ENVIRONMENTAL ASSESSMENT METHOD FOR DECARBONISED URBAN RENEWAL

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Abstract

Realising urban transformation towards sustainability and low carbon future can be easily pursued in new cities and new urban development, nonetheless the historical and established high density cities and the ancient built environment will require a substantial different types of intervention, in order to achieve reductions in GHG, to mitigate UHI effects and, consequently, to provide outdoor comfort for people.

Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be played by bioclimatic design and passive systems to be applied for spaces between buildings and at a precinct scale for creating low carbon, resilient cities.

Structural elements, finishing materials and green design play a significant role in improving outdoor comfort for people and in reducing urban environment carbon footprint as a whole in historical settlements.

The paper addresses the needs to analyse and intervene in historic districts renewal and in other consolidated public spaces, whose requirements represent one of the greatest sustainability challenge today, in order to overcome the lack of appropriate assessment tools with which to accomplish that assignment. This paper provides a qualitative and quantitative assessment method to improve sustainability in public spaces, in order also to enhance outdoor comfort, by outlining a designing approach for rehabilitation of urban built areas. Authors aim at providing a scientific method that integrates the needs of preservation of urban public spaces thanks to climate sensitive urban design, through bioclimatic design techniques and passive solutions, with support of those will enhance urban retrofitting strategies, focusing on human comfort.

1 The drive towards a low carbon awareness in urban area

Covering just 3% of Earth's surface but housing more than half of its population, cities account for 70% of global energy demands.

An increase in significant city-wide actions across all action areas demonstrates that cities are learning from their own experiences, as well as those of other cities which actions to implement, how to implement them, and where to allocate capital resources to convey the greatest benefits.

One of the most crucial issue to address is to analyse and intervene in historic districts renewal and in other consolidated public spaces, whose requirements represent one of the greatest sustainability challenge today, in order to overcome the lack of appropriate assessment tools with which to accomplish that assignment. Taking climate action is also fuelling the expanding green economy, creating new jobs, developing skills, and bringing economic advantages for city residents across the world. This is why cities can play a crucial role in ensuring a climate safe and a low carbon future.

Cities have proven themselves fervent and capable in their approaches to tackling climate change and delivering local action that contributes to national and global climate targets, both in case of new neighbourhood development and in case of urban renewal.

In that sense Climate Sensitive Urban Design CSUD aims at providing a healthy, comfortable urban environment that meets the dwellers' requirements, making buildings and open spaces climate-change resilient, ensuring an efficient use of energy and resources, to get to a complete life cycle assessment for buildings materials and components selection, thanks to passive and bioclimatic architecture principles.

These targets mean low carbon design, energy footprint awareness, carbon footprint and environmental labels for every kind of measures and initiative taken to reduce the severity of climate change or their exposure to the effects of climatic alteration inside the cities.

1.1 City renewal overview and open issues

Although questions remain about how exactly GHG emissions should be attributed geographically, most of the world's GHG emissions are ultimately attributable to cities, which are centres of economic activity.

Cities are responsible for two-thirds of global energy consumption, and this proportion is expected to grow further (IEA 2008). Although cities' ambition to scale up decarbonising measurements is reflected in their increasing allocation of staff-time and monetary resources to build efficiency in responding climate challenges, even a Climate Sensitive Urban Redesign could be extremely successful and money saving though. Climate Sensitive Urban Design is an integrative act, that depends on an extensive understanding of environmental issues, possibilities and consequences of developing different possible scenarios.

Implementing resource efficiency and climate sensitivity in existing urban environment requires a factual integration of highly complex urban conditions. Planning processes for resource-efficient and climate-sensitive neighbourhood or urban design leads to a process of decarbonizing neighbourhoods and cities.

Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be played by bioclimatic design and passive systems to be applied for spaces between buildings and at a precinct scale, with the intention of creating low carbon, resilient cities. Structural elements, finishing materials and green design play a significant role in improving outdoor comfort for people and in reducing urban environment carbon footprint as a whole in historical settlements.

A climate sensitive approach should consider the city itself as a decarbonizing lever. In that sense, a proper passive and bioclimatic design, along with specific revamping or retrofit actions for open spaces, offer a special opportunity to achieve the goal of a sustainable and low carbon city. The most challenging aspect is that the growing attention to the energy saving issues has thus crossed the traditional boundaries that just considers the building envelope, shifting the focus towards the definitions of some specific parameters and index to be translated to the scale of the urban space, public ones and transition places.

The increasing attention to the quality of the building environment and the comfort of architectural spaces has led to the adaption of some of the existing evaluation procedure in order to assess the overall outdoor conditions for users. One of the starting points is to consider that the city itself could be able to create a general condition of comfort and well being and, consequently, leads towards a reduction of GHGs emissions, thanks to many factors. The city itself is actually a dynamic resource for the enhancement and mitigation of daylight performance, temperature-humidity conditions, noise and air quality, since the city itself contains most of the elements that can generate and mitigate the climatic and microclimatic conditions.

This means that, going beyond mitigation, each urban environment, highly or lowly density built up, can adapt itself to the effects of climate chance, by scaling up different scale solutions. This paper aims at demonstration that a low carbon and climate-based approach can be very effective in reaching these targets.

Merging together qualitative and quantitative assessment methods can evidently improve sustainability in public spaces, in order also to enhance outdoor comfort, by outlining a designing approach for rehabilitation of urban built areas. Quantitative assessment passes by wind distribution, in order to evaluate the strongest wind direction, its velocity and wind air temperature. Afterward the sun path related to the specific location has to be assessed to evaluate which day is the most sunlit and which one has the longest day.

1.1.1 Levers and measures

Climate action can range in size and targets from relatively small and targeted initiatives to a large scale and citywide programme. City related initiatives to reduce carbon emissions in order to achieve a low carbon outdoor environment do not have to exhaust municipalities' resources, since city authorities can deliver actions and solutions on a variety of budgets. In moderate climate zones it is actually possible to modify the microclimate with simple strategies such as installing windbreaks and shadings, or at least providing radiation-attenuating devices. Urban forms can also modify the climate of a city and differentiate it from the climate of the surrounding rural areas.

The nature and scale of climate action vary across different sectors. This paper would mainly focus on climate-based, climate sensitive and cost effective measures to be applied on outdoor spaces like squares, public gardens and transition places inside the historical cities, where other measure could otherwise be expensive and too disruptive. Although cities' ambition to scale up decarbonising measurements is reflected in their increasing allocation of staff-time and monetary resources to build efficiency in responding climate challenges, even a Climate Sensitive Urban Redesign could be extremely successful and money saving though.

Several parameters have been demonstrated to be effective in reducing temperature and GHG emission, tackle climate change, by playing on: Topography and elevation; Ground Cover and Vegetation; Wind distribution among buildings and roads; presence of Green Mass; presence of Water bodies; Urban geometry (orientation of the streets and urban form) and Albedo values.

In case of urban renewal, regrettably, there is no inclusive set of guidelines or literature case for moderate climate zones and, even the well-known theories of Givoni (1998) or Emmanuel (2005), do not pay sufficient attention to moderate climate zone.

By contrast, this paper will be focused on Climate Sensitive Urban Design for urban renewal also in order to develop a climate-conscious and energy-efficient design, both at the building and urban scale, by stating a range of key parameters related to passive design and bioclimatic principles that affect the urban microclimate and recommendations for an urban design renewal, which provides outdoor comfort conditions for pedestrians both in summer and winter, reducing energy demands inside buildings, involving green masses, water bodies and finishing materials to control the UHI effect.

2 Vision, principles and key aspects to define a guideline for decarbonized urban renewal

A proper microclimatic assessment can be also used in case of urban renewal, in order to provide useful tips to support architects, designers and to intervene correctly. Even a sun shadow map can play a crucial role in order to point out the overcast areas or sunlit zones, clearly stating where to provide permeable and low albedo values materials, or where to design canopies to protect from overheating situations.

Since 2012 we are trying to assess a valuable design strategies to intervene in case or urban renewal inside the urban dense texture, during multiple university classes; the goal is trying to define a passive and effective qualitative and quantitative approach for resource-efficient and Climate Sensitive Urban Design.

2.1 Qualitative and quantitative assessment

For each assessment step students are asked to identify the most likely dangerous or harmful conditions in order to provide proper solutions: starting from collecting the local weather data, thanks to graphic and geometric evaluation of Urban Form & Building porosity, passing through the investigation of the dose of sunlight penetration in urban canyon, moving to Wind distribution analysis, towards the exploration of urban finishing materials, by appraising albedo values both for horizontal and normal finishing building materials.

Table 1 Assessment phases

Assessment Phase Number	Assessment Target	Objectives and action category
1	Urban form	A: Building porosity and streets geometry
2	Solar radiation	B: Sun light penetration and sun path, shadows map
3	Ventilation	C: Wind distribution
4	Vegetation and albedo	D: Finishing material properties and green canopies
		E: Water mass and evaporative cooling
5	Mitigation measures	F: Re-performing the general evaluation assessment

All these geometric and simplified data should give also evidence of the presence of green masses, water masses and other urban elements that can affect the urban microclimate.

Analysis of the prevailing wind direction is the further step in order to evaluate mitigation measures to avoid noisy wind or in order to provide natural ventilation where needed.

Eventually, shadows and sunlight hours distribution as well as related shadows overlapping maps complete the general assessing procedure. In that specific case we usually propose 4 thresholds data to perform calculation: on December 21st, at dawn, at sunset, in two intermediate thresholds (12:00 pm and 15 pm); on June 21st at dawn, at sunset, in two intermediate thresholds (11:00 pm and 16 pm); on the warmest day, at dawn, at sunset and in two intermediate thresholds (11:00 pm and 16 pm); on the coldest day at dawn, at sunset and in two intermediate thresholds (11:00 pm and 16 pm).

In order to provide all these data we suggest using the interactive 3D sun path diagram in Autodesk Revit, Vasari, Ecotect or Google SketchUp, in order to visualize shadows based on the sun's position.

Students are usually asked to resume the most interesting values assessed during the evaluation phase and they are invited to proposing some mitigation actions, corrective measures or any retrofit design solutions to reduce thermal loads and, consequently, CO_2 emissions.

That procedure has been proposed to several master class students and has been performed for moderate climate zone, in numerous northern dense and historical cities in Italy, in dense urban texture in Barcelona, in Paris and in the historic district in Cracow.

For the research purpose, the design of buildings looking towards the evaluated urban portion (walkable streets, squares and transition places) has intentionally been avoided in detailed consideration, because the research focuses on landscaping and outdoor urban environment features, in order to control and achieve a decarbonizing set of measures for the dense city.

2.1.1 Comparing the effectiveness of each measure for different urban environment and microclimatic zones

With regards to the first target "Building porosity and Streets geometry", different assessments carried out during the last 4 years with students' class have demonstrated a low efficacy in reducing carbon emission, considering that modifying the urban street geometry in consolidated urban environment is almost unbearable, both for physical and legislative constraints.

Even tough a rough qualitative assessment of urban porosity can be effective in identifying several measures, valuable for changing horizontal and vertical surfaces materials (albedo value, porosity of materials).

With regards to the second target "Solar Radiation" and its action category "Sun light penetration and sun path, shadows map", many studies demonstrated the significance of these types of evaluation, in order to identify the outdoor areas always lit or under lit, all year round.

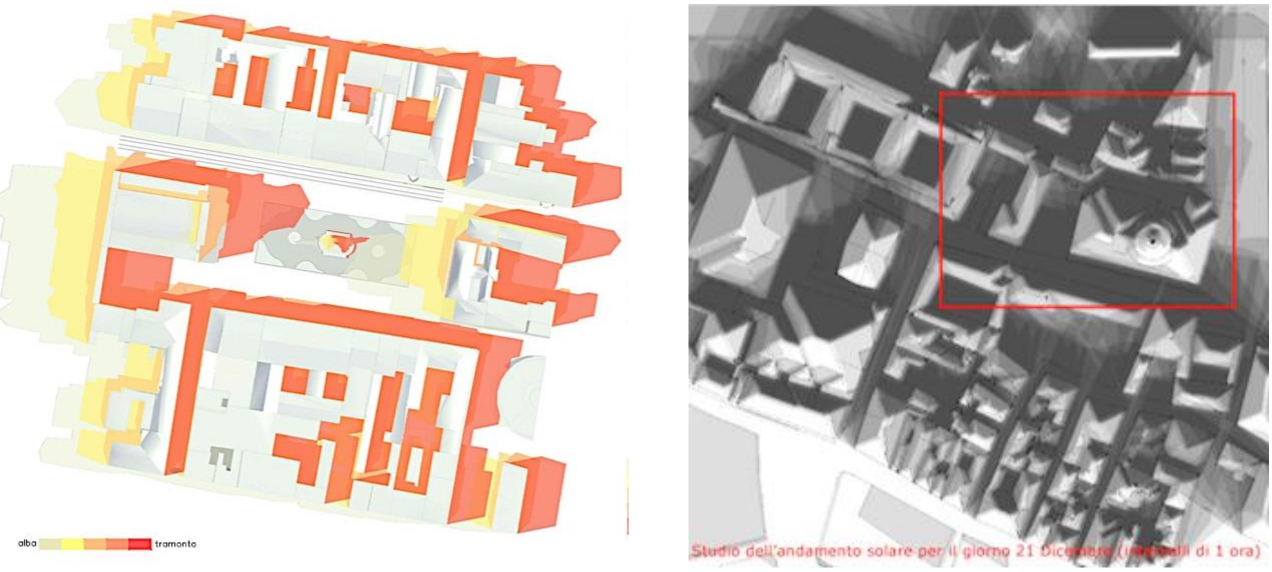

Figure 1 Sun shadows map distribution in La Spezia and in Mantua.

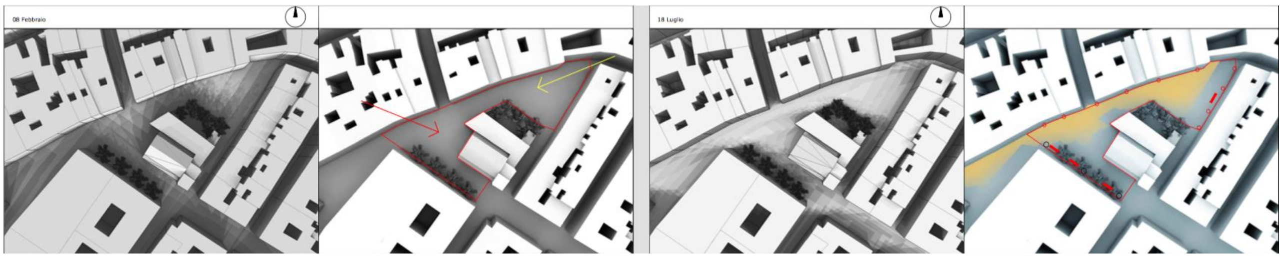

Figure 2 Sun shadow maps for 4 thresholds, with annotation of over lit and under lit zones and wind distribution, in Piazza della Pomposa, Modena.

Starting from these investigations, is now feasible to provide different types of canopies and awnings to shade over lit areas, to provide protected areas for summer times, reducing the heat loads and diminishing the UHI effect. Subsequently, students have been asked to suggest different types of shading solutions, like in the images 3 and 4.

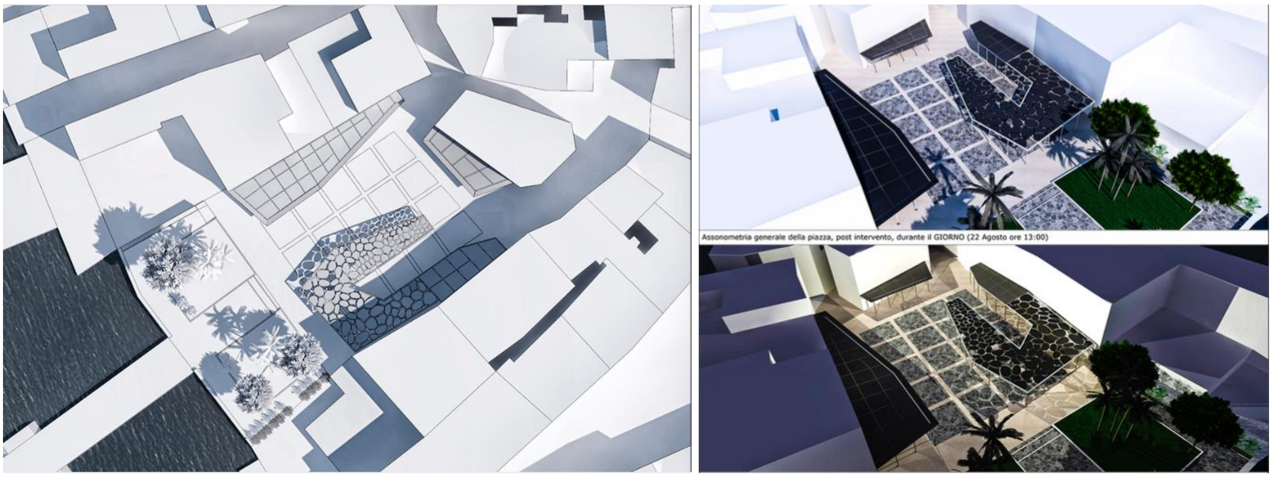

Figure 3 Shadows map for Sirmione, overlooking the Lake Garda and some mitigation measures to avoid overheating effect on the ground, thanks to different types of canopies.

Referring to the subsequent target “Ventilation” and related “Wind Distribution”, a qualitative and quantitative evaluation can be obtained by juxtaposing the wind distribution map to the assessed urban portion, both considering the wind velocity and the wind temperature, in order to establish when and where the air flow can be positively used to reduce thermal loads, or when it can be used in enhancing outdoor thermal comfort for urban dwellers, according to the Lawson’s criteria and other wind charts.

The air circulation is moreover essential in mitigation of extremely high temperatures, due to the ability of the wind to transfer cool air from vegetated or low-density areas in the direction of urban cores, pushing the hot air in the centre upwards.

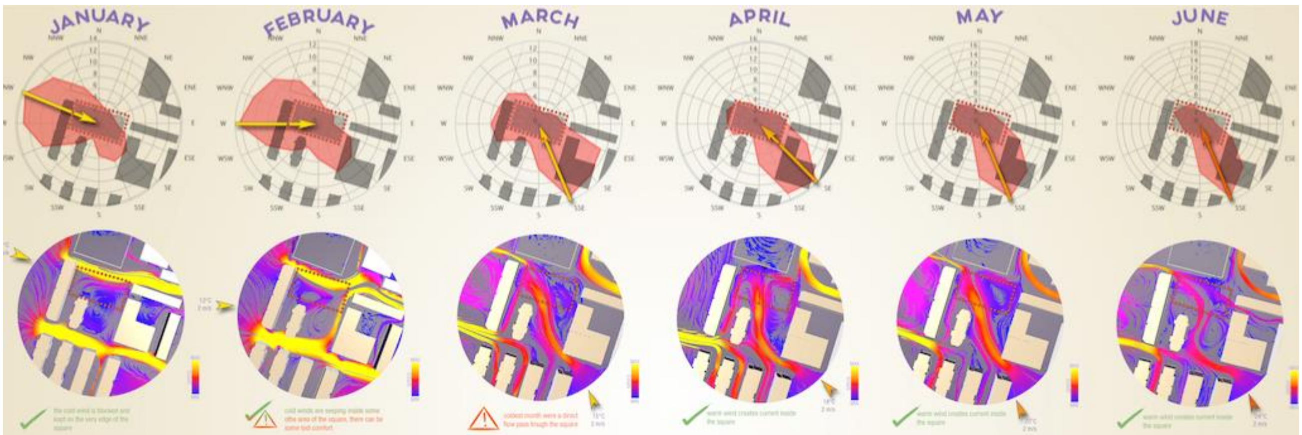

Figure 4 Wind distribution maps in Plaça de José Sánchez Rios, Barcelona.

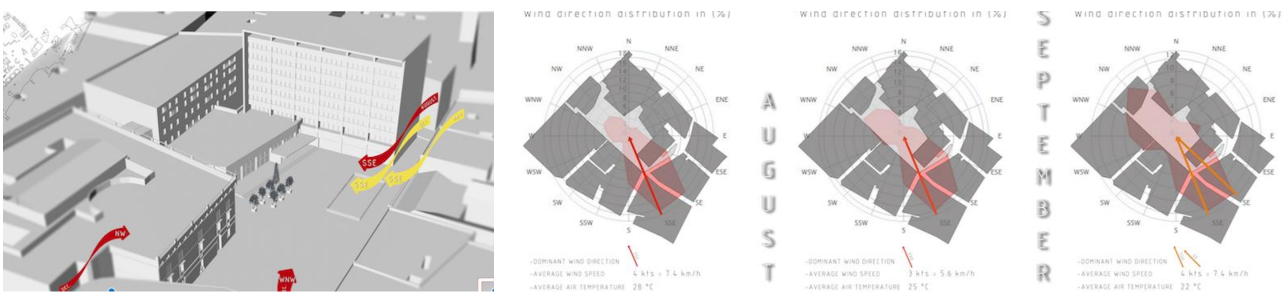

Figure 5 Axonometric view and wind distribution maps and to indicate canyon effects in Plaça de Sant Miguel Barcelona, during summer months.

Furthermore, the criteria “Finishing material properties and Green Canopies” can be carried out using aerial pictures in order to identify the most common albedo values, both for horizontal and vertical finishing materials.

A valuable measure to lower urban temperatures pursued by most authors (Givoni 1998; Emmanuel 2005; Gartland 2008) is therefore changing the albedo value, the surface reflectance of the entire system. This implies that dark -low albedo- surfaces should be replaced by light -high albedo- surfaces whenever possible, so that less solar radiation is absorbed and thus the surface temperatures kept at the minimum.

Although the notion of albedo seems to be overstressed lately, it is widely believed that a higher surface reflectance affects the total energy balance of an outdoor urban square, thus lowering the UHI effect, this is why we tried to propose some mitigation measures to control the heat distribution.

The affectivity of the albedo value in densely built-up urban areas is sometimes questionable, also due to the fact that in urban area, a huge part of the reflected rays hits walls of adjacent buildings and thus only a small amount of the solar radiation impacting on walls and streets is reflected upward. Most of the radiation is thus absorbed in the walls of the buildings, regardless of the colour and it is stored as heat and released back into the atmosphere later, causing the UHI effect (Givoni 1998).

Albedo value and cooling effect by vegetation is not only effective in lowering the temperature in the immediacy, but it is also effective in reducing the heat loads on building facades, adding more thermal loads inside the buildings and getting more HAVC, producing, as the final result, a considerable amount of CO_2 emission.

Other effective strategy can be found in the cooling effect of vegetation, in many case much higher in comparison with the effect of reflectance, as many students’ studied case have proved, especially in highly density cities.

Figure 6 Albedo values overview for vertical and horizontal surfaces in Plaça de José Sánchez Rios, Barcelona.

For the reasons above, green masses should also have a higher priority in designing of surfaces rather than creating light and reflective surfaces, as well as green belt can play the crucial role of wind barrier and urban shelterbelts or evaporative cooling zone, in order to avoid the so called “canyon effect”.

3 Conclusions of “research by design”

The research strictly focuses on defining an expeditious method that both involve qualitative evaluations and quantitative design instruments in order to define some corrective measures to be applied in renewal urban areas in order to get a decarbonized urban environment.

The campaign has been conducted since 2012, involving master degree students in Architecture, whose targets were to investigate the actual microclimatic conditions in several cities in Italy and in Europe, for a gross amount of 106 study cases.

Table 2 Case studies overview

Cities	Number of study case	Action category involved	Most Appropriate Action category	Most Effective Mitigation Strategies
Parma (IT)	17 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Reggio Emilia (IT)	11 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Modena (IT)	4 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Mantua (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Piacenza (IT)	3 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Modena (IT)	4 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Brescia (IT)	2 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Milan (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Bologna (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Cremona (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
LaSpezia (IT)	3 squares	1-2-3-4-5	A; B; C; D; E;	C; D; E
Massa (IT)	1 square	1-2-3-4-5	A; B; C; D; E;	C; D; E
Rome (IT)	1 square	1-2-3-4-5	A; B; C; D; E;	C; D; E
Southern Italy (IT)	8 cities	1-2-3-4-5	A; B; C; D; E;	C; D; E
Barcelona (ES)	5 squares	2-3-4-5	A; B; D; E;	B; C; D; E
Cracow (PL)	3 squares	2-3-4-5	A; B; C; D;	B; C; D
Paris (FR)	1 square	2-3-4-5	A; B; C; D;	B; C; D

Implementing resource efficiency and climate sensitivity in existing urban environment requires a factual integration of highly complex urban conditions that need to be merged to legislative and historical constraints. Planning processes for resource-efficient and climate-sensitive neighbourhood or urban design have been demonstrated viable, in case of dense cities and neighbourhood, by intervening on a microclimatic scale, assessing firstly the local microclimate and then considering the elements that can be easily added or modified, as green belts, shelters for sun shading and surface materials to be changed, without altering the overall aspect of the city itself. As reported in the 4th and 5th columns, every microclimatic conditions and topographic features lead to different approaches or strategies to be adopted.

Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be thus played by bioclimatic design and passive systems to get to a low carbon, resilient cities, without altering the established city’s layout.

All these results aim at demonstrating that monetary resources can be valuable to build efficiency in responding climate challenges, but even a climate sensitive urban redesign could be extremely successful and money saving though, considering, for the first time the city itself as a decarbonizing lever.

The design approach hereby proposed can be considered as an alternative scenario in order to improve microclimatic urban condition thanks to an Environmental Assessment Method For Decarbonised Urban Renewal, by promoting all form of passive natural devices, by increasing permeable surfaces or by modifying the albedo values of finishing materials used and, eventually, improving natural cooling and minimising unwelcome solar heat gains.

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