

Urban quality and environmental resilience at the edge

Valentina Dessì

Politecnico di Milano, Dipartimento di Architettura e Studi Urbani
(valentina.dessi@polimi.it)

The perception of a margin, a limit connected to the urban fringe concept, is recurrent in this paper and observed from different points of view.

The IPCC 2022 report on climate change states that there is a limit to climate change adaptation, a dynamic threshold that changes according to the 'health' of ecosystems.

On the other hand, the limit also indicates the physical passage between two conditions, often hybrid, uncertain, and even degraded, but which can represent an opportunity for transition (dynamic concept). This paper describes some strategies (shading systems, vegetation, urban materials) that can overcome physical barriers and improve both the environmental and the fruition conditions of marginal areas.

Keywords: limit; dynamic transition; nature-based solutions

Qualità urbana e resilienza ambientale al margine

La percezione di un margine, un limite connesso al concetto di frangia urbana, ricorre in questo contributo ed è osservato da diversi punti di vista.

Il rapporto IPCC 2022 sui cambiamenti climatici ricorda che c'è un limite all'adattamento ai cambiamenti climatici quale soglia dinamica che si modifica in funzione della 'salute' degli ecosistemi. Tuttavia, il limite indica anche il passaggio fisico tra due condizioni, spesso ibride, incerte, e anche degradate, ma che possono rappresentare una opportunità di transizione (concetto dinamico). L'articolo descrive alcune strategie (vegetazione, materiali urbani, sistemi di ombreggiamento) che possono essere impiegate nel superamento di barriere fisiche e per migliorare le condizioni sia ambientali sia fruibili delle aree di margine.

Parole chiave: limite; transizione dinamica; nature-based solutions

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This contribution deals with the theme of the urban fringe from different points of view and develops reasoning on how this margin, the limit between different areas, can favor a mending among contexts. It can be carried out through multifunctional ecosystem services – in particular regulatory and cultural services (including climate regulation and the water cycle, recreational and aesthetic services), which promote NBS (i.e., Nature-based Solutions - NBS) and the environmentally conscious adaptation strategies to climate change. The impact will also occur on the architectural quality, the attractiveness of urban spaces and urban livability.

As expressed in the previous contributions of this section, the definitions of the urban fringe cannot be exhaustive of a complex theme, which crosses different areas and suggests rigorously deepening the knowledge of the natural and anthropic physical elements that characterize these places.

The concept of 'urban fringe' in an urbanized area is well connected to the idea of margin, border, limit, intercepting not only a physical, geometric dimension – made up of shapes and volumes – but also an energy-environmental dimension made up of flows of energy and materials (i.e., solar radiation, wind, water), which differ significantly from the flows within a consolidated and dense urban fabric at different scales (Olgay, 1963). These flows are connected to the environmental conditions of a site and can be modified and controlled with actions to improve the specific microclimate (Alvarez *et al.*, 1992; Dessì, 2007). However, working on controlling environmental variables involves elements that could help to enhance the microclimate and, therefore, the environmental comfort (primarily thermal) condition. It also represents the driving force for improving the architectural quality and the livability of the places (Croce, 2017; Dessì *et al.*, 2016). An example is represented by a large tree in an urban space, which improves its quality, and increases its attractiveness. With its crown, the tree delimits a niche, below which one or more seats can be located for a pleasant break. The tree also generates a cooler (and, therefore, a more comfortable) environmental niche in the summer, and the shade that reaches the surfaces of the urban space reduces the risk of overheating.

It is also true that working on blue-green infrastructures, as well-connected urban elements able to limit the thermal stress in urban spaces, represents a stimulus to urban and environmental regeneration for the urbanized and consolidated areas near the marginal connected zones (Gunawardena *et al.*, 2017).

This environmental mesh ensures a continuum of green and blue elements and protected niches and allows for a gradual and seamless transition from rural natural areas that creep into established urban areas through ones that are less clearly classifiable today, up to the compact fabric, after having intercepted vegetated urban spaces, tree-lined streets, green roofs and walls, private courtyards, but also bioswales, rain gardens, and various forms of water. These areas can be either equipped or left free, but they are part of a connected ecosystem services system capable of improving the microclimatic conditions and the usability of places.

The IPCC's Sixth Assessment Report (AR6), developed by Working Group II (WGII), recognizes the interdependence between climate, ecosystems, biodiversity, and human societies. It also reminds us that each temperature increase (especially above 1.5 °C) has progressively determined social and economic inequalities, but also climate-resilient development paths and the balance between adaptation and mitigation (which varies according to circumstances and national, regional, and local geographical areas). The same development paths are defined according to the capacities, resources, vulnerability, culture and values, past development choices, and future heating scenarios; moreover, they are adapted to equity and social and climate justice needs (Working Group II - IPCC, 2022). Adaptation to climate change plays a crucial role in reducing exposure and vulnerability (Huber, 2010; Pereira, 2021). It is often designed to improve resilience as a reaction to return to a state antecedent to the event that generated the disorder. The latest WGII report introduces the concept of 'resilience', defined as the ability to maintain essential function, identity, and structure and the ability to transform. According to the WGII, resilience takes on a positive meaning when it keeps this ability to adapt, learn and/or change.

The same report specifies that climate-resilient development in urban areas must also include adaptability in rural areas by maintaining peri-urban supply chains of goods and services and financial flows. The urban fringe, which draws a border (therefore a limit) between a consolidated urban area and rural, peri-urban territories, is often subject to degradation and abandonment. This margin can represent the space for the enhancement and reconnection of the two areas, and, where it is deemed appropriate to intervene, the opportunity to implement strategies based on the environmentally conscious use of specific elements. Moreover, it can constitute an essential piece in strengthening the environmental resilience of a territory.

From a different point of view, the concept of 'limit' appears in the Sixth Assessment Report (AR6) of the IPCC, developed by Working Group II (WGII). In this context, the limit is referred to the adaptation to climate change, and it is defined as the point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions. There is the 'hard' adaptation limit (no adaptive actions are possible to avoid intolerable risks) and the 'soft' adaptation limit (options may exist but are currently unavailable to prevent intolerable risks through adaptive action) (Working Group II - IPCC, 2022). The question now is: Does the limit exist? And if so, what is the acceptable limit to the adaptation of cities to climate change?

The limit we have discussed so far can be a physical limit (the edge of the city) or a conceptual one. Still, it is increasingly evident that the strategies for tackling the various objectives in this field can happily coincide, especially if we involve ecosystem services.

The AR6 still states that the greater the role of ecosystems, the awareness of society in dealing with the causes and effects of climate change, and therefore the use of environmental strategies are, the greater our cities' adaptive capacity will be.

The already mentioned variability of the parameters (climatic, ecosystemic, biodiversity, and social) and of the limit itself is therefore inherent in the concept of 'transition'. It is no longer a static concept but a process, which can go hand in hand with the transformation processes of cities in ecological and decarbonization direction.

The concept of the limit to adaptation in the urban fringe can be experimented within the reconfiguration project of interconnected urban spaces in a system of nodes and connections to allow the users of the places and pedestrians to walk and stay without solution of continuity in pleasant and safe areas.

If the main effects of climate change that we experience in the cities of the Mediterranean area with a temperate climate are increasingly linked to overheating and the management of excess rainwater, the control of variables, such as urban materials, vegetation and water, shading devices, and their relationship with space can generate places (niches and paths) cool in summer, sunny and protected from cold winds in winter and from the risks associated with the management of excess rainwater.

The role of the elements that modify the microclimate

The application that a methodological planning process adopts for the redevelopment of the fringe areas can be of different types: in particular, the environmental approach, based on improving thermal comfort conditions and reducing the urban heat island, implies using strategies to control radiative and convective flows. The environmentally conscious selection of the elements, and in general, the reconfiguration of them in the open space, is a theme linked to adaptation to the effects of climate change. In particular, in our latitudes, interventions are aimed at reducing summer temperatures and managing excess rainwater (Alves *et al.*, 2019); if we observe the phenomenon on a local scale, typical of a single street or square, it is probably more appropriate to speak of thermal comfort improvement; if the specific interventions are connected within a green and/or blue corridor and characterized by the use of adequate materials (urban materials, vegetation, water) and shading systems, then we can say that the improvement is at the city/neighborhood scale, and we can observe a reduction of the Urban Heat Island (UHI).

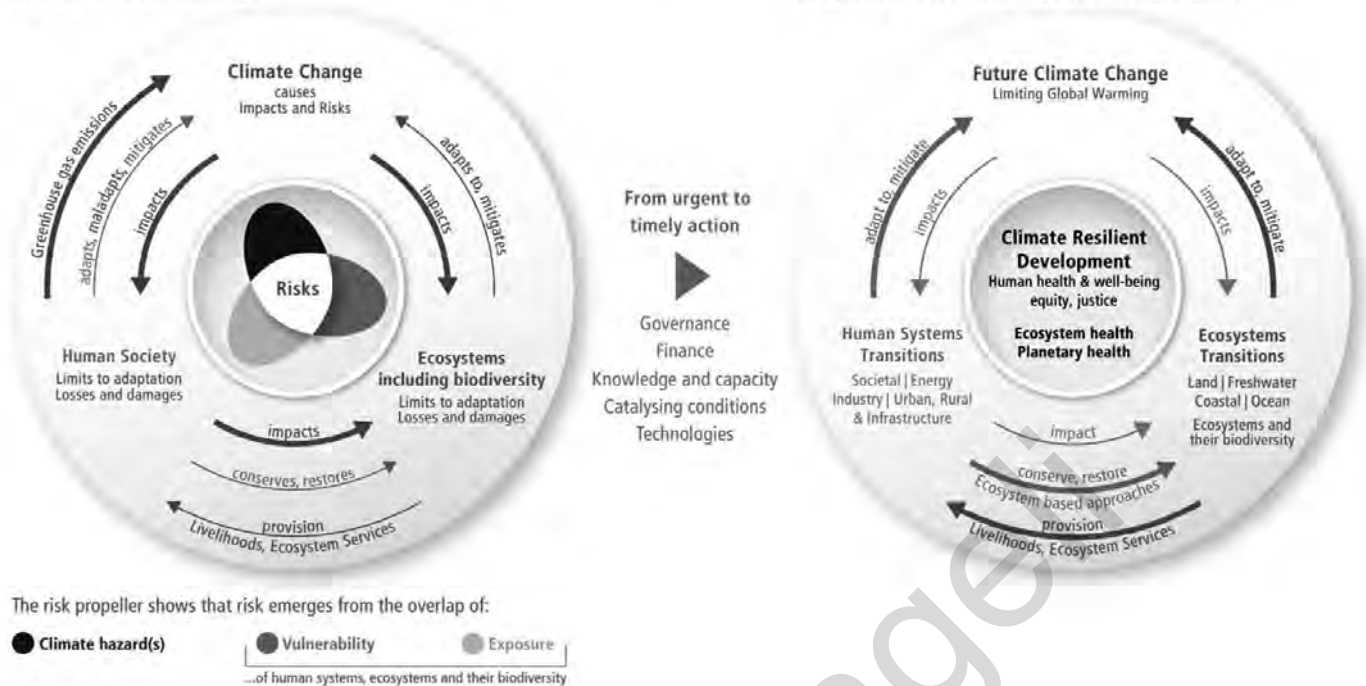
The analysis of the results of the workshop carried out within the Architectural, Urban, and Interior Design (AUID) doctorate of the Politecnico di Milano, entitled 'International workshop fringes renewal enhancing urban and peri-urban fragile areas', allows us to highlight the presence of these elements, even if not always together, but involved according to the point of view and the specific objective considered the priority to be addressed. Vegetation, in particular, has a lot of potential, responds to different purposes (not only environmental), and is considered in various strategies.

As a general outcome, it emerges that the knowledge of the area at an urban scale, from a physical, social and environmental point of view, helps to stimulate a series of considerations on the emerging criticalities and on the possible solutions at a neighborhood and local micro-urban scale, able to characterize

From climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems

(a) Main interactions and trends

(b) Options to reduce climate risks and establish resilience



1. The interactions between climate systems, ecosystems and human society. The image on the left reproduces this interaction considering that human society causes climate change, which, in turn, generates impacts and risks that can exceed the limits of adaptation and cause losses and damage. The image on the right, shows the interactions between human society, ecosystems – in a regime of ecological transition – and a climate that generates fewer impacts, resulting in fewer difficulties in the search for adaptation and mitigation. Source: IPCC, www.ipcc.ch (access: 2022.09.15).

the design approach, synthesis of different disciplinary skills, and therefore of fertile trans-disciplinarity. *The shading devices* – The proposal developed for the Rubattino-Ortica area highlights an area strongly characterized by the presence of the Lambro River, a network of super-local streets, and a highway that draws a net perimeter of about 2 sq.km. Ortica is a historic district of Milan, purely residential, in which nowadays, as evidenced by the Ph.D. candidates H. Chai, E. Maj, L. Zhu, there is a complex overlapping of functions, buildings, and open spaces, often with low quality. They are little or not vegetated and characterized by parked cars, which interface with the pre-existing structures of the traditional district and the new building interventions. The proposal *Slow and vitality community. The rebirth of Rubattino-Ortica area* proposes strategies to improve public spaces' attractiveness. The proposal identifies a series of elements that, thanks to using multifunctional systems based on greenery, rainwater collection, and shading, can simultaneously improve the attractiveness of spaces and the thermal comfort conditions and work in different climatic conditions at different hours of the day. One of these elements is a shading device, an 'overturned umbrella' which collects rainy water during rainfall. At the same time, on sunny days, it captures solar radiation and transforms it

through a photovoltaic system into electricity that could be used to power the artificial lighting. Nevertheless, providing shade is the most important role in a public space. If we do not remove the solar radiation component during the summer season from the area occupied by people, we have no chance of achieving acceptable comfort conditions. In a city like Milan (about 45°N latitude), the incident solar radiation can reach about 900 w/m²; in the shade, it can be around 50 w/m², while the radiation re-emitted by the pavement does not reach 50 w/m²; as we can see, the order of magnitude of the different components is on a very different scale. The systems that intercept solar radiation prevent it from reaching seating and walking areas; they can be horizontal or vertical and made by mobile or permanent sun awnings or canopies; in the case of mobile systems, they are used when there is a need to intercept solar radiation, both seasonal and daily, when they are permanent, as in the case of the proposal on Rubattino-Ortica, they represent an element of recognizability of the place. We can undoubtedly include vegetation such as trees and pergolas among the shading systems. Compared to 'artificial' systems, vegetation is a living system that adapts its structure to the varying intensity of solar radiation. In addition, while the other systems have limited cooling action, vegetation has further

advantages due to the temperature of the leaves being very close to the air temperature. For this reason, the radiant exchange with a person can be even 25-30 °C lower than the exchange with a dark or brick surface reached by solar radiation.

The vegetation – A different approach is proposed by C. Bulone, H. Dan, and K. Santus, on the Forlanini area and titled *Engage with the limit. The open space as design element to enhance and reconnect fringes*. In this case, the focus is on the morphology and the relationship between full and void spaces, allowing specific physical, environmental and social configurations. They can generate marginal conditions, which a project based on NBS helps to enhance (Davtalan *et al.*, 2020).

Working on the limits of these areas, which mark the passage from one context to another, means generating connections between places, increasing social relations, and designing an environmental infrastructure capable of reducing marginal conditions from different points of view. On the other hand, it means working on the small scale of the open space that enhances the areas themselves. In this research work, a catalog of possible solutions integrating green/blue elements and land use, i.e. NBS, has been proposed. It can be used for environments with similar characteristics to strengthen and redefine the functions of the open space and to reduce critical situations such as thermal stress and rainwater runoff problems.

The NBSs are always well known in some ways; using vegetation, water, and porous surfaces in open spaces represents the technology *par excellence* in meeting environmental requirements and the accessibility and usability of areas, especially in times of crisis. Green urban spaces can have many forms, such as city parks, squares, tree-lined avenues, private gardens, etc. They all have a role in the city's ecosystem, in particular the microclimate improvement and the soil condition for reducing runoff and risks of flooding, as well as the city's aesthetic quality and citizens' well-being. Some studies have verified that they are an irreplaceable system from the urban heat island reduction (UHI) point of view. It is estimated, for example, that in a city like Glasgow, a presence of vegetation greater than 20%, in 2050 would have the effects of reducing the UHI quantifiable in a share between a third and a half compared to the current values (Emmanuel and Loconsole, 2015). The impacts are mainly related to evapotranspiration, which depends on the type of vegetation cover, the levels of humidity and precipitation, and ventilation. Another research shows that global annual evapotranspiration 'consumes' around 22% of the incident solar radiation in the atmosphere (Tian *et al.*, 2013). To reduce UHI, it is, therefore, useful to increase evapotranspiration, which would mean replacing sensible heat with latent heat.

The research proposal by R.A. Mishio, S.A. Sapone and J. Li, *DePolluting Rogoredo - Renewing an urban fringe toward zero pollution*, identifies some critical issues related to air, soil, water and acoustic pollution due to the presence of infrastructure industries. It suggests remediation of the area on a three-phase track: Healing – treatment of the polluted areas, filtering (removing pollution from the environment), repurposing (modifying pre-existence to tackle pollution) with proposals for intervention at different scales.

At the neighborhood scale, actions are proposed to treat contaminated surfaces and redevelop the same with NBS strategies, such as pocket parks or green car parks. For the building scale, it provides

the green roof implementation and the use of greenery in the areas belonging to the properties, both for filtering the pollutants and for redevelopment and enhancing it.

Although the goal is to regenerate areas characterized by different pollution conditions, NBS strategies would also impact other issues, such as reducing the urban heat island.

Urban materials – The research work by C. Cempini, V. Dall'Orto, M. Pereira Guimarães, P. Gamboa *Bioclimatic regeneration of an industrial urban fringe*, has carried out an analysis on a large scale associated with the environmental analysis, in terms of surface temperatures. This mapping made it possible to identify the areas with the most significant environmental criticalities, essentially due to the morphological characteristics of the site and the soil and building materials. As a second step, a small-scale observation allowed them to propose strategies on the micro-urban scale of the external space, private and public, and the building envelope. At this scale, it was possible to identify better the criticalities of the area, linked in particular to the lack of connections -for example, between the city and the countryside, the presence of impervious industrial areas, not vegetated and therefore responsible for the UHI, the lack of public spaces and the lack of functional *mixite* that can attract different types of space users.

The wide-ranging strategy, defined Porosity, has the dual function of adapting the buildings and the ground with NBS to reduce the surface temperatures that would lead to a reduction of the urban heat island and the improvement of thermal comfort, but also the improvement of the attractiveness and livability of outdoor spaces. The environmental aspect is considered through a series of actions called Re-grounding, De-paving, Un-roofing, and Un-locking aimed at increasing permeable surfaces, vegetation, and natural ventilation.

In this case, the porosity is to be considered in two directions: on the one hand, at the urban scale, it represents a possibility of passage for example, of the wind; on the other hand, the porosity at the level of the small scale, at the scale of the building, of the road, urban space has different meanings, linked to the reduction of the UHI, to the improvement of the thermal comfort of public spaces, and is closely related to the choice of urban materials. In particular, people involved in the design of urban spaces are generally interested in what happens in the two-meters-layer above the ground, where we have the presence of people, and therefore focus on the pavements of public spaces and the facades of buildings that overlook it. Urban materials exposed to solar radiation reflect it in part, according to the albedo, i.e., the solar reflection coefficient. The other part of the solar radiation is converted into heat and stored and re-emitted over time (particularly at night) depending on the physical characteristics of materials (especially conductivity and heat capacity).

When inappropriate materials are used, the re-emitted heat increases the air temperature day and night. This phenomenon (together with the heat produced by urban metabolism) is one of the main causes of the UHI and thermal discomfort. Unlike gains from solar radiation, natural cooling techniques can change the flow's direction in infrared radiant exchanges and convert it from gains to losses. In summer, when the surfaces temperatures are lower than the person's skin (32 °C in summer), the heat dissipation determines the comfort sensation; when the surfaces temperatures are higher than the skin one, a thermal gain produces a discomfort sensation (warm). For example, using cool materials in the design

phase means helping to lower the surface temperature of urban materials, which remains at values close to the air temperature even during the day. Cool materials are characterized by high emissivity and albedo values. Almost all building materials have high emissivity (about 0.9); we, therefore, could speak of cool materials in the case of high albedo (all light-colored, slightly rough) and porous materials. However, due to flooring characteristics, it is necessary to find a balance between the need for low surface temperatures and the high reflection level that can generate glare phenomena and, thus, affect people negatively (Dessi, 2012). Among the urban materials, we can also include water, not as a fountain, but above all, in the form of jets, water walls, and nebulizers. In addition to the microclimatic contribution, water has a strong psychological impact; the sound of moving water or just seeing it from a distance anticipates a feeling of coolness that improves the perception of comfort conditions (Nikolopoulou, 2004). The water has the function of cooling the environment in two ways: through the effect of the thermal inertia of the water mass (reducing thermal excursions) and through evaporation (reducing the air temperature). Surfaces that intercept water, especially on floors, also remain at lower surface temperatures and contribute to improving thermal comfort.

Conclusions

The urban fringes, once considered marginal areas on which to concentrate new investments, especially private ones, can now represent an opportunity for the ecological development of urban areas and the reconnection of cities with their extra-urban rural areas and green belts. These are occasions that we can no longer neglect; on the one hand, the IPCC report argues that the global trend of urbanization also offers an opportunity to promote climate-resilient development. Integrated and inclusive planning and investment in daily decision-making on urban infrastructure, including social, ecological, and gray/physical infrastructure, can increase the adaptation of urban and rural settlements.

At the European level, according to the renewed commitment of the EU to the UN New Urban Agenda, on 28 April 2022, the Commission announced the 100 participating cities (nine are in Italy) which will receive the Commission's support in achieving the goal of Climate-Neutral and Smart Cities by 2030.

'Cities mission' is one of five Horizon Europe research and innovation programmes for the years 2021-2027 and is a novelty of Horizon Europe designed to meet ambitious goals and deliver tangible results by 2030. These cities represent the hubs of experimentation and innovation for green, digital and inclusive transformations.

The program includes an overall plan for climate neutrality across sectors like energy, buildings, waste management, transport, and related investment plans. This process will involve citizens, research organizations, and the private sector [see website: Inforegio - Discover the 100 cities selected for the Cities Mission (europa.eu)]. The very President of the European Commission herself, Ursula von der Leyen, stated that 'These

pioneering cities will have the task of showing us the way to a healthier future and a more livable planet'. Although cities are still responsible for climate change, they are also the privileged laboratory for launching initiatives aimed at improving urban livability, architectural and environmental quality. They also have the critical role of preserving the ecosystems, relevant aspects to consider for an ecological transition, and strengthening the cities' environmental resilience.

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