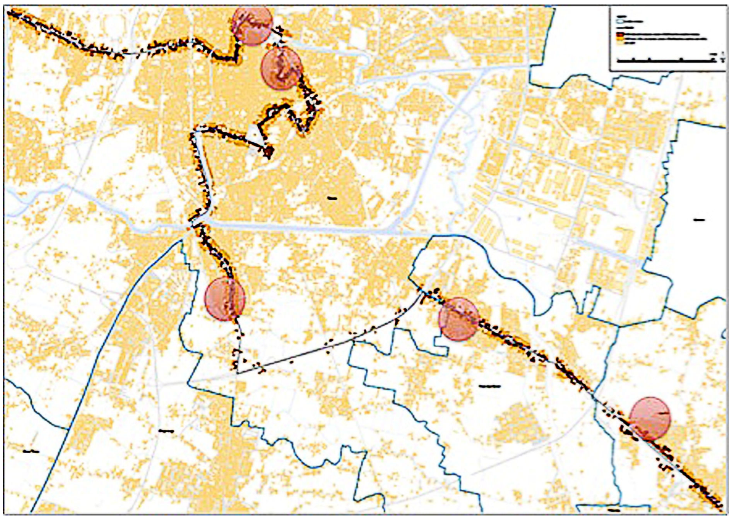

Fig. 5.3.5.2

The picture that emerged from our analysis revealed a significant difference in nocturnal temperature between the urban area and the rural area peripheral to the city. A nocturnal heat island that becomes more intense as dawn approaches is already a strong indicator of the causes of urban overheating, mainly due to its morphology and surface types.

Scientific literature (Oke 1982, Santamouris 2005) states that heat islands are caused by anthropogenic factors when developing gradually from late afternoon to night time (namely, resulting from human activities), whereas if they are detected during the night, their formation factors are dependent on the ratio between permeable and impermeable surfaces, materials used and urban ventilation (Papadopoulos, 2001).

It was therefore clear from the outset that our analyses and possible strategies should address built-up areas rather than the human activities in and around them.

Our analysis of the existing urban fabric followed the guidelines of the Technical University of Vienna, which has proposed a number of indicators for weighing and quantifying the various UHI production factors (Tab. 5.3.5.1).

Proposed variables for the specification of an urban unit of observation (U2O)

DOCUMENT WP5-UHI-01_112012

WP 5, authors: A. Mahdavi, K. Kiesel, M. Vuckovic (November 5th, 2012)

Geometric properties	Symbol	Unit	Range	Definition
Sky View Factor	ψ_{sky}	-	0-1	Mean value of the fraction of sky hemisphere visible from ground level
Aspect ratio	H/W	-	0-3+	Mean height-to-width ratio of street canyons, consider length of streets as a weighting factor
Built area fraction	A_b/A_{tot} A_b : building plan area [m^2] A_{tot} : total ground area [m^2]	-	0-1	Ratio of building plan area to total ground area; fraction of ground surface with building cover
Unbuilt area fraction	$1- A_b/A_{tot}$	-	0-1	Ratio of unbuilt plan area to total ground area; fraction of ground surface without building cover
Impervious surface fraction	A_i	-	0-1	Ratio of unbuilt impervious plan area (paved, sealed) to total ground area
Pervious surface fraction	$A_p = (A_e + A_g + A_{H2O})$	-	0-1	Ratio of unbuilt impervious plan area (bare soil, green, water) to total ground area
	A_e : earth	-	0-1	Bare soil area
	A_g : green	-	0-1	Green area
	A_{H2O} : water	-	0-1	Water bodies area
Mean building compactness	l_c $l_c = V_b / A_b$ [m^3/m^2] V_b : built volume [m^3]	m	-	Ratio of built volume (above terrain) to total building plan area
Built surface fraction	A_s/A_b A_s : total built surface area [m^2]	-	>1	Ratio of total built surface area (above terrain) of buildings (walls and roofs) to total built area
	A_W/A_b A_W : total wall area [m^2]	-	>1	Walls
	A_R/A_b $A_R = (A_{R,i} + A_{R,p})$ A_R : total roof area [m^2]	-	~1	Roofs
	$A_{R,i}/A_b$ $A_{R,i}$: total impervious roof area [m^2]	-	~1	Impervious roofs
	$A_{R,p}/A_b$ $A_{R,p}$: total pervious roof area [m^2]	-	~1	Pervious roofs
Mean sea level	h_{sl}	m	-	Average height above sea level

Surface/material properties	Symbol	Unit	Range	Definition
Reflectance/albedo	ρ_{sw}	-	0-1	Mean value of albedo (shortwave)
Thermal conductivity	$\lambda = (\lambda_i + \lambda_p)$	$W \cdot m^{-1} \cdot K^{-1}$	>0	The property of a material's ability to conduct heat
	λ_i : impervious surface	$W \cdot m^{-1} \cdot K^{-1}$	>0	Thermal conductivity of impervious surfaces
	λ_p : pervious surface	$W \cdot m^{-1} \cdot K^{-1}$	>0	Thermal conductivity of pervious surfaces
Specific heat capacity	$c = (c_i + c_p)$	$J \cdot kg^{-1} \cdot K^{-1}$	>0	The amount of heat required to change a unit mass of a material by one degree in temperature
	c_i : impervious surface	$J \cdot kg^{-1} \cdot K^{-1}$	>0	Specific heat capacity of impervious surfaces
	c_p : pervious surface	$J \cdot kg^{-1} \cdot K^{-1}$	>0	Specific heat capacity of pervious surfaces
Density	$\rho = (\rho_i + \rho_p)$	$kg \cdot m^{-3}$	>0	The mass density of a material is its mass per unit volume
	ρ_i : impervious surface	$kg \cdot m^{-3}$	>0	The mass density of impervious surfaces
	ρ_p : pervious surface	$kg \cdot m^{-3}$	>0	The mass density of pervious surfaces
Anthropogenic heat output	Q_F	$W \cdot m^{-2}$	>0	Mean annual heat flux density from fuel combustion and human activity (traffic, industry, heating and cooling of buildings, etc.)

Main references:

Mahdavi, A., Kiesel, K., Vuckovic M., 2013. *A framework for the evaluation of urban heat island mitigation measures*. SB13 Conference, Munich, Germany (to be published)

Stewart I. D., Oke T. R. 2012. *Local climate zones for urban temperature studies*. Bulletin of the American Meteorological Society

Unger J., Savic S., Gal T. 2011. *Modeling of the Annual Mean Urban Heat Island Pattern for Planning of Representative Urban Climate Station Network*. Advances in Meteorology, 2011, p. 1-9

Hens H., 2007. *Building Physics – Heat, Air, Moisture*. Ernst & Sohn, Berlin

Tab. 5.3.5.1

We quantified these indexes and compared them to our temperature readings to obtain cogent results that would approximate the real state of things. Thanks to this approach we were able to evaluate the various urban microclimates of the selected areas and single out incidence factors.

For example, the first area that we analyzed showed that heat island production factors are mostly ascribable to the low ratio between permeable - impermeable surfaces and the sky view factor, whereas the fourth area (which we later picked as final pilot area) showed that heat production is mostly ascribable to the type of materials used for buildings. Therefore, it seems obvious that mitigation strategies (and the urban planning tools for implementing project interventions) must be different for the two areas in question.

In order to ensure and maintain the high effectiveness of the proposed interventions and solutions, it is essential that the different overheating causes and issues of each area be carefully identified so as to come up with site-specific strategies. The necessary information for evaluating (and then monitoring) the resilience of an urban area to heat waves were the following:

Paved surface areas;
Permeable surface areas;
Built up surface;
Sky View Factor (SVF);
Urban compactness;
Solar incidence;
Reflectance/albedo of materials;
Thermal conductivity of materials;

Due to the great number of details provided by all this information, we had to come up with an appropriate data collection method for our analysis. Two alternative methods were used; one was a traditional analysis on the field that classified ground covering and building types as well as the height of buildings, the other used remote sensing and three-dimensional data processing from LiDAR[2] and very high resolution orthophotos.

The traditional method allowed us to map the urban tissue and determine the types of materials of all the surfaces, as well as their thermal properties. This activity required a lot of time, spent mainly on the field, but yielded a complete and current set of facts for the area.

The remote sensing method required less time to collect the data and yielded useful information to describe and map the phenomenon. Depending on the infor-

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2 Il LiDAR (Laser Imaging Detection and Ranging) performs remote sensing to determine the distance of an object or surface through the emission of high frequency laser pulses by a flying sensor (plane or drone). The distance of an object is given by the length of time elapsed between emission and reception. Very high frequency pulses bouncing from objects or the ground are converted into georeferenced and dimensioned points, thus giving rise to a "point cloud" from which the exact reconstruction of an area can be created in the form of three-dimensional digital models.

mation, computers and technology available to individual local administrations, this method could be applied easily and quickly to the whole of the Veneto region.

Remote sensing analyses require LiDAR data and high resolution orthophotos (0.2-0.5 m per pixel), preferably including the infrared band, for the entire administrative area.

For each selected area, this methodology allowed us to find out the sqm of vegetation (divided by height), the ratio between permeable and impermeable surface, the incident solar irradiation, and the sky view factor (P. Berdahl, Bretz., 1997). Technically, the analysis involved the creation of three-dimensional digital models of the terrain, DSM (Digital Surface Models) and DTM (Digital Terrain Models), which made it possible to identify and inventory the composition of urban surfaces. By adding the DEM (Digital Elevation Models) obtained by processing the LiDAR data with the multispectral orthophotos, we also got to an automatic breakdown of the horizontal surfaces of the city by type and height, resulting in an atlas of surfaces composed of green spaces, with their respective heights, and impermeable spaces (buildings, roads, parking lots).

Next, we used software like *LAStools*, *Saga Gis* and *eCognition* to produce sky view factor and solar irradiation maps, which most importantly provide essential information to determine the specific areas that require intervention, in addition to which interventions should be performed to mitigate the UHI phenomenon and adapt the urban environment to climate changes.

The key strength of these innovative analysis techniques is that they can be replicated over very extensive urban areas, whose level of detail would require months to obtain with traditional topographical detection methods. However, we must realize that not all areas are equipped with LiDAR or similar detection devices, which means this methodology is still used in limited areas despite the fact that it is innovative and efficient.

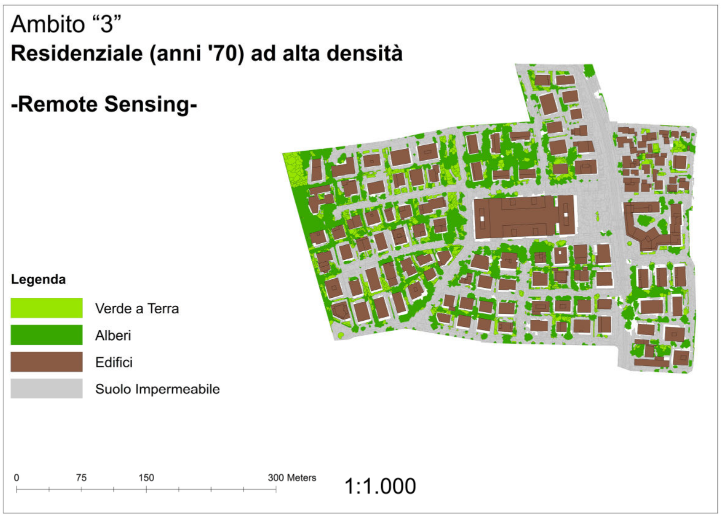
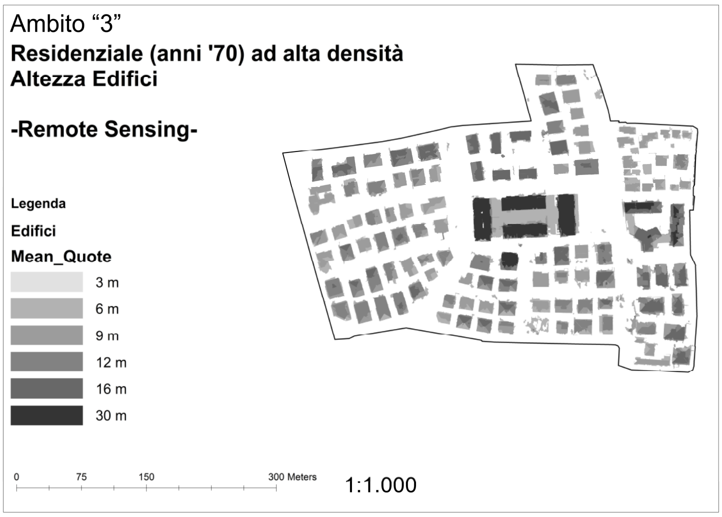


Fig. 5.3.5.3



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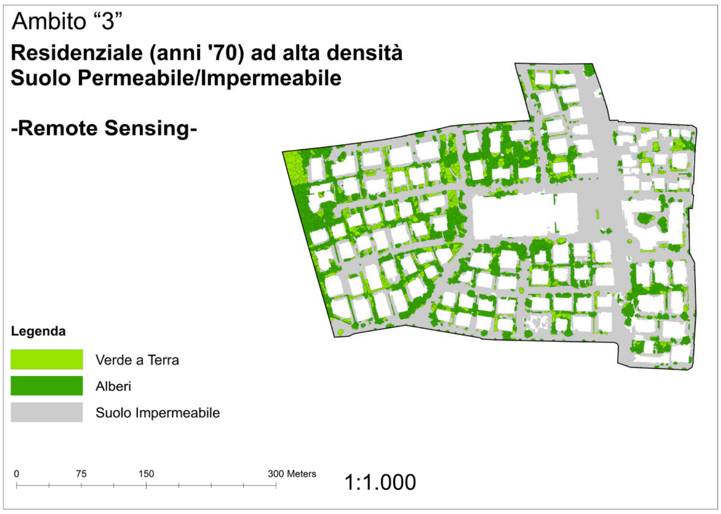

Fig. 5.3.5.5

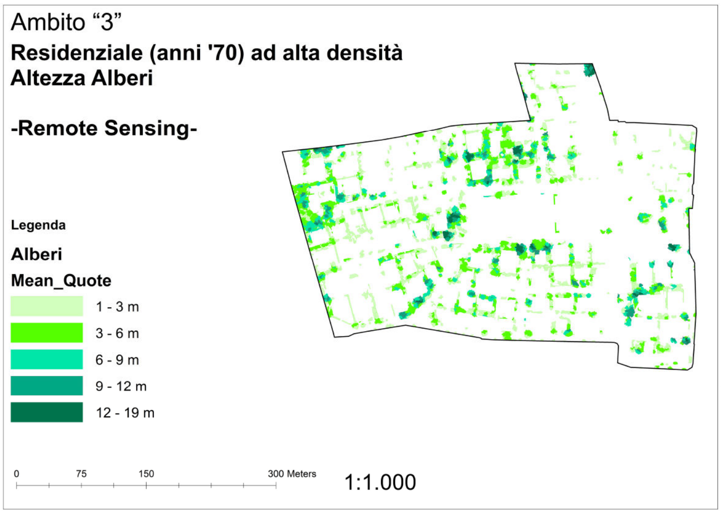

Fig. 5.3.5.6

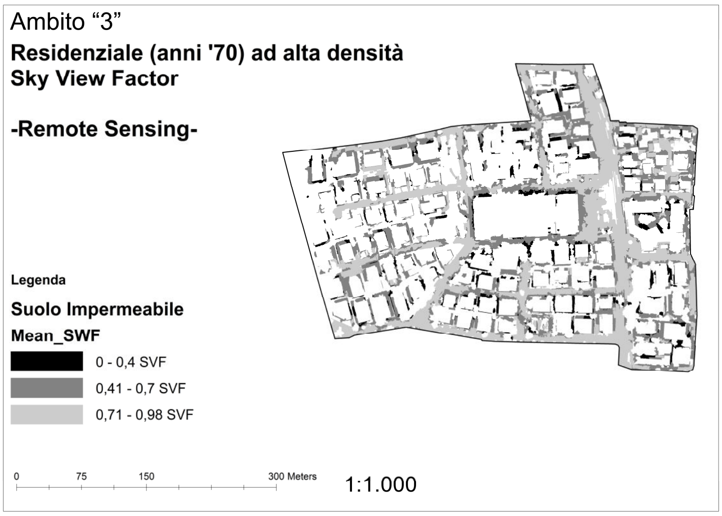

Fig. 5.3.5.7

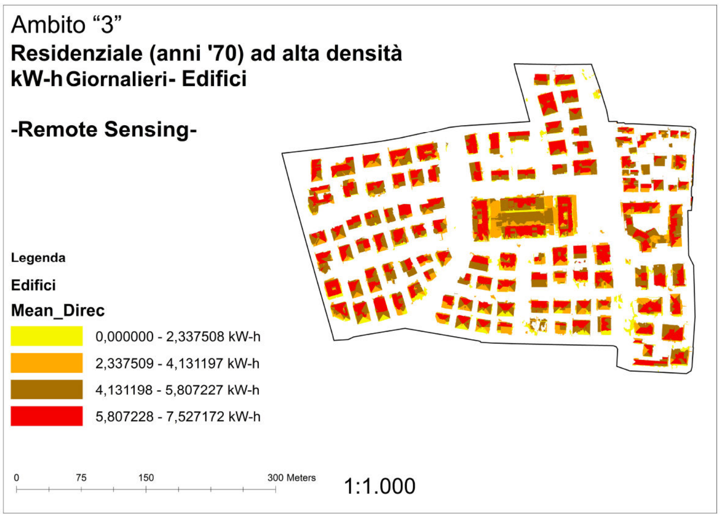

Fig. 5.3.5.8

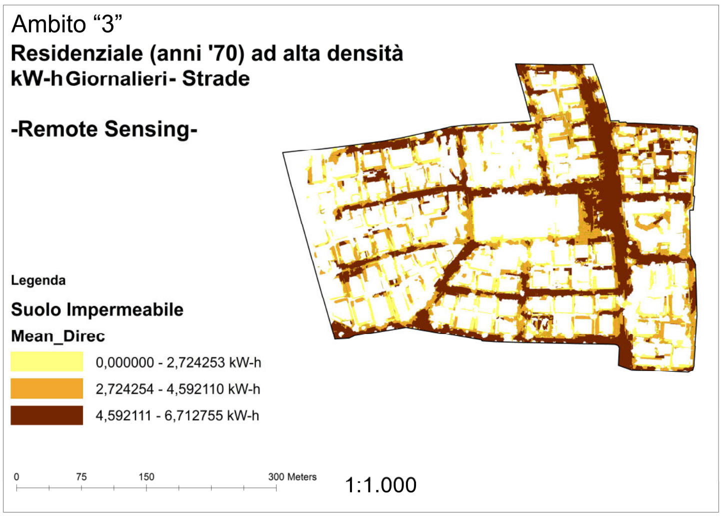

Fig. 5.3.5.9

The collected information, converted into vector format, can be queried using height and covering type data. Breaking down the city in all its three dimensions, we can identify the areas that are most vulnerable to heat waves, and also adapt portions of the city to the extreme weather phenomena, suggesting some possible strategies to achieve that goal. So as to test and evaluate the efficacy of the interventions, we then proceeded to build four different transformation scenarios of the area under study.

The four scenarios, and their specific interventions, which resulted from the integration of accurate temperature readings and the indicators research, were then processed using the *ENVI-met* software, which simulates air temperature changes based on the physical changes proposed within a selected area. It can therefore verify and indicate mitigation strategies for the UHI phenomenon by showing the results of the proposed interventions. For example, this simulator can show what benefits would be derived from adding trees to an actual area or modifying the albedo of some of its surfaces. *ENVI-met* can not only verify the effectiveness of an intervention but also the optimal location for its application.

Feasibility study

After processing the data pertaining to the areas inside the survey transept, it became necessary to understand what mitigation and adaptation interventions should be considered based on the morphological aspects of this specific neighborhood of the city of Padua, including buildings, outdoor public spaces, and private spaces.

The integration of these sets of interventions produced the "transformation scenarios" that were later tested for effectiveness with the *ENVI-met* software.

Through this process, we initiated an actual project for the pilot area, by adapting to it specific mitigation measures that until then had been generic proposals for other areas. As a result of the preliminary project test performed inside the pilot area, we came up with four different project scenarios as follows:

"green ground": **a scenario where the permeable surface of the area is increased (from 18% to 23%) by turning a paved parking lot into a grass surface and planting 10 m tall trees along the main roads of the area;**

"cool pavements": **substituting the traditional paving material (0.2 albedo) and concrete (0.4 albedo) used on streets and sidewalks with high albedo (0.5) "cool" materials;**

"cool roofs": **substituting the traditional tile or covered flat roofs with "cool" materials (0.3 to 0.6 albedo);**

"green ground + cool pavements": **a scenario that adopts both these mitigation interventions simultaneously.**

The precision of the digital terrain model, obtained through the use of *LiDAR* and orthophotos data, made it possible to increase the number of details with which to perform the effectiveness measuring simulations in terms of temperature reduction, using the various mitigation interventions considered for each of the four scenarios.

The subsequently performed simulations allowed us to close the working cycle through the virtual testing of the interventions under consideration, thereby assessing the best strategies for the pilot area.

The fourth scenario, *"green ground + cool pavements",* tested with the *ENVI-met* software, provided the best results from the point of view of temperature reduction. Based on this, we used this scenario for our project.

The pilot area as testing ground for the Veneto Region

The scenario we selected for the pilot area is aimed at increasing resilience to negative externalities caused by climate variability. This urban green infrastructure plan becomes a driving force for the adaptation of urban and regional systems to climate changes.

A network of natural and semi-natural areas has a good ability to make the land more resilient; if well designed, green infrastructure can mitigate the effects of floods and the increasing droughts, improve water and air quality, effectively promote soil protection, and oppose hydrogeological instability. In addition, it ensures air filtration, erosion protection, water flows regulation, coastal protection, soil structure maintenance, and carbon storage.

The multiple benefits of green infrastructure are also set forth in the European strategy for green infrastructure published last year (EU, 2013). For example, trees and green areas may prevent flooding in cities while reducing air pollution and noise levels. Furthermore, the use of natural systems can often be cheaper and more durable than a hard artificial structure.

However, we have yet to understand how to apply these changes to a real area. Veneto's central area, having been greatly transformed over the last 40 years, mostly through a series of small spread out interventions, requires a specific design approach. By the same talking, the pilot area transformation project produced by our feasibility study can be implemented through small interventions that will be made presumably over a period of about twenty years.

Our project and its graphical representations provide a potential scenario that can presumable be striven for. Its mitigation measures against the heat island effect can be effectively used in the first place through the adoption of appropriate land and urban management and planning tools that can implement the new adaptation priorities arising from climate changes.

Based on this, in order to make our mitigation measures as applicable as possible, our work group performed a survey of the existing land management and planning tools, linking each measure to a potentially modifiable planning tool (Tab. 5.3.5.2).

GROUND SURFACES	**Intervention**	**Main regulating body**	**Tool (for urban planning or managment)**	**Indication type**	**Notes**
Management of the Reflectance and Emissivity of impermeable surfaces for public and private spaces	1) Pigmentation type 2) Material type	Municipal Administrations	Municipal urban plan (the name will change according to the specific regional legislation)	Indications on the surfaces of each ordinary transformation area	The pigmentation of existing pavements should be modified gradually. New surfaces should employ materials that combine greater reflectance and a low impermeabilization rate.
			Ordinary and extraordinary maintenance plan	Reflectance parameters of existing surfaces	
			Infrastructure plan	Reflectance parameters of new infrastructure surfaces	
			Building regulation	Reflectance parameters of surfaces of new private and public buildings	

Tab. 5.3.5.2 Ordinary urban planning and management tools: possible UHI moderation interventions. Source: *IUAV data processing, 2014*

Possible transformations of the pilot area

The possible transformations/interventions proposed below refer to the previously analyzed *"green ground + cool pavements"* scenario. We took the basic pattern used for *ENVI-met* modeling and came up with a number of potential transformations for the pilot area.

These possible interventions are not part of a single urban planning project, but they are structured rather as small interventions to be implemented through the use of the urban planning tools analyzed above (see table 3).

It should be noted that the proposed interventions can be effective on their own in mitigating the heat island effect; however, more specifics are needed on the areas they are going to be applied to, so as to make effective and cost effective decisions. Maximum effectiveness can be reached when all of these interventions together become part of a general strategy of adaptation to climate changes combined with the more important urban and/or socio-economic concerns of a given area.

Intervention 0 actual conditions + summary of intervention 0 actual conditions

Outdoor public spaces

Fig. 5.3.5.10 Intervention 1 + summary of intervention 1.
Modify the albedo of streets. Modify the reflectance of the road surface

The first intervention posits an increase in the reflectance of the road surface. This can be done by means of several types of materials. Two technical options may be considered: the more immediate one would be acting on the pavement's coloration/pigmentation, the other would involve a more structured approach of asphalt type modification. This type of intervention can be planned on a municipal scale over a set period of time, for example, the years it would take to pave everything over and remanufacture some types of streets signs. For the sake of economic sustainability, it would make sense to prioritize such interventions by area with the aid of specific maps. For larger cities, the mapping process can be integrated with urban heat studies, using direct readings or indirect photogrammetric data processing. Municipalities that do not have access to complex analyses of urban heating phenomena can prioritize their most densely occupied areas, and also apply the indexes suggested by the University of Vienna for this specific project.

Fig. 5.3.5.11 Intervention 2 + summary of intervention 2.
Modify the albedo of sidewalks and parking lots. Modify the reflectance of sidewalks and parking lots

The second intervention also concerns the reflectance of impermeabilized urban surfaces; however, in this case, the spaces considered - sidewalks, parking lots, and city squares - do not involve car traffic. These surfaces, like the ones we just discussed, need to be approached according to a set of urban planning priorities. Modifications will necessitate the application of street furniture programs that will include reflectance limits to the repaving of city squares and sidewalks. For the application of this intervention inside the pilot area, we considered also parking lots and street side parking areas, which are normally paved, and which will have to be handled using a different approach, like more permeable materials for improved absorption of rainwater.

Fig. 5.3.5.12 Intervention 3 + summary of intervention 3.
Add green areas on the ground of public spaces in addition to public trees

Public green spaces: create new traffic islands and plant new trees.

The third intervention focuses on increasing public green spaces. Here too, we are not talking about great new parks or large green areas; these are micro interventions that can be applied in a city with a consolidated infrastructure. Practically speaking, it is about creating new traffic islands and planting new trees. These interventions necessitate an innovative approach based on a new public space management vision. At present, for most Italian cities to add new trees and traffic islands in urban areas where everything has already been built could involve an increase in maintenance costs and a loss of needed urban space (for car, bicycle, and pedestrian traffic, parking, etc.). This is why this new approach would have to be adopted as part of a strategic paradigm shift in the general management of city spaces. Creating new green spaces inside the context of a built up city entails changing one's perception of street space as just for transit, parking, and car maneuvering. A new paradigm for the use of public green spaces requires a strategic rethinking of urban greenery, insofar as what it can offer in terms of the urban ecosystem adapting to climate changes. Going down this road means understanding and valuing the gamut of services that green spaces can offer to mitigate the heat island effect in addition to other negative externalities due to weather phenomena: lamination for the containment of water during extended rainfall, reducing air pollution, helping to reduce the speed of urban traffic, and even a general improvement in the environmental and aesthetic quality of public spaces. New traffic islands were added inside the pilot area along the streets whose width could reasonably be reduced or that could be switched from two-way to one-way traffic. We also added a green area on a space used as a square along Via Guizza.

Private Outdoor Spaces

The management of private outdoor spaces is also a major factor in determining the occurrence and intensity of urban heat islands. Depending on the type of settlement, a significant portion of Veneto's cities that is not covered by buildings is private property; in the case of Padua's pilot area, private property covers more than 1\3 of the total surface.

It is obvious that the management of these surfaces is greatly relevant to the mitigation of the heat island effect. However, in this case, even a simple technical solution (increasing the green surface and the reflectance of impermeable surfaces) must be justified at the management and legislative level; a cogent response is necessarily based on a general strategic vision that can harmonize individual management needs with the understanding of the importance of adapting to climate changes. Private outdoor spaces can easily be handled when it comes to new buildings, where building codes can set new extension and surface type parameters, but they require a much more thorough consideration for consolidated urban areas, as is the case of the pilot area, since it is more difficult to find legislative levers or incentives to modify already built property.

In these cases, implementation can be achieved through the following:

- come up with education programs for the city's inhabitants, so that the more sensitive section of them may be stimulated into performing ordinary maintenance of their private spaces;
- coordinate with the water department to establish incentive policies where bill payments reflect how much of a property is impermeabilized.

Within the pilot area, we proposed to modify only the reflectivity of the private surfaces currently impermeabilized by asphalt, concrete or the like with intervention 4, whereas with intervention 5 we proposed to replace them with greenery.

Fig. 5.3.5.13 Intervention 4 + summary of intervention 4. Albedo on private paved surfaces. Modify the reflectance on private surfaces

Fig. 5.3.5.14 Intervention 5 + summary of intervention 5. Put greenery on private surfaces Add green areas on private surfaces

Post-scenario intervention

The last project intervention on the pilot area takes a step beyond the interventions encompassed by the feasibility study, proposing a more incisive transformation that involves buildings as well.

This intervention pictures a gradual transformation of the roofs of private buildings, first by modifying the reflectance of flat surfaces and then by turning them into green roofs. A real expansion of green roofs can only occur if our cities will understand and assess their value in terms of the services that they can offer to the community: mitigation of the heat island effect, lamination of rainwater, improvement of air quality, and last but not least, recreational use.

This final scenario is not meant to offer a new utopian vision of what a city should be like, but it is rather an attempt to propose the application of solutions that would adapt the current state of affairs to a no longer so remote future of rapid climate changes.

To increase concretely the resilience of our urban system to climate changes, such as in the case of heat island mitigation demonstrated by this project, we must utilize several approaches: in-depth climate evolution studies on the regional and local scale, the use of climate modeling, the use of new technologies as a support for urban planning, the research of new building materials, the revision of the urban governance system, and above all the creation of a new strategy to review and harmonize all the aspects of the matter.

Fig. 5.3.5.15 Intervention 6 + summary of intervention 6. Green roofs: extra scenario intervention

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