Chapter 22
Shading Architectures—Bioclimatic Approach to "Well Tempered" Civic Spaces

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Abstract In relation to the growing impact of urban heat island, thermal well-being in outdoor spaces becomes a relatively new environmental problem architectural designers have to take in charge. Bioclimatic approach to architecture can give a substantial contribution to achieve liveable conditions in outdoor spaces as well as to maintain multi sensorial comfort conditions, sustain natural rhythms, and stimulate human senses. Adaptive approach to thermal comfort in inner spaces—recently adopted by UE—is opening the road to more sensitive comfort approaches also for outdoor spaces. Green structures contribute to mitigate urban microclimates through a multi scale "climate control strategies": shading, air temperature reduction, setting off and canalising cold breezes. Architects have now a responsibility to develop bioclimatic-based design to promote mutual support among natural and social communities of living beings as a tool for co-existence and progress. A toolbox can supply architects a basic knowledge on green systems morphology and metabolism in order to develop sensibility and bioclimatic design capability by shaping accordingly the green/built environment since the preliminary design phases. Basic knowledge of such a toolbox are: bioclimatic urban and building design tools; morphology, metabolism and sociology of green systems; building physics; principles of urban climatology; sensorial experiences, and evaluation of comfort conditions in outdoor spaces.

Keywords Shading architecture · Bioclimatic approach · "well-tempered" outdoor spaces

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22.1 Introduction: Environmental Crisis and Ecological Regeneration

Trans-scalar design, realisation and maintenance of built contexts had in the past very low sensibility and evaluation of their environmental fallouts. Global urbanisation has exerted enormous impacts on ecosystem matrixes (bio diversity, ground, water, air, agriculture, energy), causing the current crisis, which has brought to high risk the environmental balance of many ecosystems and of a large part of mankind in the planet.

Nowadays, architecture has to take in charge complex environmental problems, which were not considered in its modern and contemporary programmes, developed within the "without limits growth" paradigm (Scudo 2009). Nevertheless, some very important pioneer contributions have been done since the half of the XIX century such as:

- the British utopians—More, Swift, Morris[1]—and the anarchist movements (Kropotkin 1973), (Bookchin 1974) to be reread in the context of Italian contemporary environmental debates (Bottero 2005);
- the Anglo Saxon Bioregionalism contribution—Munford, Geddes, Berg and others—to be reread within the framework of the 'Italian territorial' school (Magnaghi 2010, 2011; Fanfani and Saragoza 2011)

In the context of the current global climate crisis mitigations and adaptations policies, promoted by international Institutions (UN COP 21, Paris 2015 9), European Union Environmental Energy Directives, National and Local Government Policies, environmental citizen associations, aim mainly to improve materials and energy efficiency to reduce environmental pressure. Only recently, efficiency begin to be structurally associated to 'sufficiency'[2] and 'inclusive wellbeing'.[3]

22.2 Adaptation and Inclusive Thermal Comfort in Outdoor Spaces

Inclusive comfort processes, based also on a 'sufficiency' concept, affect all environmental regeneration aspects of human settlements, with special attention to outdoor spaces (streets, squares, courts, parks) which are the new, old rooted places to meet and aggregate (Consonni 2000).

Multi-cultural aggregation policies, design and management of urban landscapes contribute to the wellbeing in outdoor spaces through various strategies: soft mobility, presence of water bodies, urban furniture's, and green structures (Cooper Moore 1984), which play a very important role, largely undervalued so far.

22.3 Shading Architecture

Bioclimatic performance is a characteristic of site-specific architecture projects. It can be evaluated using the concept of 'shading architecture' following nature and life rhythms (day/night; winter/summer) within ecosystem coevolution (Magnaghi 2010), as the opposite to 'zero shading' architecture, which follows global growth commercial rhythms: night/day, summer/winter according to market demand.

Shading architecture is a structural aspect of the bioclimatic approach, which "takes shape" from site topography, anisotropic field of local microclimatic forces (solar and thermal radiation, air and radiant temperature, wind, relative humidity) ground and vegetation, along with historical tradition and demand of inclusive housing in comfortable environment with high level of vitality (defined as a performance indication of liveability).

22.4 Vitality, Consonance and Thermal Comfort

Lynch defines vitality through three levels of performance: sustenance, security, consonance (Lynch 1990).

The first two are predictable (even if urban security in general—including health—is still an open problem, at least in the Italian context). The consonance is linked to its field of actions: maintain multi sensorial comfort conditions, sustain natural rhythms, stimulate senses.

In shading architecture, consonance performance concerns environmental comfort in a trans-scalar continuum from a room to outdoor spaces.

The adaptive approach to thermal comfort in indoor spaces—recently adopted by UE—is opening the road to more sensitive comfort approaches also for outdoor spaces.

The adaptive model, which proposes a positive correlation of summer indoor comfort temperature in a given day to the average outdoor temperature in the previous weeks, allows for designing buildings with lower energy use when compared to a restrictive interpretation and application of statistic models, such as Fanger's. (Pagliano and Zangheri 2010). Furthermore, thermal (and environmental) comfort in outdoor spaces is much more influenced by behavioural and psychological aspects.

In outdoor spaces, human behaviour is more variable and random than in indoor spaces, and expectations to change comfort conditions can play an important role. As an example, if I am walking in a sunny street in midday summer and I see a green structure non far away, I feel better: my thermal balance did not change, but the view of a green structure anticipates the cool sensation I will have in a short time. Since our thermal sensors are not distance receptor, we have to rely on other senses (in this case, seeing) to give us comfort clues in advance.

22.5 Green Structures as Bio-Climatically Sustainable Matrixes in Outdoor Spaces

To be environmentally efficient, 'sufficient' and 'inclusive', green structures must involve all spatial scales, from "room" to townscape, and be organised as matrixes of different types: linear green networks for "sweet" mobility (cyclist and pedestrians lanes), connecting extended green outdoor spaces (squares, parks, courts) to multi-functional agricultural and forestry landscapes (regional and national parks).

Particularly, agricultural landscapes must have a new life as "common goods", facilitating public access without disturbing their activities and economy.

To reach this ambitious aim, it is important to implement various strategies such as: "political measures to set up green matrixes; curbing the tendency to escape from congested cities to apparently more rural hinterland; providing multi-functional green structures as integrated and inclusive character of any urban community".[4]

In this renewed continuity and symbiosis of green structures with the urban environment, a new aspect needs to be evaluated besides the functional performance: the multi sensorial perception, which stimulates "environmental pleasure" as a sophisticate ecological value (Pallasma 2007).

"There is an extra delight in the delicious comfort of a balmy spring day as I walk beneath a row of trees and sense the alternating warmth and coolness of sun and shade".[5]

Green structures contribute to mitigate urban microclimates and heat island through a multi scale "climatic service" from interior spaces, to buildings, neighbourhood, city, landscape. Efficiency of air temperature mitigation can be in the order of 3–6 °C at the urban landscape scale (great urban parks, e.g., Tier Gartner in Berlin, or regional agricultural parks, e.g. South Milano Park), and in the order of 1–3 °C at local scale (local and" pocket" parks, street, squares, courts, green walls and roofs).

Green urban structures deeply modify local microclimates (or "Local Climatic Zones" defined by Oke) and give a substantial contribution to reduce thermal stress in open spaces through the following strategies:

- shading: foliage and canopy shade solar radiation, producing different intensity shaded zones as a function of form and density of foliage;

At mid-latitudes (35–50° lat. North), it is always convenient the use of deciduous trees which have genetically a seasonal bioclimatic behaviour, shading in summer and allowing partial solar radiation transmission through skeleton in winter (in the range of 40–80%).[6]

Deciduous shrubs, shading opaque and transparent building facades give an important bioclimatic contribution to radiation and heat control.

- air temperature reduction is produced by the effect of vegetation shading and by the effect of evaporation and transpiration from leaves, branches and ground. Evaporation process cools the air near the foliage by the mechanism of heat absorption in the phase change water/vapour process.

A big tree (i.e., a 25/30-m-high beech with a foliage surface of around 7000 sm.) evaporate about 400 water litres per day, resulting in a cooling effect similar to that of 18 small domestic air conditioning. Cooled air effect is close to canopy and is dispersed by air movements. Therefore, evaporative cooling effect by trees is function of trees concentration, mainly if they are planted at two levels of height (oasis effect).

- cool green surfaces; leaves temperature is usually equal, or a little less than, the air temperature; hence, the temperature of foliage exposed to solar radiation is generally much lower than that of irradiated mineralized surfaces (asphalt, grey stone, bricks). Vegetated green surfaces (green walls and pavements, trees) constitute, therefore, a relatively "cool sink" (about 1–2 °C less than air temperature).
- Breezes generated by the effect of temperature difference between vegetated cool areas and mineralized hot zones can be set off in winter and canalise in summer with respect to buildings, neighbourhood, and urban layout. Convective breezes can be induced in green street and places, in neighbourhood parks, in urban greenbelt.[7]

In addition to the impact on microclimate and comfort, green structures have several other important environmental functions:

Reduction of air particulate and gas pollution; shelter belt (protective plantation screens); protection against radioactivity; promotion of urban ventilation and protection by winds, noise reduction, oxygen release, and the above mentioned "consonance" linked to physical and mental health.[8]

22.6 Basic Knowledge and "Tool Box" to Preliminary Design of Green Structures Integrated to the Built Environment

The large contribution of green systems to microclimatic control and thermal comfort in outdoor spaces, in the context of the global climate crisis, calls for architects' responsibility to develop ecologically based design. This will promote "mutual support among natural communities of living beings as tool for co-existence and progress"[9] and equip themselves with a "tool box" to design integrated green systems as a contribution to the ecological regeneration of built environment.

The toolbox has to supply architects with the basic knowledge on green systems morphology and metabolism and to develop sensibility and capability to give bioclimatic shapes to the new green/built environment metabolism in the preliminary design phase.

The "tool box" has to support designers with:

A. Knowledge and practice of the bioclimatic approach to 'civic architecture urban networks' (Los 2013, 2019) and of bioclimatic design tools (Givoni 1969, Olgyay 1981; Serra 1997; Bottero et al. 1984; Szokolay 2008; Rogora 2012; Grosso

2017), which help to represent site climatic forces to “give bioclimatic shape” to multiscale “shading architecture”, with particular attention to the mutual interactions vegetation/built systems.

B. Basic knowledge on morphology, metabolism and sociology of green systems. Architects must approach the “mutual support” among human and “natural” communities through detailed overlap mapping of built and green requirements underling potential future performances of new green hybrid systems in a symbiosis perspective. In particular, the toolbox has to supply:

   a. basic knowledge on plants dimensional and metabolic characters (shape, height, canopy diameter, growing time, leaves metabolism, dimension and LAI—Leaf Area Index-, skeleton, deciduous period, solar radiation transmission in different seasons).[10]
   b. basic knowledge of climatic/environmental conditions which stimulate the correct growing of vegetal community integrated into architecture (water, cold, wind, ground, atmosphere) (Navés Vinas 1992; Chiusoli 1985).

C. Basic knowledge of building physics as can be found in handbooks targeted to architects (Butera 1995, 2012)
D. Basic principles on urban climatology such as the ones included in the above-mentioned handbooks. To extend urban microclimates knowledge, the fundamental contribution on Urban Climates (Oke et al. 2017) can be read.
E. Knowledge, sensorial experiences, and evaluation of comfort conditions (or reduction of the thermal stress) in outdoor spaces (Hoppe 1999; Dessì 2007a, b). Direct experience on outside comfort conditions is very important, because we have a consolidated experience to feel and evaluate comfort in indoor space, but we lost the experience in outside spaces. Therefore, it is important to promote and practice “bioclimatic walks”, experiencing different Urban Local Climates thermal sensations accompanied by some simple measures (air, surface temperatures, wind, RH). Thermal comfort evaluation in urban spaces is relatively complex, because we have to calculate the energy balance person/environment (evaporative, thermal and radiant fluxes,) which change place by place when the person moves, modifying continuously the view factor. Many programmes are available, at different complexity level[11], together with bioclimatic indicators[12] used in different fields of activities from health monitoring to urban design.

22.7 Green Outdoor Places Design Through Mutual Support of Vegetal and Human Communities

Outdoor spaces with their heterogeneity, living environments, attraction capability are the connective system of human societies and constitute those cultural, vital and liveable milieus where mutuality with vegetal communities play a fundamental role.

These milieus have been strongly compromised by the development of new global urban "cyber virtual" spaces. The origin of this compromise is a very different conception of the relations man/nature, built environment/natural cycles.

On one side, an environmental local knowledge/conception interprets man/nature relations as synergic and co-evolutive and requires, for outdoor spaces, mutuality and consonance, phased on natural cycles and biological rythms.

On the other side, a globalizing anthropocentric conception interprets this relation on the basis of a functional performance: "it is winter or summer according to the desire to take a bath in a fake see shore or skiing in a simulated snow covered mountain".[13] In this case, biological rhythms are completely alterated and, therefore, the symbiotic and emotional relations with green structures completely marginalized and used as a simple "décor".

Bioclimatic gradients (hot, warm, tepid; shadow, half shadow, sun…), which contribute to the sensitive richness of local places, tend to disappear and leave space to artificial dimensions, which degrade environmental experiences and produce emotional typologies and architectures to be replicated and sold everywhere.

Architects have to develop a new feeling toward the "Plant Nation" and provide themselves with a toolbox to design neo–symbiotic processes between green systems and the built environment.

The toolbox methodological contributions help also to stimulate design environmental imagination, integrating architecture conventional characters (Utilitas, Firmitas, Venustas) with emerging environmental characters in order to relieve the dominant visual perception constraints and enter in a multisensory design culture, able to design liveable and consonant outdoor spaces, ensemble of intangible and beneficial fluxes, which are part of our local cultural values canalised by built environment shapes and materials in our collective behaviour.

Notes

1. My idea of architecture is a broad concept because it embraces human life whole environment; (…) it represents the whole of modifications and elaborations operated on the earth surface with the view of human needs (…) Each one of us is committed to watch and preserve earth landscape right order, everyone with the portion up to him to avoid to pass on our sons a treasure which is less of that passed on by our fathers. W. Morris, Prospectus of Architecture in Civilization, 1881 p. 3, 4; quoted in Bottero (2005).
2. Sufficiency is a condition in which services basic needs (house, energy, water, food etc.) are satisfied in a socially fair and inclusive way respecting planet ecological limits (Pagliano and Erba 2019).
3. UNEP, Inclusive Green Economy, 2016.
4. Munford (1964).
5. Heshong (1979), p. 19.
6. Native vegetal associations have a natural shading pattern that is completely phased with cooling demand of building and settlement of the site (Olgyay 1981, Chap. 7).

7. Urban forestation has a great tradition. The “green belts” were often a must in the XIX and XX Centuries Urban planning (paradigmatic examples: London and Frankfurt).
8. A short review of green structure environmental services ca be found in the classical handbook Bernatsky 1978.
9. Mancuso 2019, articolo 8 p. 125.
10. Leaf as bioclimatic masterpiece in vegetal system climatic adaptation process is well synthetized in Tucci 2008 pp. 65–91.
11. The most diffused are: Solene, Radtherm, Raymen, Townscope, COMFA+, Envimet. For a synthetic description see Dessi V.
12. Humidex, PET—Physiological Equivalent Temperature. For a short description of bioclimatic indicators, see WMO/WHO 2015.
13. Barbara (2000) a. op. cit. p. 307.

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