DESIGNING RESILIENCE

Strategies for the sustainable development and understanding of urban complexity

a cura di
F. Mosca
G. Oneto

GENOVA UNIVERSITY PRESS

ADDDOCS
DOCUMENTS
3

Collana / Collection
ADDDOCS Documents - Quaderni di Dottorato

Dottorato in Architettura e Design
Dipartimento Architettura e Design
UniGe – Università degli Studi di Genova

DESIGNING RESILIENCE

Strategies for the sustainable development and understanding of urban complexity

a cura di
F. Mosca
G. Oneto

GENOVA UNIVERSITY PRESS

GENOVA UNIVERSITY PRESS
è il marchio editoriale dell'Università di Genova
Università di Genova

I contributi qui pubblicati sono stati selezionati dal Comitato Scientifico del Convegno

e-ISBN (pdf) 978-88-3618-337-1

Pubblicato a ottobre 2025

Realizzazione Editoriale
GENOVA UNIVERSITY PRESS
Via Balbi 5, 16126 Genova
Tel. 010 20951558
e-mail: gup@unige.it
https://gup.unige.it

INDICE

FOREWORD

Evolution or Persistence in the Concepts of Environmental Sustainability and Resilience

Adriano Magliocco[1]

I have often pondered that within the concept of sustainable development, as we have developed it, at least in Europe, two potentially opposing principles coexist: the principle of 'persistence' and the principle of 'evolution'.
'Sustainable' means « *able to continue for a long period of time* » (Oxford Dictionary), and the French translation 'durable' seems more fitting than our 'sustainable' which is understood as « *capable of being sustained, manageable* » that is, acceptable, and only recently has it come to mean 'environmentally compatible' (while for the social and economic aspects, it is always necessary to add an adjective for clarity). In the famous phrase from the Brundtland Report of 1989, it speaks of « *meeting the needs of the present without compromising the ability of future gen-*

erations to meet their own needs». It is therefore a concept predominantly economic, linked to the use of resources as necessary for the satisfaction of needs (which can also be of a social nature). The environment then becomes central as the repository of all resources (aside from solar energy, the only resource that comes from outside our planet) needed to meet our needs. It talks about development but also about present needs. The present (it was the 1980s, although the debate had started much earlier) becomes the point of reference, and it is a very 'Western' point of reference; speaking of meeting present needs, we can deduce that it intends to establish the European lifestyle as the baseline (even though not everyone in Europe was, and is, able to meet their own needs). Therefore, a concept based on persistence linked to the noun 'development', which instead indicates a desire for evolution.

In the face of the dynamics and effects of climate change, we have begun to say that we should not only be sustainable but also resilient, that is, we must be able to face events, even the most disastrous ones, with the ability to return to the previous equilibrium or to a new one (depending on how we define resilience, see the Introduction chapter of this volume). In this concept too, persistence (returning to the previous state) and evolution (finding a new equilibrium) coexist. With the concept of resilience, two strategic approaches are linked: mitigation (reducing the causes of climate change) and adaptation (ensuring that the effects are not disruptive). Again, in this case, we could link the two coexisting approaches – somewhat forcibly, I admit – to persistence (mitigation) and evolution (adaptation).

This continuous oscillation, seemingly contradictory

+ between the desire for persistence and for change;

+ rather typical of human beings – is reflected in the projects (and consequently in the texts that follow, which deal with projects and design), whose conditions of 'sustainability' range from attention to the use of resources, especially non-renewable ones, to the attempt to find new forms of living, in defining urban space not only as a 'place of opportunities' but as the habitat of contemporary man, possibly in harmony with other forms of life.

note

[1] Adriano Magliocco – ORCID ID: 0000-0002-3414-0090, adriano.magliocco@unige.it, Dipartimento Architettura e Design – Università di Genova

CHAPTER 1. DESIGNING RESILIENCE

Francesca Mosca[1], Gabriele Oneto[2]

1. Exploring the concept of resilience

With the meaning of 'the ability to withstand impacts without breaking' the word resilience has gained surprising popularity in recent decades.

Like many scientific terms, resilience has a Latin origin: the verb *resilire* is formed by adding the prefix re- to the verb *salire*, meaning 'to jump, to spring forth,' with the immediate sense of 'to jump back, to return quickly, to rebound' but also the transferred sense of 'to retreat, to contract' (Oxford Latin Dictionary, Fascicle VII, edited by P.G.W. Glare, Oxford University Press 1980, translated).

From a scientific perspective, the concept of resilience has been embraced by various disciplines and fields of study, ranging from engineering and materials science to psychology and ecology. A positive connotation has been attributed to the meaning of resilience, specifically regarding the ability of a system (city,

environment, individual, element) to adapt to changing conditions due to external stresses. For a shocked system, resilience represents the capacity for adaptation and transformation in response to stress while maintaining its essential functions and identities (Steven *et al.* 2014).
In physics and engineering, for example, resilience indicates the ability of a material to resist an impact, absorbing the energy that can be released to varying degrees after deformation. This aspect is also related to other characteristics of materials, such as adaptive, or flexible, highlighting the continuous flow of energy which characterizes all the natural processes on earth (Xue *et al.* 2018).

The concept of resilience has gained increasing attention in recent years to address the challenges and uncertainties that cities are facing in the 21st century. A first comprehensive definition of resilience for urban habitats has been provided by the United Nations Office for Disaster Risk Reduction (UNDRR):

> *The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.* (UNDRR, 2007).

More recently, the European Union has defined resilience as the ability not only to withstand and cope with challenges but also to undergo transitions, in a sustainable, fair, and democratic manner (EU, 2020 Strategic Foresight Report).
The necessity of having a common definition of the concept is also related to the fact that the current environmental degradation is having a great impact on worldwide urban systems, from not only the environmental perspective but also the economic and social ones. The increasing frequency of external stresses and extreme events have posed the need for adaptation strategies: in this framework, the temporal variable is crucial.

Indeed, the concept of resilience and that of time are closely interdependent and correlated. The increase in frequency and duration of external events that cause stress on the analysed system implies the need for this system to be resilient in relation to these variables, thus requiring an adequate response time to the temporal interval with which the external agent acts. Also, the resilience of a system also relies on its ability to return to a state of equilibrium after the disturbing event, and on the time-frame, it takes to achieve this new status (Meerow *et al.* 2016). Furthermore, the concept of resilience is meaningful only when referred to a specific objective, depending on the reference field. The research question should always be 'resilient with regard to what?', depending on the most critical aspects and external stresses which can alter the system balance, the main objectives should be identified. The definition of an objective is needed to verify the effective response of the analysed system, i.e., its resilience. This aspect is crucial to allow the application of the concept of resilience in real-world case studies, independently from the field of research or intervention.

2. The urban system: an intricate playground

Resilience plays a crucial role in shaping the future for humans, especially as we tackle multifaceted challenges such as climate change, growth, and resource limitation. As the tendency for human to choose their habitats is an urban one, it is only logical that resilience is studied in cities. Cities are a human phenomenon whose continuous expansion is signalled in numerous reports, with alarming rates (Mahtta *et al.* 2022). This does not only mean that more humans will live in urban environments, but also that the consequences of an increased urbanized lifestyle will affect both the wellbeing of human and the quality of urban settlements. Local and international policies strive toward controlling this expansion, although they are still lacking a cohesive inter-scalar approach. Dealing with urban problems is often a matter of local knowledge and site-specific insights, as regional guidelines can prove ineffective in describing local peculiarities. This scale-behaviour is typical of systems where

uncertainty and heterogeneity elevate normal actions to a more difficult level of interpretation, while still providing room for flexibility. Cities have been called adaptive complex systems, as in entities regulated by non-linearity and circular causality and yet robust (Bettencourt 2021). As cities are human products, their primary objective should be to effectively host human life. Before, delving into how to explain 'effectively', we should discuss change.

Generally speaking, urban systems are lazy, in the sense that if not interacted with they will choose the most convenient short-term path to problem solving. These systems are often shaken by stresses, internal or external forces that causes a metabolic reaction. Coping to these stresses is a matter of identifying the type of effect, as naturally different phenomena make for entirely different scenarios. One thing is to suddenly restructure human life in the occurrence of a global pandemic, another is to slowly adapt to the inexorable sea level rise with the added complication, technical aspects aside, of human perception of risk and willingness to act (Kolte *et al.* 2023). This willingness is instrumental in enacting a certain type of policy and design, as for resilience-based solutions, and while politicians and committees are dealing with this delicate aspect, architects and designers can spearhead this paradigmatic shift with their proposal (Fig. 1).

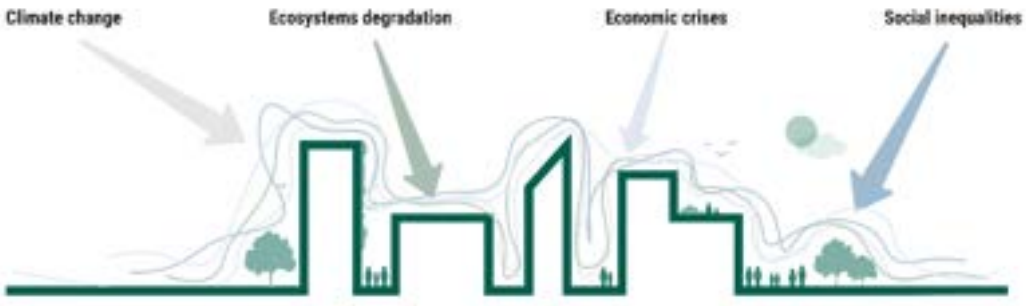


Fig. 1: the urban environment and the most impactful external stresses.

Remaining on the simple premise of protecting human life, we can start exploring the measures to define urban resilience. Understanding the level of 'bendiness', as in flexibility to change, of urban system is therefore a matter of thermodynamic inquiry. On one hand there is the problem of boundary, of input-output of resources, executed by identifying and parametrization how the edge conditions can be pushed and how far without rips. As with open systems, i.e., a system permeable to exchange of resources and energy, a border analysis can quickly assess the status of the system by posing it in relation to the surroundings. Another, more sensible, matter is to inquire the internal status of an urban system. Disregarding outside interventions, internal stresses pose enough complexity that a number of indexes have been developed to try and summarize this extraordinary heterogeneity. For example, the City Resilience Index (The Rockefeller Foundation and Arup 2016) considers factors like infrastructure, governance, social cohesion, and environmental sustainability. In both cases, the effectiveness of the 'bounce back' effect is expressed in how human can expect to go back to the previous living standards.

3. Resilience, resistance, and sustainability

During the last decades, due to the increasing complexity of city development and external stresses which threaten human settlements and the related processes, researchers have explored different strategies to fight against these external factors.
Historically, the initial response strategies to these environmental alterations focused on defining sustainable development, to address the underlying causes of environmental imbalances (United Nations, 2015). For example, one of the key objectives of sustainable development was to reduce consumption, and consequently, the extraction of fossil fuels, which are responsible for the increase in global temperatures causing climate change (Achakulwisut *et al.* 2023). In parallel, considering the need to respond to extreme events, in addition to addressing the causes, various strategies have been defined to make urban systems resilient to various criticalities, such as floods, storms, and over-

flow (Bulkeley & Tuts, 2013). Only in the last few decades, due to the steady increase in the frequency and intensity of extreme events, the concept of resilience has been considered one of the most promising approaches to ensure the survival of urban systems, by making them adaptive and transformable towards changes (Glaeser, 2022).
The consequentiality of the development and study of these three concepts (sustainability, resistance, and resilience) is worthy of note and further analysis (Fig. 2).

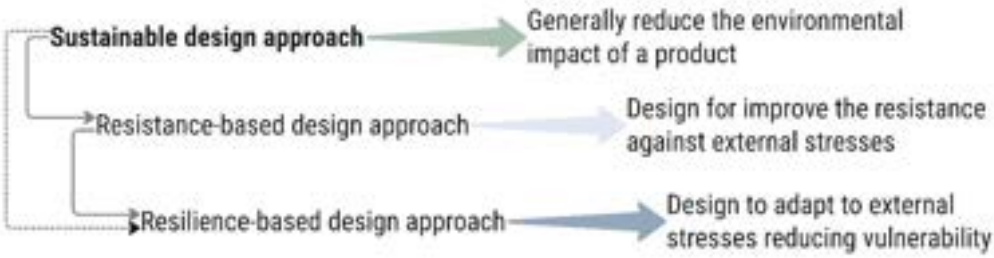


Fig. 2: The differences between the three approaches: sustainable, resistant, and resilient.

After the initial scientific demonstrations of the effects of anthropogenic activity on the environment, with the Brundtland Report and subsequent collective meetings, the most obvious and optimistic response to the problem was to address the causes directly. However, international scientific reports such as those from the Intergovernmental Panel for Climate Change (IPCC) demonstrate that even if global states were able to reduce resource consumption as stipulated by international goals, there would still be a transition period to allow the Earth's ecosystem to process the accumulated emissions in the atmosphere and reverse the process of global warming (IPCC, 2021). In parallel, the already-triggered process of climate change still causes extreme events that threaten the health of ecosystems and humans, prompting the need for protection. Therefore, after the concept of sustainable development, strategies for resisting extreme events began to be proposed (Nel *et al.*, 2014). Similar directives come from the Sustainable Development Goals (SDG, United Nations 2023), partic-

ularly SDG 11 (Sustainable Cities and Communities): emphasizing making cities inclusive, safe, sustainable, and resilient, as a goal for urban planning. Simply speaking, the objective is again to slow down external stresses with an intention of 'blocking' negative interferences. This friction perfectly describes the traditional resistance-based methodology, the equivalent of an inflexible wall to the bendiness of resilience. The need for sustainability comes after the realisation that resistance-based solutions are not always the right course of action. Save the most extreme events, grey solutions and traditional engineering are often misused, causing complications and damage on the same assets that were sworn to protect. Often, resistance-based solutions are found to be overpriced and are difficult to adjust to human well-being, while also creating difficult scenarios in the occasional conversion or urban transformation process (Ouyang *et al.* 2019).

Versatility and adaptability are sustainable qualities rarely found in grey solutions, although are a common norm for resilient strategies. These resilient frameworks integrate strategies and practices that lead to liveable, self-sustaining communities over the long term, meeting both the needs of the current and next generations (Liu *et al.* 2023). Versatility speaks of the polyfunctionality of resilient solutions, attracting different stakeholders into wanting something different for their habitats. Contrary to traditional design solutions, a versatile resilient composition changes its usage and role depending on the time of the year and the degree of external stresses. The Netherlands, for example, have deeply invested in researching floodable landscape architectures that can accommodate the routines flooding events while providing a liveable space during normal days (Oukes *et al.* 2020).

While scientific projection might correctly estimate external stresses on urban environments, one of the actual biggest benefits of adaptability is the capability of change to the different spatial needs of human dwellers. Grey-solutions, often difficult to remove or modify, are often incapable of following the cur-

rent direction of urban development, being a product of a past epoch where urban lifestyle was different.
But the strongest reason for introducing resilience in urban strategies is of economical nature. A growing portion of literature already shows the evidence of long-term benefits in many different fields of application, from climate change (Egerer *et al.* 2021) to people well-being (World Health Organization 2022), or heritage preservation (Fabbricatti *et al.* 2020).
If the administrations are finally starting to understand the importance of resilient solutions in urban environments, the next step is to explore what do designers have to offer.

4. Resilient Design Strategies

Given the importance of introducing new planning and design strategies to manage the increasing complexity of cities and the external stresses that can influence their development, in recent decades, various lines of research and action have been defined with attention to different aspects of sustainability: starting from environmental sustainability to social and economic ones.

In order to face environmental degradation, biodiversity loss and the reduction of ecosystem services provision, the European Commission has started promoting research projects and activities to promote innovative and low-impact solutions. Among them, the concept of Nature-based solutions (NBS) has been recognized at the International level as one of the most promising: defined as solutions which can integrate natural elements in the urban environment or which are inspired by nature, this category of solutions have the main goal to fight the urbanization process through the regeneration of natural processes within cities, by introducing vegetation and other living species, to support local biodiversity, reduce environmental risks, improving climate change adaptation and ecosystem services provision (Bernd Eisenberg *et al.*, 2019). In parallel with the development of these kinds of greening strategies, which can be implemented starting from the building scale (with vertical and roof greening), up to the urban scale, particular attention has been given

also to the biophilic design theories. The term *biophilia* refers to the natural and innate connection between human beings and their natural surroundings, which plays a key role in improving psychological well-being, reducing physical stress and diseases, but also increasing social cohesion and reducing crime risks. Starting from this theory, a biophilic design theory has been developed by Timothy Beatley (2011), considering the positive effect of vegetation and more in general of nature on humans, and how it can be systematically implemented in the urban environment to provide positive effects both on the environmental aspects and on the social ones.
It is however worth mentioning that the complexity described in the above section poses the necessity to develop strategies for holist approaches to sustainability (Reubens, 2016). For example, only during the last years also economic sustainability been deeply studied not only in relation to cost reduction, typically included in the circular design approaches (which aims at reducing waste production by reusing and recycling components of a specific product or process), but also in relation to the reduction of costs brought from the mitigation of environmental risks. This field of study is widely known as the 'natural capital accounting' approach, which aims at quantifying the monetary value of nature in the urban environment in relation to its capacity to reduce risks related to environmental hazards, as well as improve the provision of ecosystem services (Azqueta & Sotelsek, 2007). In fact, one of the key aspects of this theory is that the environmental degradation which characterizes our cities is increasing costs related to actions needed to react to extreme events which can have negative impacts on local infrastructures, the built environment, and human beings (Gasper *et al.*, 2011).

In this context, the need to structurally introduce the concept of resilience, encompassing environmental, social, and economic dimensions, into land planning and management practices is even more evident.

Following these concrete needs, innovative design approaches which try to go beyond the traditional design solutions as well as the approaches listed above, have been developed. Currently, in architecture and urban planning, two main categories have been identified: regenerative design approach, and adaptive design. The former aims at supporting the co-existence between humans and the natural environment, by considering the built environment and the natural one as a one single system which co-evolve for a joint well-being of all the inhabitants (Cole, 2012). This design approach poses the basis for a holistic design approach considering not only human needs but also environmental ones, as well as the needs of different living organisms which play a key role in ecosystems regulation and development. The latter, instead, aims at promoting the adaptation capacity of the designed object in relation to external forces. Today is mainly studied in relation to climate change, and this is the reason why it's commonly known as climate-adaptive design approach. Differently from the regenerative design approach, which can be potentially worldwide applied, this field of study is more site-specific, and it depends on the critical aspects of a precise area/design. To propose a practical example, depending on the geographical location of interest, adaptive design strategies can vary significantly. For instance, if designing a building in an area prone to frequent flooding, its adaptive capacity would need to address this phenomenon (Roös, 2021). Conversely, if planning a park in an area susceptible to heatwaves, the design strategies would focus on adapting to such extreme conditions. The presented approaches are strictly interconnected and go beyond the traditional meaning of 'sustainable design' with reference to minimize the environmental impact of the design and set the ground for more holistic and comprehensive design strategies. Among the most recent design theories, the responsive design approach emerges, stemming from the need for adaptation and regenerative design. It places a central focus on the capacity of a project (a product, a building, or even an urban area) to dynamically respond to external and internal inputs, aiming to

ensure the achievement of necessary performance levels (Mehager, 2015) (Fig. 3).

Although these approaches aim to overcome the limitations of previously studied and developed design strategies, some limitations remain. In particular, given the complexity of the subject and the level and quantity of data now available to designers, the definition of a true holistic approach to resilient design still seems to be distant. Simply reducing the negative effects in cities is not easy, nor intuitive. As we move from the most extreme events to more mundane ones, more and more factors fuzzy the designer vision, making it difficult to identify a clear line of action. While global stresses are for politician an occasion for a top-down design, designers can leverage the privilege to interact directly with the urban fabric for a bottom-up approach. And from the latter, usually new stakeholders and initiatives shine in urban systems. Cities are a collection of human initiatives built in accord to our need and provide the perfect canvas for a new season of interventions.

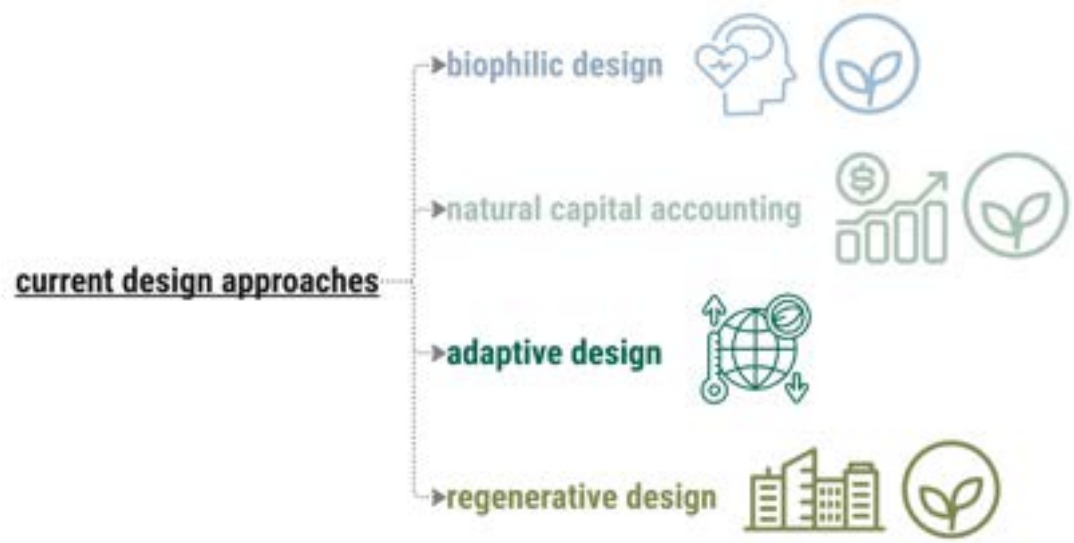


Fig. 3: Current sustainable design approaches.

This book aims to propose a comprehensive overview of the role of resilience in urban design and planning, by collecting different perspectives and methodologies to manage current urban complexity. In particular, the contributions will offer a multi-disciplinary view of possible design approaches to different aspects of the urban context: starting from the need for new design approaches for resilient buildings, to the potential of re-using and adapting the cultural heritage to current needs, the necessity to make cities self-sustaining and able to produce foods and other resources for citizens, or also the needs for adaptive regulation and monitoring systems for cities.

references

+ Achakulwisut, P., Erickson, P., Guivarch, C., Schaeffer, R., Brutschin, E., & Pye, S. (2023). Global fossil fuel reduction pathways under different climate mitigation strategies and ambitions, *Nature Communication*, 14(1), 5425. https://doi.org/10.1038/s41467-023-41105-z.
+ Bettencourt, L.M.A. (2021). Introduction to Urban Science: Evidence and Theory of Cities as Complex Systems, *The MIT Press: Cambridge*, ISBN 9780262366441. https://doi.org/10.7551/mitpress/13909.001.0001.
+ Bulkeley, H., & Tuts, R. (2013). Understanding urban vulnerability, adaptation and resilience in the context of climate change, *Local Environment*, 18(6), pp. 646–662. https://doi.org/10.1080/13549839.2013.788479.
+ Cole, R.J. (2012). Regenerative design and development: Current theory and practice. Building Research & Information, 40(1), 1–6. https://doi.org/10.1080/09613218.2012.617516.
+ Egerer, M., Haase, D., McPhearson, T., Frantzeskaki, N., Andersson, E., Nagendra, H., & Ossola, A. (2021). Urban change as an untapped opportunity for climate adaptation, *npj Urban Sustainability*, 1, 22. https://doi.org/10.1038/s42949-021-00024-y.
+ Fabbricatti, K., Boissenin, L., & Citoni, M. (2020). Heritage Community Resilience: towards new approaches for urban resilience and sustainability, *City Territorial Architecture*, 7, 17. https://doi.org/10.1186/s40410-020-00126-7.
+ Glaeser, E.L. (2022). Urban resilience, *Urban Studies*, 59(1), pp. 3–35. https://doi.org/10.1177/00420980211052230.
+ IPCC (2021). *Climate Change 2021 The Physical Science Basis*. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.
+ Liu, Z., Fang, C., Liao, X., Fan, F., Sun, B., & Mu, X. (2023). Adaptation and adaptability: Deciphering urban resilience from the evolutionary perspective, *Environmental Impact Assessment Review*, 103, 107266, https://doi.org/10.1016/j.eiar.2023.107266.
+ Mahtta, R., Fragkias, M., Güneralp, B., Mahendra, A., Reba, M., Wentz, E.A., & Seto, C.S. (2022). Urban land expansion: the role of population and economic growth for 300+ cities, *npj Urban Sustainability*, 2, 5 (2022). https://doi.org/10.1038/s42949-022-00048-y.
+ Meagher, M. (2015). Designing for change: The poetic potential of responsive architecture. Frontiers of Architectural Research, 4(2), pp. 159–165. https://doi.org/10.1016/j.foar.2015.03.002.
+ Meerow, S., Newell, J.P., & Stults, M. (2016). Defining urban resilience: A review, *Landscape and Urban Planning*, 147, 2016, pp. 38-49. https://doi.org/10.1016/j.landurbplan.2015.11.011.
+ Nel, J.L., Le Maitre, D.C., Nel, D.C., Reyers, B., Archibald, S., Van Wilgen, B.W., Forsyth, G.G., Theron, A.K., O'Farrell, P.J., Mwenge Kahinda, J.M., Engelbrecht, F. A., Kapangaziwiri, E., Van Niekerk, L., & Barwell, L. (2014). Natural hazards in a changing world: A case for ecosystem-based management, *PLoS ONE*, 9(5). https://doi.org/10.1371/journal.pone.0095942.

+ Oukes, C., Leendertse, W., & Arts, J. (2022). Enhancing the Use of Flood Resilient Spatial Planning in Dutch Water Management. A Study of Barriers and Opportunities in Practice, *Planning Theory & Practice*, 23(2), pp. 212-232, https://doi.org/10.1080/14649357.2022.2034921.
+ Ouyang, M., Liu, C., Xu, M. (2019). Value of resilience-based solutions on critical infrastructure protection: Comparing with robustness-based solutions, Reliability Engineering & System Safety, 190, 106506. https://doi.org/10.1016/j.ress.2019.106506.
+ Roös, P.B. (2021). A Regenerative-Adaptive Pattern Language. In P.B. Roös (Ed.), Regenerative-Adaptive Design for Sustainable Development: A Pattern Language Approach, *Springer International Publishing*, pp. 145-160. https://doi.org/10.1007/978-3-030-53234-5_10.
+ Rushikesh, K., Shipra, G., Ashwani, K., & Satish, P. (2023). Challenges in practical implementation of the concept of urban resilience in cities, *International Journal of Disaster Risk Reduction*, 99, 104142. https://doi.org/10.1016/j.ijdrr.2023.104142.
+ Southwick, S.M., Bonanno, G.A., Masten, A.S., Panter-Brick, C., & Rachel Yehuda (2014). Resilience definitions, theory, and challenges: interdisciplinary perspectives, *European Journal of Psychotraumatology*, 5(1). https://doi.org/10.3402/ejpt.v5.25338.
+ The Rockefeller Foundation and Arup (2016). City Resilience Index. https://assets.rockefellerfoundation.org/app/uploads/20171206110244/170223_CRI-Brochure.pdf.
+ UNDRR (2007). Terminology on disaster risk reduction, s.v. 'Resilience'. https://www.unisdr.org/we/inform/terminology.
+ United Nations (2015). TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT. https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.
+ United Nations Department of Economic and Social Affairs (UN DESA) (2023). *Global Sustainable Development Report 2023: Times of crisis, times of change: Science for accelerating transformations to sustainable development. United Nations*, New York. https://sdgs.un.org/sites/default/files/2023-07/The-Sustainable-Development-Goals-Report-2023_0.pdf.
+ Xue, X., Wang, L. & Yang, R.J. (2018). Exploring the science of resilience: critical review and bibliometric analysis, Nat Hazards, 90, pp. 477–510. https://doi.org/10.1007/s11069-017-3040-y.

note

[1] Francesca Mosca – ORCID ID: 0000-0001-8898-8727, francesca.mosca@edu.unige.it, Dipartimento Architettura e Design – Università di Genova
[2] Gabriele Oneto – ORCID ID: 0000-0003-3621-1179, gabriele.oneto@edu.unige.it, Dipartimento Architettura e Design – Università di Genova

CHAPTER 2. PLANNING THE CIRCULAR CITY

Towards a complex model for regenerative, adaptive, and sustainable urban systems

Marco Ingrassia[1]

Abstract

The biosphere's capacity to support human life through ecosystem services is today compromised by a relentless increase in the anthropogenic impact of human societies, driven by an extractive development model catalysed by consumeristic lifestyles. Ecological transition demands a social and economic transformation, supported by the development of tools and strategies, and a crucial field of action is represented by cities. The city not only forms the primary habitat for humans but also stands as the predominant centre for political, economic, and cultural activities. Due to the globalization of the economy, urban systems have emerged as interconnected hubs within a worldwide network. This network, facilitated by globally extended supply chains, dic-

tates processes of resource extraction and waste generation, consequently accounting for over 70% of emissions.
This contribution describes the main results of an in-depth study on the emerging model of the 'Circular City', assessing its capacity to serve as a paradigm and a driver for the transition to regenerative, adaptive and sustainable urban systems. Thus, it introduces a theoretical model to identify territorial and spatial planning principles for urban circularity, with objectives related to four key value chains – mobility, consumer goods, food and biomass, buildings and construction – and a digital interface to analyse their systemic correlation.

Keywords: Circular City, Circular Economy, Urban Planning, Urban Sociology, Urban Ecology

1. Introduction

The biosphere's capacity to support human life through ecosystem services is today compromised by a relentless increase in the anthropogenic impact of human societies. This is driven by processes depleting resources and natural capital, environmental pollution, and disruption of atmospheric balance through climate-altering gasses. There is a deep correlation between our extractive economic and production system, the consumerist social model that catalyses its growth processes, and the territorial models associated with them, predominantly urban in nature (Ingrassia, 2023). Fueled by processes of production and power centralization inherent to the industrial economy, urbanization has led the majority of the world's population to live in an urban context. The city constitutes not only the primary human habitat but also the predominant political, economic, and cultural center. Due to the globalization of the economy, urban systems have emerged as interconnected hubs within a worldwide network. This network, facilitated by globally extended supply chains, dictates processes of resource extraction and waste generation, consequently accounting for over 70% of emissions.

In 1972, the authors of 'The Limits to Growth' (Meadows *et al.*, 1972) delineated the profound interrelation between ecosystem transformation, social processes, demographic dynamics, and the production and economic model based on 'growth'. Drawing from Systems theory, they described planet Earth as a 'complex system', governed by nonlinear logic and feedback mechanisms (both positive and negative). The authors underscored the necessity for systemic and multidisciplinary approaches capable of intervening in the determinants of anthropogenic impact, thereby fostering a transformation of the economic and social development model. Drawing upon the insights of sociologist and systems theorist Edgar Morin, we find ourselves today in the age of 'polycrisis' (Morin and Kern, 1999), where the development of new approaches becomes imperative. These approaches must generate a holistic understanding of reality, acknowledging that solutions to one crisis may have ripple effects on others. It is now more necessary than ever to outline systemic and multidisciplinary approaches for the transformation of the development model, starting from cities as fundamental nodes of the social and economic system. While the Sustainable Development Goals of Agenda 2030 provide a clear definition of what Sustainability is, transition requires more than mere targets. It necessitates the identification of underlying drivers of unsustainable processes and the formulation of strategies that address systemic issues.
The transition towards sustainable urban development models poses multiple challenges at two different levels. The first level involves sectoral actions. Here, the challenges are dictated by the need to develop analytical, design, and forecasting strategies and tools capable of supporting the actions of experts, policymakers, and stakeholders in individual disciplinary fields. The second level pertains to the globality of collective and individual social actors, with the challenge of promoting a different model of development – non-extractive, anti-consumerist, and aimed at wellbeing – by identifying coherent objectives that go beyond a remedial approach and instead promote genuinely transformative practices. In this perspective, clear paradigms are necessary to guide collective and individual action.

In recent years, there has been a gradual consolidation of the concept of the Circular Economy, aimed at introducing sustainable resource management processes through the development of various production and consumption models, reuse, recycling, and recovery of materials, goods, and resources. This model targets the extractive economic and production model underlying anthropogenic impact. Its origin can be traced back to Boulding's research (1966), with further development in the field of industrial ecology to describe synergy processes within production chains. Subsequent developments have led to the definition of multiple principles and strategies with an economic and social nature.
Research exploring the implementation of Circular Economy principles has extended to urban systems, leading to the emergence of the concept of Circular City. Various studies across multiple disciplines, particularly in the socio-economic realm, examine this concept. They propose a range of principles and transition strategies involving economic and administrative policies, economic-production models, and social innovation strategies.
However, the very concepts of Circular Economy and Circular City remain ambiguous (Kirchherr, 2017; Paiho *et al.*, 2020), leading to different approaches with objectives that do not always align with the needs of ecological transition. Furthermore, there has not been a clear understanding of what are the territorial and spatial planning principles of the Circular City model, taking into consideration the centrality of territorial and spatial strategy to define the social, economic and environmental trajectories of cities.
This contribution describes the main results of an in-depth study on urban circularity and circular economy in cities and introduces a complex model aiming to support the definition of planning strategies for Circular Cities, conceived as regenerative, adaptive and sustainable urban systems.

2. Circular City in literature

The analytical phase of our research utilized an integrative literature review methodology, focusing on keywords such as 'Circular City', 'Circular Economy and Urban Planning', and 'Circular Economy and Urban Planning'. Analyzing 295 articles and doc-

uments from various disciplinary fields enabled us to identify urban circularity objectives, territorial principles, and a significant research gap, characterized by the absence of holistic and systemic approaches that connect sectoral studies.
From the literature analysis, specific objectives have emerged regarding four value chains: mobility, food and biomass, consumer goods, and construction. Researchers have investigated how these production and consumption systems can be organized and operated within urban systems, with a circular perspective. Among these, the following can be highlighted:

+ *Mobility*

(i) Intermodal and active mobility; (ii) Changing access and consumption patterns; (iii) Conversion of mobility infrastructure.

+ *Consumer goods*

(i) Local production and remanufacturing; (ii) Promotion of craftmanship; (iii) Local repair and reuse; (iv) From possession to use: sharing and servicing of goods; (v) Different access to non-durable goods; (vi) Refusal to consume: quality of life and well-being.

+ *Food and biomass*

(i) Local production; (ii) Sustainable forms of distribution and consumption; (iii) Recycling of organic waste (food and biomass); (iv) Integrated management of natural areas.

+ *Buildings and Construction*

(i) Extension of the life cycle of buildings; (ii) Synergy with other urban systems and functions; (iii) Reuse, recovery and recycling of components; (iv) development of new methods of access and use of buildings.

In relation to territorial and spatial planning, some key principles emerge: localization of production, transformation and recycling systems within the urban fabric; adaptivity over time; regeneration of built environment; curbing soil consumption; urban-rural integration; integration of ecological systems and green infrastructures; NBS nature based solution and naturalistic engineering; distributed and non-centralized models; multifunctionality.

There is also a certain vagueness regarding the definition of the circular city itself. Three main approaches emerge.

+ *Circular City conceived as Urban Metabolism*

This perspective focuses on Urban Metabolism optimization – flows of energy and matter within the urban system – using models from Urban Ecology. Some studies overlook the principles of the Circular Economy, confining themselves to recycling and process efficiency without considering the social and economic dynamics related to consumption and production patterns.

+ *Circular City conceived as Regenerative Urban System*

These approaches focus on a positive relationship between ecological and social systems. However, without a clear theoretical framework within the Circular Economy, there is a risk of overlooking crucial economic and social aspects related to the transformation of consumption and production models.

+ *Circular City conceived as application of Circular Economy at the urban scale.*

This perspective applies the principles of Circular Economy to cities, often overlooking their specificities and complexities. This can lead to vertically integrated and oversimplified solutions that do not consider the social and political dimensions of urban life. They may focus exclusively on logistical and production issues, neglecting the relationship with social and environmental systems.

An additional fundamental issue related to conceptualizing the Circular City is the underlying definition of Circular Economy. In the literature on Circular Economy it's possible to identify two distinct approaches, already defined as the 'weak' and 'strong' approaches (Ingrassia e Cusumano, 2023). A strong Circular Economy is one that reinterprets and mitigates the extractive-linear model, advocating for a radical transformative action in the goals and tools of development. It acknowledges that complete circularity may not be achievable and promotes consumption reduction through a lower demand of social consumption, favors participatory approaches, distributed systems, and open-source solutions. A weak Circular Economy, on the other hand, does not question the growth model, promotes effi-

ciency to maintain high levels of consumption, assumes unlimited recycling, and relies on top-down and technocratic approaches. Often the concept of Circular Economy on which the various contributions are based is found on a spectrum between 'weak' and 'strong' circularity. Among the main critical issues, the persistence, in the majority of the contributions analyzed, of the objective of economic growth should be noted. Nonetheless, this objective often coexists with objectives of reducing and changing consumption models (sharing, servitization, promotion of quality of life), for which valid strategies and actions are articulated, as well as participatory and distributed approaches.
Finally, it should be underlined that the social dimension of consumption processes and lifestyles is addressed by only a few studies. Many of these overlook the role of the consumerist model in promoting consumption, hindering the adoption of alternatives such as servitization and sharing. Lifestyles are in fact influenced by social and economic factors that are often ignored.

3. Towards a systemic approach to the Circular City

A comprehensive approach to the concept of the Circular City is necessary, one that incorporates both the ecological and systemic dimension inherent to the *Urban Ecology*, and the dimension related to the social and economic processes of production and consumption, typical of the 'strong' Circular Economy (Fig. 1). From this perspective, the Circular City can be defined as a model for the ecological transition of cities that is based on, and promotes, the principles of the 'strong' Circular Economy through all the value chains that permeate the urban system – mobility, consumer goods, food and biomass, construction – with an organization and transformation model based on the principles of urban ecology: looking at the city as an 'urban ecosystem', with a complex evolutionary dynamic and non-linear relationships, which requires interventions of a systemic nature.
However, the need emerges for a synthetic interpretative framework for the territorial planning of the Circular City, which highlights the correlation between the different principles and the different value chains, in order to make it an operational tool for

the transition. Therefore, providing a model, or paradigm, capable of defining clear territorial development objectives, and promoting understanding of how these are related to each other.

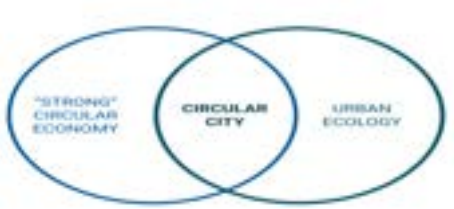


Fig. 1: Circular City - Elaboration of the author.

4. The territorial dimension of the Circular City: modelling and planning

Our research has enabled us to define a comprehensive model for territorial planning through in-depth analysis of sector literature, reference to sociological research and perspectives, and a deductive approach based on the articulation of Circular Economy principles. The model is based on four territorial principles, articulated into two categories – drivers and enablers – and structured according to the four value chains.

With 'drivers' direct factors are identified, capable of guiding the transition towards the circularity of various value chains in urban contexts. 'Enablers', on the other hand, refer to indirect factors for the introduction of circular models into the urban system, influencing the adoption of circular models in urban systems. They do not represent sufficient elements to guide the circular transition, but rather necessary factors to facilitate and make it feasible, promoting them to support the circular transition.

The Planning Circular City model is articulated into the following territorial principles and objectives:

4.1 Distribution and accessibility (driver)

Production, reuse, and recovery systems for goods and products are located within the urban system at the most appropriate scale, following a decentralized and distributed model. The city becomes productive again and permeated by short and circular value chains, with nodes of these chains easily accessible to both

citizens and businesses. This transformation reduces the gap between production and consumption locations, promoting process integration. Key strategies are:

+ Intermodal mobility (people).
+ Multimodal and branched logistics infrastructure.
+ Productivity distributed in the territory (Industrial areas, craft spaces, indoor agriculture, Urban gardens).
+ Local proximity commerce.
+ Distributed energy production and Synergy to reduce consumption.
+ Distributed infrastructure of Sharing, reuse, and repair centers.

4.2 Adaptability and regeneration (driver)

The urban system, similar to an ecological system, is capable of adapting and regenerating to respond to different functions over time (day-night, hourly, weekly-weekend, yearly) and meet the needs of citizens. This adaptive capacity is structured through design and planning solutions supported by digital technologies, but it also requires specific regulations.

The adaptation and regeneration of existing structures correspond to the curb to land consumption. It also requires a change in regulations to allow for variable land use modes and to avoid speculative land rent. Key objectives are:

+ Curb on land consumption.
+ Fast, experimental and adaptive solutions.
+ Adaptive reuse of unused or underused buildings and land.
+ Promoting adaptive reuse over demolition.
+ Construction of new buildings with modular and flexible objectives.

4.3 Multifunctionality and Proximity (enabler)

To support decentralized and distributed models, a necessary condition is the promotion of the multifunctionality of neighborhoods and buildings, overcoming functional zoning. The integration of functions creates social and economic diversity, making the system more resilient and adaptive, and creates conditions to support the

distribution of production, reuse, and recovery systems of goods and products within the urban fabric. It also promotes lifestyles based on proximity, supporting social interaction and vitality in neighborhoods and buildings, as well as increased efficiency and reduced forced mobility. Key objectives are:

+ Proximity and centrality.
+ Multifunctionality of buildings and districts.
+ Quality and anti-consumer public space.
+ Equity and strengthening of social cohesion.

4.4 Renaturalization and Integration (enabler)

The city is designed as an ecological system, where possible, using methods and materials that mimic or implement natural processes. Urban renaturalization occurs through the adaptive transformation and regeneration of existing structures, avoiding piecemeal and disconnected actions and instead promoting integrated planning of urban, rural, and intermediate contexts. In this way, the city fosters (i) the strengthening of the ecological network with green infrastructure that enhances the regenerative capacity of the urban system, generating ecosystem resources and services, and (ii) local synergies and value chains. Key objectives are:

+ Renaturalization and ecological approach.
+ Recovery of traditional relational forms to the landscape.
+ Continuity of the urban and rural ecological network.
+ Integrated design of urban systems and ecosystems.
+ Use of NBS and naturalistic engineering.

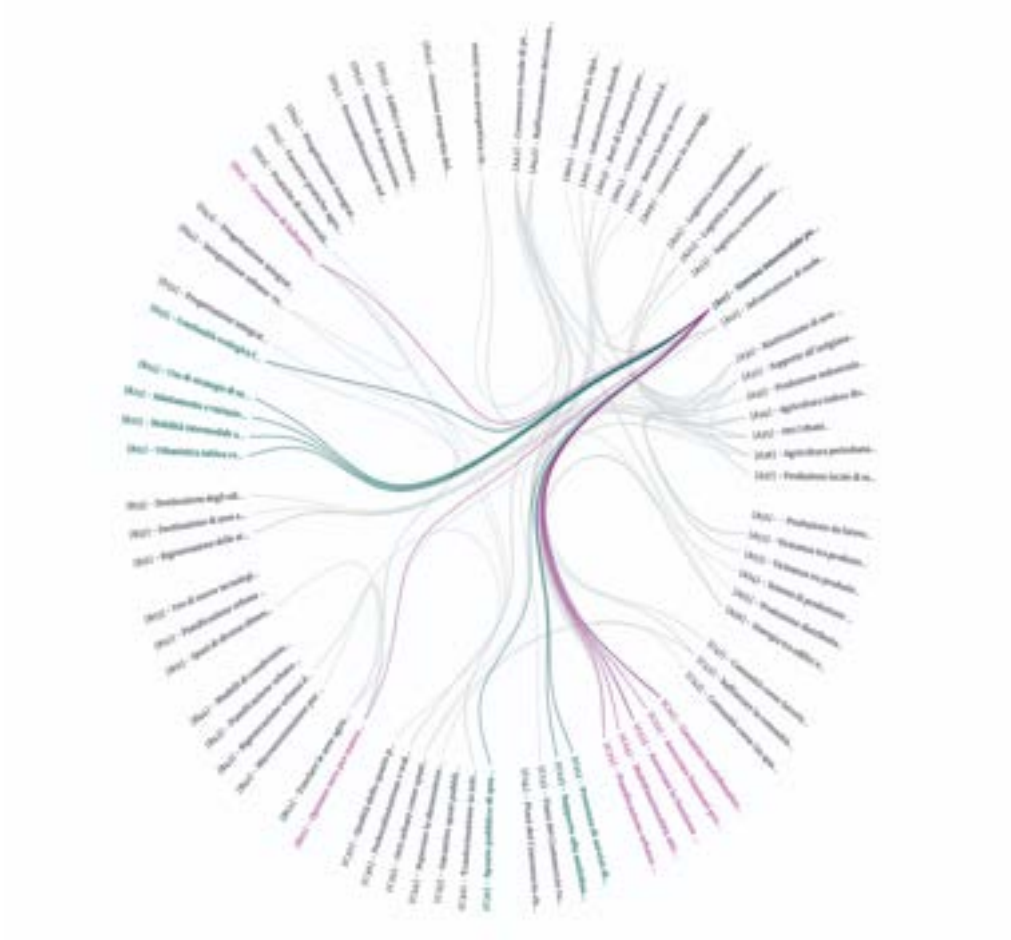
Our model details the articulation of these principles for the different value chains – mobility, food and biomass, consumer goods, and construction – and identifies the correlation between these principles and territorial objectives. The implementation of each of these objectives is capable of generating positive or negative feedback effects on other elements of the system – or urban ecosystem. The complexity of these relationships cannot be described in detail but can be outlined according to general 'trends' to guide the action of collective actors and public decision-makers.

To achieve this, the research introduces a digital interactive model that enables understanding the correlation between different factors[2]. In Figure 3, for illustrative purposes, it is possible to visualize the correlation of the strategy 'A.1.1 - Intermodal Transportation' with other dimensions of the Circular City, which can be synthesized as follows.

One notable benefit is its role in curbing land consumption, particularly through the implementation of a 'zero option' approach for new automotive transport infrastructure (B.1.1). By prioritizing alternative modes of transportation and discouraging further expansion of road networks, it creates opportunities for renaturalization and creation of green and blue infrastructure, through the progressive dismantling of unnecessary mobility infrastructure (D.1). Underutilized roads or parking lots, cities can be reclaimed as spaces for parks, green corridors, and waterways, thereby enhancing biodiversity, mitigating the urban heat island effect, and improving overall environmental quality. Another benefit is the capacity to promote the multifunctionality of buildings and districts (C.2), which is necessary to reduce land and energy consumption, as well as to promote vibrant urban life.

On the other hand, the intermodal public system can be reinforced by the adoption of fast, experimental, and adaptive solutions in urban planning (B.2). Tactical urban interventions, such as the implementation of bike paths, pedestrianization schemes,

Fig. 2: Digital Interface for the Planning Circular City Model. Example based on the activation of 'Intermodal Mobility System'.



and responsive signaling systems, enable cities to quickly test and implement innovative mobility solutions that respond to evolving needs and preferences of urban residents. Moreover, by prioritizing the design and maintenance of high-quality public spaces (C.2) that are safe, accessible, and inviting, cities can encourage active mobility by walking and cycling, and therefore increase the use of intermodal mobility. Finally, multifunctionality of Buildings and neighborhoods is also favoring the use of intermodal mobility. The model thus outlines a complex correlation between the various objectives, in a systemic perspective that combines circularity and urban ecology objectives.

Fig. 3: Planning Circular City Model.

5. Conclusions

The ecological transition requires a transformation of urban systems from social, economic, and territorial perspectives, which cannot ignore the development of accessible models and new urban paradigms. In this regard, the model for Circular City Planning aims to provide interpretative tools to various urban actors – from city makers to active citizens – and sectoral experts, in order to stimulate debate and identify new fields of sectoral and transdisciplinary research.

Biography

Marco Ingrassia is an Architect and Researcher, with a PhD in Environmental and Territorial Sociology. He carries out his research activity at the University of Enna Kore and in the non-profit sector between Palermo and Barcelona.

His research focuses on cities as complex socio-ecological systems, exploring the intertwined and co-evolutionary relationship between urban Space and Society. His expertise encompasses Participatory Design and Social analysis, Circular Economy, Ecological Planning. From 2015 to 2020 he worked at IAAC Institute for Advanced Architecture of Catalonia (Barcelona) as Academic Coordinator, Faculty and Researcher in European Projects. Most notably, as project manager of the Creative Europe Project 'Public Play Space', his research delved into serious games and gamification as drivers of participatory design of the Public Space. He collaborated with different architectural offices in Barcelona and Palermo. His projects have been exhibited in renowned venues, including MAXXI museum and Design Museum in Barcelona.

references

+ Boulding, K. (1966). The Economics of the Coming Spaceship Earth. In *Environmental Quality in a Growing Economy* (pp. 3–14). Resources for the Future/ Johns Hopkins University Press, pp. 3–14.
+ Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, pp. 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005.
+ Ingrassia, M. (2023). Limiti dello Sviluppo e pianificazione urbana: Il paradigma della Città Circolare come strategia per la pianificazione ecologica. *Culture della Sostenibilità 32/2023*, 43. https://doi.org/10.7402/CDS.32.005.
+ Ingrassia, M., & Cusumano, M. (2023). Politiche Urbane per l'Economia Circolare. Tre città europee a confronto. *Culture della Sostenibilità 30/2023*, 1. https://doi.org/10.7402/CDS.31.09.
+ Meadows, D., Meadows, D., & Randers, J. (1972). *The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind*. Universe Books.
+ Morin, E., Kern A.B. (1999). *Homeland Earth: A Manifesto for the New Millenium. Advances in Systems Theory, Complexity, and the Human Sciences*. Cresskill, N.J: Hampton Press.
+ Paiho, S., Mäki, E., Wessberg, N., Paavola, M., Tuominen, P., Antikainen, M., Heikkilä, J., Rozado, C. A., & Jung, N. (2020). Towards circular cities – Conceptualizing core aspects. *Sustainable Cities and Society*, 59, 102143. https://doi.org/10.1016/j.scs.2020.102143.

note

[1] Marco Ingrassia – ORCID ID: 0000-0001-7209-1384, ingrassia.arch@gmail.com, Dipartimento di Scienze dell'uomo e della società – Università di Enna "Kore"
[2] Accessible at the website https://www.planningcircular.com/

CHAPTER 3. DESIGNING RESILIENCE:MULTI-DISCIPLINARY PERSPECTIVES

Francesca Mosca, Gabriele Oneto

This section of the book consists of a collection of contributions on the design approach to urban resilience from various perspectives, objectives, and scales. These contributions, emanating from diverse vantage points, objectives, and spatial dimensions, collectively describe the intricate interplay between urban fabric and its adaptive capacity. The discourse commences at the building scale, encompassing neighbourhoods, districts, and urban systems. Finally, it extends its focus to the landscape scale, where cities merge seamlessly with their surroundings. The different aims try to forge resilient strategies capable of withstanding contemporary and impending challenges. While at the building form, the contributors grapple with form, function, and materi-

als. Zooming out, urban designers consider neighbourhoods and districts, weaving together threads of social sustainability and environmental robustness. Some of these strategies transcend traditional aesthetic and compositions, delving into the sinews and implications of urban metabolism. Resilience is an occasion for addressing climate change, demographic matters, resource scarcity. Whether through systemic resilience, community-forced approaches or ecological harmonies, the goal remains the same: resilient cities that thrive amidst chaos, anticipate the unseen, and strive toward adaptability. The contribution from young researchers heeds this call and embrace from their perspective this important contemporary design paradigm.

KINETIC FACADES AND 4D PRINTING FOR A RESILIENT BUILDING

Proposal for a facade component made with Shape-Memory Polymers

Caterina Battaglia[1]

Abstract

The present work originates from the identification of the concept of resilience and its application to the construction industry. Although resilience refers to the ability to cope with external stress loads without being damaged by them, we are often accustomed to using this term to refer to a human capacity, a tendency of a person's character and psyche, and rarely associate it with elements such as buildings, neighbourhoods or even cities. But the city, like us, must be able to show resilience in order to respond to the increasingly urgent challenges of our

time, such as climate change and pollution, which increasingly expose it to new fragilities.
From an analysis of the existing literature, two trends emerge that could prove to be salvific within such a transitional path. On the one hand, it is worth noting the remarkable strides that are being made in the area of additive manufacturing, especially with regard to 4D printing. The latter is nothing more than the advanced version of 3D printing that almost everyone is familiar with, but it differs from its predecessor in its amazing capabilities, such as the shape memory effect, which allows objects made with these techniques to change their conformation depending on the stimuli they receive.
Another innovative technology that is well suited to the evolving needs of the construction industry are the so-called kinetic facades, consisting of systems, mechanically operated, that can change the spatial conformation of a facade, so as to allow better exploitation of solar radiation at various times of the day. Many advantages could result from the combination of these two technologies, related to the possibility of harnessing the capabilities of 4D-printed objects to drive the kinetic mechanisms of facades without the need for external power systems, thus reducing the building's energy consumption.

Keywords: 4D printing, smart materials, kinetic facade, passive systems, Construction 4.0

1. Introduction

From the Latin *resilire*, the term resilience denotes the ability of an organism to cope with situations of extreme stress without harming its essential functions. Custom dictates that this concept is employed to define a typical characteristic of the human psyche or the intrinsic property of certain materials to absorb a shock without fragmenting, but it is interesting to see what its possible declinations are in the field of construction. In fact, by making a parallelism between organisms and cities, it becomes clear that the latter also need to increase their degree of resil-

ience in order to cope with the increasingly urgent difficulties that characterize today's world, among which stand out the phenomena of global warming, the increase in the emission of pollutants, the ever-increasing consumption of resources, and many other external stressors that threaten the safety of our planet. Indeed, among the greatest challenges of our century, many constitute a source of stress for human beings but also for cities and the buildings that make them up. The causes of such imbalances in the equilibrium of the system can be attributed to several factors, and responsibility falls on the entire production system, which needs a phase of updating and transformation in order to improve its performance in terms of sustainability and environmental impact. Among the many sectors, however, the construction sector turns out to be one of the biggest culprits for this surge in consumption and production of pollutants: it alone produces one-third of global emissions, consumes 30 percent of resources, 40 percent of electricity and 25 percent of water, and generates 40 percent of the total waste production. Since estimates predict that by 2050 87% of the world's population will live in urban areas (UN-Habitat, 2022), CO2 emissions from the construction sector are expected to reach 15.6 billion tons by 2030 (Balasubramanian *et al.*, 2024; Balasubramanian & Shukla, 2017).

One of the reasons for this negative record is to be found in the still very present difficulty in integrating recent technological innovations, which have revolutionized many aspects of everyday life but are still struggling to find fertile ground in the construction sector (Ghobakhloo, 2020; Klinc & Turk, 2019). In some cases, technologies that originated within other manufacturing sectors, such as the processing of sheet metal through progressive molding, have since found application in the design field, especially with regard to furniture elements or architectural components. The process, however, is still a long one, and there is an increasing need to put into practice a phenomenon of transition of the city and buildings, based on the principles of sustainability and reduction of environmental impact, which takes advantage of the potential arising from the development of innovative technologies.

2. Context analysis

The facade element has always played a key role within the design process, as it represents the outermost envelope, capable of creating a connection between building and observer, who can thus read and understand the architecture through the formal choices implemented. In the evolutionary history of architecture, from the earliest pyramids to contemporary times, building elements have always been connoted by an intrinsic static nature, and the building has traditionally been identified as an immovable asset, in time, space and form (Alotaibi, 2015).

In spite of the many innovations that have affected the subject of the facade in recent decades, presenting advanced technological solutions such as energy-efficient glass or photovoltaic facades, the limitations imposed by the element's static nature have not yet been overcome. In fact, the mentioned solutions allow reliable results in terms of thermal comfort and energy efficiency improvement, but they are not able to show suitable resilience and transform the building into an organism capable of reacting to changes in the surrounding environment (Juaristi *et al.*, 2018).

Today, however, the challenges of the construction industry are increasingly beginning to refer to issues such as dynamism and the ability to adapt to a variable, ever-changing environment, and this need for resilience has found a virtuous declination in so-called adaptive envelopes.

Among the first to talk about climate adaptive building shells (CABS), Loonen shows how in fact the attempt to integrate the building with climatic conditions has already been made in the past, for example in the work of Davies (Rubio Hernández, 2017) who describes the dynamic envelope as a 'multipurpose wall', but had to contend with the limitations imposed by the technological advancement of the times, insufficient to make a substantial step forward. With the advent of recent technologies and innovative materials, however, the topic of kinetic facades and adaptive envelopes has begun to spread systematically in recent decades, marking an important milestone in the journey toward energy efficiency in the built environment. CABS, then, are defined

by Loonen as an envelope that « has the ability to repeatedly and reversibly change some of its functions, characteristics or behaviours over time in response to changing performance requirements and varying boundary conditions and does so with the goal of improving the overall performance of the building ». (Loonen *et al.*, 2013).

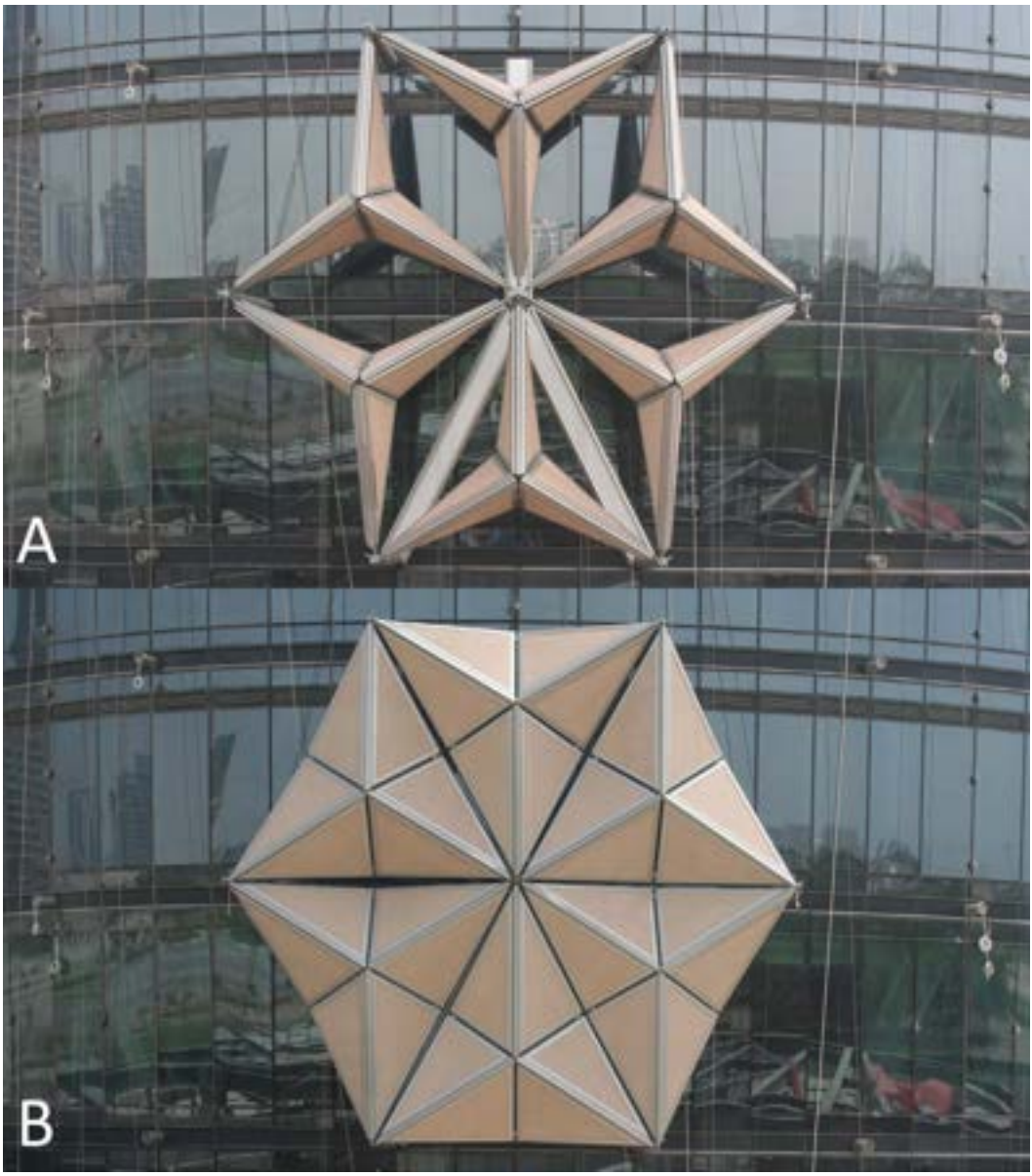
The term "adaptive" in reference to facades can be the subject of confusion and misunderstanding because of the variety of semantic facets it takes on depending on the context of reference. In this regard, the review carried out by Tabadkani constitutes a key reference point for gaining a comprehensive view of the topic. Indeed, the author proposes a classification of adaptive enclosures according to the control techniques employed, distinguishing the following types: active, passive, biomimetic, kinetic, intelligent, interactive, mobile, responsive, smart and switchable (Tabadkani *et al.*, 2021).

Specifically, when we talk about kinetic facades, we refer to a technology that has been widespread in recent decades, which is characterized by its ability to allow the building to deviate from the archetype of a fixed, immobile and immutable element. Indeed, kinetic, or dynamic, facades use movable systems driven by a motor, capable of changing their spatial conformation for reasons beyond pure aesthetics. Often, in fact, these solutions have been an optimal compromise between form and function, thanks to the possibility of exploiting their dynamic behaviour, for example, to constitute solar radiation protection systems that adjust their inclination, and consequently the degree of protection, as needed (Narbuts & Vanaga, 2023).

Among the best-known examples of the application of kinetic facades, the Institut du Monde Arabe designed by Jean Nouvel turns out to be one of the best examples of how the combination of dynamism and architecture can yield excellent results. In fact, the system designed by the French architect consists of shading elements that function according to the mechanism of a diaphragm, adjusting their opening to let light filter in (Turco & Pagliero, 2018).

Fig. 1: Al-Bahr Towers, ARUP, 2012 (Source: ARUP).

Another iconic example of a kinetic facade is the Al-Bahr Towers (Fig.1), built in 2012 by the architectural firm ARUP in collaboration with the company AHR, can be considered the perfect synthesis of aesthetics and performance.



Inspired by the arabesque patterns of the *mashrabiya*, the movable components that partially cover the glazed surface of the two lanceolate towers mainly perform a filtering function between solar radiation, which is particularly high at that latitude, and the interior, which is maintained at excellent levels of living comfort, despite the considerable temperature changes in the surrounding environment (Babilio *et al.*, 2019).
In a hypothetical balance of the pros and cons associated with the use of kinetic facades as a decisive technology in transforming the building into an adaptive organism, it becomes apparent that such a system needs a source of energy to fuel the operation of the mechanism, as well as regularly performed maintenance. In the face of improved thermal comfort conditions and the possibility of varying the aesthetic conformation of the components according to changes in the surrounding environment, while satisfying the needs of the user, the kinetic facade system appears to be a solution that is only partially preferable to the traditional, static envelope, and it is necessary to reason about the potential for transforming the system to untether its operation and transform it into a passive system.

3. Aim of the work

The objective of the present research is to direct the design towards technological solutions that allow the regulation of the behaviour of the envelope in relation to environmental conditions, transforming it into a dynamic element, capable of adapting and transforming as needed.
The present contribution, which is part of a broader PhD program, is developed around the proposal of a production process aimed at the realization of a facade component capable of making the building's external envelope adaptive without resorting to the integration of a motorized system, so as to avoid unnecessary energy consumption and decrease the level of environmental impact of the construction process and the entire life cycle of the asset.
Indeed, there are numerous examples in the literature of kinetic facades, systems that allow the components of the envelope to

move and change their conformation as needed, allowing for better management of living comfort and energy flows exchanged between the interior and exterior. These systems, however, have some disadvantages related to the activation mechanism, including the noise produced by the motor and, far more relevant to emissions containment, the energy consumption required to power the mechanism.
It is therefore necessary to find an alternative system to achieve the movement of facade elements without exploiting motorized mechanisms. For this purpose, it is convenient to analyse the current state of the art with respect to some innovative technologies that have already produced outstanding results in other production sectors but are instead struggling to find a concrete application in the field of construction, such as 4D printing and smart materials.

4. Challenges of the AEC sector

In order to improve the performance of a building, it is convenient to direct the focus of research on the envelope, the outermost portion of the building, which regulates its relationship with the surrounding environment, simultaneously acting as a barrier between environments and as a filter in regulating energy exchanges between inside and outside. Acting on the interaction between the envelope and environmental stimuli (solar radiation, airflow, wind, noise pollution) can lead to an improvement in indoor comfort and, above all, in reducing energy consumption and the environmental impact of the building system (Sommese *et al.*, 2022). Although facades are traditionally designed to respond to both average and extreme weather conditions, in most cases the envelope is not optimized by design (Juaristi *et al.*, 2018). Conventional facade systems, therefore, are not a sufficient solution to cope with the increasingly abrupt climatic changes we are confronted with nowadays: the static nature that has always connoted buildings and their constituent parts can no longer be considered a strength or an indicator of building quality, but rather a limitation that prevents the structure from adapting to climatic variations in the surrounding environment.

Substantial progress has been made in recent decades with regard to the introduction of the dynamic component within the design of facades and envelopes, but the proposed solutions, despite their effectiveness, still have numerous drawbacks related to the presence of motorized mechanisms. The behaviour of so-called kinetic facades, in fact, is the result of the action of an active system, consisting of a motor that uses electrical energy to operate and requires constant maintenance. Such systems also inevitably produce an amount, albeit small of noise pollution due to the noise of the mechanism (Alotaibi, 2015).
In order to overcome these problems, it is necessary to transform adaptive enclosures and kinetic facades into passive systems, that is, systems that exploit the physical and natural properties of environmental conditions without consuming energy. For this transformation to be possible, it is necessary to exploit the behaviour of materials that can move and change shape without the support of a motor.

5. Innovation

The construction sector has always played a key role within the evolutionary processes that characterize the transformations of society. Indeed, it is a field whose potential for growth, since ancient times, has been intricately linked to technological innovations often already present and tested in other fields of science or art, which are only later introduced into this sector. This phenomenon of lagging behind in the translation of some innovations from other languages to that of building and construction has had significant repercussions on the level of digitization and updating of the sector, which today lags far behind other areas of production where innovations have spread effectively for some time.
Among the most interesting breakthroughs of the last decade is the spread of the 4D printing methodology, derived from the already existing 3D printing, with which it shares almost every feature except for the materials used in making objects. The substantial difference between the two additive manufacturing methodologies, in fact, lies in the use of materials called smart,

a category to which both polymers and alloys belong, characterized by the so-called shape memory effect. Objects produced by 4D printing, in fact, are capable of changing their spatial conformation the moment they are subjected to a stimulus of a variable nature (thermal, magnetic, chemical, etc.), transforming without affecting the integrity of its structure, and then returning to its original shape once exposure to the stimulating element has ceased (Fig. 2).

Fig. 2: Example of shape recovery mechanism (source: MIT).

Reporting what Eujin Pei says, 4D printing is «the process of building a physical object, with appropriate additive manufacturing technology, by depositing consecutive layers of stimulus-responsive composites or multi-materials, with different properties» (Pei, 2014). The operation of 4D printing is based on the change in shape that is achieved either as the physical effect of a residual voltage or through the energy released by an active, or smart, material (Nezhad *et al.*, 2022).

Although this is a relatively recent technology, there are numerous cases of the application of 4D printing techniques in different sectors of industry, especially in biomedical engineering, medicine and aerospace, where very promising results have been obtained. In the biomedical field, for example, it has been used to make scaffolds, elements designed to restore the functionality of damaged tissues and organs, precisely because of its potential related to the material's ability to adapt and change as needed. The potential of this innovative method of printing, however, is not limited to the fields of medicine and biomedical engineering, and it is expected that in the coming years 4D printing will

spread to many areas of production, bringing significant benefits and enabling a leap forward in the digital transition of different sectors (Mascaretti, 2019).
This opens interesting scenarios related to the introduction of 4D printing in the construction sector. Indeed, the change in shape of an object due to the response to stimuli can be exploited to make intelligent and adaptive building components, which as a result of natural stimuli can change allowing for different structures than those without the stimulus. Another advantage offered by 4D printing is the ability to print with smart materials simple components that can, then, self-assemble to achieve the desired complex final shape. In general, the potential of structures fabricated with this technology stems from their ability to self-assemble, adapt and self-repair. Finally, the use of this methodology could save space in construction product storage and transportation activities.

6. Integrating the Shape-Memory effect (SME) in the adaptive envelope

The goal of the present work is to investigate the integration of the change and shape memory properties within a dynamic facade system that can adapt to the external context by transforming according to conditions.
Attempts to exploit the potential of these two technologies to combine them in an innovative mechanism have already been made, as in the case of the work of Yi *et al* (Yi & Kim, 2021), in which the behaviour of a facade mechanism whose shape is reminiscent of the flaps of an umbrella was investigated, capable of opening and closing thanks to the action of a PLA element that, depending on temperature, expands or contracts allowing the structure to change conformation.

The results of this study had shown positive opportunities, indicating that this area could truly be a key to the transition path of the construction industry. The common denominator of all studies conducted on dynamic facade systems and smart materials, however, is the lack of full-scale experimentation

(Pathan *et al.*, 2023; Yi, 2021). In fact, as work indicates, experiments conducted on the behaviour of facade elements produced by 4D printing have always been limited to the scope of the laboratory scale (Fig. 3), which allows for reliable results only up to a certain point. In order for us to really take a step forward within the transformation of cities and their buildings into resilient systems, therefore, it is necessary to understand what the major shortcomings and difficulties are encountered in the first attempts to integrate the two technologies, in order to try to overcome them.

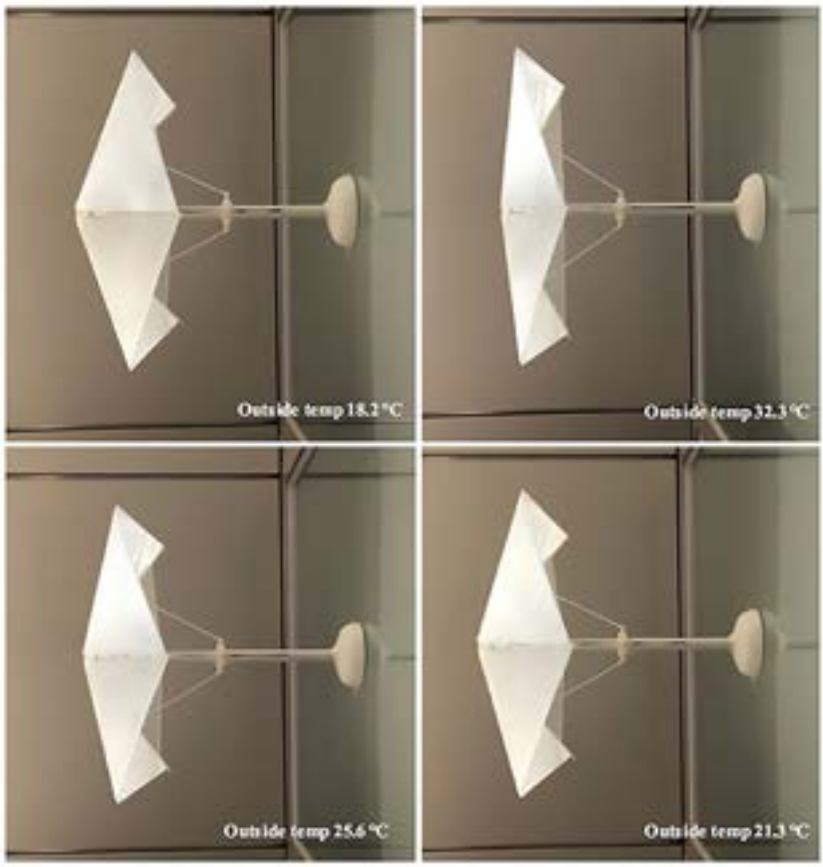


Fig. 3: SM-based module design and experimental evaluation of shape change with temperature variation (source: Yi *et al.*, 2020).

Aside from a limitation related to the scale of experimentation, in fact, almost all studies regarding the application of Shape-Memory Polymers (SMP) polymers have focused on the use

of PLA, due to its availability and the low cost of the material and the mechanisms needed to process it (Paolini *et al.*, 2019; Volgin & Shishkovsky, 2021). PLA, however, has a relatively high activation temperature range of 65 to 95 °C. This factor clearly proves problematic when assuming that the PLA element is applied on a facade, where temperatures do not reach such peaks. Another of the next challenges to be overcome in order to succeed in the objective of the present work is to find a material with similar characteristics to PLA but with a lower activation temperature. To do this, one can refer to studies conducted in the medical and biomedical field, where the production of stents, valves and other medical instruments printed in 4D is becoming increasingly popular, and where the activation temperatures, for biological reasons, must be within the physiological ranges of the human body, i.e., within 36-37°C, temperatures that are also more suitable for a facade surface (Ghosh *et al.*, 2023).
If materials research in the biomedical field does not prove fruitful, it will be necessary to investigate alternative systems of heating the surface of the PLA-printed element, such as through the use of coatings that can increase the surface temperature of the object while maintaining its shape-changing behaviour in relation to temperature changes in the surrounding environment. Although to date the attempt to integrate the two technologies has not yet produced definitive results, the potential of 4D technology and its excellent results in other areas of application suggest that it is only a matter of time before this technology takes hold and spreads within the construction industry as well, becoming an integral part of the construction process not just as a facade element.

Biography

Caterina Battaglia, Civil Engineer, received her bachelor's degree in architecture and master's degree in construction engineering from the University of Genoa. She is currently in the second year of her PhD program in Architecture at the University of Genoa, and her research topics include sustainable design, the application of 3D and 4D printing to architecture, and the integration of kinetic facade systems and smart materials.

references

+ Alotaibi, F. (2015). The Role of Kinetic Envelopes to Improve Energy Performance in Buildings. *Journal of Architectural Engineering Technology*, 04(03). https://doi.org/10.4172/2168-9717.1000149.

+ Babilio, E., Miranda, R., & Fraternali, F. (2019). On the kinematics and actuation of dynamic sunscreens with tensegrity architecture. *Frontiers in Materials*, 6. https://doi.org/10.3389/fmats.2019.00007.

+ Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: an empirical investigation on the construction sector. *Supply Chain Management*, 22(1), pp. 58–81. https://doi.org/10.1108/SCM-07-2016-0227.

+ Balasubramanian, S., Shukla, V., Islam, N., & Manghat, S. (2024). Construction Industry 4.0 and Sustainability: An Enabling Framework. *IEEE Transactions on Engineering Management*, 71, pp. 1–19. https://doi.org/10.1109/TEM.2021.3110427.

+ Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *In Journal of Cleaner Production* (Vol. 252). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2019.119869.

+ Ghosh, S., Chaudhuri, S., Roy, P., & Lahiri, D. (2023). 4D Printing in Biomedical Engineering: a State-of-the-Art Review of Technologies, Biomaterials, and Application. In Regenerative Engineering and Translational Medicine (Vol. 9, Issue 3, pp. 339–365). *Springer Science and Business Media Deutschland GmbH*. https://doi.org/10.1007/s40883-022-00288-5.

+ Juaristi, M., Monge-Barrio, A., Sánchez-Ostiz, A., & Gómez-Acebo, T. (2018). Exploring the potential of smart and multifunctional materials in adaptive opaque façade systems. *Journal of Facade Design and Engineering*, 6(2), pp. 107–117. https://doi.org/10.7480/jfde.2018.2.2216.

+ Klinc, R., & Turk, Ž. (2019). Construction 4.0 – Digital Transformation of One of the Oldest Industries. *Economic and Business Review*, 21(3). https://doi.org/10.15458/ebr.92.

+ Loonen, R.C.G.M., Trčka, M., Cóstola, D., & Hensen, J.L.M. (2013). Climate adaptive building shells: State-of-the-art and future challenges. In *Renewable and Sustainable Energy Reviews*, Vol. 25, pp. 483-493. https://doi.org/10.1016/j.rser.2013.04.016.

+ Mascaretti, S. (2019). LA STAMPA 4D: STATO DELL'ARTE, APPLICAZIONI E SPERIMENTAZIONE DI MATERIALI TERMOPLASTICI IN COMMERCIO [Laurea Magistrale]. *Politecnico di Milano*.

+ Narbuts, J., & Vanaga, R. (2023). Revolutionizing the Building Envelope: A Comprehensive Scientific Review of Innovative Technologies for Reduced Emissions. *Environmental and Climate Technologies*, 27(1), pp. 724–737. https://doi.org/10.2478/rtuect-2023-0053.

+ Nezhad, I.S., Golzar, M., Behravesh, A. hossein, & Zare, S. (2022). Comprehensive study on shape shifting behaviors in FDM-based 4D printing of bilayer structures. *International Journal of Advanced Manufacturing Technology*, 120(1-2), pp. 959–974. https://doi.org/10.1007/s00170-022-08741-z.
+ Paolini, A., Kollmannsberger, S., & Rank, E. (2019). Additive manufacturing in construction: A review on processes, applications, and digital planning methods. In *Additive Manufacturing* (Vol. 30). Elsevier B.V. https://doi.org/10.1016/j.addma.2019.100894.
+ Pathan, M., Devaramani, R., & M Adinarayanappa, S. (2023). Modelling, simulation, and experiments of 4D printed twisting actuator. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2023.03.004.
+ Pei, E. (2014). 4D printing – Revolution or fad? Assembly Automation, 34(2), 123–127. https://doi.org/10.1108/AA-02-2014-014.
+ Rubio Hernández, R. (2017). 'A Wall for all Seasons', un modelo sostenible de 'piel' tersa de vidrio. Rita_. https://doi.org/10.24192/2386-7027(2017)(v8)(01).
+ Sommese, F., Badarnah, L., & Ausiello, G. (2022). A critical review of biomimetic building envelopes: towards a bio-adaptive model from nature to architecture. In *Renewable and Sustainable Energy Reviews* (Vol. 169). Elsevier Ltd. https://doi.org/10.1016/j.rser.2022.112850.
+ Tabadkani, A., Roetzel, A., Li, H.X., & Tsangrassoulis, A. (2021). Design approaches and typologies of adaptive facades: A review. In *Automation in Construction* (Vol. 121). Elsevier B.V. https://doi.org/10.1016/j.autcon.2020.103450.
+ Turco, M. Lo, & Pagliero, Y.B. (2018). Representation, design, and management of generative algorithms for architecture: The case study of the institute of the arab world, in paris. In *Handbook of Research on Form and Morphogenesis in Modern Architectural Contexts*, IGI Global, pp. 243-362. https://doi.org/10.4018/978-1-5225-3993-3.ch012.
+ UN-Habitat. (2022). World Cities Report – Envisaging the Future of Cities.
+ Volgin, O., & Shishkovsky, I. (2021). Material modelling of FDM printed PLA part. *Engineering Solid Mechanics*, 9(2), pp 153–160. https://doi.org/10.5267/j.esm.2020.12.004.
+ Yi, H. (2021). 4D-printed parametric façade in architecture: prototyping a self-shaping skin using programmable two-way shape memory composite (TWSMC). *Engineering, Construction and Architectural Management*, 29(10), pp. 4132–4152. https://doi.org/10.1108/ECAM-05-2021-0428.
+ Yi, H., & Kim, Y. (2021). Prototyping of 4D-printed self-shaping building skin in architecture: Design, fabrication, and investigation of a two-way shape memory composite (TWSMC) façade panel. *Journal of Building Engineering*, 43, 103076. https://doi.org/10.1016/j.jobe.2021.103076.

note

[1] Caterina Battaglia – ORCID ID: 0009-0000-9709-3079, caterina.battaglia@edu.unige.it, Dipartimento Architettura e Design – Università di Genova

NATURE AND CULTURE IN CORVIALE RESIDENTIAL COMPLEX

Exploring the Human Landscape through Linear Megastructures

Ayla Schiappacasse[1]

Abstract

There is an undeniable allure to the grandeur of human-made structures that grace the landscape, the intricate tapestry of cities themselves, and the purposeful designs of civil constructions. Consider, for a moment, the natural landscape devoid of human interventions – a vast expanse of undisturbed beauty, resembling a luminous desert, untouched by the imprint of human hands. Pure natural beauty. Yet, the world we inhabit,

the landscapes we traverse, and the cities we call home are all products of human endeavour. As we interact with the natural world, we transform it with our vision, aspirations, and needs. It is in these dynamic landscapes, where skyscrapers pierce the sky, bridges span vast rivers, and bustling urban centres pulsate with life, that we find our most profound reflections of human manufactures. In this intricate dance between artifice and nature, we find a reflection of ourselves, as individuals and as a society, etching our presence onto the canvas of the world, creating a vibrant net that intertwines culture and the natural world.
Throughout the 20th century, the twin forces of industrialization and urbanization laid the foundation for innovative visions of mechanized urban life. As technology advanced astonishingly, architects and urban planners composed ideas and projects aimed at shaping our cities. This era also marked a profound human engagement with machines on an unprecedented scale, giving rise to both admiration and frustration. Within the delicate balance between artifice and nature, the realms of architecture and urban environments emerge as quintessentially human expressions. This contribution delves into the intricate relationship between nature and culture in linear megastructures with a particular focus on the *Corviale* residential complex.

Keywords - Bigness, Culture, Urbanization, Nature, Megastructures

« E dove si dirige? Verso l'allontanamento dal noto,
Au fond de l'Inconnu pour trouver du nouveau
(Le Voyage, VIII, 8),
per uscire comunque dal mondo, non importa dove
(*Anywhere out of the world!*, in Spleen de Paris, XLVIII) ».
Bodei R., Limite, 2016

1. City as Environment

In the posters for *The Propaganda for Welwyn* (1920), the idea of responding to a widespread popular intolerance of inhabiting modern cities is blatant: people are refusing the consuming hab-

its of « living and working in the smoke » or « to waste two hours daily in trains, buses and trams to and from the workshop », looking for « pure and healthy atmosphere ». These and similar sentiments stem from the cultural challenges of urban living and are still perceived nowadays: the grind of daily work, the reality of living in a polluted environment, the lack of vegetation in the concrete urban jungle and the lack of spaces for leisure and contemplation. Lynch summarizes in four points the main shortcomings of the American city: the « perceptual wear and tear imposed by the city » as an environment often with conditions unfavourable to human well-being due to being too hot and noisy; the lack of visual identity that generates oppressive monotony; the illegibility of cities as they lack a system of decipherable symbols, producing a sense of alienation; the rigidity and lack of outlets in the city (Lynch, 1960: 18-23). These factors, which we can find reproduced also in the European suburban environment, fuel a longing for escape, a yearning for environments more closely aligned with nature's embrace.

Nature is a word with such a vast meaning that it lends itself to be used in a misunderstood and deceptive way. This happens, for example, when a material is defined as 'unnatural', or 'too chemical', forgetting that nature itself is chemistry. Nature, from the Latin *natūra*, derived from *natus*, the past participle of *nasci* 'to be born', is by definition « the total system of living beings, animals and plants, and inanimate things, which present an order, realize types, and are formed according to laws » (Treccani). It is a word with a vast and misunderstood meaning. At the same time, universal and potentially extraterrestrial: everything that is, that exists, that is born animate or inanimate and is regulated by any order. If perhaps it will never be clear what nature is and what it is not, certainly the distinction of the sophists between νόμος and φύσις, respectively the laws of man and the laws of nature, opposed to each other, appears clearer. Is the city natural? Following the definition of the word nature, the city itself can be considered nature permeated with nature. The city is an environment that presents an order, realized by types, and formed according to laws, an environment generated by man

for man, by nature for nature. Spaemann has systematically and comprehensively unmasked this issue: « Plato's counter-critique does not consist in claiming for nomos a non-natural origin; rather, he transforms the very concept of phýsis in such a way that nomos appears as the realization of the teleologically conceived nature of man, the καλόν (kalón) as ἀγαθὸν (agathón), the noble as what is at the same time fitting »[2]. (Spaemann, 2012: pp. 33-35).
Perhaps, when we feel that the city "lacks nature", we feel the lack of a possibility of contemplation linked to places where the absence of a very dense cultural and human matrix allows ample space for silence: this feeling comes to the concept of *otium*, which our ancestors already sought in the *polis*, long before the "megapolises" where today most of the world's population is concentrated. Perhaps, we feel that there is a lack of a predominantly green environment of trees and meadows made up of a fauna different from the human one. Or perhaps it is simply the lack of any variation in the monotony of daily work, as Lucrezio argued: « (It is) pleasant, when on the vast sea the winds disturb the open waters, from the land to see the great toil of another; not because it is a pleasant joy that someone is troubled, but because it is pleasant to see from what evils you are free » (Lucrezio).

Urban planning becomes increasingly complex with urbanization, as the city transforms into the home of humanity and the quantitative aspects started inevitably dictate the qualitative ones. When abandoning the countryside for the city, theories and visions generates to try to resolve the dichotomy that sees humans in conflict between rural and urban identities and the city becomes the daily panorama of almost all human beings in the world. Tom Turner writes *City as landscape. A post-postmodern view of design and planning*, where he argues for a city of the future as « an infinite series of landscapes: psychological and physical, urban and rural, flowing apart together » (Tuner, 1955:V). Aldo Rossi, while writing in 1966 his famous work supposed to be titled 'Manuale di Urbanistica' (a), argues for the state of the city as a totalizing human landscape: « Placed

between artifice and nature, architecture and the city become the quintessential human thing. Viollet Le Duc has defined architecture as la *creation humaine*. And nothing strikes us like the great artifacts that cut through the countryside, like the city itself, like civil constructions. The landscape of nature, without constructions, is nothing but a luminous desert; and all the landscape in which we live and know is the work of man »[3] (Rossi, 1966b:70). The city is born and evolves as a way for humans to inhabit nature: like a bee, the architect tries to build the hive, shaping natural materials and simultaneously achieving its purpose (Marx, 2013:215). Lewis Mumford (1938) evokes the cave as an ancestral shelter and dwelling for humanity, to demonstrate that the city, with its complex weave of art and human mind, is nature[4]. The frenetic advancement of progress during the 20th century, though, has generated the perception of a consistent distancing of artificial urban products from the idea of nature untouched by human hands: the two can no longer coexist but must generate a hybrid that makes us feel at peace with our conscience. Boundless material has been produced on dreams and nightmares of a mechanized future. Humans can become a machine, and the machine can become human, as Oswald Mathias Ungers depicts. The building can become a machine for living, as Le Corbusier asserts. The city can become a mega-machine spread out for its inhabitants, as Yona Friedman writes and draws. Artifact and nature can merge, as Soleri theorizes with *Arcology*. The megastructures phenomenon – the enlargement of human artefacts – accentuates the gap between nature and culture. A gap that clarifies the definitions of each and the interdependence between the two. As already argued, man needs nature not only for environmental but also for cultural necessities. Le Corbusier designs the densification of buildings as a key to reduce land consumption and balance the impact of the built environment. Yona Friedman flies over the earth's surface with a city-machine, elaborating on the human relationship with nature in coexistence on different vertical levels. Bigness – like the machine – is presented as a trend that is part of our cities: from the Italian phenomenon of the *Grande Dimensione* to the Asian metabolic design theories, through massive Soviet buildings

and Asian megacities. Humans seek to manage their relationship with machines and the large scale between love and rejection. The suffering arising from this relationship is determined by the dichotomy between nature and culture. When these mechanistic visions emerge, the relationship between human nature and culture is also called into question, almost as if man were the natural element of the city: O.M. Ungers, in his drawings, presented in 1976 at the *MANtransFORM* exhibition at the Cooper-Hewitt Museum in New York, seems to explicitly state that man himself is nature. The human body is dissected and compared to the city and the machine: the three subjects share analogical matrices that bind them indissolubly together. The natural element of the triptych is man. What has become of nature understood as vegetation? Today, would O.M. Ungers, to fit into the environmental discussion, ever include a tree in this analogical scheme? (Fig.1) Perhaps it would haven't been a tree with leaves and branches, but a tree as Christopher Alexander envisions it.

2. Corviale, Rome (1975-1984)

Some of these visionary megastructures of the 60s materialized partially in the form of built environments, with *Corviale* emerging as one such example. *Corviale* sought to address the housing crisis of the post-World War II era by reimagining suburban living. Its core idea was to revolutionize the concept of suburbs by integrating private spaces with communal activities, combining residences with essential services, and rejecting the notion of suburban dormitories in favour of creating livable and multifunctional neighbourhoods reminiscent of historical city centres. *Corviale* is a mass housing project almost one kilometre long designed and built during the 70s. One unique building and a linear urban structure at the same time: an exceptionally large residential complex condensing urbanity in the form of a building, a monumental linear block that contains and expresses the complexity and richness of the city. The project is located in an urban periphery, nestled amidst greenery. As a territorial threshold between the city and the countryside, the project intended to symbolise the end of the city, enclosing the silent

expansion of the territory of the Roman periphery. When it was built, the city was still far away: today the building has been reached by the city's urban sprawl but it's still at the south-west political border of the Metropolitan City of Rome. On one side *Corviale* dominates the city, and on the other the countryside towards Fiumicino and the sea: it thus connotes both the agricultural landscape and the urban landscape. *Corviale*, west of Rome, is built on the crest of a low hill. The position reminds both typical ancient Italian towns and a fortress protected by its surroundings of green areas. *Corviale* judgmental and esthetical perceptions are controversial: the abstraction and the stark contrast with the landscape in which the building is set is one of the aspects that make huge concrete block architecture so difficult to appreciate by people. In the sustainability era the blatant juxtaposition between culture and nature, between concrete and vegetation generates a sense of guilt. The project refers in some aspects to Le Corbusier's concept of the *Unité d'Habitation* as a solution to a compact artifice in the middle of nature: building in nature, letting nature and architecture live in their sharp dichotomous contrast. Many other themes meet Lecorbuserian ideas and forms: the forms of the *Plan Obus* the interruption of the residential block with a half-story dedicated to services, and the integration of different functions in the same building system. However, there are also several Lecorbuserian themes that Fiorentino tries to stress, criticise, and evolve: an open patio as an evolution of the *Rue intérieure*, and a unique concept and non-reproducible artefact as an evolution of the generic urban block.
Roma, however, was not alone in exploring large-scale residential design concepts. Other notable endeavours included *Zen* in Palermo, *Monte Amiata* in Milano, *Forte Quezzi* in Genova, *Rozzol Melara* in Trieste, *Vele* in Scampia, and *Sant'Elia* in Cagliari, among others. The analysis of a city's *forma urbis*, or the form of the city, has been a recurring theme in architecture as metropolises continued to expand. Questions like how to construct various parts of a city and its countless variations, how to design compact buildings that work as city-in-the-city, how to create high-density housing without creating *behavioural sinks*, and how

to erect urban monuments that are not eyesores, have remained at the forefront of urban architectural discourse. These inquiries have spurred numerous theories and projects, with utopian and dystopian visions garnering the most intriguing critical discussions. Throughout the last century, the rapid pace of technological progress often created a perceived chasm between culture and nature. It seemed that these two forces could no longer coexist without giving rise to a hybrid solution that could reconcile our conscience, just as *Bosco Verticale* tries to do today.
The big concrete housing complexes, rising amidst lush vegetation, have been perceived as symbols of nature's subjugation. The interplay between green architecture and conspicuous sustainability, reminiscent of Le Corbusier's thoughts on the relationship between buildings and land, is often misunderstood today as humanity's dominance over the natural world. Ironically, an isolated villa nestled in the greenery, producing a great urban infrastructure and pollution to be reached, is perceived more in harmony with nature, even though it's not giving any help in the sustainable design of the cities. Nevertheless, certain theories and projects from 20th-century utopian visions contain valuable elements that can guide efforts to enhance the environmental quality of our cities and effectively integrate culture with nature, as well as harmonize city living with rural surroundings. Often, it happens that the victims of our frustration and intolerance are less terrible than how we describe them. Similarly, the models worthy of our esteem and admiration are more perfectible than we believe. It happens with people, with services, and also with architects, buildings, and cities. If Stefano Boeri's *Bosco Verticale* satisfies an aesthetic sense that can reconcile artifice and nature at this historical moment, it is also true that it does not contribute to solving environmental-urban problems. If it is true that Mario Fiorentino's *Corviale* and Francesco di Salvo's *Vele di Scampia* do not currently satisfy an aesthetic sense that can reconcile artifice and nature, it is also true that some of the insights of the cultural project behind them can contribute to the research and resolution of environmental-urban problems. Megastructures, linear or not, embrace the fact

that « the ever-growing contemporary trend in transit oriented development is essentially a combination of the aspirations for sustainable urban development » providing a formal and spatial answer to problems « such as efficient energy consumption, walkable communities, car-independent transportation, eco-friendly living environment, coupled with the emphasized importance of transportation systems » (Memišević, 2019: 59).
The nuances of linear city designs drawn and described throughout the twentieth century take on many facets (Collins, 1960). Soria y Mata *Ciudad Lineal* is just the beginning of an architectural theory trend: Edgar Chambless' *Roadtwon* (1910), *Linear City* (1960) by Peter Eisenman and Michael Graves, but also, the *Urban City Corridor* (1966) by Atelier Ziggurat, *Hundred Mile City* (2017) by Peter Barber. The theory came to the design with constructed part of linear megastructure concepts such as *Red Wien Hofe*, German *Siedlungen*, French *Banlieau* and *Corviale* Residential Complex. The 'linear city' theoretical concept was brought back to architectural discussion by the recent and ambitious *The Line* project by NEOM. One of the core concepts of the project is to have an artificial compact construction, in stark contrast with the beautiful but harsh nature. The aim is both esthetical and environmental: the building tries to disappear in the landscape, while avoiding the planned consumption, growing in disproportionate sizes both in height and especially length. Linear megastructural visions tend to consider the densification of artificiality while leaving space for nature and focus almost exclusively on the design of artificial spaces, promoting an idea of wild nature. Le Corbusier does this when he designs the *Plan Obus* (1930), and Hilbesaimer does it by juxtaposing the order of the artefact with the disorder of vegetation in the *Lafayette Park* model (1954). An idea of a city that attempts to progressively (re)conquer the continuum of nature, the essence of *Natura naturans*, the true antagonist/counterpart of Human Beings, against the anthropomorphizing logic of everything. « Architecture faces nature without disguising itself but presented as the only alternative: *natura naturans* and *natura naturata*. One may cross deserts, cover over canyons, join up Alpine lakes, also use,

geometrically, hills and rivers with new horizons. Or other operations on earth, mountains and sea, always examples of rational operations, organized and measured » (Superstudio, 1969:32). The linear city project is characterised by a limited width and an emphasis on length, usually with a connecting function located in the central axis. The horizontal development of linear megastructures is revealed to be inseparably linked to vertical development: Orsini *et al.* (2017) argue this thesis by analyzing some linear structures in a section and commenting on them as « *urban raumplan* », assuming the detachment of public space from the ground level of the city as a fact.

Linearity often holds together the design of the building with the idea of the infrastructure, whether it is the public transport connecting the entire line (in the case of *Ciudad Lineal, Roadtown* or *The Line*), or the idea of the continuity of a linear infrastructure such as the aqueduct (in the case *Urban City Corridor* or *Corviale*). This segment function generates two categories of linear design: there's the line that is potentially extendable to infinity but also the line that connects two points. In the first case, *Continuous Monument* designed a utopia that could fold the entire world. Instead, the *Urban City Corridor* is connecting the medieval city centre with the outskirts.

The linear project assumed the idea of the single and unique gesture that shaped the space, the essence of architecture enclosed in one strong recognisable act. This concept is described in Superstudio's work at the time they visualised *Continuous Monument*: « We can imagine a single architectural construction with which to occupy the optimal living zones, leaving the others free. [...] A single form of architecture, capable of shaping the earth (measuring it, like longitude and latitude), a recognisable architecture. [...] The *Continuous Monument* is the extreme pole of a series of projecting operations centred around the idea of the 'single design', a design which can be transferred from one area to another, remaining unchanged: an impossible, unalterable image, whose static perfection moves the world through the love of itself that it creates » (Superstudio, 1969). That's also why linearity involves a deep focus on

the relationship with the context in which it is dragged. Natural or urban, the line usually defines itself in the juxtaposition and the contrast of the parts. That is almost completely summarised by all the different locations Superstudio draws for *Continuous Monument*: the desert (as Neom's *The Line*), the medieval city (as the *Urban Corridor*), the megalopoli or other urban patterns (as *Plan Voisin*), the greenery (as *Ciudad lineal, Roadtown* or *Corviale*). Some projects, instead, aim to control nature in an urban compromise: Motopia, probably the inspiration of the first Ideal City *2000-Ton City* (1971) by Superstudio, organizes controlled urban greenery within the empty spaces between buildings. It seems, « with its parks and gardens », to « achieve at last its one-time goal, and become what it has supposed itself to be: Urbs in Horto – a City in a Garden! » (Hilberseimer, 1950). Similarly, the *Lower Manhattan Expressway project* (1970) by Paul Rudolph is a linear city that potentially extends infinitely with a triangular section where a linear green park is designed between the two linear buildings, accompanying the entire urban settlement.

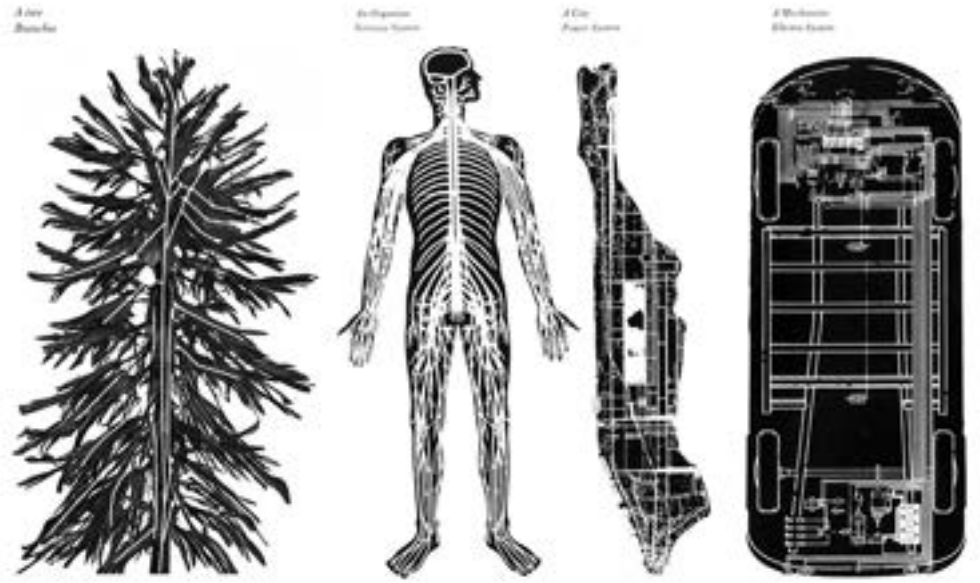
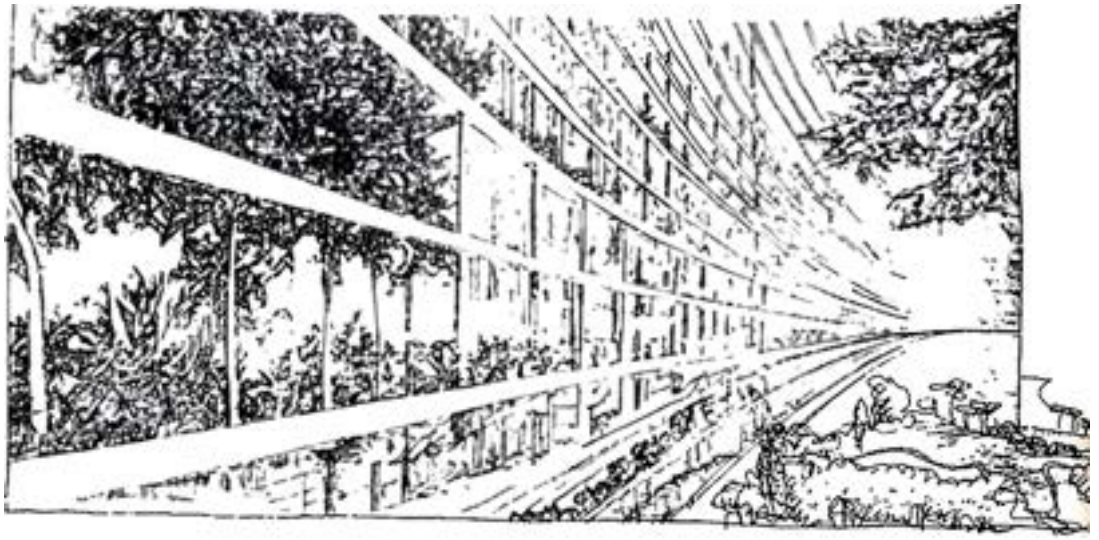


Fig.1: A tree. Original image: 'Drawing from City Metaphors' by Oswald Mathias Ungers, MANtrans-FORM. New York: Cooper-Hewitt Museum, 1976. Remixed by the author, 2023.

The exercise of imagining a city without end, proposed by Kevin Lynch in the essay *City as Environment* (1965)[5], generates a vision of totalized anxiety. The modern artefact, on the other hand, lives in a poetics of contrast: culture and nature define each other through their differences. The same happens with the new and the old. What sense would Le Corbusier's *Plan Voisin* make if it were a new town, without the contrast with the historical fabric? The *Unité d'Habitation*, repeated in an infinite pattern amid vegetation, what urbanity would it produce? Yona Friedman's spatial mesh, without flying over the existing city, but only an empty grid flying in the air, what would it mean? The *Continuous Monument* takes on value based on all the facets of all the contrasts it can generate depending on the context it encounters. It's about inserting white into the context, inserting a generic grid and a blank slate into a stratified context, and using the void to analyze the existing. The megastructural proposals of the twentieth century generated a dialectical discussion between past and future, using contrast as an aesthetic and programmatic element of architectural design. The meeting between the two proposed today with the environmental and sustainable design is more in vogue, leading to the idea of artefacts' aggression by nature. The boredom produced by the monotony of the globalized urban environment generates a desire for a wild and bucolic urban vision. Can the balance of things be restored by generating a visual dominance of nature over culture, where wild animals invade built visions of mechanized cities? We can imagine the symbolic value of visions like the *Plan Obus* (1930) or Louis Khan's *Philadelphia Civic Center* (1952) being invaded by vegetation (Fig. 2, Fig. 3). The bucolic megastructural trend is real: if it is true that the park adjacent to the sails of *Scampia* does not yet host colonies of monkeys (Fig. 4), at *Corviale* we can find sheep and horses (Fig. 5), while the singer Mahmood dances with cows at *Rozzol Melara* Residential Complex[6].



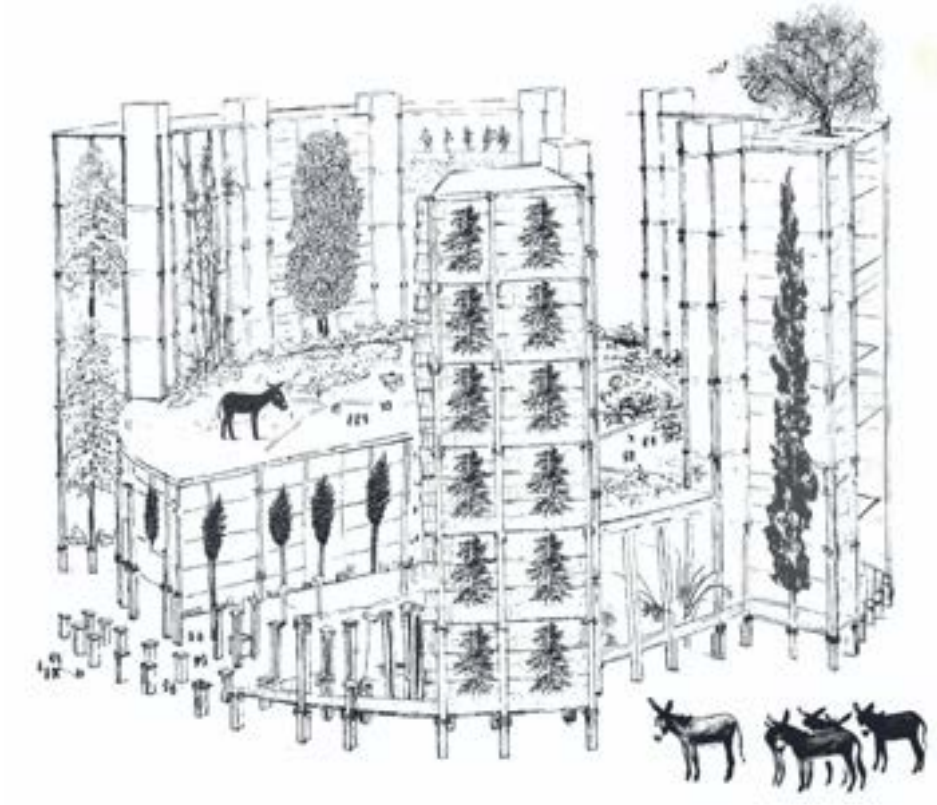


Fig.2: Bucolic Megastructure_Plan Obus. Original image: 'Perspective, master plan of Algiers. Futuristic vision for a city in transition: Plan for Algiers, 1931-42' In Phaidon, (2008). Le Corbusier Le grand. New York: Phaidon Press. Remixed by the author, 2023.

Fig.3: Bucolic Megastructure, Philadelphia Civic Center. Original image: 'Philadelphia. Suggestion by Louis Khan to provide circular multi-storey car parks within a circle of offices' in Motopia, di G.A. Jellicoe, Studio Books, London, 1961, p.132. Remixed by the author, 2023.

Fig.4: Bucolic Megastructure, Corviale, Roma. Photo by the author, remixed by the author, 2023.

Fig.5: Bucolic Megastructure, Le Vele, Scampia
Photo by the author, remixed by the author, 2023.

Biography

Ayla Schiappacasse, class 1995. A full degree in architecture from the University of Genova. She embarked on travels to Europe, Latin America, and Asia for study and research endeavours. She collaborated with diverse architectural firms in Milan and Genova while co-researching the Erasmus+ Programme 'Climate Labs' and co-editing the work 'Pianta Analoga di Genova'. Currently a PhD student at the Department of Architecture and Design of the University of Genova. Her research focuses on exploring the morphological consequences of the interplay between high-density housing and architectural bigness analysing and mapping the linear city-building typology.

references

+ Bodei, R. (2016). *Limite, Il Mulino*.
+ Chiodo, S. (2015). *La bellezza dell'architettura* in Rivista di Estetica, Architettura n.58.
+ Collins, G.R. (1960). *Linear Planning Throughout the World*. Ekistics, 9(54), pp. 242-253. http://www.jstor.org/stable/43622692.
+ Consonni, G. (2008). *La difficile arte. Fare città nell'era della metropoli*, Maggioli.
+ Ferrari, M. (2005). *Il progetto urbano in Italia 1940-1990*. Alinea.
+ Gaggero, G. (1987). Luccardini R., *Mostri edilizi*, Sagep.
+ Gargiani, R. (2019). Lampariello B., *Il Monumento Continuo di Superstudio*, Sagep.
+ Hilberseimer L. (1955). *The nature of cities; origin, growth, and decline, pattern and form, planning problems*. P. Theobald.
+ Koolhaas R. (2019). *Testi sulla (non più) città,* Quodlibet.
+ Lang P., Menking W. (2003). *Superstudio Life without Objects,* Skira.
+ Lucrezio. (1570). *De rerum natura*, II, 1-14. Translation W.H.D. Rouse, rev. M. Ferguson Smith, Cambridge Ma. 1992.
+ Lynch, K. (1965). *La città come ambiente* in Casabella Continuità, 29/299, pp. 18-23.
+ Mei, P., Orsini, F. (2019). Orizzontale vs verticale. *Lo spazio pubblico in sezione.,* in *Horizontality/verticality in architecture* n.17, Technè, pp. 119-132. DOI: 10.13128/Techne-23895.
+ Memišević, T.T. (2019). *Linear Megastructures. An Eccentric Pursuit in Tackling Urban Sustainability Challenges* in Housing Environment 66, pp. 54-59. https://doi.org/10.4467/25438700SM.19.041.11672.
+ Monica, L. (2008). *Gallaratese Corviale Zen. I confini della città moderna: grandi architetture residenziali. Disegni di progetto degli studi Aymonino, Fiorentino, Gregotti*, Festival Architettura.
+ Marx, K. (2013). Il Capitale, eNewton. 'Titolo originale: Das Kapital. Kritik der politischen Ökonomie'. (1867). Traduzione dal tedesco di Ruth Meyer.
+ Mumford, L. (1938). *The Culture of Cities*, Harcourt.
+ Treccani. (nd). Natura nel *Dizionario Treccani Online*. Estratto nell'agosto 2023 da https://www.treccani.it/vocabolario/natura/ Porqueddu L. (2019). Dalla grande dimensione alla Bigness, Quodlibet.
+ Rossi, A. (1966a). *L'Architettura della città*, Marsilio.
+ Rossi, A. (1966b). *Tipologia, manualistica e architettura* in Istituto Universitario di Architettura di Venezia. *Rapporti tra la morfologia urbana e la tipologia edilizia*, p. 70.
+ Schittich, C. (2005). *Alta densità abitativa*. Birkhauser.
+ Spaemann, R. (2012). *Sulla preistoria del concetto di natura nel XVIII secolo* in *Cos'è il naturale*. Rosenberg & Sellier, 33-35 On the prehistory of the concept of nature in the 18th century, pp. 33-55.
+ Superstudio. (1969). The continuous monument. An Architectural Model for Total Urbanization.
+ Ungers, O.M. (1977). The city in the city. Berlin: a green archipelago, Lars Muller Publisher.
+ Ungers, O.M, e Vieths S. (1997). Ungers. Oswald Mathias Ungers. La città dialettica. SKIRA.
+ Vieths, S. (2021). O.M. Ungers: Luoghi urbani. Maggioli.
+ Unwin, R. (1971). La pratica della progettazione urbana. Il Saggiatore.

note

[1] Ayla Schiappacasse – Orcid ID: 0009-0008-8058-6924, ayla.schiappacasse@edu.unige.it, Dipartimenti di Architettura e Design – Università di Genova

LEARNING FROM LOCAL CLIMATE PLANNING IN DENMARK: BARRIERS AND RECOMMENDATIONS

Clarissa Attombri[1], Martin Lehmann[2], Thomas Skou Grindsted[3], Nicola Tollin[4]

Abstract

Denmark is the first nation in the world to have successfully involved all its municipalities in drawing up their local climate plans according to a unifying framework. The Region of Southern Denmark sought to analyze the plans of the municipalities in its territory to acquire an overview of barriers and opportunities encountered during the development process and to provide support and resources going forward with the implementation.

Common elements surfaced from the analysis, and the municipalities reported a multitude of challenges from which, as some of them can potentially be common to other contexts, there are some lessons to learn.

Keywords: Local Climate Plans, Climate Mitigation, Climate Adaptation, Urban Resilience

1. Introduction

Denmark is set on a path to climate neutrality by 2050. National targets are in place to reduce GHG emissions by 70% in 2030. The DK2020 pilot project was initiated in 2019 by Realdania, one of the most significant Danish philanthropic associations, by involving 20 municipalities selected from all five administrative regions. The objective was to provide guidelines for the municipalities to develop their Local Climate Plans (LCPs) to contribute to the nation's advancement towards its Paris Agreement goals, and to encourage ambitious mitigation and adaptation subgoals before mid-century. Through a collaboration with C40, a global network supporting local climate action, and Concito, Denmark's green think tank working on the same topic, an adapted version of C40's Climate Action Planning Framework (C40, 2020) was provided to the municipalities to guide the development of their LCPs by requiring a common standard for all, that would cover both mitigation and adaptation planning. Once their content was checked by the collaborating organizations, the LCPs would get certified as complying with the framework. The project was then extended to other municipalities, not least on the initiative of Region Southern Denmark, by creating a partnership with KL, the interest organization representing the local governments, and the five regional administrations. Up to 50 municipalities were estimated to take part in it, but eventually, all 98 expressed the willingness to participate and drew up their LCP.

In early 2023, after all municipalities had delivered their LCPs and got them certified to comply with the Climate Action Planning Framework, the Region of Southern Denmark created and

financed a collaboration with the UNESCO Chair on Urban Resilience at University of Southern Denmark, and Aalborg University, to perform a preliminary analysis of the LCPs of the municipalities in its territory. The aim was to provide an overview of the current planned efforts in the region's 22 municipalities, identify key climate challenges, and provide insights on how regional support could enable further and better implementation of the LCPs. From the results of this study, several takeaways can be taken as lessons for other territories.

2. Materials and Methods

A taxonomy and an evaluation framework were developed to extract data from the LCPs, using over 100 indicators. The methodology was inspired by the work on the global analysis of the urban content of the NDCs (UN-Habitat, 2022) and brought to a local focus by learning from the experiences of existing work on the evaluation of LCPs around the world, both those focusing on mitigation (Brown *et al.*, 2021; Covenant of Mayors, 2023; Herbert *et al.*, 2022; Johnson *et al.*, 2022; Palermo *et al.*, 2020; Pietrapertosa *et al.*, 2023; Rivas *et al.*, 2022; Salvia *et al.*, 2021; Vanhuyse *et al.*, 2023) and adaptation (Donoghue & Katz-Rosene, 2023; Olazabal *et al.*, 2019; Reckien *et al.*, 2023; The EURO-LCP Initiative). The data was collected into a database according to indicator groups that would differentiate among mitigation or adaptation challenges, goals, actions, and means of implementation.

3. Lessons

3.1 General Climate Planning

Many municipalities report that the DK2020 project was the starting point for comprehensive LCPs, gaining political attention and putting the climate agenda under the spotlight for the entire administration, which was not the case previously. The role of the Region of Southern Denmark, in parallel with KKR Syddanmark, KL's regional representative organization (called De geografiske organiseringer, or DGO'er), has been fundamental for coordinating the development and implementation of the

LCPs of the municipalities in its territory, as it was tasked with collecting the plans together with any integrating technical document that would provide information on their planned actions, checking which barriers are experienced locally. This suggests that having one coordinating authority that facilitates climate action is key to harmonized local action.

Climate issues are cross-sectoral, and planning solutions must involve diverse stakeholders, whom each municipality was called upon to bring together for collectively discussing the development of the LCPs: the recurring public involvement events gathered key actors in the public sector, businesses, and civil society. This can allow for the acknowledgement of the interdependencies within the urban system and lead to a plan by taking into consideration the synergies among sectors, potentially having the opportunity for co-financing: for example, half of the municipalities planned the conversion of livestock manure, or other available biomass such as straw and slurry, into biogas, creating circularity among the sectors of agriculture, energy, and waste management; another example is in the consideration of the ever-present competition for land, that is highly scarce and in need of multifunctionality as opposed to single-use only (e.g., crop fields converted into forests). The lack of consideration of such interdependencies can be seen in the traditional approach of planning at the urban level; in fact, multiple LCPs reported a lack of climate-related competencies throughout all municipal departments, a setting that challenges to operate in an integrated manner. It is here that climate planning can facilitate integration: a first step to counter silo thinking has been to assign a dedicated climate coordinator in each local administration that would bring together the various departments to coordinate the development and implementation of the LCP.

This issue of lack of competencies within the municipal workforce manifests both during the development of policies (e.g., when there is the need to politically align planning themes) and in their implementation (e.g., approval of Power-to-X projects

without in-house competence to evaluate them and translate them into a plan for the city). Therefore, it is fundamental to leverage capacity building and peer-to-peer learning among municipalities. On this front, as common problems can share the same solutions, an innovative platform to transfer knowledge and experiences across all Danish municipalities was created: the Climate Alliance (*Klimaalliance*), a partnership agreement to ensure continuous improvement in local climate action when, at the end of 2023, the DK2020 project came to an end. Also, the involvement of academia as knowledge centers such as in this study can foster continuity for long-term and up-to-date expertise.

3.2 Mitigation

The Climate Action Planning Framework requested the accounting of GHG emissions from three of the major emitting sectors in Denmark, namely Energy, Transport, and Agriculture, Forestry and Other Land Use, which would fall under Scope 1 emissions as referred to by the United Nations (United Nations, 2015), and recommended estimating those from waste, wastewater, and chemical process, that would fall under Scope 3 emissions. Scope 2 emissions, which would account for energy import into the municipality, were voluntarily considered by one municipality only. Providing clear indications on which sectors to address with priority favored a harmonized accounting at a regional level. Nevertheless, to ensure that action is encouraged across all sectors, Scope 3 emissions should not be overlooked.

Dependence on innovation and technological advancements in various emissions sectors generates uncertainty in the mitigation realm. For example, while the results of this study show that greenhouse reductions will be effective in energy and transport, the agricultural sector presents more limitations as it needs more research and application on how to tackle emissions from nitrogen fertilizers, the use of biochar, the change in feed composition for livestock, etc. Some general actions also rely on technologies not in place at the appropriate scale yet (e.g., carbon capture and Power-to-X); hence their actual impact cannot be ensured.

3.3 Adaptation

Uncertainty in adaptation can come from the capacity to predict risks, which is highly dependent on the availability of data and established scenario modelling. In the case study, the risk of flooding is the most assessed and the most touched by adaptation actions: this can be associated with more awareness of water management, and with the number of tools that are more commonly available for users to simulate extreme flooding events, such as ScalgoLive, a very popular software utilized in most municipalities in Denmark, but also in Norway, Sweden, Poland, Germany, France, and the United Kingdom. The regional administration had also provided a flood risk map for the whole region. Other risks might not be as well-assessed due to the lack of data and know-how, as reported in the LCPs. National, regional, and municipal level climate data to assess the risks of heavy precipitation, sea level rise, temperature rise, drought, and extreme wind is provided in the national Danish Climate Atlas (*Klimaatlas*) (Danish Meteorological Institute, 2022) but, in some cases (e.g., sea level rise), risk assessments at a local scale would provide a higher degree of accuracy.

Ideally, climate risk assessment should focus much more on multiple types of hazards, as well as coupled events and multiple risks, as opposed to narrowing the analysis down to single hazards only. In addition, high-impact, low-probability events – defined as « events or occurrences that cannot easily be anticipated, arise randomly and unexpectedly and have immediate effects and significant impacts » (European Commission, 2022) – as well as tipping points – described as « a critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly » (IPCC, 2023) – should be embedded as part of the municipalities' LCPs, including as a starting point for a dialogue on action and how this can be seen in a longer-term development perspective. One gap in the Climate Action Planning Framework is that it doesn't require the consideration of both exposure and vulnerability when producing climate risk assessments, though such concepts are key to determining the real extent of climate risks.

They can also provide a base for the calculation of potential loss and damages, which can help with gaining political willingness for prevention and obtaining funds for implementation, as some municipalities demonstrated by estimating them.

4. Conclusion

Through the analysis of the LCPs from every municipality in the Region of Southern Denmark it has been possible to understand how the climate planning process was conducted in Denmark, which can be taken as an exemplary model towards a unified efforts for action on the climate front. The role of the regional administration as a coordinator for local action can be taken as the demonstration that an authority that facilitates the development and implementation of the LCPs is essential. On top of that, a platform for exchanging experience and knowledge among municipalities such as that of the Climate Alliance can leverage capacity building across borders and the retention of competencies, together with the continuous involvement of knowledge institutions.

Interdependencies can be tackled by employing a cross-sectorial and multi-stakeholder approach, which creates a dialogue between sectors creating synergies when implementing actions.

Uncertainties in the impact of mitigation actions can emerge from the reliance on emission reductions by solutions that are not yet fully available yet, while in adaptation they can be linked to the lack of knowledge and/or data to fully depict the extent of climate risks.

An important element that might be overlooked in current climate planning practices include the accounting of Scope-3 emissions when calculating emission inventories and projections, which were not originally requested by the Climate Action Planning Framework, but will be part of the next generation of LCPs to be in line with C40's new Cities Climate Transition Framework. In addition, it is also cardinal to consider exposure and vulnerability, as well as high-impact, low-probability events, and tipping point, when producing climate risk assessments, informed by the estimation of the avoided loss and damages.

Biographies

Clarissa Attombri is a Research Assistant at the UNESCO Chair on Urban Resilience at the University of Southern Denmark, and she has a background in architecture and urban planning. She graduated with a Bachelor's in Science of Architecture at the University IUAV of Venice, Italy, and worked as a Junior Architect in Geneva, Switzerland. She holds a Master's Degree in Planning and Policies for Cities and the Environment from University IUAV of Venice, and a Master of Engineering in Urban and Rural Planning from Tongji University, Shanghai. Her research interest focuses on ecological approaches to climate mitigation and adaptation.

Martin Lehmann is Associate Professor of Sustainable Development at Aalborg University, and the co-founder of KlimaLab – the UCCRN Nordic Node – a climate change innovation laboratory aimed at rapidly scaling climate action and solutions. Primarily, his research is conducted in the fields of sustainable urban innovation systems, partnerships for sustainable development, and climate change adaptation. Martin has for more than 20 years worked closely with Danish and international stakeholders in developing local and regional partnerships for sustainable development, thereby bridging gaps between municipalities, knowledge institutions, civil society and business, and developing capacities for smart and sustainable transformation in cities around the World.

Thomas Skou Grindsted is a Lecturer in Geography and Planning and Research Group Lead of MOSPUS (Mobility, Space, Place, and Urban Studies) at Roskilde University, Department of People and Technology. His research focuses on connections between political ecology, sustainable finance and ESD. He particularly examines the knowledge base upon which geographers, urban planners and architects shape the cities of tomorrow, a center piece in the study of green(er) planning and regulation models. He also researches the geographies of sustainable financialization and algorithmic economies.

Nicola Tollin is Professor with special responsibilities in Urban Resilience, Chairholder and coordinator of the UNESCO Chair on Urban Resilience at University of Southern Denmark, within the section of Civil and Architectural Engineering. He has over 20 years of international experience in research, capacity-building, and education on sustainable development, resilience, climate change, circular economy, and innovation, focusing on cities and regions.

references

+ Brown, M.A., Dwivedi, P., Mani, S., Matisoff, D., Mohan, J.E., Mullen, J., Oxman, M., Rodgers, M., Simmons, R., Beasley, B., & Polepeddi, L. (2021). A framework for localizing global climate solutions and their carbon reduction potential, *Proc Natl Acad Sci USA*, 118(31). https://doi.org/10.1073/pnas.2100008118.
+ C40. (2020). *Climate Adaptation Planning Framework*.
+ Covenant of Mayors. (2023). *CEESEU-SECAP Evaluation Tool*. European Commission. https://eu-mayors.ec.europa.eu/en/ceeseu-secap-evaluation-tool.
+ Danish Meteorological Institute. (2022). *Klimaatlas*. https://www.dmi.dk/klimaatlas.
+ Donoghue, S., & Katz-Rosene, R. (2023). Evaluating the comprehensiveness of municipal climate change adaptation plans in Ontario, Canada. *Regional Environmental Change*, 23(44).
+ European Commission. (2022). *Enhanced preparedness and management of High-Impact Low-Probability or unexpected events*. https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl3-2022-drs-01-02.
+ Herbert, Y., Dale, A., & Stashok, C. (2022). Canadian cities: climate change action and plans. *Buildings and Cities*, 3(1), pp. 854-873. https://doi.org/10.5334/bc.251.
+ IPCC. (2023). *Annex I: Glossary (Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Issue*.
+ Johnson, L., Krisko, P., Malik, M., O'Donnell, C., Pendleton, N., Ahn, D., Bizberg, A., Chafe, Z.A., Kim, D., McCormick, S., Naidoo, S., & Anenberg, S.C. (2022). Environmental, Health, and Equity Co-benefits in Urban Climate Action Plans: A Descriptive Analysis for 27 C40 Member Cities. *Frontiers in Sustainable Cities*, 4. https://doi.org/10.3389/frsc.2022.869203.

+ Olazabal, M., Galarraga, I., Ford, J., Sainz De Murieta, E., & Lesnikowski, A. (2019). Are local climate adaptation policies credible? A conceptual and operational assessment framework. *International Journal of Urban Sustainable Development*, 11(3), 277-296. https://doi.org/10.1080/19463138.2019.1583234.
+ Palermo, V., Bertoldi, P., Apostolou, M., Kona, A., & Rivas, S. (2020). Assessment of climate change mitigation policies in 315 cities in the Covenant of Mayors initiative. *Sustainable Cities and Society*, 60. https://doi.org/10.1016/j.scs.2020.102258.
+ Pietrapertosa, F., Olazabal, M., Simoes, S.G., Fokaides, P.A., Ioannou, B.I., Viguié, V., Spyridaki, N.A., Salvia, M., De Gregorio Hurtado, S., Geneletti, D., Heidrich, O., Tardieu, L., Flamos, A., Rižnar, K., Belšak Šel, N., Feliu, E., Matosović, M., V. Balzan, M., & Reckiens, D. (2023). Adaptation to climate change in cities of Mediterranean Europe. https://doi.org/10.13039/501100011033.
+ Reckien, D., Buzasi, A., Olazabal, M., Spyridaki, N.-A., Eckersley, P., Simoes, S.G., Salvia, M., Pietrapertosa, F., Fokaides, P., Goonesekera, S.M., Tardieu, L., Balzan, M.V., de Boer, C.L., De Gregorio Hurtado, S., Feliu, E., Flamos, A., Foley, A., Geneletti, D., Grafakos, S., Wejs, A. (2023). Quality of urban climate adaptation plans over time. *npj Urban Sustainability*, 3(1). https://doi.org/10.1038/s42949-023-00085-1.
+ Rivas, S., Urraca, R., & Bertoldi, P. (2022). Covenant of Mayors 2020 Achievements: A Two-Speed Climate Action Process. *Sustainability*, 14(22). https://doi.org/10.3390/su142215081.
+ Salvia, M., Reckien, D., Pietrapertosa, F., Eckersley, P., Spyridaki, N.-A., Krook-Riekkola, A., Olazabal, M., De Gregorio Hurtado, S., Simoes, S.G., Geneletti, D., Viguié, V., Fokaides, P.A., Ioannou, B.I., Flamos, A., Csete, M.S., Buzasi, A., Orru, H., de Boer, C., Foley, A., Heidrich, O. (2021). Will climate mitigation ambitions lead to carbon neutrality? An analysis of the local-level plans of 327 cities in the EU. *Renewable and Sustainable Energy Reviews*, 135. https://doi.org/10.1016/j.rser.2020.110253.
+ The EURO-LCP Initiative. *Climate Change Adaptation Scoring Tool*. https://www.lcp-initiative.eu/climate-change-scoring-tool/.
+ UN-Habitat. (2022). *Urban Climate Action. The Urban Content of the NDCs: Global Review 2022*.
+ United Nations. (2015). *Climate Neutral Now Guidelines*.
+ Vanhuyse, F., Piseddu, T., & Jokiaho, J. (2023). Climate neutral cities in Sweden: True commitment or hollow statements? *Cities*, 137. https://doi.org/10.1016/j.cities.2023.104267.

note

[1] Clarissa Attombri – ORCID ID: 0000-0001-9135-8427, clat@iti.sdu.dk, UNESCO Chair on Urban Resilience – University of Southern Denmark (SDU.Resilience)
[2] Martin Lehmann – ORCID ID: 0000-0003-2089-4550, martinl@plan.aau.dk, Department of Sustainability and Planning – Aalborg University
[3] Thomas Skou Grindsted – ORCID ID: 0000-0002-6528-3166, tskoug@ruc.dk, Department of People and Technology – Roskilde University
[4] Nicola Tollin – ORCID ID: 0000-0002-6028-4733, nto@iti.sdu.dk, UNESCO Chair on Urban Resilience – University of Southern Denmark

THE ROLE OF ETHNOECOLOGICAL APPROACH FOR CITIES IN TRANSITION

Francesca Coppola[1]

Abstract

In the face of accelerated changes in ecosystems and geographies, the design of resilient cities becomes imperative. This study underscores the crucial role of ethnoecology as a tool to achieve urban resilience by intertwining cultural roots with environmental and social sustainability. Ethnoecology provides a holistic approach to understanding the interaction between human communities and the environment, forming a robust foundation for designing urban spaces aligned with cultural and ecological needs. Shifting our focus to urban ecosystems, we recognize cities as highly complex socio-ecological systems. Throughout

history, cities have served diverse needs, ranging from religious and political to economic and aesthetic, leading to the global spread of industrial urban logic. The contemporary metropolis represents a phase in the continuous reinvention of cities, where human influence shapes natural processes. The city is perceived as a humanized nature, a 'second nature' constructed by mankind, integrating society and nature inseparably. Urbanization is viewed as a natural phenomenon, with cities born and built on natural and ecological processes and urban ecosystems exhibit variability in occupation patterns, influenced by daily and seasonal migrations between suburbs and city centers. Despite the existing dichotomy between the natural and human aspects of cities, the study acknowledges ongoing ecological actions and awareness. While examples of ethnoecological projects in urban settings are scarce in the scientific literature, participatory methods are seen as a potential avenue for incorporating local ecological knowledge into public policy, enriching scientific understanding with the everyday ecological and historical knowledge of city residents. The study concludes by proposing further exploration and analysis of urban ecology to collaboratively design resilient cities.

Keywords: landscape architecture, ethnoecology, ethnobotany, processes, urban ecosystem

The city and the process urban are a network of intertwined processes, all at the same time, human and natural, real and imaginary, mechanical and organic... There is nothing "purely" social or natural in the city, and even less antisocial or unnatural, the city is both social and natural, real and fictional... In the city, society and nature, representation and being are inseparable, mutually integrated, infinitely connected, simultaneous, this hybrid the socio natural "thing" called a city is full of contradictions, tensions and conflicts (Swyngedouw, 2001 p.84).

Cities are highly complex socio-ecological systems, and this paper tries to start a reflection on the potential inclusion of an ethnoecological approach in the landscape design of urban areas.
Historically, the construction of cities has served to satisfy various needs, including religious, political, economic and aesthetic. Today, we are in a period of transformation in which the urban logic of the industrial city has spread on a global scale. The contemporary metropolis represents only one phase in the continuous reinvention of the city.
Our age is characterised by an accelerated rhythm of change, driven by the rapid dissemination of information thanks to technology. This speed of change does not only affect the personal sphere, but also involves cities, which are in a phase of feverish transformation. A tangible example of this phenomenon is the city of Milan, which has undergone a radical transformation in recent decades, moving from an industrial centre to a green metropolis, with projects such as the Bosco Verticale, Bosco in Città and Citylife. This fervour towards reinvention is a driving force pushing cities to reconsider their identity and project themselves towards new horizons. There is a kind of thrill in the possibility of becoming something new, of challenging pre-existing limits and shaping the future according to a shared vision (Granata, 2019). When we talk about the city, we conceive of a space where the technical and cultural domain shapes natural processes, imposing human rhythms over those of nature. The humanised nature of the city can be seen as a new form of nature, highlighting a gradient of artificiality in spaces, stretching from virgin forest to rural areas to urban hypercentres.

The history of the city is not limited to the dominance of urban-industrial society over nature, but can be considered a natural phenomenon, a 'second nature' constructed by mankind (Fig. 1). So, in the city, society and nature are inseparable, mutually integrated, infinitely connected, simultaneous. Despite the apparent subordination of nature, cities are built on the foundations of natural and ecological processes – the basis of their functioning

(the water cycle and geomorphological processes, for example). In the process of occupying and modifying the space, we leveled the landscape, channeled streams, replaced native vegetation with ornamental plants, mostly exotic species in parks and gardens. Starting from the previous points, we can say that urbanisation can be understood as a natural phenomenon, as humanity, the result of evolutionary and biological processes, builds this 'second nature'. Cities are born and built on natural and ecological processes.

Fig 1: Biblioteca degli Alberi - Milano. Guilhem Vellut, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons.

Just like 'natural' ecosystems, urban ecosystems are particularly variable. Indeed, we notice a variation – daily and seasonally – in the way urban areas are occupied. Every day, people migrate between the suburbs and the city center. We can therefore say that urban areas are formed by a mosaic of individual places, with different levels of artificiality. The people who migrated to urban areas bring with them knowledge, customs, culture, but also many animal and plant species. Therefore,

there is a constant flow of social resources and biodiversity to urban areas.

> *People who migrated to urban areas also brought with them myriad plant and animal species. Therefore, there is a constant flow of social and biodiversity resources to urban areas. Cities are home to a diversity of cultures, people from different backgrounds and their 'urban tribes' (Almada, 2011 p.4).*

In this perspective, it is interesting to mention Elysée Reclus (1830-1905), a prominent French geographer and anarchist of the 19th century. He was a passionate advocate of the abolition of slavery and colonisation and believed strongly in individual freedom and the need for a balance between human beings and the natural environment. Reclus is famous for his work in the field of geography, in particular for his major work 'La Nouvelle Géographie universelle' (1875-1894), in which he described in detail the different regions of the world, their history and culture. However, he was also a social activist, who spent many years in exile due to his radical political views,

Fig 2: BioCultural Landscape – Nouvelle géographie universelle – la terre et les hommes (1876)
Paul LangloisReclus, Elisée, 1830-1905, No restrictions, via Wikimedia Commons.

remembered for his vision of society as an interconnected organism, in which humanity and nature are inextricably linked entities (Fig. 2).
The human essence, for the geographer, develops in harmony with nature, rather than in spite of it. This view, in line with the distinction proposed by Bookchin, separates the world into a 'first nature' and a 'second nature', corresponding to the natural and social realms. First nature, as a concept, exists outside the influence of humanity and has existed for a much longer period than humanity was aware of itself. In human evolution, an intimate connection with the outer sphere of nature is maintained (Reclus and Andreco, 2022). However, what emerges is a new natural being, defined by Reclus as the 'human social environment', which does not represent a second nature. This relationship, the human social environment, this constant interaction of information and knowledge between human and non-human is approached by ethnoecology.

> *Ethnoecology is the study of interactions between humankind and the rest of the ecosphere, through the search for understandings, feelings, attitudes, knowledge and beliefs about nature and characteristics of a biological species (Homo sapiens) - that being highly polymorphic, phenotypically plastic and ontogenetically dynamic (Marques 2001, p. 49).*

Ethnoecology is the discipline that explores how human cultures interpret, understand and relate to their surrounding ecosystems, including ecological classification systems, natural resource, practices and traditional knowledge about biodiversity, paying attention to the ecological and social dynamics that influence the sustainable management and use of natural resources. Ethnoecology focuses on the ecological and social dynamics that influence the sustainable management and use of natural resources, explores the emotions and feelings that emerge when culturally associated with certain foods, products, medicines or other natural resources, and offers an integrative approach to the study of the process of nature appropriation (Toledo, 2001).

The KCP (kosmos-corpus-praxis) triad proposed by Toledo (1992) can also be applied to ethno-ecological city studies. The city dweller constructs his or her space and operates in his or her ecological environment through the knowledge he or she acquires in everyday experience and through the mechanisms of knowledge transmission. Such knowledge and practices are embedded in the collective imagination of cities, in a kind of urban cosmology (Grange, 1999), which can explain and give meaning to the (dis)order of cities. The first *kosmos*, refers to the way a specific community or culture conceives and organises reality around it. The second *corpus* is to be understood as the set of local and traditional knowledge related to the environment and nature; the last term *praxis* relates to the actions or practices of a community related to the environment.
Ethnoecological and ethnobotanical approaches can be used as tools for inclusion and sustainable design, there are several projects that have used ethnobotany and ethnoecology as a tool to regenerate and design landscapes and urban systems. Most projects are concentrated in Mesoamerica with a few examples in the Mediterranean region such as Spain and Morocco. Many of these projects work with indigenous or small communities and try to conserve a natural heritage by valorising and preserving historical memory, traditions and sometimes even language. For example, several studies show that the higher is the linguistic biodiversity, the higher is the natural biodiversity[2]. The connection between languages and hotspot areas is further highlighted by the constant threat they face: an estimated 50 living species are lost every day (Ispra, 2021), with an estimated one million species at risk of extinction within a few decades. Of the 7000 existing languages, 50% are considered to be at risk of extinction, with one language at risk of disappearing every three months (Bromham, L. *et al.*, 2021).

The first project worth mentioning is the *Agdal* system implemented by the Centre for International Forestry Research (CIFOR) in 2009. This project is a traditional community-based natural resource management system in Morocco. The project comes to life thanks to a tradition dating back hundreds of years and an

effective strategy in maintaining ecological balance and ensuring sustainable access to natural resources. *Agdal'* are characterized by strict rules and cultural traditions that regulate access to and use of resources within a specific area. These rules may include restrictions on water use, livestock grazing, timber harvesting and other activities that could damage the local ecosystem. They play an important role in conserving biodiversity and protecting fragile ecosystems. Local communities have developed management practices that favour the natural regeneration of resources, the maintenance of soil fertility and the protection of animal and plant species. *Agdal* management is typically a community affair, with rules and decisions taken by consensus by the local community. This involvement of the people living nearby is essential to ensure compliance with the rules and the long-term sustainability of the system. Cultural significance: *agdal* are not only resource management systems, but also have a deep cultural and social sig-

Fig 3: AGDAL - Marocco. Mounir Neddi, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons.

nificance for the communities that use them. They represent people's connection with the land and its environment and are often associated with religious practices and local traditions (Fig. 3). Another project that includes landscape, culture, and ethnobotany is certainly the Oaxaca Botanical Garden in Mexico. The ethnobotanical garden is part of the Santo Domingo Cultural Centre, a former convent of Dominican monks built between the 16th and 17th centuries and used as military barracks from the mid-19th century until 1994. Following an initiative by the painter Francisco Toledo and Luis Zárate in collaboration with the Civil Association Pro Oaxaca, the project to save the old building and create a botanical garden around it was born with the aim of raising awareness and preserving plant diversity. Inside the garden, it is still possible to appreciate the different uses of the space in colonial times: irrigation and drainage canals, ponds, lime kilns, laundry, a ceramic oven and a cobbled road for carts that provided food and fuel. The project aims to show the relationship that exists between vegetation and the different cultures present. In fact, Oaxaca is not only the entity where more ethnic groups live and where more indigenous languages are spoken, but it is also the state where there are more species of plants and animals (Fig. 4). As mentioned on the Garden's website: *«Lo denominamos ETNObotánico porque las plantas que escogemos tienen un significado cultural.»*[3]. The botanical design within the garden is incorporated into the surrounding landscape: plant transitions are organised according to the botanical associations found in the natural landscape of Oaxaca, not only purely botanical associations but also cultural associations. The management of plants by different cultural groups within the entity (or context) may present various patterns of composition. These patterns are recognisable in the structure of the garden design itself (Márquez López, 2013).

The projects previously mentioned are effective as they react in areas considered natural, both in terms of design and reference to the ecosystem. However, what if we were to apply this approach within cities as well? Despite often struggling to

Fig 4: Oaxaca Botanical Garden. Kaldari, CC0, via Wikimedia Commons.

break out of the city-nature dichotomy, the city, although an ecosystem, also has its own ecological dynamics, and residents of urban areas usually build local knowledge about this space. Therefore, the role of urban ethnoecology is to analyze and understand ecological knowledge in cities. If the city is nature, the city has its own ecosystem to be analysed. The role of urban ethnoecology is to analyse and understand the ecological knowledge in cities. The city, despite being an ecosystem, has its own ecological dynamics, and residents of urban areas usually build local knowledge about this space. Therefore, the role of urban ethnoecology is to analyze and understand ecological knowledge in cities. Although we have difficulty leaving the dichotomy of natural - human, city and nature as Elena Granata says:

> *We already have ecological awareness and are already carrying out ecological action, even ignoring the issue (...) cities are already implementing ecological behaviors, even if they do not know and cannot govern all the processes, even if they do not have all the information (...) (Granata, 2019 p.122).*

An innovative project using folk knowledge, tradition, and resource planning, conducted in the city of Phoenix and is based on urban ethnohydrology. This project focuses on recovering sufficient water resources for a growing population such as that of the city of Phoenix. This study examines cultural models of water quality and water management, termed ethnohydrology, among urban residents. The findings have significant implications for water policy development and planning, especially in disadvantaged and vulnerable communities where water quality is perceived to be low. Although ethnobotany and ethnoecology have explored different biological domains, ethnohydrology was first introduced as a research area in Backs' (1981) historical study of Native American conceptions of water. Subsequently, Gelles (1998, 2000) and Sherbondy (1982, 1992) suggested that ethnohydrology can be divided into two dimensions: spiritual beliefs and rituals concerning water, and technical knowledge of water quality and management. This study focuses specifically on the latter aspect.

This is a study conducted in 2010 is an example of how urban policies can benefit from local knowledge. In this case the study had a focus on water resources especially in disadvantaged areas in the city of Phoenix in Arizona is perceived to be low. Urban ethnohydrology is particularly relevant to the contemporary challenges of urban water management. This study led to three key findings. First, it appears that urban residents share a pattern of ethnohydrology that suggests there are significant water quality risks due to low financial investment in water treatment throughout the city, especially in desert areas such as Phoenix. However, there is a belief that an effective combination of monitoring and government management, together with household-level water treatment, can produce water of acceptable

quality. According to this, people with higher incomes tend to engage in expensive water filtration activities and seem to agree more with the cultural ethnohydrological model. In addition, people living in communities that are highly concerned about water quality are less likely to agree with the ethnohydrological model. These findings have important implications for water policy-making and planning, especially in disadvantaged and vulnerable communities where water quality is perceived to be low. This research has the potential to expose a wide and diverse range of local strategies to conserve and ensure the sustainability of local water resources.

By looking at and analysing the city as a system, and more broadly by understanding the city as a (natural) ecosystem, we can integrate a systemic ethnoecological approach into the design of resilient cities, capable of interpreting new ecological and non-ecological knowledge and putting it at the service of careful and sustainable design. Today, the scientific literature on ethnoecological projects in urban settings is almost non-existent or inconsistent. Some authors, such as Vesa Yli-Pelkonen and Johanna Kohl, believe that with participatory methods it is possible to incorporate local ecological knowledge into public policy, thus enriching scientific knowledge with the everyday ecological and historical knowledge of city dwellers. Integrating ecological information into the urban spatial planning process has been recognised as an important practice to preserve green spaces and ecosystem services for city residents. Research such as that conducted by Sukopp *et al.* (1995), Niemelä (1999) and Kansanen (2004) has helped to consolidate this idea, demonstrating the effectiveness of basing land-use decisions on reliable ecological information and the active involvement of the local community. (Yli-Pelkonen & Kohl, 2005). In Finland, the 1999 Land Use and Construction Act emphasised the importance of considering not only ecological information from scientific studies, but also the opinions and knowledge of local residents, nature enthusiasts and other user and participatory groups. This inclusive and participatory approach provides valuable information on the biodiversity of an area and the needs of the com-

munity, thus contributing to more sustainable spatial planning adapted to the local context.

In the contemporary landscape, how can architects effectively integrate people's knowledge of urban ecosystems and understand the evolving nature of cities in transition? This work does not claim to offer a definitive answer, but it aspires to stimulate debate and thought in the quest for diverse strategies to enhance a city's resilience. Participatory methods can become an effective tool for incorporating local ecological knowledge into public policies, enriching scientific understanding with the everyday ecological and historical knowledge of city residents. Ethnoecology presents a unique and potentially innovative starting point, but it is just one of the many possibilities. Together, we may uncover alternative approaches to studying and analyzing urban ecology to collaboratively design resilient cities. There is a need for further exploration and analysis of urban ecology, with a collaborative approach to designing resilient cities. Ethnoecology, as a discipline, offers a broad framework for understanding human-environment interactions, integrating cultural roots with environmental and social sustainability.

Biography

Francesca Coppola, Landscape architect and PhD student at the Department of Architecture and Design (DAD) of the Polytechnic School of the University of Genoa. Co-founder of P432 studio and Radice Comune Aps. Her field of research focuses on migrant landscape and contemporary landscape design.

references

+ Almada, E.D. (2011). Urban socio-biodiversity: ethnoecology of cities. *Bioremediation, biodiversity and bioavailability*, 5, 1-8.
+ Bromham, L. et al. (2021). 'Global predictors of language endangerment and the future of linguistic diversity', *Nature Ecology & Evolution*, 6(2), pp. 163–173. Available at: https://doi.org/10.1038/s41559-021-01604-y.
+ Granata, E. (2019). Biodivercity: città aperte, creative e sostenibili che cambiano il mondo. Prima edizione. Firenze - Italia: Bra (CN) - Italia: Giunti ; Slow Food editore (Terrafutura).
+ ISPRA 2021, Rapporti Direttive Natura (2013-2018). Rapporti 349/2021
+ Pais JM, Blass LMS (2004). Tribos Urbanas: Produzione artistica e identità, Annablume, San Paolo.
+ Simmel G (1976). A metropole ea vida mental. In: *Velho OG* (a cura di) O Fenômeno Urbano, Zahar Editores, Rio de Janeiro, pp 11-25 .
+ Toledo, V. (1992). Cos'è l'etnoecologia? Origini, portata e implicazioni di una disciplina nascente. *Etnoecológica* 1, pp. 5-21.
+ [Text Wrapping Break]Toledo, V. M. (2001). Indigenous peoples and biodiversity. *Encyclopedia of biodiversity*, 3, pp. 451-463.
+ Marques, J.G. (2001). Pescando Pescadores: Ciência e Etnociência em uma Perspectiva Ecológica, NUPAUB/USP, São Paulo.
+ Márquez López, F.C. (2013). Paisaje vegetal de México: lenguaje y composición vegetal en los jardines: Las Pozas, Xilitla, San Luis Potosí y Jardín Etnobotánico de Oaxaca, México (Master's thesis, Universidad Autónoma Metropolitana (México). Unidad Azcapotzalco. Coordinación de Servicios de Información).
+ Reclus, E. and Andreco (2022). Natura e società scritti di geografia sovversiva. Nuova edizione. Edited by J.P. Clark. Milano Elèuthera 2022.
+ Swyngedouw, E. (2001). A cidade como um híbrido: Natureza, sociedade e "urbanização-cyborg". In: Acselrad H (a cura di) A Duração das Cidades: Susten-tabilidade e Risco nas Políticas Urbanas, DP&A Editora, Rio de Janeiro, pp. 83-104.
+ Yli-Pelkonen V, Kohl J (2005) The role of local ecological knowledge in sus- tainable urban planning: Perspectives from Finland. *Sustainability: Science, Practice and Policy* 1, pp. 3-13.

note

[1] Francesca Coppola – ORCID ID: 0009-0005-8516-3769, francesca.coppola@edu.unige.it, Dipartimento di Architettura e Design – Università di Genova
[2] In this regard, it is worth mentioning several studies that have investigated the relationship between small communities and the preservation of biodiversity, including: Ens, E., Scott, M. L., Rangers, Y. M., Moritz, C., & Pirzl, R. (2016). Putting indigenous conservation policy into practice delivers biodiversity and cultural benefits. Biodiversity and Conservation, 25, pp. 2889-2906., Fourmile, H. (2002). Indigenous peoples, the conservation of traditional ecological knowledge, and global governance. In Global ethics and environment (pp. 215-246). Routledge. Gafner-Rojas, C. (2020). Indigenous languages as contributors to the preservation of biodiversity and their presence in international environmental law. Journal of International Wildlife Law & Policy, 23(1), pp. 44-61.
[3] Translation: 'We call it ETNObotanical because the plants we have selected have a cultural significance'.

DESIGN FOR COHABITATION

Towards a multi-species design practice in architecture based on affordance

Philipp Gruber[1]

Abstract

Cities are dynamic habitats for both people, animals, and plants. Yet architecture as a design discipline is primarily focused on human needs, neglecting other species and thus, the potential of architecture promoting biodiversity. The research of the thesis explores to what extent a multi-species design practice in architecture based on affordances helps to stimulate a symbiotic relation between architecture and biodiversity. By embracing the concept of affordances, the research seeks to cater to the needs and abilities from the perception of multiple species interacting with urban spaces. Affordances describe the relation between the environment and its multi-species actors and are defined as possibilities for action provided to an animal by the environment – by the substances, surfaces, objects, and other living creatures that surround it (Kiverstein & Rietveld, 2014, p.325). In this

paper, a theoretical framework was developed which triangulates affordances, multi-species design and architecture. This required questioning the nature of the architectural object and the role of the architect. It was concluded that the architectural object should be seen as an open dynamic socio-ecological system with both physical and non-physical structures. Designers are asked to propose the envelope of the object as a profound relational space shared in cohabitation between humans, animals and plants. In this threshold between outside and inside, symbiotic exchanges can be stimulated by introducing affordances which support the life of all beings. This can lead to a mutually beneficial symbiosis between architecture and biodiversity, if architects take a reflective design position considering both species needs and conflict mitigation. In a multi-species design practice based on affordances, the architect's role extends beyond the traditional design to initiating a collaborative process in which other species interact, actively shaping the built environment.

Keywords: Cohabitation, biodiversity, affordances, multi-species design, architecture

1. Introduction

Cities are dynamic and diverse habitats both for people, plants and animals. Yet architecture as a design discipline is primarily focused on human needs, neglecting other species and thus, the potential of architecture promoting biodiversity. Since 1970, biodiversity has declined with an alarming amount of 70%, which presents a significant threat to non-human and human lifes. Contributing to this development the man-made built environment is responsible for rapid land take, the depletion of natural systems and the destruction of habitats for animals, plants and insects (Kuhnert *et al.*, 2022, p.4).

Despite the growing awareness of architects towards a more ecologically sound practice, the architectural design discipline lacks the consideration of non-human needs which diminishes biodiverse life. The trajectory of a declining biodiversity has to

be actively countered through other narratives and approaches especially in regards to the disciplinary understanding and making. This thesis investigates the concept of affordances as a valuable notion helping architectural practitioners to reposition. It argues that the concept of affordances can alter the architectural practice catering to the needs and abilities from the perception of multiple species interacting with urban spaces. Affordances describe the relation between the environment and its multi-species actors and are defined as possibilities for action provided to an animal by the environment – by the substances, surfaces, objects, and other living creatures that surround it (Kiverstein & Rietveld, 2014, p.325). The theory of affordances originates from the field of ecological psychology. Initially, it was introduced by James Gibson in 1986 and further developed by Erik Rietveld and Julian Kiverstein in their paper titled 'A Rich Landscape of Affordances' published in 2014. Its exploration in the context of architecture is relevant because it allows for an architectural understanding of the urban fabric from a phenomenological and socio-cultural perspective of multi-species users. In this paper, it is particularly used to bridge the academic gap between multi-species design and architecture, aiming to explore how a multi-species design practice in architecture based on affordances helps to stimulate a symbiotic relation between architecture and biodiversity. As literature study is of importance to think about the disciplinary understanding, a theoretical framework was developed which triangulates architecture, multi-species design and affordances. This required questioning the nature of the architectural object and the role of the architect.
The paper will begin by defining and contextualising affordances in the field of architecture. In the following section, the notions of *Zoöp*, *Nature-Inclusive Design* and *Animal-Aided Design* are analysed. Here, their scientific understanding as contemporary multi-species design concepts in relation to affordances are discussed. Each notion brings a particular aspect, which is of importance for characterising a multi-species design practice based on affordances. The concluding section on the link to architec-

ture will define the architectural object and its relationship to multi-species users and the environment.

2. A multi-species design practice in architecture based on affordances

2.1 Affordances

'Affordances (Gibson, 1979/1986) are possibilities for action provided to an animal by the environment – by the substances, surfaces, objects, and other living creatures that surround it. A common assumption has been that affordances primarily relate to motor actions, such as locomotion and manual behaviours like reaching and grasping. We propose an account of affordances that extends beyond these traditional notions. We argue that the affordances an environment offers to an animal depend on the skills possessed by that animal' (Kiverstein & Rietveld, 2014, p.325).
Gibson describes affordances as a network consisting of physical elements such as substances, surfaces, objects, living beings that are part of the environment. In this context, physical conditions represent opportunities for action for humans, animals, or plants. However, Kiverstein and Rietveld extend this notion by thinking beyond a solely linear understanding. They emphasise the additional consideration of non-physical aspects, such as the skills and abilities specific to each species, as they define the actions that species can perform. The authors argue that an animal's dynamically shifting skills and abilities influence its ability to respond to affordances in a given scenario. The specific affordances utilised by an actor in a particular setting will vary based on their current activities and concerns. Therefore, it is essential to highlight the temporal aspects such as the day and life cycles of humans, animals, and plants.
Non-human and human beings are embedded in socio-cultural practices, which encompass patterns of behaviour in relation to objects and ways of coexisting with other beings. Thus, the concept of affordances represents a socio-ecological notion, as objects and species are rooted within ecological and social cycles of the environment. This perspective aligns with the broader concept of ecology, which 'is the science that studies the rela-

tionship between living organisms and their interactions with the environment' (Vink, Vollard, De Zwarte, 2022, p.31). Ecology fundamentally focuses on connections, relations, and processes involving multi-species actors and their resourceful environments, all essential for living and taking action. From this we learn that affordances as an approach asks for a change in the perception and interpretation of 'what architecture is'. It requires questioning the nature and structure of our designed objects. In this regard, architectural objects, being embedded in the environment as physical entities, can be perceived as affordances, too. Offering physical and non-physical structures, they are capable of providing humans, animals, and plants with the action of habitation, but the question arises of how to acquire knowledge to design and implement affordances inviting multi-species actors.

2.2 Multi-species design

Prof. Dr. Thomas Hauck, founder of studio *Animal-Aided-Design*, highlights a crucial concern when designing for multi-species actors. He acknowledges that architectural interventions stimulated by design will inevitably alter the conditions for biodiverse species in a given place. Hauck emphasises the need to accept this reality and recognizes that every formative human intervention either creates or destroys opportunities for habitation. What benefits one species may harm another. Therefore, designers must carefully consider the consequences of their actions on the existing environment, as interventions in biodiversity are inherently experimental and self-dynamic (Hauck, 2022, p.203).

2.2.1 Zoöp

Looking at Hauck's ideas through the lens of Rietveld and Kiverstein concept of affordances, it becomes clear that affordances are subject to temporal aspects, as the possibilities and conditions for action in one location change over time. Thus, analysing existing affordances in a given place is essential before designing for multi-species contexts. In this regard, the *Zoöp* model developed by the research department of *Het Nieuwe Instituut* in Rotterdam brings helpful aspects and serves as a valuable

tool. *Zoöp*, short for *Zoöperatie*, represents an organisational model for cooperation between human and non-human life that safeguards the interests of all living beings (Het Nieuwe Instituut, n.d.). The model incorporates the *Zoönomic Year Cycle*, consisting of the four stages *Demarcating*, *Observing & Sensing*, *Characterising*, and *Intervention*. In the *Demarcating* stage (see Figure 1.1), a mapping of the physical and living bodies of the *Zoöp* is conducted, which is relevant to find out existing affordances in their physical appearance. For example, the regional species group, as well as local objects, substances, and materials are identified. The subsequent *Observing & Sensing* stage (see Figure 1.2) focuses on the non-physical structures of affordances such as movements and interactions of the actors depending on the daily activities and socio-cultural practices of different species. A valuable stage for the notion of affordances is *Characterising*, where the health condition of the *Zoöp* is assessed. Within this stage, the condition of existing affordances at one place can be analysed, forming the basis for the subsequent *Intervention* phase, in which new affordances can be implemented.

Fig 1: Example of Zoöp methods – Demarcating (1.1) and Observing & Sensing (1.2) (own work).

2.2.2 Nature-inclusive Design and Animal-Aided Design

When designing affordances that are to be introduced as part of an intervention, *Nature-inclusive design*, a notion which is currently gaining importance in the Netherlands, provides valuable aspects on how to design for the non-human domain. It sees the urban environment and architecture as an integral part of ecological systems and seeks to catalyse a symbiosis between

nature and architecture. The essential features an environment must provide for species include access to food, water, shelter, and suitable conditions for breeding activities. These conditions encompass various factors such as space, climate, thermal comfort, orientation, and protection from air pollution, light pollution, and disturbance caused by both humans and predators (Van Stiphout, 2019; Vink, 2024).

Animal-Aided-Design also brings another framework to design for non-humans. Their approach is based on understanding life cycles and the needs that vary throughout the year due to individual temporal mechanisms and changing life concerns of different species. This notion incorporates temporal aspects, including seasonal variations and designing with a changing climate over the year (Hauck, 2022, p.200). Its recognition of activities, temporalities and abilities embedded in the socio-cultural practices of beings is of particular importance for the concept of affordances. Architects can find relevant information in this concept when considering the dependencies of affordances on the specific skills possessed by each species, as discussed by Rietveld and Kiverstein. In the course of this paper, a diagram of affordances was developed (see Figure 2). As possible affordances given in a particular environment, *Shelter*, *Community*, *Nourishment, Accessibility*, *Safety & Well-being*, *Climate*, and *Material Environment* are defined using the principles stated above. Moreover, the effect on *Other species*, as well as *Cultural Practice* are set as skills and abilities the actor brings. This information can be used by architects to design and implement affordances for other species in their projects and thus, to enrich the offers of the designed environment to actors. As an example of this scheme, one diagram representing affordances, skills and abilities of the *House Sparrow* was made. Central to this diagram is the life cycle of the bird connected to its socio-cultural practice. The outer circle represents the environment with the various embedded affordances (see Figure 3).

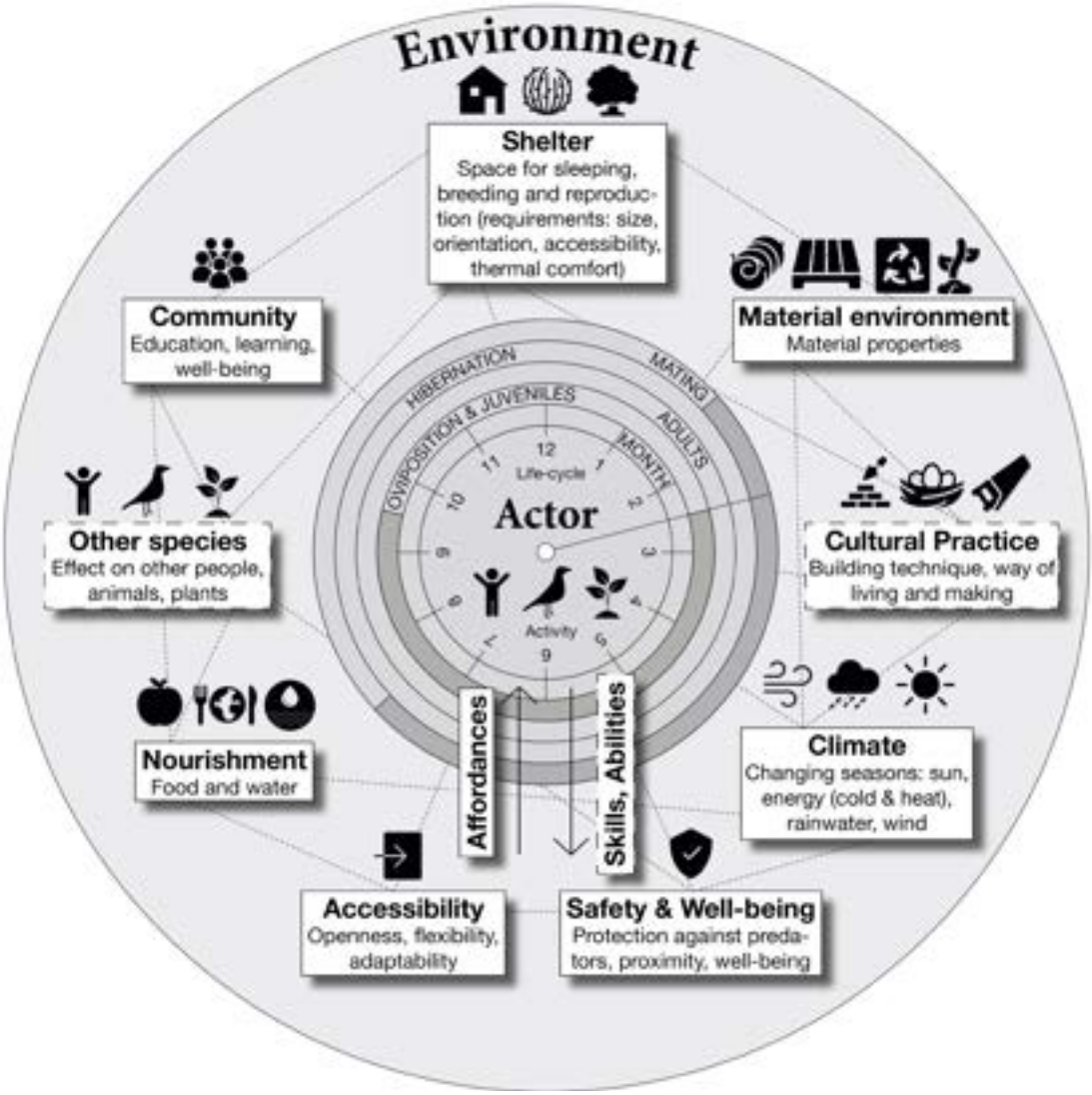
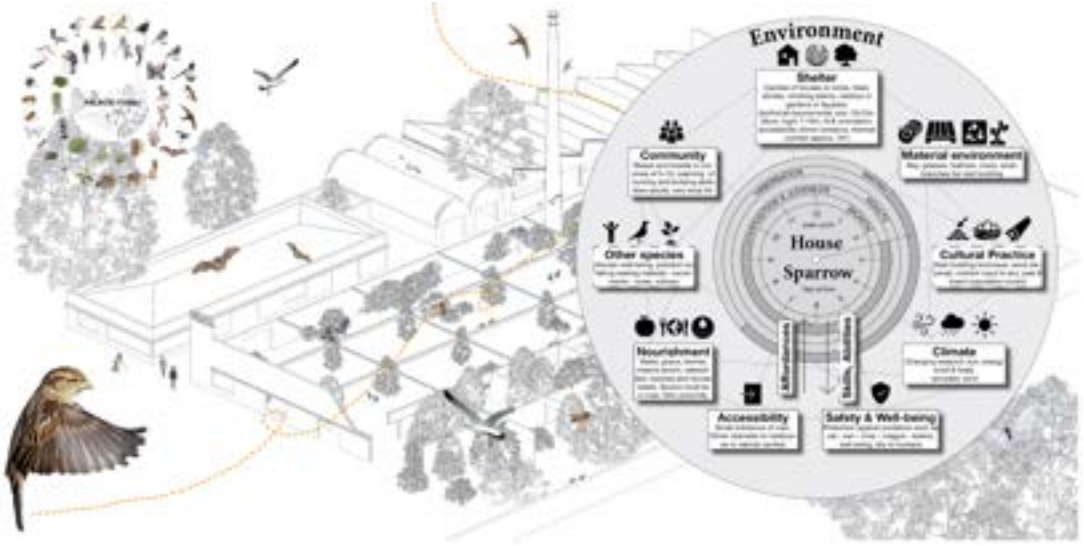


Fig 2: Diagram of affordances (own work).



2.3 Architecture

Architectural object

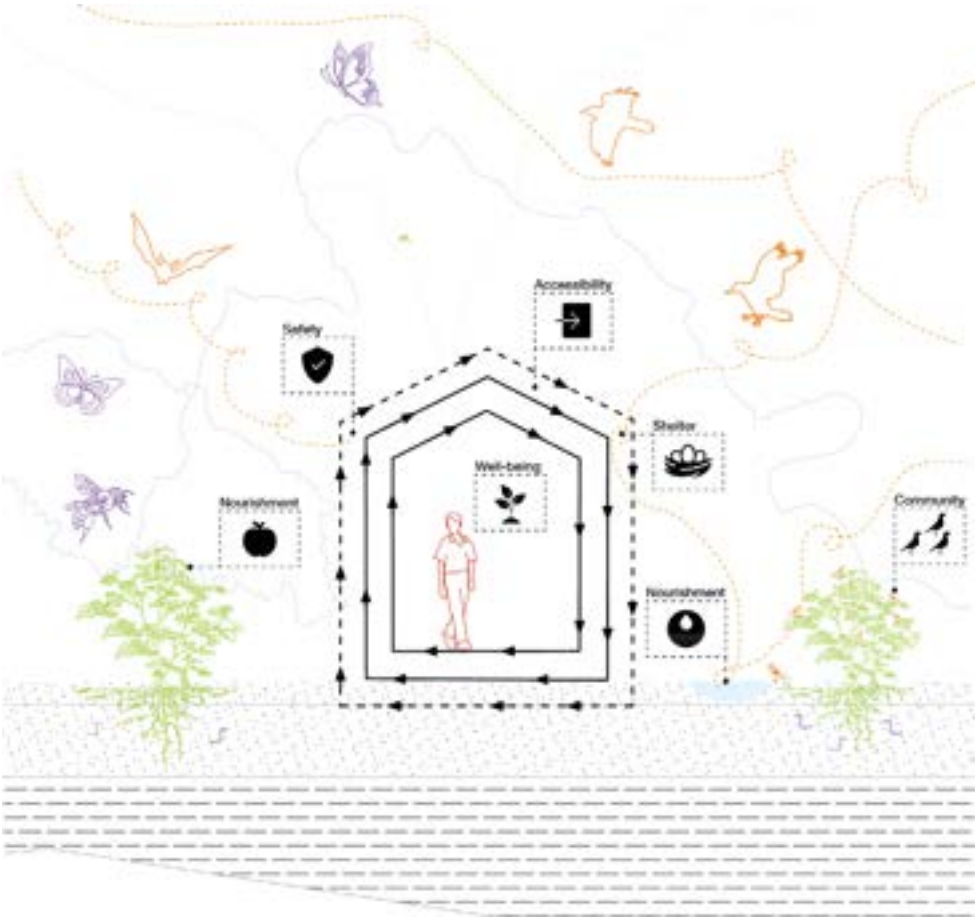
Triangulating the concept of affordances, multi-species design and architecture raises questions about the nature of architectural objects. In their essay titled 'Architecture and Ecological Psychology - RAAF's Exploration of Affordances', published in the book 'Habitat – Ecology Thinking in Architecture' (2020), Erik Rietveld and Janno Martens argue against viewing the built environment as a collection of static objects. Instead, they propose understanding it as an ecological system consisting of dynamic objects, and advocate for process-related design in architecture.

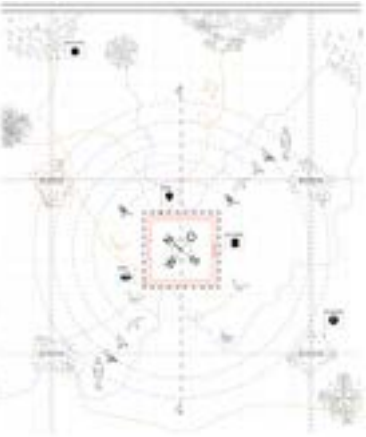
Moverover, *Animal-Aided-Design* highlights the diverse life-cycles of species and the varying climate conditions throughout the year, which highlights the importance of developing climate-adapted architectural objects. This requires architects to design the object in accordance with processes, time, and relationships. In this sense, the architectural object also encompasses a profound non-physical structure associated with the socio-cultural behaviours of its inhabitants. Thus, the architectural object should be understood as a dynamic socio-eco-

Fig 3: Diagram of affordances illustrated using the example of the House Sparrow (own work).

logical object with both a physical and non-physical structure, integrated into the larger context of the environment. It must be designed as an open living system with affordances embedded that enable multi-species user engagement while mitigating conflicts among species. An effective intermediate space and layer for this is the envelope of the object, as mentioned in the paper 'Creating ecologically sound buildings by integrating ecology, architecture and computational design' published in collaboration by different authors from the *TU München*, *TU Wien*, *Animal-Aided-Design* and more in 2023. The authors envision the envelope to be designed as an *Ecolope*, which they define as following: « We propose the design of an ecolope, a shared multi-species architectural space which blurs the boundaries between the outside environment, the building's envelope and the interior. [...] An ecolope will be in intensive exchange with the environment outside the building and needs to be designed to allow for this exchange. The ecolope then has the potential to act as an enabler of human–nature interactions. This can be accomplished by designing it with the aim to support the life of other species as well as for humans » (Weisser et al., 2023, pp. 10, 11).

Analysing the authors' way of understanding, it becomes clear that designing the envelope of architectural objects can be a powerful tool for creating different structures of affordances within the outer shell, a dynamic space that can be shared by diverse species (see Figure 4). In this threshold, humans, animals, plants and microbiota can perceive affordances enabling them to generate symbiotic impacts on each other, the object and the environment. Architectural design has the potential to stimulate these impacts by offering affordances implemented in the objects structure. Thus, through a process driven by multi-species design, human and non-human interactions can establish symbiotic relationships, benefiting mutually from one another. In the course of this paper, a hypothetical architectural object was developed illustrating various species interacting dynamically with the architectural object (see Figure 5).


Accessibility
Safety
Shelter
Well-being
Nourishment
Community
Nourishment



3. Discussion & conclusion

The research conducted has shown that a multi-species design practice in architecture based on the concept of affordances can be regarded as a relevant tool for stimulating a symbiotic relationship between architecture and biodiversity.

First, the investigation reveals that existing architectural design practices pose challenges within multi-species domains. These practices often exclude non-human spatial users and contribute to the production of homogenous urban landscapes, as they primarily focus on human-centred design parameters. Consequently, the architecture profession faces the challenge of considering non-human needs and incorporating habitat facilities for other beings into their proposed objects.

Second, by acknowledging the presence, needs and socio-cultural practices of non-human actors, a multi-species design in architecture allows establishing relations and interconnections between different species. A useful tool for designers in this approach is the notion of affordances, which refers to the potential actions enabled by the environment to people, animals, plants. Understanding affordances helps designing objects that better align with the abilities and needs of the individual multi-species users interacting. Rather than focusing solely on the physical properties of objects, the notion of affordances emphasises the intrinsic relationship between perception and action. Implementing affordances into architectural thinking helps to make design decisions on the basis of how much the designed intervention creates or strengthens possibilities for action to multi-species users. To design affordances, architects can inform themselves through various multi-species design guides, aiding in acquiring knowledge about the design parameters of other species. This process often requires extensive ecological research, and thus, architects would benefit from working closely with ecologists and urban planners. One outcome of the research is the development of a diagram of affordances, which can effectively communicate specific affordances, as well as the skills and abilities of individual actors. It becomes evident that solely relying on literature brings limitations in a multi-species design practice. For

Fig 4: Architectural object as open dynamic system of affordances (own work).

Fig 5: Example of a hypothetical architectural object - Situation, section and floor plan (own work).

example, identifying regional species groups requires field research. To do so, useful tools for analysing existing affordances are provided by the *Zoöp* model, which involves *Demarcating, Observing & Sensing* local actors, their behaviours, and their interconnections with the environment. This data can then be used to interpret the needs and abilities of different species and make informed design decisions. Architects are challenged to adopt a reflective multi-species design practice, as decisions are speculative, and multi-species design inherently possesses an experimental and self-dynamic nature. Thus, actions introduced through architectural intervention have temporal and dynamic aspects and need to be monitored over time and adjusted if necessary. In a multi-species design practice based on affordances, the architect's role is not limited to traditional design but extends to initiating a collaborative process in which other species interact, actively shaping the built environment.

Lastly, a good multi-species design based on affordances should ideally make possibilities for action to humans, animals and plants explicit. This can be most efficiently done through the design of the architectural object as an open and dynamic socio-ecological object with both physical and non-physical structure. Moreover, the object must be understood as an embedded element in its environment, which consists of a multiple set of affordances. Thus, the chance is given to locomotive action and skills related to the socio-cultural behaviour of different multi-species users. In this process, the role of the architect is to design affordances and hence, to promote possibilities for multi-species actions. These actions can ultimately make it possible for human and non-human actors to enter into a symbiotic relationship. Here, the future challenge for architects is to envision a climate-adapted object, which considers needs and life-cycles of different species changing dynamically over time, as well as conflict mitigation. Designers are asked to propose the envelope of the object as a profound relational space shared in coexistence between humans, animals and plants. In this threshold between outside and inside, dynamic exchanges between the environment, the object and the multi-species users can be designed with the affordanc-

es to support the life of all beings. But most important, it is in this powerful situation, where design can enforce multi-species interactions which allow the establishment of symbiotic relations between architecture and biodiversity.

Biography

Philipp Gruber works across architecture and ecology as a freelance researcher and designer. With this focus, he studies the power of multi-species design to stimulate symbiotic relations between architecture and biodiversity. He graduated in Architecture, Urbanism and Building Sciences (M.Sc.) from TU Delft in 2023. His graduation project titled 'Growing Residency – Towards a multi-species design practice in architecture based on affordances' got nominated for the Dutch National Archiprix 2024. Prior to this, he studied architecture at FAUP in Porto/Portugal and at THWS in Würzburg/Germany. He gained practical experience by collaborating with Walden Studio in Rotterdam, Prof. Eike Roswag of ZRS - Ziegert Roswag Seiler Architekten und Ingenieure in Berlin, Prof. Nuno Brandão Costa Arquitectos in Porto and Architekten Gruber | Hettiger | Haus in Karlstadt/Marktheidenfeld

references

+ Hauck, T.E., Weisser, W.W. (2015). *Animal Aided Design: Broschüre*. München: TUM, Bayerisches Staatsministerium für Umwelt und Verbraucherschutz.
+ Förster-Baldenius, B. (2022, May 7). *Cohabitation Translation Pilikia*. Talk at symposium of the series 'Zoopolis Berlin' at the Floating University in Berlin. Retrieved from https://vimeo.com/732113394.
+ Het Nieuwe Instituut Rotterdam. (n.d.). *Zoöperatie: Research model for multi-species communities*. Retrieved from https://zoop.hetnieuweinstituut.nl.
+ Kiverstein, J., & Rietveld, E. (2014). *A rich landscape of affordances*. Ecological Psychology, 26(4), pp. 325-352. https://doi.org/10.1080/10407413.2014.958035.
+ Kuhnert, N., & Ngo, A. (Eds.). (2022). *ARCH+ Zeitschrift für Architektur und Urbanismus, Heft #247: Cohabitation*. Berlin: Arch+ Verlag.
+ Ludwig, F., Schönle, D. (2023). *Growing Architecture: How to Design and Build with Trees*. Basel: Birkhauser.
+ Rosinska, M., & Szydłowska, A. (2019). *Zoepolis: Non-anthropocentric design as an experiment in multi-species care*. Retrieved from https://doi.org/10.21606/nordes.2019.006.
+ Sanz, V.M., Martens, J., & Heuvel, D.v.d. (2020). *Habitat: Ecology Thinking in Architecture*. Rotterdam: nai010 publishers.
+ Stiphout van, M. (2019). *First guide to nature inclusive design*. Amsterdam: nextcity.nl.
+ Vink, J., Vollard, P., & Zwarte de, N. (2022). *Stadsnatuur maken, Making urban nature*. Rotterdam: NAI010 publishers.
+ Vink, J., Vollard, P., & Zwarte de, N. (2024). *Building urban nature: Towards a nature-inclusive architecture*. Rotterdam: NAI010 publishers.
+ Weisser, W.W., Hensel, M., Barath, S., Culshaw, V., Grobman, Y.J., Hauck, T. E., Joschinski, J., Ludwig, F., Mimet, A., Perini, K., Roccotiello, E., Schloter, M., Shwartz, A., Hensel, D.S., & Vogler, V. (2023). Creating ecologically sound buildings by integrating ecology, architecture and computational design. People and Nature, 5, pp. 4–20. https://doi.org/10.1002/pan3.10411.

note

[1] Philipp Gruber – ORCID ID: 0009-0004-7642-7841 philippgruber@posteo.de, Faculty of Architecture and the Built Environment – TU Delft

+ This paper has previously been published for a large part at TU Delft, 2023, as part of the master thesis 'Growing Residency – Towards a multi-species design practice in architecture based on affordances' (M.Sc. Architecture) by Philipp Gruber.
Source: http://resolver.tudelft.nl/uuid:57f28586-71fc-4492-a51b-5fb5ab3323d2

PROGRESS VS UTOPIA RESILIENT URBAN PARADIGMS FOR SUSTAINABLE DEVELOPMENT

Mattia Borrione[1]

Abstract

Urbanization is accelerating at an unprecedented rate, defining complex and urgent challenges for cities worldwide. Climate change, unchecked urban expansion, and population growth are testing the resilience of urban communities. Urbanization continues to consume agricultural and natural lands, compromising environmental quality and increasing the risk of extreme weather events. The world's growing population is increasingly concentrated in cities, exerting unprecedented pressure on urban

infrastructure and resources. Land consumption is steadily increasing, contributing to the fragmentation of natural territories and exacerbating issues related to climate change.
In this critical context, the emerging concept of 'resilient cities' assumes a central role. Cities must adopt innovative and interdisciplinary approaches to address current and future challenges. The convergence of urban resilience and artificial intelligence (AI) offers new opportunities for the design and management of future cities. Integrating AI into urban planning practices promotes the creation of more flexible, sustainable, and adaptive urban communities. Advanced algorithms and predictive models enable optimized resource management, improve urban mobility, and foster civic engagement. However, the adoption of AI must be guided by ethical and responsible principles, ensuring transparency and respect for citizens' privacy. Architects play a key role in guiding this evolution toward conscious and sustainable urban design, addressing global challenges related to urbanization and climate change. Research and development of advanced urban solutions are fundamental to creating resilient and inclusive cities capable of tackling the challenges of the 21st century. Only through joint commitment and long-term vision can we build a sustainable urban future conducive to human life.

Keywords: Anthropization, Resili(G)ence, AI, Progress, Utopia

There are many issues that cities around the world are facing today, such as climate change, « *unsustainable patterns of production, land use, consumption, and population growth, all of which are challenging the planet's ecological and biological elasticity and resilience to support human activities* » (Costruttori di Futuro, n.d.).
Climate change represents one of the most urgent and widespread challenges that cities must face. Rising temperatures, extreme weather events, and sea-level rise threaten the safety and stability of urban communities worldwide. The land use related to rapid urbanization leads to the loss of agricultural and natural lands, habitat destruction, and uncontrolled expansion

of urban areas, resulting in the deterioration of air and water quality. The expansion of impermeable surfaces, such as roads and parking lots, coupled with the reduction of green areas, limits the land's ability to absorb water, increasing hydrogeological risk during intense rains, causing water accumulations and potential floods. Persistent population growth strains cities' resources and infrastructure, underscoring the need for innovative solutions to ensure sustainable quality of life for all residents.

Over the past 50 years, cities, serving as primary hubs for exchange and interaction, have undergone radical transformations in both definition and structure. Old disciplinary paradigms, based on tools like zoning and formal planning, have proven inadequate in addressing the speed of progress and environmental challenges. The current crisis, triggered by the exponential consumption of resources, has made cities and urban areas increasingly fragile and vulnerable ecosystems (Gausa, 2021a).

According to the latest data, the world population is estimated to reach around 8.5 billion by 2030 and 9.7 billion by 2050. It is projected to peak at approximately 10.4 billion people during the 2080s and then remain relatively constant until 2100 (United Nations, Department of Economic and Social Affairs, Population Division, 2022).
This rapid and substantial global demographic increase, which began in the 19th century, is accompanied by a phenomenon of population concentration in cities (Dematteis, n.d.). Currently, 54% of the world's population (4 billion people) lives in urban areas, a trend expected to continue to rise. By 2030, another 2 billion people will have moved to cities, which will have an unprecedented impact on existing infrastructure and resources, requiring significant adaptation to meet the needs of an increasingly urban population. By 2050, it is expected that 70% of the world's population will live in cities (The United Nations Human Settlements Programme [UN-Habitat], 2020), indicating a profound shift in settlement and lifestyle patterns. Ongoing

urbanization is one of the most transformative trends of the twenty-first century (Ambiente: nel 2030 il 70% della popolazione mondiale vivrà nelle città, n.d.).

According to OECD (Organisation for Economic Co-operation and Development) data, it emerges as one of the main causes of the increase in land consumption worldwide, contributing to urban growth and the fragmentation of natural territory (Monitoring Land cover change, 2018). « *In Italy alone in 2021, 69.1 km² were artificially covered. This averages about 19 hectares per day. This value is the highest of the last ten years* » (Consumo di suolo e urbanizzazione, 2022). Furthermore, it is estimated that about 2.15 million buildings were constructed before 1919, and up to 2016, over 9 million were built (CRESME, 2021).

Data and trends alone would be impactful enough to redefine a balance, but unfortunately, they have contributed and continue to contribute negatively to the issue of climate change, with all its effects and consequences. Currently, there are no global solutions to improve the vulnerability of our cities; therefore, specific interventions of 'territorial restructuring' are needed to counter the external pressures they will have to face in the coming years. In an increasingly interconnected world, these interventions should not be seen as mere infrastructural adjustments, but rather as complex and multifunctional processes involving urban planning, resource management, community participation, and the creation of networks of solidarity and support.

It is precisely in this context, where the world is increasingly moving away from balance, that the concept of sustainability is evolving: the crisis demands reflection, judgment, and evaluation that can serve as a premise for improvement, « *it demands that society verify its capacity to 'respond to shocks' as soon as possible or, to put it more contemporaneously, to measure its 'resilience'* » (Scala, 2013).

A new paradigm of development, therefore, in which 'the resilient city' constitutes an urban system capable of restoring its balance in response to changing surrounding conditions.
A system able to adapt to the 'pressures' resulting from anthropization processes, urbanization, and climate change, providing social, economic, and environmental responses to the crisis that currently characterizes our era. The concept of Resili(G)ence is more central than ever, proposing with this neologism to combine the term Resilience with the term Intelligence in a more complex effort to synergize with the environment and define strategies for approaching our cities and the environments in which we live (Gausa, 2021b).

In line with this perspective, thanks to recent technological advancements in digital technologies and simulations, further potential scenarios related to the application of AI (Artificial Intelligence) in the field of architecture and planning are emerging. The implicit challenge is to enhance the ability to explore the hypothetical new dimension of intelligence associated with our information over time, in order to meet the needs of more efficient and resilient scenarios.
Therefore, one could speak of '*A-ResiliGence*' as a possible advanced path to address the challenge of creating more flexible, sustainable, and adaptive urban communities: essentially a resilient artificial intelligence.
The hypothesis of A-ResiliGence is not only a matter of technological adaptability but also of learning and anticipation capabilities. Cities equipped with intelligent and resilient systems can predict and proactively respond to crises and perturbations, ensuring the safety, sustainability, and quality of life of their inhabitants. Through advanced algorithms and predictive models, AI can contribute to optimizing resource management, reducing energy consumption, improving urban mobility, and promoting civic engagement. The convergence of artificial intelligence and urban resilience opens up new perspectives for the design and management of the cities of the future. Through technological innovation and interdisciplinary collaboration, we

can create dynamic, inclusive, and sustainable urban environments that respond to the challenges of our ever-evolving era (Fig. 1, 2).

Fig 1: 'Utopian resilient city generated by artificial intelligence' – Image generated using the MidJourney software, February 2024.

The combination of the concept of urban resilience with the potential of artificial intelligence has significant theoretical and practical implications for the fields of architecture and urban planning. From a theoretical perspective, the new architectural utopia demands a revision of the concepts and traditional paradigms that guide city planning. It requires overcoming the mechanistic, deterministic, and static view of the city as a finite, defined, and

Fig 2: 'Utopian resilient city generated by artificial intelligence' – Image generated using the MidJourney software, February 2024.

controllable object, in favor of an organic, probabilistic, and dynamic view of the city as an open, emergent, and adaptive process. Additionally, it requires shifting from an anthropocentric, hegemonic, and conflictual view of the relationship between humans and the city to embrace an eco-centric, collaborative, and harmonious view of the relationship between humans, the city, and the environment.
At a practical level, it requires a transformation of the methods and tools that support city planning. Specifically, it involves integrating traditional methods and tools based on rational, analytical, and normative principles with innovative methods and tools based on computational, synthetic, and generative principles.
This entails adopting more dynamic and flexible approaches that consider the complexity and interconnection of urban systems, utilizing advanced computational models to simulate scenarios and anticipate the effects of design decisions. The use of generative algorithms, for instance, enables architects to explore a wide range of design solutions in relatively short periods, allowing for a more thorough evaluation of available options and facilitating the creation of urban environments better suited to citizens' needs and more environmentally respectful. This integrative and innovative approach promotes more responsible, aware, and future-oriented design, capable of anticipating challenges and adapting to ongoing changes, from environmental sustainability to social inclusion.

Architectural utopia has always been a form of design imagination that introduces alternative models of spatial and social organization based on ideal principles or aspirations. This concept has a deep-rooted tradition in the history of architecture and urban planning, often influenced by contemporary scientific and technological innovations (Orsini, 2017).
This kind of design imagination not only challenges the limits of existing spatial and social conventions but also aims to stimulate critical reflection and debate on the direction of progress. Utopian ideas serve as catalysts for innovation and creativity in the field of architecture, inspiring projects that transcend mere

functionality and aesthetics to embrace concepts of sustainability, social inclusion, and collective well-being. Through these visions, architects and urban planners explore new modes of organizing urban space and community life, designing environments that respond to emerging needs and global challenges. It is a dynamic and continuously evolving process, where imagination and speculation blend with the pragmatic search for concrete solutions.

In this context, the architect must not only be able to respond to the immediate needs of society but also play a key role in shaping the future of cities in a sustainable, resilient, and intelligent manner. It is a responsibility that demands a long-term perspective and an inexhaustible willingness to challenge established conventions in order to embrace new ideas and cutting-edge technologies. Artificial intelligence (AI) is revolutionizing how we design, build, and manage cities. From simulating and optimizing traffic flows to forecasting and managing natural risks, AI offers powerful tools to enhance the efficiency, safety, and quality of urban life. However, it is essential that the use of AI be guided by ethical and responsible principles, ensuring transparency, data protection, and respect for individuals' privacy.

The combination of urban resilience and artificial intelligence opens new horizons of possibility for the discipline of architecture, and architects have the responsibility to lead this evolution towards more advanced and conscious urban design. Research and development of advanced urban solutions are crucial in addressing global challenges related to urbanization and climate change. Only through joint commitment and long-term vision can we create resilient, inclusive, and livable cities in the 21st century.

Biography

Mattia Borrione (Genoa, 1987) graduated with honors in Architecture from the Polytechnic School of the University of Genoa. After gaining various experiences abroad, in 2016 he began collaborating with Studio ARCHEA ASSOCIATI / MC&P, focusing

particularly on the project and Artistic Direction of the National Stadium of Albania, overseeing the entire construction site in Tirana. In 2019, he successfully completed a Master's degree in BIM Management at the Polytechnic University of Milan with a score of 110/110, with a thesis titled 'Project Management of a Stadium in BIM'. In 2021, he also obtained certification as a BIM Coordinator from the ICMQ institute. His interests and research activities focus on architectural composition across different project scales and in relation to new technologies in digitalization. Currently, he is conducting research as a PhD student in the XXXVIII cycle of the PhD program in Architecture and Design (ADD) at the Polytechnic School of the University of Genoa.

references

+ Gausa, M. (2021a). I-Framework: Resili(G)ent cities and advance urbanism. In Gausa, M. (Ed.), RESILI(G)ENCE Intelligent Cities/Resilient Landscape, pp. 19-20. Actar.
+ Gausa, M. (2021b). Through Resili(g)ence: Nuove sfide sociali e ambientali, Genova: GUP-Genova University Press, p. 13
+ Orsini, F. (2017). Utopie urbane: forma della città. Maggioli Editore.
+ Ricci, M. (2013). Nuovi Paradigmi. LISt, Trento.
+ Laruccia, A. (2019). La Resilienza Urbana dalla Teoria alla Pratica (Master's thesis, Politecnico di Torino).
+ Davoudi, S. (2012). Resilience: A Bridging Concept or a Dead End? Planning Theory and Practice.
+ Infante, C. (2014). (Ri)generazioni urbane. La nuova ecologia.
+ Scala, P. (2013, October 24-26). Rigenerazione, resilienza e progettazione urbana. Paper presented at the XXVIII INU National Congress. Academia.edu. Retrieved from www.academia.edu.
+ Spirn, A.W. (2012). Ecological Urbanism: a Framework for the Design of Resilient Cities.
+ United Nations, Department of Economic and Social Affairs, Population Division. (2022). World Population Prospects 2022: Summary of Results. Retrieved from www.un.org/development/desa/pd.
+ Dematteis, G. Sviluppo urbano e aumento della popolazione. Retrieved from www.treccani.it/enciclopedia.
+ The United Nations Human Settlements Programme (UN-Habitat). (2020-2023). STRATEGIC PLAN 2020-2023. Retrieved from https://www.unhabitat.org/the-strategic-plan-2020-2023.
+ Monitoring Land cover change. (2018). OECD. Retrieved from www.oecd.org/env/indicators-modelling-outlooks/brochure-land-cover-change.pdf.
+ Capobianco, F. (2014). Architetture della resilienza. Retrieved from http://presstletter.com/2014/10/architetture-resilienza-francesca-capobianco/
+ Costruttori di Futuro. (n.d.). Resilienza. Retrieved from www.costruttoridifuturo.com.
+ Ambiente: nel 2030 il 70% della popolazione mondiale vivrà nelle città. (n.d.). AWN. Retrieved from www.awn.it/news.
+ Rigenerazione urbana, resilienza e innovazione sociale per riequilibrare il rapporto perduto tra città e campagna. La smart city in una green society. Retrieved from www.urbanexperience.it/rigenerazione-urbana-resilienza-e-innovazione-sociale-per-riequilibrare-il-rapporto-perduto-tra-citta-e-campagna-la-smart-city-in-una-green-society/.
+ "Architettura e resilienza." (2013). Retrieved from http://casabellaweb.eu/2013/12/26/architettura-e-resilienza-5/.
+ Consumo di suolo e urbanizzazione. (2022). *Openpolis*. Retrieved from www.openpolis.it.
+ The Report 'Consumo di suolo, dinamiche territoriali e servizi ecosistemici' | ISPRA (Istituto superiore per la Protezione e la Ricerca Ambientale). (2022). Retrieved from www.isprambiente.gov.it.
+ CRESME (Centro di Ricerche di Mercato) data in Piano nazionale del Lavoro. (2021, December 2). Circular No. 111. CNAPPC. Retrieved from www.awn.it/.

note

[1] Mattia Borrione – ORCID ID: 0009-0000-5206-7475, mattia.borrione@edu.unige.it, Scuola Politecnica – Università degli Studi di Genova

SUSTAINABILITY IN ARCHITECTURAL DESIGN STUDIOS

A comparison of Case Studies

Tina Selami[1]

Abstract

Designing Resilience requires knowledge and skills from different disciplines and domains which should be transferred to the next generation of architects during their study. Design studios have an important role in architectural education, since the project-based learning environment of design studios allows to establish new links between already available knowledge and new findings by conducting research on the design task.

The integration of sustainable design principles in design studios can support the learning process of designing with considerations of complex correlations between built and natural environment. However, recent studies show that there is a

lack of teaching methodologies for the integration of holistic sustainable design approaches.
This paper includes a qualitative comparison of selected case studies from 2012 to 2022 in different geographic areas to show the variety of existing teaching methods and sustainable design approaches. As a selection criterion, the case studies' main topic is architectural education, and they include a design studio which is related to sustainability. The comparison will be based on specific criteria which describe the organization of the course, topics which are covered by the course and relate to sustainable design as well as applied teaching methods. In addition, this paper investigates the challenges and potentials of design studios to integrate education for sustainable development (ESD) in the architectural curriculum.

Keywords: Architectural Education, Education for Sustainable Development, Sustainable Design, Design Studio, Studio Pedagogy

1. Introduction

The impacts of climate change affect cities in particular due to anthropic activities (Perini, 2017). The resulting challenges related to climatic and ecological aspects in urban areas require reconsideration of current design criteria and methods to ensure and improve livability in cities in the long term (Elmqvist *et al.*, 2015). To achieve the UN sustainable development goal 'Sustainable Cities and Communities' (SDG11), sustainable development in architecture and urban development has to be implemented and integrated within all dimensions of sustainability; namely society, environment, and economy (Passe, 2020). The next generation of designers has to be prepared adequately to fulfill design criteria from all sustainability dimensions. However, university curricula seem to lack the effective and explicit integration of sustainable design in architectural education (Altomonte, 2009). Therefore, in recent years, some teaching programs already have started to integrate new subject areas including sustainable and climate resilient design (Lin *et al.*,

2022). Due to the complexity and interdisciplinarity nature of the subject areas, a re-organization of architectural curricula is often needed. Moreover, there is demand for new pedagogical methods to transfer the required knowledge in a more efficient way in order to achieve the desired educational results (Boarin & Martinez-Molina, 2022).

Design studios are considered to be one of the core elements in architectural education (Mohamed & Elias-Ozkan, 2019). It is a space and a learning environment where students work on a design project in groups or individually while being supervised by design educators (Schoen, 1983). The collaborative studio environment seems to be suitable for facilitating knowledge exchange and application from theoretical lecture-based courses to empirical approaches while developing a project. The opportunity provided by this setting enables students to use their creative potential as well as train reflective thinking through feedback sessions (Boarin & Martinez-Molina, 2022).

The aim of this paper is to investigate the potential of design studios to integrate Education for Sustainable Development (ESD) in the architectural curriculum as well as highlight the challenges which arise from the perspective of teachers and students. This paper includes results of a desk research on cases from 2012-2022 in different geographic areas to show the variety of existing teaching methods and sustainable design approaches. The preliminary results of the systematic qualitative comparison, as presented in this paper, address a set of five cases from 2016-2022, which can help to gain a better overview and first understanding of the requirements for the integration of sustainability in design studios.

2. Material and Methods

In this section, the selection process and analysis method of case studies is described in detail. The results of the desk research which were published from 2012-2022 are located in different geographic locations, as shown in the map displayed in Figure 1. The list of case studies can be found in the annex.

Fig 1: Map with marked locations of selected case studies – Map produced with 'National Geographic Map Maker'. https://www.nationalgeographic.org/society/education-resources/map-maker-launch-guide/.

Table 1: Keywords for initial literature search in Scopus.

Table 2: Keywords for refined literature search in EndNote.

In the following, the process of selection of the case studies is described in detail. Firstly, an initial search of the Scopus database was made to get a collection of relevant topic articles. The search was made with the following keywords as shown in table 1.

TITLE-ABS-KEY
sustainable AND design AND architectural AND studio
teaching AND sustainability AND architectural AND education
teaching AND sustainable AND urban AND design AND architectural AND education

In order to identify and analyze existing approaches of implementing sustainable design principles in architectural design studios, a refined search from the initial collection was made to select suitable case studies. The selection criteria of the case studies are described in table 2.

Level 1: Title						
architecture	OR	architec-tural	AND	education	OR	pedagogy
Level 2: Any Field						
sustainable	AND	method	AND	studio		

The analysis was supported by the use of MAXQDA which is a digital tool for qualitative and mixed-methods analysis (Kuckartz & Rädiker, 2019). Table 3 shows the system which was used to analyze the papers by categorizing sections as 'codes'. The categories were defined by the author through an initial screening of the literature and identification of relevant information for the analysis. The goal was to develop a method which enables the comparison of case studies which can vary in their structure, content and results.

In order to compare the case studies at different levels, the categories are clustered in four main groups. Text segments which are categorized in group 'A' contain information regarding the research scope of the case study article. A comparison between the problem statements and research questions may indicate trends or differences in the main research ground and approaches of the research facilities in different geographic locations. Group 'B' includes information regarding the course organization. The comparison of categories within these groups is in particular important when it comes to details in the course structure. It is expected to find some similarities in the course schedule, since the fundamental idea of a design studio is very established across different architectural schools and universities. However, information about study level, number of participants and collaboration mode might give insights into the respective structure of study programs. A more detailed view on pedagogical issues is provided through the categories in group 'C'. The categorized sections in this group provide information about characteristics of architectural education and curricula as well as the applied pedagogical concepts, teaching methods and learning outcomes of the respective design studios. A comparison can provide an overview of different approaches and their advantages and disadvantages. Furthermore, possible hybrid solutions as a combination of different teaching methods can be identified. Last but not least, the categories in group 'D' address topics around sustainability and education with a focus on Education for Sustainable Development (ESD) particularly in architectural education.

Table 3: List of defined codes (selection criteria) with descriptions applied in the qualitative literature analysis with MAXQDA.

Group	Categories of Codes	Description
A1	article type	specification of the case study by the article
A1.1	problem statements	definition of general problem statements by the article
A1.2	teaching challenges	specification of teaching challenges regarding design studios with focus on sustainability
A1.3	research questions	specification of research questions which are addressed by the article
B1	studio organization	information related to organizational issues such as semester schedule, stages, duration, etc.
B1.1	university	name of organization facility of the design studio
B1.2	involved institutions	other institutions involved/collaborating in the organization of the design studio (internal and external)
B1.3	study level	associated study level (bachelor/master) of the design studio
B1.4	course type	specification of the course as a design studio
B1.5	time span	time span of implementation of the design studio presented by the article
B1.6	studio name	name/description of the design studio
B1.7	amount of participants	total number of students participating the design studio in one run (semester or year)
B1.8	collaboration mode	type of collaboration between the students in the design studio
C1	architectural education and curricula	information related to general architectural education and characteristics of curricula
C2	pedagogical concept	overarching pedagocial concepts applied in the design studio
C2.1	teaching method	specific teaching methods applied in the design studio
C2.2	learning outcome	specification of learning outcome of the design studio
D1	Sustainable Development Goals (SDGs)	general references to SDGs by the article
D2	Education for sustainable development (ESD)	general references to education for sustainable development (ESD) by the article
D2.1	ESD in architectural education	information about education for sustainable development (ESD) particularly in architectural education
D2.2	studio topics	specification of topics addressed in the design studio in relation to ESD

3. Results

In this paper, preliminary results of the case study analysis with a set of five cases between 2016 and 2022 are presented and structured according to the categorized sections as mentioned before.

3.1 Group A: Problem Statements

When organizing and realizing a design studio which addresses sustainable design with the aim to prepare future architects for complex and demanding tasks, the teaching teams often encounter challenges of a higher hierarchical level (Mishra, 2019). Some of the main challenges of implementing sustainable design in architectural education reported by the case studies are the lack of a common ground on suitable teaching methods and curriculum design to deal with the complexity of knowledge related to sustainable design (Dib & Adamo-Villani, 2014; Mohamed & Elias-Ozkan, 2019). It is also mentioned that the skill to work in an inter- or transdisciplinary environment is not yet sufficiently taught, since there are not enough training opportunities for architectural students to learn how to collaborate with students from other disciplines (Mohamed & Elias-Ozkan, 2019; Yu, 2014). Another challenge that occurs in architectural design education is to fill the gap between acquired and applied knowledge. With regard to real-world design tasks, for which future professionals have to be prepared, the focus of many architectural design studios on new building design leads to lack of training opportunities on designing within existing building structures in particular in undergraduate architectural education (Lin *et al.*, 2022). Limited time and funding resources as well as the large personnel effort which is required to coordinate a design studio are identified as main teaching challenges (Mishra, 2019).

3.2 Group B: Studio Organization

Team collaboration is highlighted as a suitable mode of practice for design studios with complex tasks but needs to be carefully moderated and monitored by the teaching team to avoid unfavorable group dynamics (Passe, 2020). It is also common to change the structure of teams within the course of the semester

to encourage different types of interaction. This happens when students work in larger groups in the research and analysis phase and then build smaller teams in the design phase (Hengrasmee & Chansomsak, 2016). The course schedule is mentioned to have an impact on whether the focus of the design studio lies on the final design or the design process itself. A modular structure in the schedule is considered to favor the latter (Mohamed & Elias-Ozkan, 2019). When integrating research topics in the design studio, the usual studio sessions are often supplemented with lectures and workshops. This ensures that theoretical knowledge which is required for informed design decisions is also provided to the students alongside practical design work. If sufficient time resources are available, design studios can be divided into a first semester of research which supports the second semester with a more detailed design phase. However, such organization is often not possible, since the average duration of a design studio is only one semester (Lin *et al.*, 2022).

3.3 Group C: Studio Pedagogy

The design studio is regarded as a very important component of the curriculum of architectural studies, as the setting provides the opportunity for students to apply and test theoretical knowledge in a practical environment (Mohamed & Elias-Ozkan, 2019). On a methodological level of design studio pedagogy, Bloom's taxonomy for teaching and learning is considered to be a suitable model to be applied in design education (Kaiser & Ogoli, 2016). In Bloom's taxonomy the process of learning is described as the transition from simple to more complex ways of thinking (Xiang *et al.*, 2021). The hierarchical framework which is provided by the taxonomy can support design educators in the articulation of clear and consistent learning objectives (Doyle & Senske, 2016).

As Hengrasmee & Chansomsak describe it very accurately, one of the overarching learning outcomes is «to educate architectural students into professionals who are able to understand, having the skills and awareness necessary for the implementation of

environmentally friendly architectural design » (Hengrasmee & Chansomsak, 2016, p. 162)
On a practical level, applied teaching methods in this context are: Student-centered learning (SCL), Problem-based learning (PBL), Learning by Doing, Learning by Demonstration, Learning by Teaching Others, Learning through Audio-Visuals, Deep Learning, Practice by Doing, and Group Discussions (Hengrasmee & Chansomsak, 2016; Mohamed & Elias-Ozkan, 2019; Xiang *et al.*, 2021).

3.4 Group D: Education for Sustainable Development (ESD)

One of the stated overarching aims of higher education is awareness building for students to be responsible global citizens (Hengrasmee & Chansomsak, 2016). Buildings have a large impact on climate and resource depletion and therefore there is a demand for re-thinking design strategies to meet the UN Sustainable Development Goals. Societal, environmental and economic issues are integrated in Education for Sustainable Development (ESD) in architectural education, as buildings are situated at the interface between all three dimensions of sustainability (Passe, 2020). The implementation of Sustainable Education (SE) is considered as a three-stage model, which is required to achieve a paradigm shift in academic and professional training platforms. The first stage 'Accommodation' deals with possible changes within existing boundaries without changing the paradigm leaving sustainability as a separate subject in the curriculum. In the second stage 'Reformation' assumptions behind basic values and influences are examined and critically reflected which can result in change of values and change management to adopt the concept of sustainability in the curriculum. 'Transformation' is described as the last stage, in which deep awareness is reached through continuous creations and revisions. In this stage, a fundamental cultural shift in education and public awareness is achieved (Hengrasmee & Chansomsak, 2016; Mohamed & Elias-Ozkan, 2019).
Among others, addressed themes in the design studios in this context are: urban climate, energy consumption, renewable energy distribution and storage, human comfort and occupation, re-

search-integrated design, parametric design, climate-responsive design, nature-based solutions, mixed functional program, socio-economic and demographic context, sustainable heritage preservation, vernacular architecture, spatial sequences from public to private, building envelope properties and mechanical systems, lifecycle costs, potentials and limitations of building materials and structures (Hengrasmee & Chansomsak, 2016; Kaiser & Ogoli, 2016; Lin *et al.*, 2022; Mishra, 2019; Passe, 2020). Some design studios applied an iterative workflow which consists of hypothesizing, predicting, testing and evaluating in a cyclical way (Kaiser & Ogoli, 2016). Alongside to the creative design process, a broad variety of methods were used for analyzing lifecycle and climate impacts, daylight distribution, energy consumption, and natural ventilation, while using digital modelling tools in addition with tools for virtual and augmented reality to support design decisions on building massing and orientation, selection of materials and evaluation of the outcomes (Hengrasmee & Chansomsak, 2016; Kaiser & Ogoli, 2016; Lin *et al.*, 2022; Mishra, 2019; Passe, 2020).

4. Conclusion and Discussion

Design studios, which last a semester or a full year, often have a focus on a specific area of application. Examples are urban planning and open space design, designing for a specific usage, historical and vernacular architecture, design of exhibition spaces and cultural facilities such as theaters, opera buildings, etc. While some design studios focus on a specific structural material such as timber, others encourage the application of a specific (digital) design method such as BIM (Building Information Modelling), simulation and algorithmic design tools. The design studios which focus on various aspects of sustainable design, for instance energy efficiency, sustainable materials, circular economy, climate-responsive design, and biodiversity sensitive design often cover many of the beforementioned points as well.

The combination of conducting research to understand the framework conditions, application of specific design methods, utilization of digital tools for design, optimization and performance

evaluation as well as acquisition of inter disciplinary knowledge to understand the basics of urban climate and ecology demands a high amount of time. To accommodate the teaching contents and knowledge exchange from different disciplines, high effort in schedule organization and funding resources are necessary. In addition, students have to be committed to the studio and motivated to learn outside of their discipline in order to reach learning outcomes. This is challenging due to overcrowded semester schedules and few training opportunities in interdisciplinary collaboration.
The gap in knowledge, skills, and competencies which we are experiencing in the field of sustainable design in architectural education though exists not only for students, but also for teachers. There is need to broadly introduce more train-the-trainer programs to support teachers to overcome the barriers and challenges caused by insufficient training in sustainability, didactics, and lack of knowledge exchange between teachers and practitioners from different disciplines. However, it is difficult for teachers to invest time and energy to expand their own knowledge or teaching practice with no additional funding of resources. (Sarah O'Dwyer, 2023). Altogether, this leads to a major effort for the teaching team and students, which cannot be compared to the majority of design studios. Therefore, on the one hand universities have to increase the time and funding resources for design studios which contribute to ESD. On the other hand, regular interdisciplinary knowledge exchange between students, teachers and practitioners has to be encouraged more systematically and not restricted due to bureaucracy, as is often the case. These measures together are necessary for a future-oriented quality assurance in architectural education.

Biography

Tina Selami was born in Vienna in 1995 and is currently a PhD student at TU Wien. Her main research focus is Education for Sustainable Development in architectural studies. After completing her Master of Science degree in Architecture at TU Wien with honors, she worked at the Institute of Architectural Sciences

in the EU project 'ECOLOPES'. Currently, she is leading the innovation lab 'Transformer', which is a Co-Creation-Space for Climate and Energy funded by the Austrian Research Promotion Agency (FFG) and is employed at the research division of Process Systems Engineering for Bioresources and Sustainability at TU Wien.

references

+ Altomonte, S. (2009). Environmental education for sustainable architecture [Article]. *Review of European Studies*, 1(2), pp. 12-21. https://doi.org/10.5539/res.v1n2p12.

+ Boarin, P., & Martinez-Molina, A. (2022). Integration of environmental sustainability considerations within architectural programmes in higher education: A review of teaching and implementation approaches [Review]. *Journal of Cleaner Production*, 342, Article 130989. https://doi.org/10.1016/j.jclepro.2022.130989.

+ Calikusu, A.N., Cakmakli, A.B., & Gursel Dino, I. (2022). The impact of architectural design studio education on perceptions of sustainability [Article]. *International Jouranl of Architectural Research: Archnet-IJAR*. https://doi.org/10.1108/ARCH-09-2021-0251.

+ Dabaieh, M., Lashin, M., & Elbably, A. (2017). Going green in architectural education: An urban living lab experiment for a graduation green design studio in Saint Catherine, Egypt [Article]. *Solar Energy*, 144, pp. 356-366. https://doi.org/10.1016/j.solener.2017.01.010.

+ Dib, H., & Adamo-Villani, N. (2014). Serious sustainability challenge game to promote teaching and learning of building sustainability [Conference Paper]. *Journal of Computing in Civil Engineering*, 28(5), Article A4014007. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000357.

+ Doyle, S. E., & Senske, N. (2016). Between Design and Digital: Bridging the Gaps in Architectural Education.

+ Elmqvist, T., Setälä, H., Handel, S. N., van der Ploeg, S., Aronson, J., Blignaut, J.N., Gómez-Baggethun, E., Nowak, D.J., Kronenberg, J., & de Groot, R. (2015). Benefits of restoring ecosystem services in urban areas. *Current Opinion in Environmental Sustainability*, 14, pp. 101-108. https://doi.org/https://doi.org/10.1016/j.cosust.2015.05.001.

+ Hengrasmee, S., & Chansomsak, S. (2016). A novel approach to architectural education for sustainability: A quest for reformation and transformation [Article]. *Global Journal of Engineering Education*, 18(3), pp. 160-166. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84994635754&partnerID=40&md5=64352ee45c35192231936be993344a4f.

+ Hlaváček, D., & Čeněk, M. (2019). Hands-On: Sustainable Approach in *Architectural Education*.

+ Kaiser, K.P., & Ogoli, D.M. (2016). Expression and Evidence, *Advances in Architecture Studio Pedagogy*.

+ Kuckartz, U., & Rädiker, S. (2019). *Analyzing Qualitative Data with MAXQDA: Text, Audio, and Video*. https://doi.org/10.1007/978-3-030-15671-8

+ Lin, H., Yin, S., Xie, C., & Lin, Y. (2022). Research-Integrated Pedagogy with Climate-Responsive Strategies: Vernacular Building Renovation Design [Article]. *Buildings*, 12(9), Article 1294. https://doi.org/10.3390/buildings12091294.
+ Lüley, M., Pifko, H., & Špaček, R. (2019). Adaptability and a scenario-based design methodology for architectural education [Article]. *Global Journal of Engineering Education*, 21(2), pp. 97-102. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85070005183&partnerID=40&md5=f99497dc49071284a6b543d0958edd25.
+ Mishra, A. (2019). Material Craft: An Approach to Teaching Building Materials in *Architectural Education*.
+ Mohamed, K.E., & Elias-Ozkan, S.T. (2019). Incorporating sustainability principles into architectural design education: Results of an experimental design studio [Article]. *Journal of Green Building*, 14(3), pp. 143-158. https://doi.org/10.3992/1943-4618.14.3.143.
+ Passe, U. (2020). A design workflow for integrating performance into architectural education [Article]. *Buildings and Cities*, 1(1), pp. 565-578. https://doi.org/10.5334/bc.48.
+ Sarah O'Dwyer, E.G., Essi Nisonen, Raul Castano De la Rosa, Sofie Pelsmakers, Ioannis Lykouras, Elizabeth Donovan, Marco Alvise Bragadin, Caterina Morganti, Ugo Maria Coraglia. (2023). *Architectural Education: Methods for Integrating Climate Change Design (CCD) in the Curriculum* A Focus on Pedagogy: Teaching, Learning and Research in the Modern Academy, Muncie, United States. https://orca.cardiff.ac.uk/id/eprint/157096/1/ARCHITECTURAL%20EDUCATION_METHODS%20FOR%20INTEGRATING%20CLIMATE%20CHANGE%20DESIGN%20%28CCD%29%20IN%20THE%20CURRICULUM.pdf.
+ Schoen, D. (1983). *The Reflective Practitioner: How Professionals Think In Action* (Vol. 34). https://doi.org/10.1080/07377366.1986.10401080.
+ Utaberta, N., Hassanpour, B., Abdullah, N.A.G., Tahir, M., & Che Ani, A. (2011). Developing sustainable architecture education approaches in Malaysia: A case study of critiques session in 2 nd Year design studio of Architecture Department, National University of Malaysia (UKM). In (Vol. 71-78, pp. 5003-5006).
+ Xiang, X., Wu, Q., Zhang, Y., Zhu, B., Wang, X., Wan, A., Huang, T., & Hu, L. (2021). A pedagogical approach to incorporating the concept of sustainability into Design-To-Physical-Construction teaching in introductory architectural design courses: A case study on a Bamboo construction project [Article]. *Sustainability (Switzerland)*, 13(14), Article 7692. https://doi.org/10.3390/su13147692.
+ Yu, F. (2014). Impact of Digital Technology on Architectural Design Teaching. *Advanced Materials Research*, 989-994, 5390-5393. https://doi.org/10.4028/www.scientific.net/AMR.989-994.5390.

annex

Case Study Title	Source	Department, University
Developing Sustainable Architecture Education Approaches in Malaysia: A Case Study of Critiques Session in 2nd Year Design Studio	(Utaberta *et al.*, 2011)	Department of Architecture, UKM – National University of Malaysia,
A novel approach to architectural education for sustainability: a quest for reformation and transformation – The green architecture design studio	(Hengrasmee & Chansomsak, 2016)	Naresuan University, Phitsanulok, Thailand
Expression and evidence, advances in architecture studio pedagogy	(Kaiser & Ogoli, 2016)	School of Art, Design and Architecture, Judson University, Elgin, Illinois, USA
Going green in architectural education: An urban living lab experiment for a graduation green design studio in Saint Catherine, Egypt	(Dabaieh, Lashin, & Elbably, 2017)	MIU – Misr International University, Cairo, Egypt
Hands–On: Sustainable Approach in Architectural Education	(Hlaváček & Čeněk, 2019)	Faculty of Architecture, CTU – Czech Technical University, Prague, Czech Republic
Adaptability and a scenario–based design methodology for architectural education	(Lüley, Pifko, & Špaček, 2019)	Slovak University of Technology, Bratislava, Slovakia
Material Craft: An Approach to Teaching Building Materials in Architectural Education	(Mishra, 2019)	Department of Architecture and Design, College of Engineering, Abu Dhabi – University, Abu Dhabi, United Arab Emirates
Incorporating sustainability principles into architectural design education: Results of an experimental design studio	(Mohamed & Elias-Ozkan, 2019)	Architecture Department at the Izmir Institute of Technology (IYTE), Turkey
A design workflow for integrating performance into architectural education	(Passe, 2020)	Department of Architecture, College of Design, Iowa State University, Ames, Iowa, USA
The impact of architectural design studio education on perceptions of sustainability	(Calikusu, Cakmakli, & Gursel Dino, 2022)	Department of Architecture, Middle East Technical University, Ankara, Turkey
Research-Integrated Pedagogy with Climate-Responsive Strategies: Vernacular Building Renovation Design	(Lin *et al.*, 2022)	School of Architecture and Urban Planning, Guangdong University of Technology, Guangzhou, China

note

[1] Tina Selami – ORCID ID: 0000-0002-6951-5462, tina.selami@tuwien.ac.at, Department of Digital Architecture and Planning – Technische Universität Wien

REGENERATIVE TERRITORIES

Fostering a holistic process between performance and narratives

Anna Codemo[1], Sara Favargiotti[2]

Abstract

As cities increasingly face social, economic and environmental challenges posed by rising temperatures, extreme weather events and environmental degradation, the adoption of resilient agendas is pivotal to accelerate climate and energy transition. This involves developing strategies and implementing measures that can enhance their capacities to focus on multiple pathways and plurality of goals. Indeed, designing transitions requires a renewed awareness of ecological and cultural responsibility and a shift towards regenerative solutions balancing the human needs. Considering this framework, the Ecological Landscape Design (ElaDe) laboratory at the University of Trento addresses these issues through an applied research approach in several areas of the Trentino and Veneto regions in the north of Italy.

The research aims to contribute to providing positive impacts of urban transformations with a renewed approach of 'innovate with nature' and addresses the challenges through a holistic perspective, combining adaptation and mitigation efforts by experimenting with Nature-based Solutions (NbS). Specifically, the activities include support to decision-makers and designers to include NbS in the current practices by updating urban planning tools, innovating design processes. This is achieved by assessing and evaluating the distribution, the effects and socio-ecological impacts of green and blue elements in the built environment. In this view, the dimensions addressed by the research include the introduction of a landscape-based approach, the promotion of climate sensitive urban regeneration and the co-creation of new knowledge with decision-makers. The paper reports the operational outcome of the research activities focusing on the ecological performances of the proposed solutions and on the creation of new narratives to empower decision-makers.

Keywords Regenerative design, climate sensitive regeneration, nature-based solutions, climate resilience, landscape-based approach

1. Introduction

The current social, economic and environmental challenges are driving cities towards unsure and unstable scenarios, and they constitute an acceleration of transformations. This condition is questioning tools and strategies currently adopted to transform territories, which require transformative and adaptive solutions. In this view, policy efforts have been made to address climate impacts aiming to integrate climate adaptation and mitigation strategies. Despite this, current practices lack a systemic approach capable of integrating several functions and simultaneously addressing multiple challenges. Indeed, many cities give priority to either adaptation or mitigation. Moreover, often, climate efforts are not linked to biodiversity or water management plans. In this view, the regenerative approach aims to

simultaneously improve the relationship between humans and the built environment, by creating a holistic framework for building energy performances, environmental impacts, resilience to climate change and human needs (Raven *et al.*, 2018). To face such challenges, the built environment should not merely reduce the impacts of new developments, rather contribute to repairing human and natural ecosystems, by shifting from a less bad impact to a positive one through regenerative design (Cole, 2012). Indeed, adaptation and mitigation efforts are not sufficient to address the contemporary challenges if they do not remediate ecological damages (Reed, 2007). In other words, human and natural systems co-existence can be a catalyst for positive change rather than a limitation of environmental impacts (Zari, 2018). Active involvement of citizens and stakeholders should be integral to a system that evolves in a positive and health-conscious manner. Indeed, regenerative design takes into account the intricate interplay between humans, the built environment and the natural world embracing a multidisciplinary system of thinking and understanding local dynamics. By sharing critical theoretical positions and research experiences, the contribution will expand the reflection of landscape as design-agent to drive spatial transformations in urban and architectural regenerations processes. A cross-disciplinary approach among architecture, urban design, landscape architecture, engineering is set to blend the knowledge of construction engineering with knowledge of architectural and urban planning tools, with a balanced learning with practice and theory. This is how landscape design can become the common ground for the interdependence of people and species (plants and animals) and, accordingly, can drive local policies and spatial transformation for land care and heritage regeneration. This might lead to a multiplication effect that can increase the positive impact at local scale towards more regenerative landscapes.

2. Framework

Despite recognizing the pivotal role of cities in the climate and energy transition, a gap exists between research on these is-

sues and the actual implementation of resources. This gap primarily results from the inadequacy of planning tools to meet these needs and the challenges associated with intervening in the already established built environment (Magni *et al.*, 2021; Olazabal & Ruiz De Gopegui, 2021). Notably, climate adaptation practices are not seamlessly integrated into planning and design practices, creating an application gap that hinders the translation of scientific knowledge into practical solutions (Natanian & Auer, 2020). This research addresses the question of what type of knowledge is valuable and capable of enhancing climate-oriented planning and design practices (Klemm *et al.*, 2017). To answer this question, the paper presents the theoretical and methodological positions conducted by the Ecological Landscape Design Lab (ELaDe) at the University of Trento through some undergoing investigations. The action-research projects and educational activities involve both planning and design practices, providing knowledge that is comprehensible for designers, applicable in regeneration processes, and feasible in practice. In this perspective, the research aims to bridge the gap between science and spatial transformation practices through a multi-scalar and multi-disciplinary approach.

The research activities include scientific support to decision-makers and practitioners for the integration of mitigative and adaptive devices in urban transformation processes. Specifically, the aim is to innovate design practices and planning tools to facilitate the implementation of the so-called Nature-based Solutions (NbS). Indeed, NbS provide multiple benefits in several aspects and sectors, including regulation of microclimate, sustainable water management, human health and wellbeing, and energy sustainability. Moreover, their contribution is not only limited to addressing climate change, as they provide functions related to resilience and sustainability, such as habitats and biodiversity preservation, food security, and freshwater availability (Croce & Vettorato, 2021). Innovating the built environment with nature facilitates the shift from mono-disciplinary perspectives to holistic approaches enhancing relationships between natural systems, built environment

and inhabitants and entails a network between several disciplines related to planning and design and interdisciplinary system thinking (De Noia *et al.*, 2022). To control an integrated approach, framing common goals is essential to develop climate positive circular communities. Indeed, strategies of adaptation and mitigation can have incompatibilities due to different temporal and spatial scales, involvement of different stakeholders, and the complexities in the measurement and assessment of adaptation policies (Grafakos *et al.* 2018). This could lead to conflicts or trade-offs that need to be coordinated by a common vision.

3. Innovate with nature

3.1 Landscape-based design

The role of ecological infrastructure and urban biodiversity should include as values and resources of cities and territories, features such as biological diversity, innovation with nature, climate adaptation and mitigation, and species well-being. Land recovery and transformation processes find an opportunity in open air areas to improve the quality of life in cities, as they are reserves for climate adaptation, ecological transition, and social inclusion. The positive role of natural areas on biodiversity and human health is explained by the concept of biophilia intended as the 'the innately emotional affiliation of human beings to other living organisms' (Wilson 1993, p. 31). This can happen in various ways, such as: by providing ecosystem benefits and services that sustain life and regulate against detrimental health effects from climate, floods, infectious diseases; as botanical sources for both traditional and modern medicines; and by providing direct benefits to physical, spiritual and mental health through time spent in nature (MacKinnon *et al.* 2019). These actions can be driven by innovating with nature, « considering natural heritage not only as a resource to be guarded and protected, but as an element on which to build a new collective narrative to sensitize communities and institutions to imagine a broader shared territorial strategy » (Favargiotti *et al.* 2022).

However, in 2000, the European Landscape Convention defined 'Landscape' as « an area as perceived by people, whose charac-

ter is the result of the action and interaction of natural and/or human factors » (ELC 2000). Accordingly, through the landscape agency, people's creativity enables approaches for regenerating, restoring, and renewing spaces and lifestyles. This approach becomes an opportunity to reconnect communities with its landscape identity and geographical characteristics (urban, rural, regional, territorial). Pro-active contamination is needed to address the contemporary socio-cultural-economic-ecological conditions and the uncertain perspectives of multiple possible futures. Yet, landscape-based approaches are more difficult to be included in operational procedures for urban and architectural transformations. Therefore, how landscape could become a driver for territories and cities for a regenerative development in a mutual exchange between research, planning and design to foreseen crucial critical changes?

Integrating climate change, biodiversity and human health requires new methodological and operational approaches based on inter-and-trans-disciplinary working. Social integration, climate adaptation, enhancement of environmental and ecosystem services (protecting against erosion, facilitating pollination, supporting tourism and biodiversity) grounds the perspective for a sustainable and circular urban regeneration. Within this perspective with the ongoing research-action project 'S-COOL', we aim to activate regenerative landscapes processes with the implementation of two pilot interventions that reclaim and collectively care for the open spaces of primary schools. By proposing actions of soil desealing and planting of climate-proof tree species, S-COOL aims to transform two impermeable and obsolete areas into more welcoming and inclusive places (Fig. 1). In the end, this could offer spaces of higher quality and well-being for those who live in them. The design of the areas will be carried out through a participatory process that will involve teachers, families, experts and technicians, but above all children who will be able to observe the transformation of the spaces up close. By being inspired from the Coloco's approach of actively engaging communities and letting each participant become a

landscaper-gardener of space, we aim to create favorable soil fertility conditions, reduction of waste of materials, and conservation of existing biodiversity. The project will include pre- and post-intervention qualitative and quantitative monitoring phases to demonstrate the transformative capabilities of NBS and the transferability of the design approach.

The potential to include biodiversity, ecosystems and communities to develop urban and landscape design projects, through both collective and direct interventions, claims to establish an ecological relationship of active exchange between citizens, gardens, and nature, and to develop collective thoughts that respond to a contemporary urgency to care for our own spaces. This procedure emphasizes how urban areas also can contribute to the protection of species and ensure ecosystem services, benefit also of increased resilience. At the end, through the agency of landscape design, people's creativity enables more just and equitable spaces for the community (Ferretti & Favargiotti 2022).

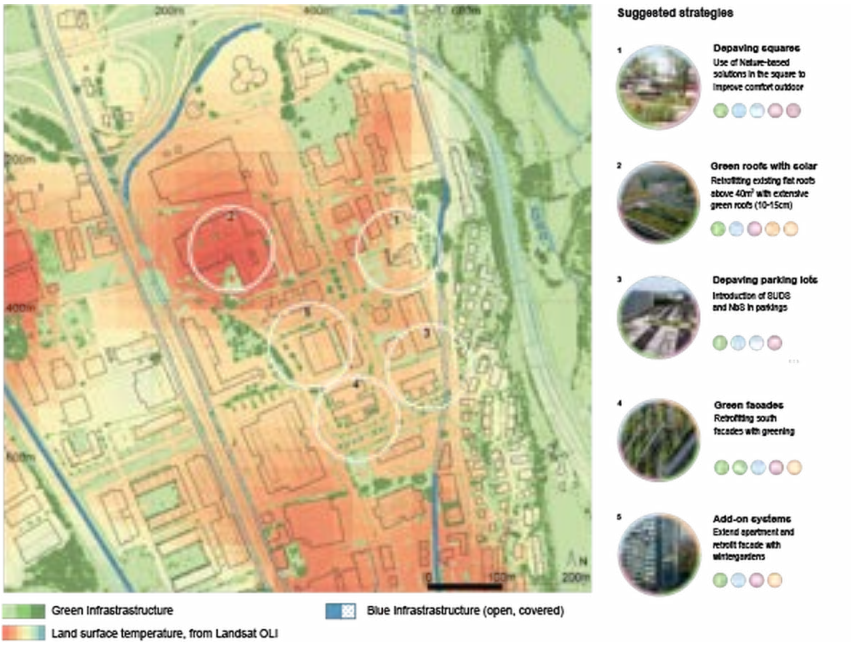
Fig. 1: Renaturalization process thought time for gradual reconfiguration of public spaces towards regenerative landscapes.

3.2 Informing climate sensitive regeneration processes

Practitioners and planners face the complex challenge of implementing adaptation and mitigation measures while reshaping urban environments. This necessitates a holistic comprehension of built environment, natural elements, and inhabitants as components of a complex system of interconnections. To effectively address societal challenges, it is crucial to combine insights from various disciplines and to acquire a comprehensive understanding of the context. Consequently, regeneration and transformation processes should be based on evidence to ensure their ability to achieve desired outcomes (Klemm *et al.*, 2017). Digital tools can be valuable instruments for explicitly mapping out potential pathways (Naboni E & Havinga L, 2019; Nava, 2021; Urech *et al.*, 2020). For instance, leveraging big data, scientific data, or historical records can enhance design practices by unraveling both local and global dynamics (Sarker *et al.*, 2020). The data can be used to inform decision-making processes and to guide transformation practices by providing a knowledge-based of the areas of interventions (Grêt-Regamey *et al.*, 2017; Peroni *et al.*, 2020), by experimenting and testing alternative scenarios or by monitoring the transformation processes (Galle *et al.* 2019).
Several approaches focus on analyzing ecological and environmental aspects of urban areas, offering insights for green urban infrastructure planning and climate adaptation. Examples include studies classifying urban areas based on heat-related risks (e.g., Morabito *et al.*, 2018; Norton *et al.*, 2015) or hydrogeological risks (e.g., Kubal *et al.*, 2009). Additionally, the categorization of bioclimatic zones or Local Climate Zones, following Stewart & Oke's (2012) framework, has become increasingly common to understand the connection between urban morphology and microclimate. Accurate mapping of urban cover is crucial in driving the transformation of human habitat and enhancing the quality and health of urban spaces (la Rosa & Wiesmann, 2013).

The research project 'Climate sensitive urban regeneration. Assessing and monitoring tools for urban transformation processes' aims to provide support to the Municipality of Trento on how to

transform urban surfaces to address the climate-related challenges. For example, a series of maps was provided to explore the relationship between built environment and urban climate. The maps are linked to the surfaces (i.e., pervious surfaces, surface temperature) and the geometry (i.e., Sky View Factor) of the built environment and to the distribution of the Green and Blue Infrastructure (BGI). Figure 2 reports an extract of the map showing the hottest surfaces and the presence of BGI in a commercial and residential neighborhood in the north of Trento. The classifications have been performed with remote sensing tools using freely available aerial images with infrared information of the municipal area. These high-resolution images (20 cm) were combined with digital elevation models (DEM).



Using spatially-explicit information can facilitate the selection of priority areas, highlight inequalities of distribution and target future interventions. Besides that, a comprehensive knowledge base of the area can support the choice of site-specific compensation actions entailed with ecological transition. Assessing the current state of urban systems interacting with climate serves as

Fig. 2: Environmental analysis of a neighborhood in the nord of Trento and suggested strategies for climate adaptation.

a baseline for integrating climate policies into urban planning, linking spatial distribution to risk and vulnerability definitions in different urban areas.

3.3 Decision-makers empowerment

The redevelopment of urban elements, such as streets and open spaces, as well as neglected neighborhoods and abandoned industrial facilities, should contribute to establishing a network of interconnected urban spaces that enhance the quality of life in open areas and facilitate the provision of ecosystem services. This integrated approach ensures that both public spaces and individual buildings contribute cohesively to creating a resilient and sustainable urban environment. According to the EU, a pivotal aspect of implementing climate adaptation strategies in urban areas involves promoting the integration of adaptation policies and approaches into existing planning processes (EU 2021).

The research project Trento Urban Transformations (TUT) provided scientific support to introduce adaptation and mitigation requirements in the currently used urban planning tools, specifically in the General Urban Plan and in the Urban Agreements (Ricci and Favargiotti 2019). The research aims to catalyze adaptive and flexible governance processes that bolster urban resilience by redefining conventional planning tools. Specifically, the aim is to support the city to embrace a green infrastructure approach within urban planning tools, emphasizing the significance of open spaces and green areas at both the neighbourhood and urban levels (Lafortezza *et al.* 2017). For example, in the case of the Urban Agreements – tools that are used to approve specific urban transformations based on a contract between public and private parties – measurable climate-related criteria have been introduced in the approval process. The criteria, associated with several types of actions, can serve as design references that serve as a guide for proposing climate-proof urban design interventions. The proposed approach introduces the evaluation of potential urban transformation practices based on their ecological performance (e.g. sustainable water manage-

ment, cooling capacity, biodiversity protection, carbon sequestration), to facilitate climate-sensitive design (Codemo 2023) and to increase ecosystem services in the built environment by using for example trees, forests and green areas (Fig. 3). The established criteria stem from prior research conducted by the research group (e.g., Ricci and Favargiotti 2019; Codemo *et al.* 2021), existing studies outlining climate-related challenges in the area (e.g., Giovannini *et al.* 2011; Eccel *et al.* 2016), and ongoing discussions with administrative staff. These criteria are aligned with the challenges and specific objectives outlined in the strategic document developed by the Municipality of Trento (Comune di Trento 2019) aimed at enhancing the quality of life in Trento. The six criteria include temperature regulation, sustainable water management, energy sustainability, health and well-being of citizens, circular economy, and sustainable mobility. Each criterion is linked to specific performance metrics that will be essential for the transformation of the built environment. Additionally, measurable parameters have been identified to gauge the effectiveness of interventions in meeting these criteria. This systematic approach ensures a comprehensive and structured assessment of the transformation process, aligning it with the overarching goals outlined in the strategic document.

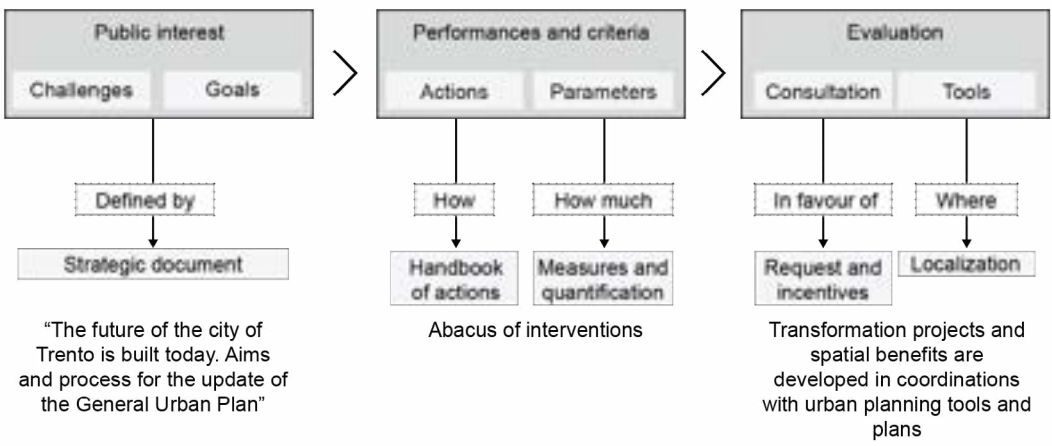


Fig. 3: Proposed methodological process to apply a performance-based approach in the Urban *Agreements*.

A co-creative approach has been effectively employed in the collaboration between the TUT research group and the Municipality of Trento. Research activities within the TUT group involved active participation in a technical table, including representatives from the University of Trento, the Municipality of Trento, and professional associations. This collaborative approach facilitated comparison and knowledge-sharing among diverse professionals engaged in urban transformations, providing a comprehensive understanding of the challenges that may arise at various scales and stages of intervention. It enhanced knowledge related to the subject under investigation and gathered diverse perspectives from each participant. Through addressing various topics, this collaborative effort has contributed to a deeper understanding of the dynamics, fragilities, and potentials of the Trento territory. The active involvement of different stakeholders has broadened the scope of insights and fostered a more comprehensive view of the issues.

4. Conclusion

The research adopts an interdisciplinary approach, encompassing city planning, urban design, and architectural design. It carefully considers the paradigms, objectives, and reference tools within these disciplines. Its scientific significance lies in its multi-scalar and multi-disciplinary nature, delving into and testing multifunctional solutions aligned with both European and local policies. These policies focus on fostering resilient and sustainable scenarios, particularly in relation to green and blue infrastructures. Moreover, the research aims to advance existing climate planning methodologies by proposing flexible and open procedures. The outcomes are a result of collaboration with researchers, experts, and decision-makers in the investigated area. In a broader context, the research contributes to addressing climate change in urban settlements, striving to enhance living conditions, well-being for both people and ecosystems, and the resilience of structures and infrastructures. The research activities are grounded in the local and regional policies of the Trentino region, focusing on both adaptation and mitigation strategies.

Within this framework, the contribution aims to contribute by sharing research experience on three dimensions related to urban transformations: landscape-based design, urban adaptation and policy makers empowerment. The collaboration between municipality, citizens and researchers facilitates experimentations and models to support urban transition in the local context allowing exchange between disciplines, enabling new knowledge, and strengthening the support given to the planning process. Among the research outputs, the entire collaborative and open process shows the need to move from prescriptive design techniques, characterized by a top-down approach, to more inclusive techniques, participative actions and shared decisions. It refers to a shift from over imposed choices by authorities in the urban and territorial transformation, to a process of community-based co-design process of decision, transformation and stewardship.

Acknowledgements

The outcomes of the research projects mentioned in the contribution have been developed within 'Trento Urban Transformation' project (founded by the Municipality of Trento and the University of Trento within the framework of UniCittà memorandum of understanding), 'S-COOL' project (co-founded by Capitale Naturale 2023 Fondazione Cariverona), and 'Climate sensitive urban regeneration. Assessing and monitoring tools for urban transformation processes' project (founded by Postdoc 2023 Fondazione Caritro).

Biographies

Anna Codemo, Postdoctoral fellow in the Department of Civil, Environmental and Mechanical Engineering at the University of Trento. Her research focuses on the promotion of climate adaptation and energy transition of the built environment, through a landscape-inclusive, co-creative and regenerative approach. Her PhD thesis investigated climate sensitive strategies at the urban and territorial scale through the disciplines of urban planning and design. She participates in several research projects, such as PEARLS (MSC RISE, 2017-2023) and ARV (EU Horizon

2020 research and innovation, 2022-2025), S-COOL (Cariverona, 2024-2026). As part of the European project PEARLS, she carried on visiting periods at Territoria, análisis y gestión del medio S.L. (Seville), Claner (Seville) and Consortis Geospatial (Thessaloniki).

Sara Favargiotti, Associate Professor of Landscape Architecture at the Department of Civil, Environmental and Mechanical Engineering, University of Trento. Her research and teaching investigate the multiple identities of the landscape with research by design approach based on transformation through adaptation and innovation. She is specialized in landscape urbanism and ecological design with a specific focus on emerging infrastructures and their influence on cities, landscapes, and territories. Since 2018 she is a member of the Directive Board of IASLA. She is co-founder and scientific advisor of RUMA S.r.l. Società Benefit. She is coordinator of the Trentino hub in the Branding4Resilience research project (PRIN 2017, Young Line, 2020-2023), P.I. of the S-COOL project (Cariverona, 2024-2026) and Seeds-4Future project (EIT Food, 2024). She is author of numerous essays internationally published and of the book Airport On-hold. Towards Resilient Infrastructures (Trento: LISt Lab, 2016).

references

+ Codemo, A. (2023). Climate sensitive design for regenerative cities. Adaptation strategies for climate-resilient, energy efficient and RES-based urban eco-systems. Doctoral dissertation: University of Trento.
+ Codemo, A., Favargiotti, S., & Albatici, R. (2021). Balancing adaptation and mitigation strategies through an integrated approach: climate responses in the human habitat, *Sustainable Mediterranean Construction*, 13: pp. 123–129.
+ Comune di Trento. (2019). *Il futuro della città di Trento si costruisce oggi. Obiettivi e Percorso Della Variante Generale al Piano Regolatore Generale*. Retrieved from: https://www.comune.trento.it/Aree-tematiche/Ambiente-e-territorio/Urbanistica/Il-nuovo-PRG-Piano-regolatore-generale/Obiettivi-e-percorso-della-variante-generale-al-Piano-regolatore-generale-2018/. Il-futuro-della-citta-di-Trento-si-costruisce-oggi-Schema-del-documento
+ Cole, R.J. (2012). Regenerative design and development: current theory and practice, *Building Research & Information*, 40(1), pp. 1–6.
+ Council of Europe (2000). *European Landscape Convention, European Treaty Series n 176*. Retrieved online at https://rm.coe.int/1680080621.
+ Croce, S., & Vettorato, D. (2021). Urban surface uses for climate resilient and sustainable cities: A catalogue of solutions. *Sustainable Cities and Society*, 75, 103313.
+ De Noia I., Favargiotti S., Marzadri A. (2022). Renaturalising lands as an adaptation strategy.
+ Towards an integrated water-based design approach. *TEMA*, Vol.15, n. 2, pp. 263-286, DOI: 10.6093/1970-9870/9074,
+ Eccel, E., Zollo, A.L., Mercogliano, P., & Zorer, R. (2016). Simulations of Quantitative Shift in Bio-Climatic Indices in the Viticultural Areas of Trentino (Italian Alps) by an Open Source R Package'. *Computers and Electronics in Agriculture*, 127 (September): pp. 92–100. https://doi.org/10.1016/j.compag.2016.05.019.
+ European Commission (2021). *Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change*. COM(2021) 82 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN.
+ Favargiotti S., Pasquali M., Chioni C., Pianegonda A. (2022).Water Resources and Health Tourism in Val di Sole: Key Elements for Innovating with Nature in the Italian Inner Territories. *Sustainability*, Vol.14, n. 18, pp. 1-23, DOI: 10.3390/su141811294.

+ Ferretti, M., Favargiotti, S. (2022). Commons in Marginal Landscapes. Collective practices for an alternative narrative and use of common spatial resources in peripheral landscapes. *Ri-Vista*, 19, pp. 176–189. https://doi.org/10.36253/rv-11412.
+ Galle, N.J., Nitoslawski, S.A., & Pilla, F. (2019). The Internet of Nature: How taking nature online can shape urban ecosystems. *Anthropocene Review*, 6(3), pp. 279–287.https://doi.org/10.1177/2053019619877103.
+ Giovannini, Lorenzo, Dino Zardi, and Massimiliano de Franceschi. 'Analysis of the Urban Thermal Fingerprint of the City of Trento in the Alps', *Journal of Applied Meteorology and Climatology* 50, 5 (2011): pp. 1145-1162, accessed Mar 31, 2022, https://doi.org/10.1175/2010JAMC2613.1.
+ Grafakos, S., Pacteau, C., Delgado, M., Landauer, M., Lucon, O., Driscoll, P., Wilk, D., Zambrano, C., O'Donoghue, S., & Roberts, D. (2018). Integrating Mitigation and Adaptation: Opportunities and Challenges. *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*, 101–138. https://doi.org/10.1017/9781316563878.011.
+ Grêt-Regamey, A., Altwegg, J., Sirén, E.A., van Strien, M.J., & Weibel, B. (2017).
+ Integrating ecosystem services into spatial planning – A spatial decision support tool. *Landscape and Urban Planning*, 165, pp. 206–219. https://doi.org/https://doi.org/10.1016/j.landurbplan.2016.05.003.
+ Klemm, W., Lenzholzer, S., & van den Brink, A. (2017). Developing green infrastructure design guidelines for urban climate adaptation. *Journal of Landscape Architecture*, 12(3), pp. 60–71. https://doi.org/10.1080/18626033.2017.1425320.
+ Kubal, C., Haase, D., Meyer, V., & Scheuer, S. (2009). Integrated urban flood risk assessment – adapting a multicriteria approach to a city. Natural Hazards and Earth System Sciences, 9(6), pp. 1881–1895. https://doi.org/10.5194/nhess-9-1881-2009.
+ Lafortezza, R., & Giannico, V. (2019). Combining high-resolution images and LiDAR data to model ecosystem services perception in compact urban systems. *Ecological Indicators*, 96, pp. 87–98. https://doi.org/10.1016/j.ecolind.2017.05.014.
+ La Rosa, D., & Wiesmann, D. (2013). Land cover and impervious surface extraction using parametric and non-parametric algorithms from the open-source software R: an application to sustainable urban planning in Sicily. *GIScience & Remote Sensing*, 50(2), 231–250. https://doi.org/10.1080/15481603.2013.795307.

+ Magni, F., Litt, G., & Carraretto, G. (2021). Metropolitan Cities supporting local adaptation processes. The case of the Metropolitan City of Venice, *TeMA - Journal of Land Use, Mobility and Environment*, 14(2), pp. 125–144.
+ MacKinnon, Kathy, Chantal van Ham, Kate Reilly, and Jo Hopkins (2019). *Nature-Based Solutions and Protected Areas to Improve Urban Biodiversity and Health*. In Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvine, Aletta Bonn (eds) *Biodiversity and Health in the Face of Climate Change*, Springer, Cham: pp. 363–380. https://doi.org/10.1007/978-3-030-02318-8_1.
+ Morabito, M., Crisci, A., Georgiadis, T., Orlandini, S., Munafò, M., Congedo, L., Rota, P., & Zazzi, M. (2018). Urban imperviousness effects on summer surface temperatures nearby residential buildings in different urban zones of Parma, *Remote Sensing*, 10(1). https://doi.org/10.3390/rs10010026.
+ Naboni E, & Havinga L. (2019). *Regenerative Design in Digital Practice*. https://www.researchgate.net/publication/336121907_Regenerative_Design_In_Digital_Practice_A_Handbook_for_the_Built_Environment.
+ Natanian, J., & Auer, T. (2020). Beyond nearly zero energy urban design: A holistic microclimatic energy and environmental quality evaluation workflow. *Sustainable Cities and Society*, 56. https://doi.org/10.1016/j.scs.2020.102094.
+ Nava, C. (2021). Advanced Sustainable Design (ASD) for resilient scenarios, *Bioclimatic*.
+ *Approaches in Urban and Building Design*, pp. 255–274.
+ Norton, B.A., Coutts, A.M., Livesley, S.J., Harris, R.J., Hunter, A.M., & Williams, N.S.G. (2015). Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes, *Landscape and Urban Planning*, 134, pp. 127–138. https://doi.org/https://doi.org/10.1016/j.landurbplan.2014.10.018.
+ Olazabal, M., & Ruiz De Gopegui, M. (2021). Adaptation planning in large cities is unlikely to be effective, *Landscape and Urban Planning*, 206, 103974. https://doi.org/10.1016/j.landurbplan.2020.103974.
+ Peroni, F., Pristeri, G., Codato, D., Pappalardo, S.E., & De Marchi, M. (2020). Biotope area factor: An ecological urban index to geovisualize soil sealing in Padua, Italy, *Sustainability*, 12(1). https://doi.org/10.3390/SU12010150.

+ Raven, J., Stone, B., Mills, G., Towers, J., Katzschner, L., Leone, M., Gaborit, P., Georgescu, M., & Hariri, M. (2018). *Urban planning and design*, Cambridge University Press.Reed, B. (2007). Shifting from 'sustainability'to regeneration, *Building Research & Information*, 35(6), pp. 674–680.
+ Ricci, M., Favargiotti, S., Aimini, M., Codemo, A., Mannocci, S. (2021). *Dall'urbanistica concordata all'urbanistica condivisa. Dispositivi di orientamento*. Trento: Università di Trento, p. 39 – URL: https://www.comune.trento.it/Aree-tematiche/Ambiente-e-territorio/Urbanistica/Accordi-urbanistici/Linee-guida-per-Accordi-urbanistici.
+ Ricci, M., & Favargiotti, S. (2019). Trento Leaf Plan: Cinque sfide per il metabolismo urbano. EcoWebTown, *Journal of Sustainable Design*, 19. http://www.ecowebtown.it/n_19/pdf/B9_EWT_19_Ricci_Favargiotti_stampa.pdf.
+ Sarker, M.N.I., Yang, B., Yang, L., Huq, M. E., & Kamruzzaman, M. M. (2020). Climate change adaptation and resilience through big data, *International Journal of Advanced Computer Science and Applications*, 11(3).
+ Stewart, I., & Oke, T. R. (2012). Local Climate Zones for Urban Temperature Studies, *Bulletin of the American Meteorological Society*, 93, 1879–1900.
+ Urech, P.R.W., Dissegna, M.A., Girot, C., & Grêt-Regamey, A. (2020). Point cloud modeling as a bridge between landscape design and planning. Landscape and Urban Planning, 203, 103903. https://doi.org/10.1016/J.LANDURBPLAN.2020.103903.
+ Wilson, E.O. (1993). Biophilia and the conservation ethic. In Kellert, S.R., Wilson, E.O. (eds) The biophilia hypothesis, Island Press, Washington, DC: 31.
+ Zari, M.P. (2018). *Regenerative Urban Design and Ecosystem Biomimicry (1st Edition)*.Routledge.

note

[1] Anna Codemo – ORCID ID: 0000-0003-0671-9553, anna.codemo@unitn.it, Dipartimento di Ingegneria Civile Ambientale e Meccanica – Università di Trento
[2] Sara Favargiotti – ORCID ID: 0000-0003-3598-1518, sara.favargiotti@unitn.it, Ingegneria Civile Ambientale e Meccanica – Università di Trento

URBAN CLIMATE SHELTERS TO ADAPT CITIES TO CLIMATE CHANGE

A Proposal for Schoolyards in Turin (Italy)

Bruna Pincegher[1], Maria Pizzorni[2], Ombretta Caldarice[3], Nicola Tollin[4]

Abstract

As the objective to limit the temperature increase to 1.5-2.0°C is still far-reaching, cities worldwide are promoting efforts to contrast the compound effects of climate change. Cities must undertake urgent actions to improve their adaptive capacities, working proactively with stakeholders and communities to cope with current and future climate change phenomena and impacts. This paper aims at understanding how cities can adapt to climate change, through a resilient transformation of urban spaces by design, and explicitly use climate shelters to respond to climate hazards, such as heat waves, flooding, and droughts. This paper

focuses on the transformative potential of climate shelters in urban design, particularly within the framework of the 'Climate Shelters (2019-2020)' project funded by the European Commission's Urban Innovation Actions (UIA) programme. The project aims at transforming schoolyards, currently based on impervious surfaces and low-albedo materials, to more sustainable, natural, and resilient ones, which contribute to adapting cities to climate change and citizens' quality of life and health.
Despite a lack of standardized terminology, the successful implementations in Madrid, Barcelona, London, Paris, Amsterdam, and The Hague prompted the introduction of the concept of Urban Climate Shelter (UCS), requesting a more comprehensive understating of this concept and its applicability to diverse urban contexts. The objective of this paper is to delve into the role of UCS within schoolyards. The focus extends beyond their function, emphasizing their potential as spaces that can strengthen the capacity of cities to adapt to climate change by engaging the local community and stakeholders and enhancing bottom-up approaches. Lastly, to illustrate this, a case study from Turin is presented, detailing the design of a proposed schoolyard and the upscaling process.

Keywords: Urban Climate Shelter, Climate Change Mitigation and Adaptation, Schoolyard Regeneration, Co-designing public spaces, Urban Resilience

1. Introduction

Currently, the world's population in urban areas has overtaken the population in rural areas, totalizing more than 55% of humanity living in urbanized areas. In Europe, precisely 73% of inhabitants live in the cities, expecting to achieve 82% in less than three decades. Considering the rapid growth of major urban centres, by the year 2050, over 65% of the global population is projected to live in urban and peri-urban areas (Chamie, 2019). Moreover, cities are responsible for more than two-thirds of CO2 emissions, more than half of global waste, and the consumption of three-fourths of natural resources (Kamal-Chaoui & Alexis, 2009). Certainly, cities

play a pivotal role in driving change and providing solutions for recurrent threats and disasters, such as social inequalities, energy safety, and climate change (IPCC, 2023).

This paper focuses on an innovative strategy for addressing the impacts of climate change: The Urban Climate Shelter (UCS). Despite being relatively new, the UCS has been adopted in several European cities over the past decade, yet there is no universally agreed-upon definition. For example, Madrid, Barcelona, London, Paris, Amsterdam, and The Hague developed this solution to use schools as cooling islands.

Initially, 'climate shelter' was defined as a natural space where animals used to hide from weather events (Florido & Florido, 2022). However, in the spatial planning context, 'climate shelter' is a new term used by Barcelona to refer to a cooling public space that provides thermal comfort for residents and tourists (Vetter, 2020). This paper adopts the term 'Urban Climate Shelter (UCS)'.

Urban Climate Shelters (UCS) are spaces to adapt cities to climate change by offering protection from extreme weather events like heat waves, floods, and droughts. They achieve this through a combination of green infrastructure (parks, trees) and blue infrastructure (water features, retention ponds), designed collaboratively with local communities, ensuring bottom-up initiatives.

First and foremost, this paper concentrates on implementing UCS in schoolyards. Transforming schoolyards into a greener environment has become a common strategy to adapt to climate change, including climate hazards such as heat, flooding, and precipitation, since schoolyards constitute a significant portion of open space within cities and serve diverse populations, including students, parents, and faculty, their enhancement holds multiple environmental and social benefits (Flax *et al.*, 2020).

Paris and Barcelona have received funding from the European Union through the Urban Innovative Action (UIA) project to transform a limited number of schools. However, both cities intend to expand the initiative to more schools. Paris aims at transforming all public schools by 2050, while Barcelona considers existing inequalities in green school infrastructure during the upscaling process. An essential requirement of the UIA project

is to enhance the utilization of schoolyards as public spaces, especially during summertime and after school hours, to provide cooling areas accessible to vulnerable populations (Antoniadis *et al.*, 2020; Baró *et al.*, 2022). Amsterdam shares a similar approach by opening schoolyards after school hours and intends to upscale to more schools (Antoniadis *et al.*, 2020).
Moreover, incorporating Nature-Based Solutions (NBSs) to transform schoolyards into UCSs presents a promising pathway to enhance multiple co-benefits, including improved health, well-being, and social justice, particularly for children and those vulnerable to extreme heat (Baró *et al.*, 2022; Flax *et al.*, 2020). Positioning schools as UCSs serves as compelling demonstration projects for climate mitigation and adaptation, benefiting cities and communities by reducing heat and restoring urban ecosystems through NBSs (Raymond, 2017).
However, understanding the implementation challenges and upscaling opportunities for UCSs in schoolyards across Europe requires further systematic research and practical case studies. Starting from this framework, the paper aims at presenting a design methodology to implement the UCS initiative for achieving a widespread impact, exemplified in the proposed case of Turin in Italy.

2. UCS proposal in Turin

Turin, located in the Piedmont region north of Italy, has many environmental peculiarities: it is surrounded by the Alps and has a complex hydrological system, crossed by three large rivers (the Po, the Dora, and the Sangone). Furthermore, Turin was considered the industrial capital that propelled Italy's post-war economic recovery among automotive and mechanical manufacturing companies in the 1990s (Department for Environmental Policies with the Coordination of the Environment Area, 2020). Given its urban development, the city is highly impervious and prone to climatic hazards such as heat waves and flooding.
Despite these challenges, Turin has committed to ambitious environmental goals outlined in its Strategic Green Infrastructure Plan and aspires to be the greenest city in Italy and the greenest large city in Europe. Additionally, 'Turin path within 100 Climate

Neutrality Cities EU Mission' aims at transforming towards climate neutrality by 2030. Strategies for achieving these objectives include mitigating vulnerabilities through ecosystem services, boosting ecological health and biodiversity, increasing connectivity among green areas, utilizing green infrastructure for greater social inclusion, and promoting cultural and outdoor tourism (*Piano Strategico Infrastruttura verde – Verde pubblico,* 2020).
Turin has developed three plans and policies related to environmental sustainability and climate adaptation: Action Plan for a Sustainable and Resilient Turin 2030 (2019), Climate Resilience Plan (2020), and Green Infrastructure Plan (2020). This paper explores the interplay between these initiatives and the implementation of Urban Climate Shelters. To begin with, out of the three plans, only the Climate Resilience Plan mentions the concept of climate refuge, where it categorizes the greenery as a strategy for regulating temperature; however, the strategy only focuses on increasing the usage of the hillside area of the city.
The proposal development started by identifying two main climate hazards: Urban Heat Island (UHI) and Flooding. Referring to UHI, the analysis presents a spatial overview of the city, facilitating the understanding of the warmest spots, mainly located in the industrial areas southwest and northeast. In addition, the city centre also presents high-temperature levels due to its high densification and compact urban morphology. Associated with flooding, the analysis presents an understanding of low to high-risk areas affected by it. Furthermore, an analysis of infrastructures exposed to climate hazards reported 444 schools exposed to UHI, 53 schools exposed to flooding, and 65 schools exposed to multi-hazards, thus representing more than 90% of schools in Turin (European Green Capital Award, 2022).
The following step referred to identifying the most vulnerable groups, of which four were identified. The first two groups are the children, characterized by a population under 14 years old, and the elderly, characterized by a population over 65 years old. These first two groups were explicitly identified as representing higher vulnerability to heat events and, therefore, need special attention (Vetter, 2020). The other two groups are the foreign

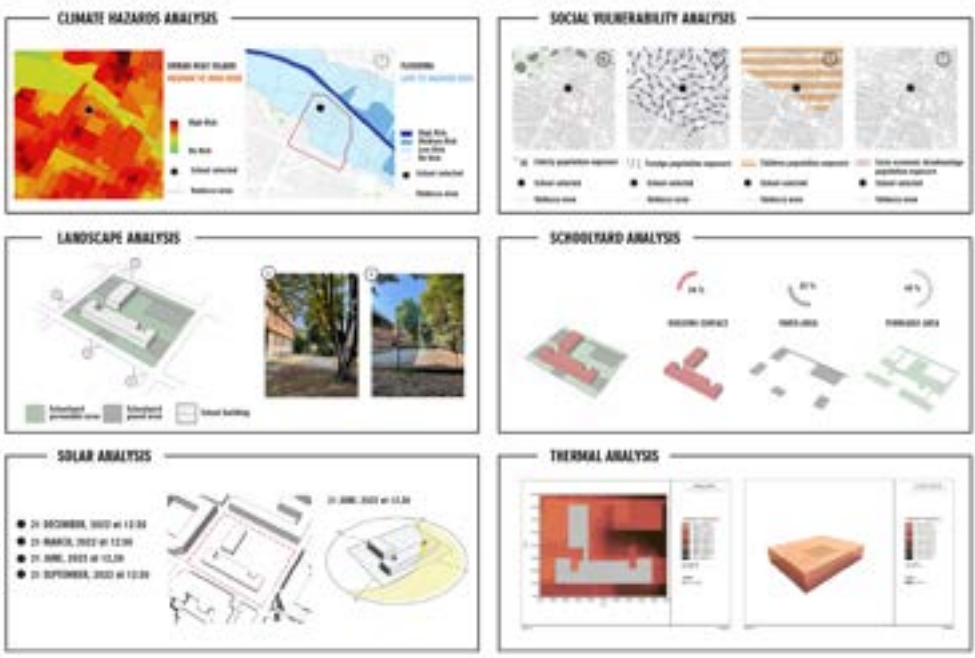
Fig 1: The co-design analysis stage applied to the pilot case in Turin.

population and the population with low socioeconomic status; these groups are mainly identified as minorities with lower resources to cope with climate events.

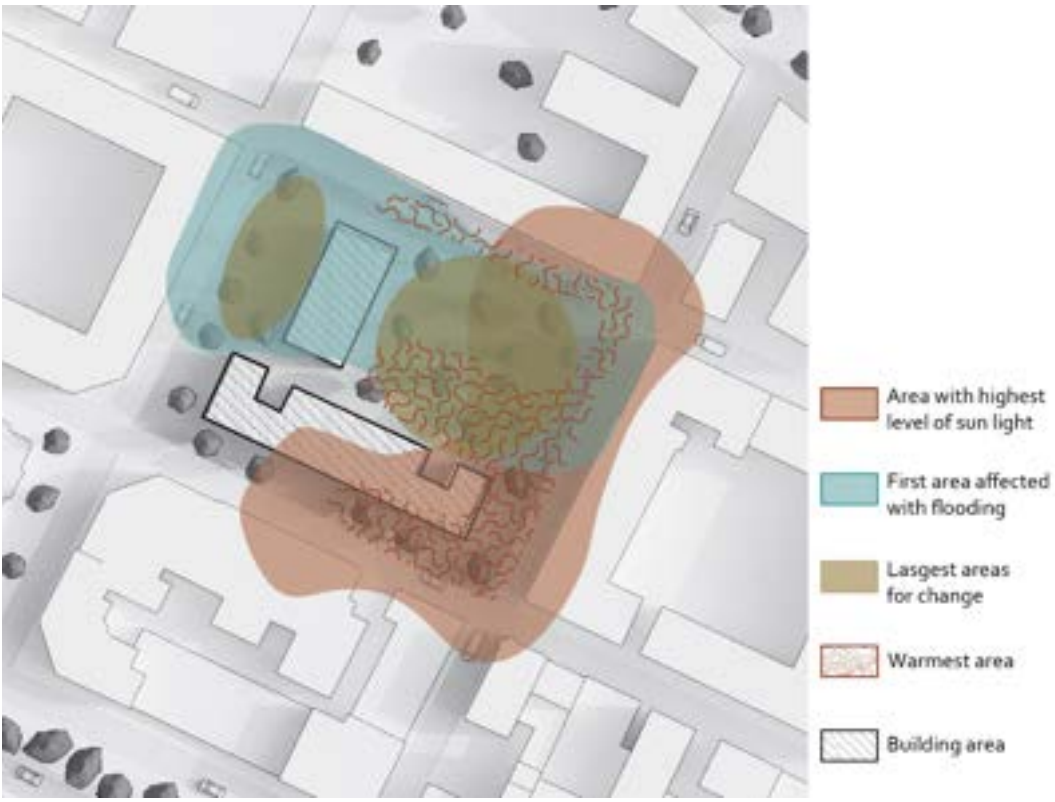
The selected schoolyard for the proposed intervention and implementation of UCS is a medium school in the north area of the Valdocco neighbourhood. The area has developed the project 'Livable Valdoco' that aims at shifting the current neighbourhood scenario characterized by 90% of the public spaces representing roads or parking to a better one by increasing the vegetation and coping with UHI and rainwater management (*Valdocco Vivibile | Torino Vivibile,* n.d.). The project focuses on the road infrastructure and redesigning sidewalks and crosswalks, bringing more areas for pedestrians, greenery, and water management.

2.1 Single UCS implementation process

This paper primarily explores the design aspect of UCS. It initiates from a comprehensive analysis comprising climate hazard analysis, social vulnerability analysis, landscape analysis, schoolyard analysis, solar analysis, and thermal analysis (Figure 1).



An approach was employed to analyse previous steps and highlight key findings thoroughly. The first one related to the thermal analysis, which provided the warmest area in the school perimeter. The second finding was from the solar analysis to understand where the sun irradiates more. The following finding was related to the area of flooding. For this step, two observations were necessary: firstly, to understand the location of the school and the location of the river and, therefore, the direction of the water; subsequently, the other observation was done from the flooding map. The building mass and schoolyard analysis provided insight into the most significant area for change. As a result, five main categories were identified: Area with the highest level of sunlight, primarily area affected by flooding, largest area for change, warmest area, and building area.



The strategy proposed focused on incorporating the key findings from the analysis into the design strategy, comprehending the school's surroundings, particularly emphasizing flooding and the Urban Heat Island (UHI) effect, both significant climate risks in Turin and present in the selected schoolyard (Figure 3). Additionally, while the existing greenery in the schoolyard is valuable, there is potential for enhancing vegetation, which offers numerous benefits. Moreover, the proposal included utilising natural materials and expanding permeable paving to improve environmental sustainability. Lastly, water management features, such as rain gardens and bioswales, were integrated to collect and manage water effectively, thereby mitigating the demands on water resources.

Finally, the proposed design incorporates a set of six strategies/elements to be implemented in the schoolyards: water management, garden, permeable path, shading elements, water fountain, and increase of greenery (Figure 4). This includes, for example, within water management, bioswale that can serve as a feature for collecting and slowing down the water, especially since this strategy can have greater results when implemented in larger areas such as highly impervious urban areas (Jusić *et al.*, 2019). Gardens enhance both the permeability and vegetation of the schoolyard while using natural materials in the permeable paths promote sustainability and reusability. Shading elements not only expand shaded areas but also offer diverse experiences for users, particularly children. Water fountains are intended to be used for drinking and as a playful feature for cooling down. Lastly, the plantation of trees, especially in the areas with a higher level of sunlight and the warmest spots.

2.2 Upscaling UCS proposal in Turin

In order to provide sheltered cities, one essential step is the upscaling. Moreover, it facilitates the transition from implementing a single UCS to establishing a network of UCS, thereby fostering adaptation to climate change. The strategy for the city of Turin is first to prioritize the transformation in the most vulnerable

Fig 2: Key findings from the analysis of the schoolyard.

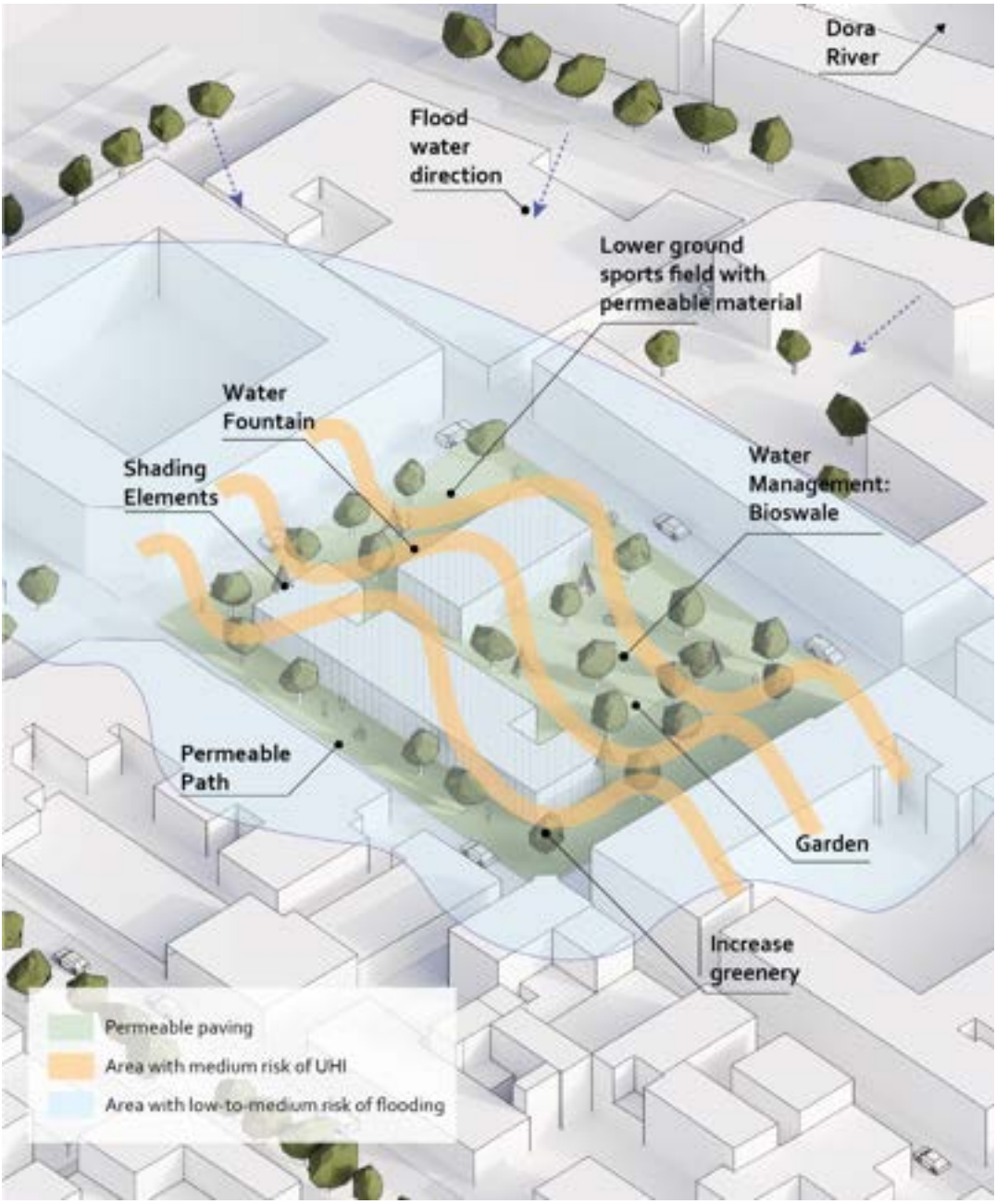
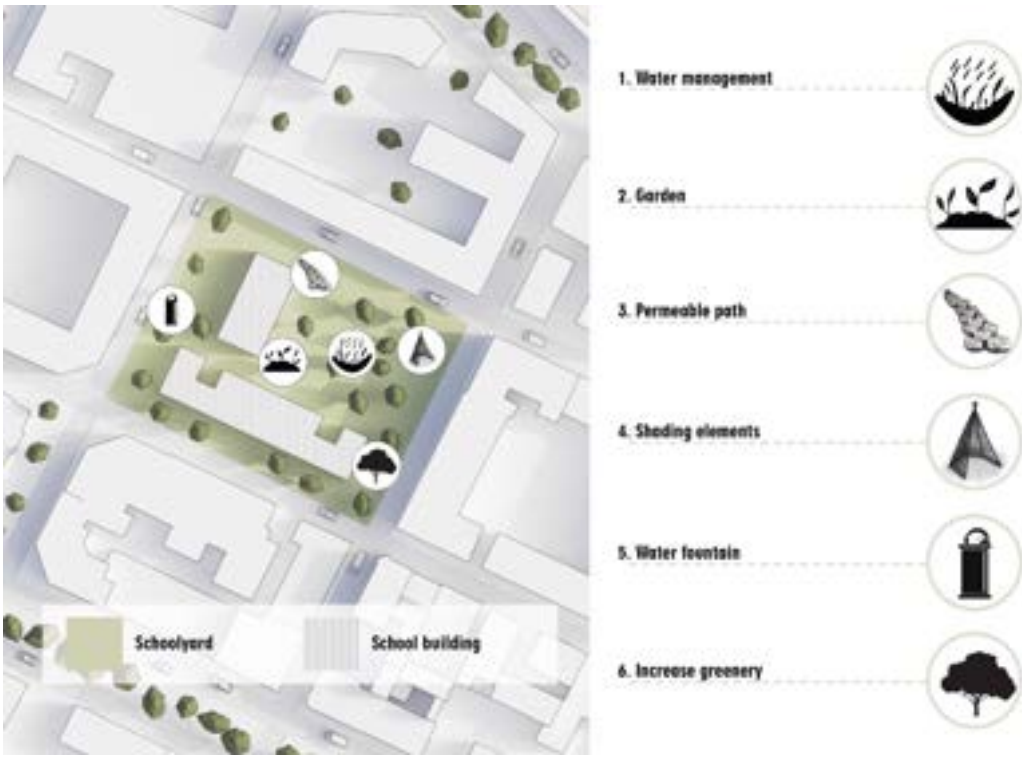


Fig 3: Design strategies.

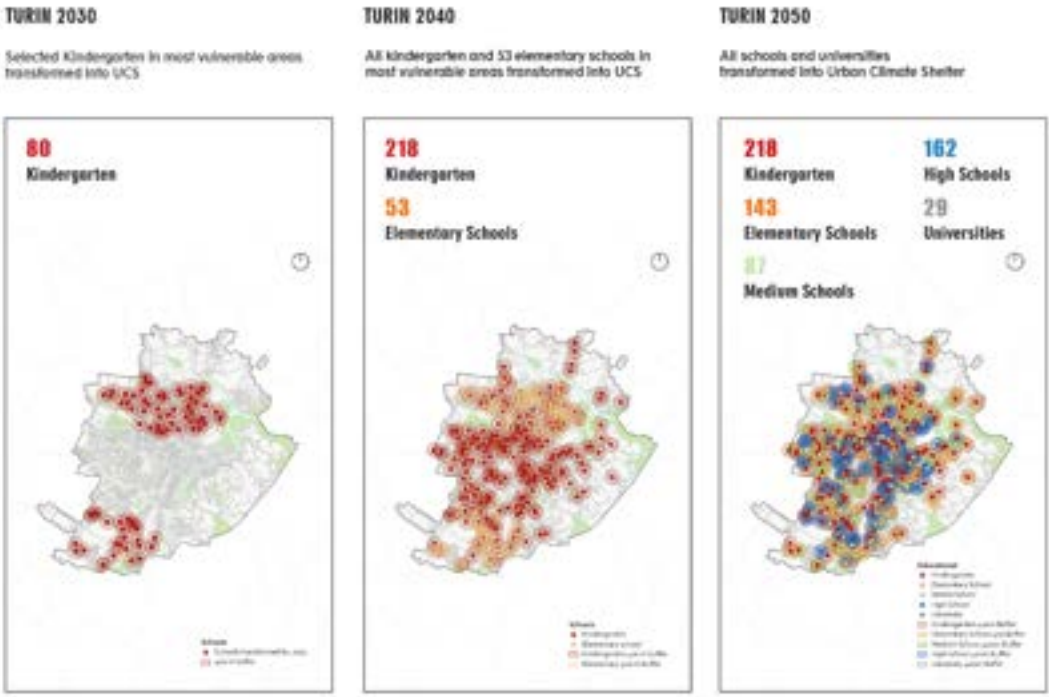
Fig 4: The schoolyard design proposal.

areas (presented with areas with high concentrations of vulnerable groups and climate hazards). The strategy entails a phased plan (Figure 5): By 2030, transform 80 selected kindergartens in the most vulnerable areas into Urban Climate Shelters. By 2040: transform 218 kindergartens in Turin and 53 elementary schools in the most vulnerable areas. By 2050: Upgrade to all schools and universities in Turin (218 kindergartens; 143 elementary schools, 87 medium schools, 162 high schools, and 29 Universities.



It is crucial to realize that the potential areas for upscaling were addressed in this research as a starting point without determining whether the area is appropriate for the project. For instance, a detailed analysis is required, including climate hazard analysis, social vulnerability analysis, landscape analysis, schoolyard analysis, solar analysis, and thermal analysis for each school in the city. In the same way, it is essential to align with existing projects, plans and policies in the given area/city. Finally, the

UCS initiative encourages the transformation beyond schoolyards involving other sectors and facilities, subsequently fostering resilient and shelter cities.



3. Conclusion

Transforming schoolyards into UCS can enhance the interaction area that is so important for the school community, improve the quality of life for everyday school usage, and provide additional public space for citizens, increasing greenery and adapting to climate change. The UCS concept encourages a gradual start by installing a single UCS as a reachable goal. Nevertheless, the objective is to upscale and implement in most spaces, fostering a sheltering and resilient city. Additionally, it enhances the idea that every space has a potential for change, whether by implementing one or all the design features.

While this paper primarily focuses on schoolyards, it acknowledges the broader applicability of the Urban Climate Shelter concept to other public spaces such as parking lots, squares, li-

Fig 5: Strategy for upscaling in Turin.

braries, and hospital yards. Consequently, schoolyards might be just the starting point of community awareness of climate change and co-production initiatives transformations at the city scale. Furthermore, UCS provides a valuable addition to the city of Turin, fostering awareness and community engagement and tangible transformations that benefit both the population and the environment. Moreover, it coordinates with the city's goals and missions to become the greenest city in Italy and the greenest large city in Europe and to move towards climate neutrality by 2030. Finally, the process of scaling up UCS in Turin extends beyond the scope outlined in the Climate Resilience Plan, not only focusing on the hilly area of the city but especially addressing the most vulnerable areas to climate hazards, including ex-industrial areas and the city centre.

Biographies

Bruna Pincegher, Research Assistant in Urban and Regional Planning, Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning (DIST), Responsible Risk Resilience Centre (R3C).

Maria Pizzorni, PhD Candidate on 'Multi-risk assessment of urban flood and drought' at the UNESCO Chair on Urban Resilience, Section of Civil and Architectural Engineering, Department of Technology and Innovation (ITI), Faculty of Engineering (TEK), University of Southern Denmark.

Ombretta Caldarice, Assistant Professor in Urban and Regional Planning, Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning (DIST), Responsible Risk Resilience Centre (R3C).

Nicola Tollin, Professor with special responsibilities in Urban Resilience at the UNESCO Chair on Urban Resilience, Section of Civil and Architectural Engineering, Department of Technology and Innovation (ITI), Faculty of Engineering (TEK), University of Southern Denmark.

references

+ Antoniadis, D., Katsoulas, N., & Papanastasiou, D. (2020). Thermal Environment of Urban Schoolyards: Current and Future Design with Respect to Children's Thermal Comfort. *Atmosphere*, 11(11), 1144. https://doi.org/10.3390/atmos11111144.
+ Baró, F., Camacho, D.A., Perez del Pulgar, C., Ruiz-Mallén, I., & García-Serrano, P. (2022). Nature-Based Climate Solutions in European Schools: A Pioneering Co-designed Strategy Towards Urban Resilience. In *Urban Book Series* (pp. 125-146). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-07301-4_6.
+ Caldarice, O., Tollin, N., & Pizzorni, M. (2021). The relevance of science-policy-practice dialogue. Exploring the urban climate resilience governance in Italy. *City, Territory and Architecture*, 8(1). https://doi.org/10.1186/s40410-021-00137-y.
+ Department for Environmental Policies with the coordination of the Environment Area. (2020). *Climate Resilience Plan*. Comune Torino. Retrieved August 7, 2023, from http://www.comune.torino.it/ambiente/bm~doc/resilienza-climatica_en.pdf.
+ *Developing cooler, greener schoolyards across the city | Resilient City Den Haag*. (n.d.). Retrieved July 19, 2023, from https://resilientthehague.nl/en/projects/koelere-en-groenere-schoolpleinen-in-de-stad/.
+ Flax, L., Korthals Altes, R., Kupers, R., & Mons, B. (2020). Greening schoolyards – An urban resilience perspective. *Cities*, 106. https://doi.org/10.1016/j.cities.2020.102890.
+ Florido, F., & Florido, F. (2022, October 21). What are climate shelters? – Blog CREAF. Blog CREAF – EL BLOG DEL CREAF. *Novetats sobre recerca en ecologia terrestre del CREAF*. https://blog.creaf.cat/en/knowledge/what-are-climate-shelters/.
+ Giezen, M., & Pellerey, V. (2021). Renaturing the city: Factors contributing to upscaling green schoolyards in Amsterdam and The Hague. *Urban Forestry and Urban Greening*, 63, 127190. https://doi.org/10.1016/j.ufug.2021.127190.
+ IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)].
+ IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001
+ Jusić, S., Hadžić, E., & Milišić, H. (2019). Urban Stormwater Management – new technologies. In *Lecture notes in networks and systems,* pp. 790-797. https://doi.org/10.1007/978-3-030-18072-0_90.

+ Kamal-Chaoui, Lamia and Alexis Robert (eds.) (2009), 'Competitive Cities and Climate Change', *OECD Regional Development Working Papers N° 2*, 2009, OECD publishing, © OECD.
+ Meerow, S., & Newell, J.P. (2019). Urban resilience for whom, what, when, where, and why? *Urban Geography*, 40(3), pp. 309–329. https://doi.org/10.1080/02723638.2016.1206395.
+ *OASIS – Schoolyards: Openness, Adaptation, Sensitisation, Innovation and Social ties: Design and transformation of local urban areas adapted to climate change, working jointly with users | UIA – Urban Innovative Actions*. (n.d.). Retrieved July 19, 2023, from https://uia-initiative.eu/en/uia-cities/paris-call3.
+ Orsetti, E., Tollin, N., Lehmann, M., Valderrama, V.A., & Morató, J. (2022). Building Resilient Cities: Climate Change and Health Interlinkages in the Planning of Public Spaces. *International Journal of Environmental Research and Public Health*, 19(3). https://doi.org/10.3390/ijerph19031355.
+ *Piano Strategico Infrastruttura verde – Verde pubblico*. (2020). http://www.comune.torino.it/verdepubblico/il-verde-a-torino/piano-infrastruttura-verde/.
+ Raymond, C.M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M.R., Geneletti, D., & Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science and Policy*, 77, pp. 15–24. https://doi.org/10.1016/j.envsci.2017.07.008.
+ Chamie, J. (2019). *World Urbanization Prospects: The 2018 Revision*. https://doi.org/10.18356/b9e995fe-en.
+ *Valdocco vivibile | Torino vivibile*. (n.d.). https://www.torinovivibile.it/aree-tematiche/valdocco-vivibile/.
+ Vetter, R. (2020). *Cooling Schools Experiences from C40'S Cool Cities Network, C40 Knowledge*. urly.it/31chh9.

note

[1] Bruna Pincegher – ORCID ID: 0009-0002-9663-5950, bruna.pincegher@polito.it, Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio –Politecnico di Torino
[2] Maria Pizzorni – ORCID ID: 0000-0002-0355-5904, mpiz@iti.sdu.dk – Department of Technology and Innovation – University of Southern Denmark
[3] Ombretta Caldarice – ORCID ID: 0000-0001-6172-908X, ombretta.caldarice@polito.it, Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio – Politecnico di Torino
[4] Nicola Tollin, 0000-0002-6028-4733, nto@iti.sdu.dk, UNESCO Chair on Urban Resilience – University of Southern Denmark

BIOAGRICORRIDORS

Urban ecosystem networks to enhance biological diversity, ecosystem services and food production in Barcelona – Spain

Capra-Ribeiro Fabio[1], Vegezzi Filippo[2]

Abstract

Urbanisation and environmental degradation pose significant challenges to biodiversity, ecosystem services, and food production. The Bioagricorridors strategy addresses this by integrating agroecology in the urban environment, emphasising the continuity principle to connect diverse ecosystems through green infrastructure. Employing a mapping strategy, bioagricorridors bridge theory and space, using maps as communication tools and deep mapping to explore multi-layered, digital cartographic representations. This approach aids in addressing pressing urban conditions, enhancing genetic diversity, and improving soil and water quality. The exploration uses Barcelona as a case study, a city marked by historical urban planning shifts and landscape fragmentation. Taking into account the already existing initiatives like the Poble Nou Superblock and the Barcelona Green Infrastructure and Biodiversity Plan 2020, the bioagricorridors

strategies aimed at implementing partially edible and biodiverse continuous corridors. This urban strategy involves transforming sealed surfaces, incorporating treated wastewater, and introducing livestock to restore degraded land. The synergy between urban agriculture and wastewater systems enhances resilience, positively impacting soil regeneration, and fostering biodiversity. The strategy engages an eco-friendly urban agriculture system, involving residents in design decisions and creating spaces for interaction with nature while addressing local food production needs. Bioagricorridors serve as a spatial exploration, translating abstract issues into specific contexts and facilitating the imagination of better urban conditions. It also pays attention to incoming challenges, such as infrastructure requirements and potential societal concerns and conflicts, requiring further development for a plausible future. The Bioagricorridors strategy represents a holistic approach to address global trends in environmentally negative practices, biodiversity loss, and climate change through innovative urban interventions.

Keywords: Urban Agroecology, Multispecies Design, Mapping Urban Transition, Living with Nature

1. Introduction

Agriculture dominated the landscape surrounding the medieval city of Barcelona for over 18 centuries until Ildefons Cerdà designed the new expansion plan in 1854 (Aibar & Bijker, 2017; Ajuntament de Barcelona, 2017, p. 15; MUHBA, n.d.). The city's increasing population and several health issues related to the city's high density forced it to expand its borders far beyond its medieval walls at the expense of the remaining natural area and the agricultural fields (Aibar & Bijker, 2017). An ecological analysis revealed that Barcelona's 18th-century expansions forced the surrounding natural ecosystems into isolated spots, resulting in what is defined today as 'landscape fragmentation' (Ajuntament de Barcelona, 2020a, p. 12).

Cerdà's planning proposal adopted the hygiene theories of the period, resulting in an urban expansion that prioritised natural ventilation, sunlight and large green spaces to enhance life quality (Aibar & Bijker, 2017; Ajuntament de Barcelona, 2017, p. 15). Subsequently, the over-building and over-sealing of Barcelona due to housing speculation, corruption and prioritising cars demolished a significant percentage of the innovative concepts applied to the original design proposal of Ildefons Cerdà (Aibar & Bijker, 2017; Sabaté, 2009, p. 68). Present-day Barcelona has steadily increased the distance of the imported food and goods (Ajuntament de Barcelona, 2020b). Local food production could significantly reduce this dependence, considering that only about 10% of the whole food consumed in Barcelona is locally produced. Furthermore, having a local source of healthy and sustainable products could help reduce the prevalence of health issues, such as the high rates of childhood obesity in the city (Ajuntament de Barcelona, 2020b).

Facing these problems, the city council understood the importance of the concepts described by Ildefons Cerdà, and it has begun to promote an urban transition to limit traffic, favouring vegetation and people's well-being (Ajuntament de Barcelona, 2017, p. 15). For example, in 1987, the director of the Urban Ecology of Barcelona, Salvador Rueda, began work on a plan for urban renovation that included the realisation of about 500 superblocks – which turn streets into pedestrian areas – wherein the newly reconverted space hosts a variety of social areas and activities that can enhance social value and life quality (*La rivoluzione urbanistica di Barcellona*, 2019; Rueda, 2016).

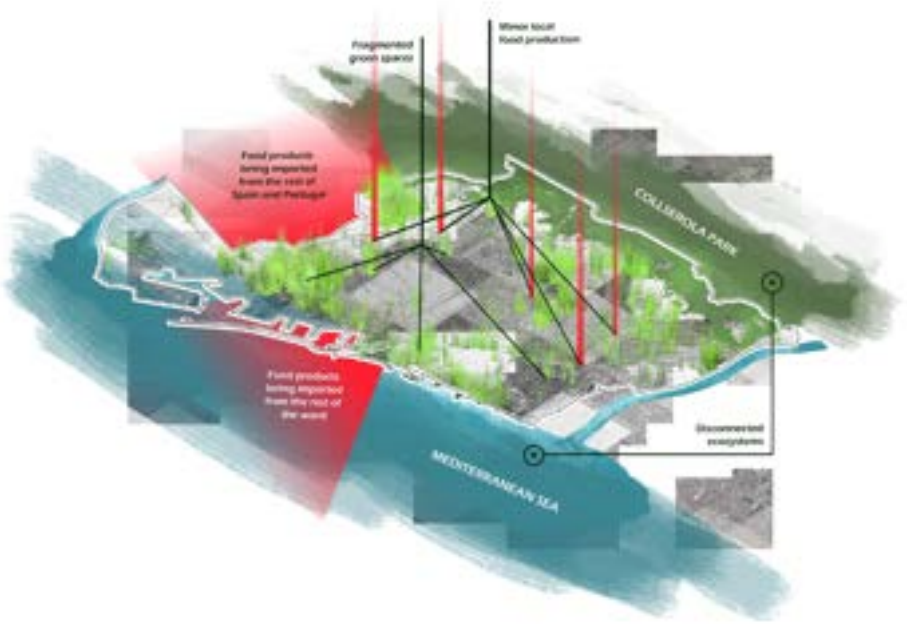
In 2015, the Barcelona city council developed the 'Poble Nou Superblock' project. However, this rapid intervention resulted in inadequate information and collaboration among the residents of the area, who experienced radical changes in their neighbourhood on an almost daily basis (*La rivoluzione urbanistica di Barcellona*, 2019; D. Roberts, 2019). Consequently, many people living in the area criticised and rejected this project, forcing the city council to slow down the timing of the intervention and adapt the project to the social scale (*La rivoluzione urbanistica di Barcellona*,

2019; D. Roberts, 2019). Despite these initial issues, currently, none of the residents of Poble Nou would like to go back to the previous situation; thus, this intervention can be considered an example of contemporary urbanism transition (*La rivoluzione urbanistica di Barcellona*, 2019; D. Roberts, 2019).

In a similar way, the more recent Barcelona Green Infrastructure and Biodiversity Plan 2020 aims to encourage interaction between citizens and nature towards improving the city's green infrastructure by adopting the concept of ecological connectivity (Ajuntament de Barcelona, 2020a, p. 63). This plan should enhance both the natural and urban environment of the city while halting biodiversity loss and improving life quality (Ajuntament de Barcelona, 2020a, p. 63). The generation of an urban « network of urban green corridors » to connect the natural ecosystems in the surrounding Barcelona with the urban biotopes, allowing biodiversity and nature to thrive within the city, is meant to generate a « real, robust and functional network of green infrastructure. » (Ajuntament de Barcelona, 2020a, pp. 63, 66). However, according to the same plan, to be considered a corridor, it must guarantee continuity and not be interrupted by a street at every block (Ajuntament de Barcelona, 2020a, pp. 16, 65). Starting from this briefly explained context and understanding this spatial dilemma, bioagricorridors propose a series of strategies to implement partially edible and biodiverse continuous corridors in the city.

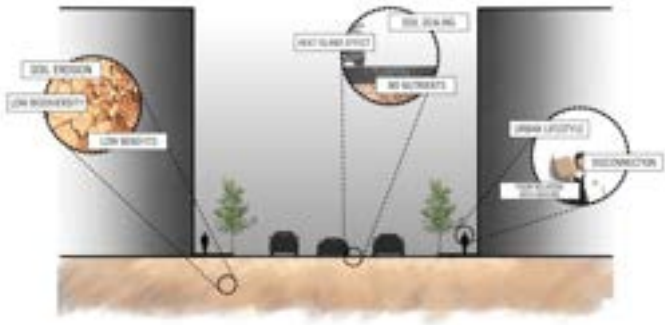
2. Remapping urban food production

Currently, on the city scale, seminatural areas around the city are disconnected, the local food production is very low and dispersed, and the city's inhabitants have a poor relationship with its food production process. At the street level, the surface is completely sealed, resulting in poor soil quality, reducing its capacity to retain and absorb water and nutrients needed to sustain life under the ground. In addition, the city's limited number of trees and the high concentration of cars negatively impact air quality (Fig. 1). All these factors contribute to the city's high temperatures and pollution levels. From this understanding, the use of bioagricorridors offers the possibility of connecting various ecosystems.



In Barcelona, about 60% of streets are devoted to cars (Bausells, 2016), even though 80% of citizens do not possess a private vehicle and elect alternative modes of transportation (Bausells, 2016). Therefore, the first step of the street transition will be the removal of sealed surfaces to extend planted areas. However, since the surfaces have been covered for a long time, it is expected to be highly damaged and difficult to restore (European Environment Agency, 2019, p. 8; IPBES, 2019) (Fig. 2). Incorporating treated wastewater into the system could play an important role in this restoration process and could be crucial to ensuring resilience against future uncertainty and extreme heat events. Moreover, combining urban agriculture and wastewater systems can result in remarkable synergy – it can solve problems relating to sewage runoff and extreme storms while restoring the urban water cycle (Brown *et al.*, 2016, p. 15). At the same time, biosolids can be extracted from the treatment process as a natural fertiliser and improve the soil organic matter. Lastly, restoring the urban hydrological cycle can result in positive benefits for sustaining and attracting biodiversity in the cities (B.M. Gawlik *et al.*, 2017; Brown *et al.*, 2016, p. 100).

Fig. 1: Mapping of the current general situation in Barcelona. Image by the authors.



To complement this process, the bioagricorridors strategy considers temporarily incorporating livestock into the corridors. Besides helping to restore degraded land, animals in the city could contribute to the social acceptance of biodiversity. This experiment can provide enough data to understand whether a future coexistence could be possible. Moreover, cities are high-biomass producers that can also be combined to accelerate the soil regeneration process (Brown *et al.*, 2016, p. 153). Therefore, it will be essential to regenerate the city's soil layer before starting to seed (Fig. 3). Furthermore, an agricultural intervention is necessary to ensure the longevity and resilience of the system.

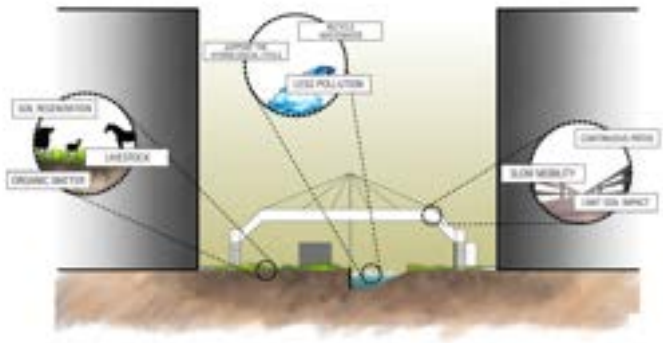
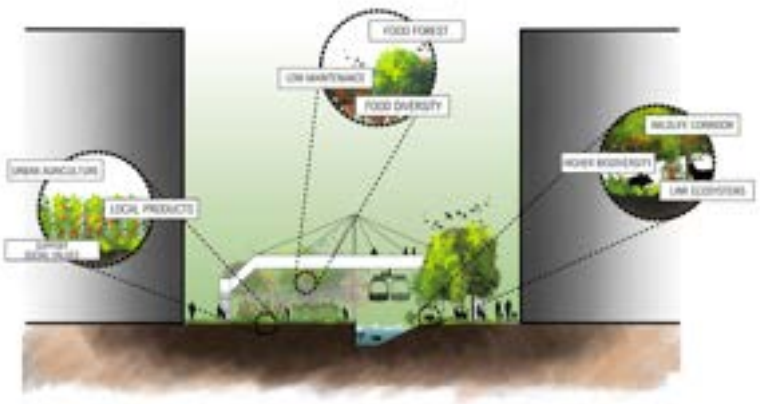


Fig. 2: Transversal mapping of the current typical situation in Barcelona streets. Image by the authors.

Fig. 3: Transversal mapping of the bioagricorridors' initial transformation. Image by the authors.

The next step in the bioagricorridor strategy would be to develop an eco-friendly urban agriculture system in which residents benefit from local waste and water while permitting inhabitants to interact with nature and learn from it. This would include

food forest areas and an edible infrastructure with a relatively low management need. The size of these areas depends on the interests of the local neighbourhood in participating in the agricultural system. Therefore, citizens must be involved in the design. In addition, the high potential of agroecosystems to attract and sustain a wide range of biodiversity can substantially tackle the loss of species (Brown *et al.*, 2016, p. 237). At the same time, their synergies within the agricultural field enhance food production (Food and Agriculture Organization of the United Nations, n.d.). The urban agroecosystem network will generate remarkable spaces for people to interact with nature. Urban biodiversity can represent the only interaction citizens have with nature in some areas (Ajuntament de Barcelona, 2020a). Moreover, local food production can limit the exploitation of the wild environment and meet cities' rising demand for food (Brown *et al.*, 2016, p. 238) (Fig. 4).



Depending on its conditions and needs, some streets would be more focused on food production, while others would have wilder habitats. These areas would always occupy a maximum of 60% of the street to maintain the current liability of the spaces. Considering that 60% of the area is currently occupied by cars, it is important that paved pedestrian areas still be maintained. Together, these actions would result in the creation of networks of green spaces for socialisation and relaxation (Fig. 5).

Fig. 4: Transversal mapping of the bio-agricorridors possible results. Image by the authors.

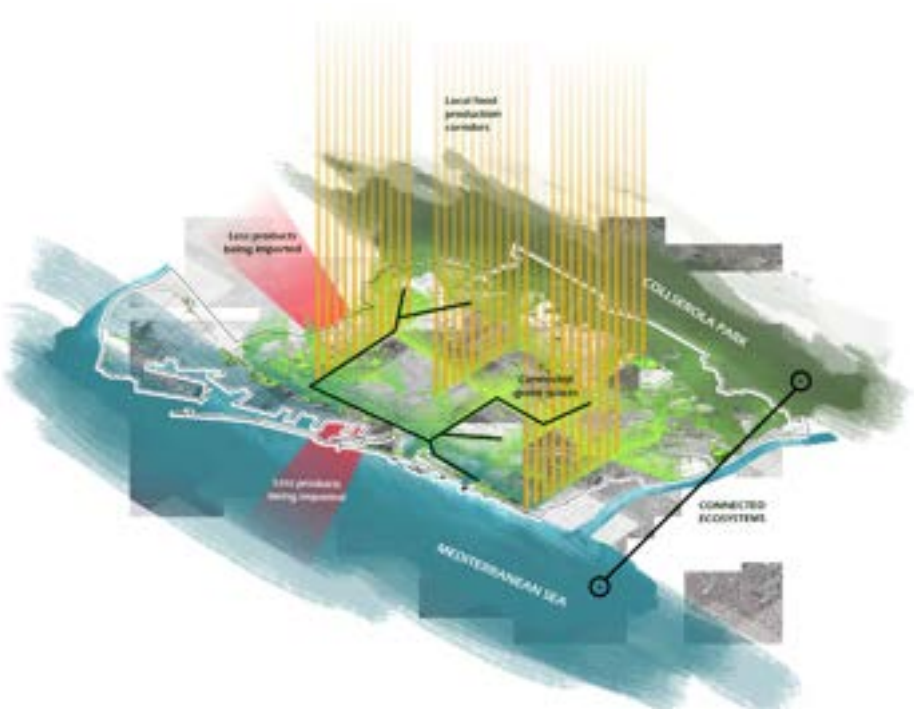


Fig. 5: Mapping of the bioagricorridors possible results for the city of Barcelona. Image by the authors.

3. Spatial laboratory

Environmentally detrimental food production practices, biodiversity loss and climate change are some of the global trends that have accelerated in recent years. Certain actions necessary for facing these issues should focus on urban areas, where – directly or indirectly – most environmental degradation is generated. Particularly, urban food production could play a key role among the very complex factors that need to be considered to improve our chances of reversing these trends. However, these massive global problems are very hard to understand within the context of our daily lives. This is where mapping plays a central role in understanding multi-layered realities, translating abstract issues to specific contexts and communicating ideas and possible scenarios. The bioagricorridor strategy is an exploration that helps improve our understanding of some of the problems that society is currently facing and the solutions that are being discussed. This begins through an understanding of the geographic space that allows for the inclusion of locations, dimensions and distances in

the facts that are being discussed. In other words, the strategy allows the translation of abstract topics to specific definitions, such as from 'disconnected ecosystems' to locate them around the city and considering their possible relations, from the 'construction of green corridors' to test and define specific places that could be changed, and from 'favouring local food production' to calculating areas of intervention and an intervention methodology. How can we identify ecosystem disconnection? What are the factors involved in street restoration? Is a list of characteristics sufficient for a definition? Many of the considerations that could build some answer seem to be related to the spatial dimension, which is necessary to move from multigovernmental documents and reports to laboratories for experimenting and adapting these initiatives. Maps not only serve as tools to understand the current conditions but facilitate the imagination and possibly the creation of better conditions.

The interventions in Poble Nou and the Barcelona Green Infrastructure and Biodiversity plan 2020 are good examples of how complex it is to adapt, develop and finally build solutions that could make cities a better place. In the same way, strategies such as bioagricorridors would most probably require a huge investment with hard-to-calculate returns. Asphalted streets would be needed for vehicles, such as emergency vehicles, to circulate, which means that a different or complementary mobility system would be required. The direct relation with animals, insects and diverse plant species could represent problems such as allergies to an important sector of the population. In other words, further development is needed to translate these ideas into a more plausible future.

Throughout history, continuous efforts have been made to improve representation techniques to achieve increasingly precise maps and to contribute to the understanding of the existing world (Lachmund, 2004, p. 220). More recently, however, maps have also been intensively used as instruments to analyse information thanks to their visualisation capabilities (Trochim & McLinden, 2017, p. 169). The development of the bioagricorridors strategy is another example of the utilisation of these

visualisation capabilities, configuring a methodology to face different circumstances while attempting to maintain an integrated understanding.
The following steps of this research are aimed towards investigating ways to encourage inhabitants to approve and become involved in larger-scale local food production processes, including more diverse and sustainable natural urban habitats. Among other efforts that are currently being developed in this direction, a graduate studio course titled 'Live Corridors' runs annually and allows students to explore green corridors and identify key interventions needed to support their communities. At the same time, new cases in Louisiana (US) and Lugano (Switzerland) have been explored by the researchers to establish relations with different local organisations, discuss this approach and gather feedback to refine further and develop it.

Biographies

Fabio Capra-Ribeiro received his BA and his MSc from the Universidad Central de Venezuela, his Double Degree Master of Education from SUMMA University (US) and from Instituto Europeo de Postgrado (Spain), and his PhD in Urbanism from Università IUAV di Venezia (Italy). His research focuses on social, spatial, and environmental justice, with emphasis on boundary conditions and residual spaces. He taught at the Universidad Central de Venezuela for ten years where became Associate Professor and Director of the School of Architecture. Currently, he is an Assistant Professor at Louisiana State University where he recently founded the Caribbean Spatial Justice Lab. Author of the book 'Uncertain Regional Urbanism in Venezuela. Government, Infrastructure and Environment'.

Filippo Vegezzi is an architect and researcher working on the intersection of ecology and architecture. His work places a significant emphasis on the integration of wildlife and habitats into urban environments, with keen attention to addressing issues related to social acceptance and attitudes toward the ecological transition. After completing his architectural studies in Switzer-

land, Filippo gained diverse professional experiences worldwide, including in Australia and Colombia. Following his specialisation in ecological architecture in Barcelona, in 2020, he co-founded Coharc Studio in Madrid. The studio is dedicated to creating immersive natural experiences within the built environment through innovative architectural design, developing cohesive and effective strategies aimed at conserving and promoting biodiversity and natural resources.

references

+ Aibar, E., & Bijker, W. (2017). Constructing a City: The Cerda Plan for the Extension of Barcelona. *Undefined*. https://www.semanticscholar.org/paper/Constructing-a-City%3A-The-Cerda-Plan-for-the-of-Aibar-Bijker/3ad6f178c2a468dd7bc15e13c65beb8af8369120
+ Ajuntament de Barcelona. (2017). *Trees for. life: Master Plan for Barcelona's Trees 2017-2037*.
+ Ajuntament de Barcelona. (2020a). *Barcelona green infrastructure and biodiversity plan 2020*.
+ Ajuntament de Barcelona. (2020b). *Climate emergency declaration*.
+ Bausells, M. (2016). *Superblocks to the rescue: Barcelona's plan to give streets back to residents*. https://www.theguardian.com/cities/2016/may/17/superblocks-rescue-barcelona- spain-plan-give-streets-back-residents.
+ B.M. Gawlik, P.Easton, S. Koop, K. Van Leeuwen, & R. Elelman. (2017). *Urban water atlas for Europe*. European Commission – DG XVI.
+ Brown, S., Hodges Snyder, E., & McIvor, K. (Eds.). (2016). *Sowing Seeds in the City: Ecosystem and Municipal Services* (1st ed.). Springer Netherlands: Imprint: Springer. https://doi.org/10.1007/978-94-017-7453-6.
+ Castro, J., Ostoić, S.K., Cariñanos, P., Fini, A., & Sitzia, T. (2018). 'Edible' urban forests as part of inclusive, sustainable cities. *Unasylva. Forest and Sustainable Cities*, 69(250), pp. 59–65.
+ Depietri, Y. (n.d.). *Ecosystem services in practice: Well-being and vulnerability of two European urban areas*. United Nations University Institute for Environment and Human Security. Retrieved July 24, 2022, from https://collections.unu.edu/view/UNU:2848.
+ Dobbs, C., Eleuterio, A., Amaya, J., Montoya, J., Kendal, D., & others. (2018). The benefits of urban and peri-urban forestry. *Unasylva*, 69(250), pp. 22-29.

+ Earley-Spadoni, T. (2017). Spatial History, deep mapping and digital storytelling: Archaeology's future imagined through an engagement with the Digital Humanities. *Journal of Archaeological Science*, 84, pp. 95–102. https://doi.org/10.1016/j.jas.2017.05.003.
+ European Environment Agency. (2019). *Land and soil in Europe: Why we need to use these vital and finite resources sustainably*. Publications Office of the European Union. https://data.europa.eu/doi/10.2800/779710.
+ Food and Agriculture Organization of the United Nations. (n.d.). Protecting ecosystem services and biodiversity: FAO's mission and solutions. Ecosystem Services & Biodiversity (ESB). Retrieved July 24, 2022, from http://www.fao.org/ecosystem-services-biodiversity/background/en/.
+ Harris, T.M., Corrigan, J., & Bodenhamer, D.J. (2015). Conclusion. In T.M. Harris, J. Corrigan, & D.J. Bodenhamer (Eds.), Deep Maps and Spatial Narrratives, Indiana University Press, pp. 223–234; JSTOR. https://doi.org/10.2307/j.ctt1zxxzr2.14.
+ IPBES. (2019). IPBES Global Assessment Summary for Policymakers.
+ La rivoluzione urbanistica di Barcellona. (2019, June 2). Il Post. https://www.ilpost.it/2019/06/02/barcellona-superilla/.
+ Lachmund, J. (2004). Mapping as a cultural practice. In H.J. Rheinberger & J.P. Gaudillière (Eds.), Classical Genetic Research and its Legacy. The mapping cultures of twentieth-century genetics, Routledge, p. 220.
+ MUHBA. (n.d.). Carta Històrica de Barcelona. Carta Històrica de Barcelona. Retrieved July 24, 2020, from http://ajuntament.barcelona.cat/museuhistoria/cartahistorica.
+ Roberts, D. (2019, April 9). Barcelona wants to build 500 superblocks. Here's what it learned from the first ones. Vox. https://www.vox.com/energy-and-environment/2019/4/9/18273894/barcelona-urban-planning-superblocks-poblenou.
+ Roberts, L. (2016). Deep Mapping and Spatial Anthropology. Humanities, 5(1), Article 1. https://doi.org/10.3390/h5010005.
+ Rueda, S. (2016). La supermanzana, nueva célula urbana para la construcción de un nuevo modelo funcional y urbanístico de Barcelona. BCN Ecologia.
+ Sabaté, J. (2009). La razón en la ciudad: El Plan Cerdá. 76, pp. 67–70.
+ Trochim, W.M., & McLinden, D. (2017). Introduction to a special issue on concept mapping. Evaluation and Program Planning, 60, pp. 166–175. https://doi.org/10.1016/j.evalprogplan.2016.10.006.
+ Warf, B. (2015). Deep mapping and Neography. In D.J. Bodenhamer, J. Corrigan, & T.M. Harris (Eds.), Deep Maps and Spatial Narrratives, Indiana University Press, pp. 134–149; JSTOR. https://doi.org/10.2307/j.ctt1zxxzr2.10.

note

[1] Capra-Ribeiro Fabio – ORCID ID: 0000-0003-0230-7287, fribeiro@lsu.edu, School of Architecture – Louisiana State University
[2] Vegezzi Filippo – ORCID ID: 0000-0002-1250-9520, vegezzi.filippo@gmail.com, Department of Environment Constructions and Design – University of Applied Sciences and Arts of Southern Switzerland: Mendrisio

CHAPTER 4
CONCLUSIONS

Francesca Mosca, Gabriele Oneto

The various approaches outlined within this volume demonstrate how the theme of urban complexity and the need to define methodologies for resource, risk, and heritage management are more crucial than ever and are at the forefront of scientific debate. It firmly confirms the close relationship between the environmental, social, and economic context in which interventions take place, emphasizing the importance of planning, design, and management approaches that are as holistic as possible. Building upon this general commentary, several crucial points can be identified on which both design practice and scientific research should focus: the figure of the designer has always stood halfway between technique and art, method, and interpretation. In the context of urban resilience, this peculiar position is in fact a multifaceted role, expressing a multitude of careful and oriented approaches for conserving and safeguarding cities. This role is of course of paramount importance as of today. straddling the realms of technical expertise and artistic creativity. Their work involves translating abstract ideas into tangible forms, balancing functionality with aesthetics. In the context of urban resilience,

this dual role becomes even more critical, as this trade-off often means the success or failure of a design solution. On one hand, the designer has technical knowledge of what is necessary to do in order to adapt to a critical scenario. On the other, the same designer has to accommodate for inclusion, acceptability, quality of space, and other sensible features that escapes the straight realm of functionalism. But urban resilience is not just about physical infrastructure: it's deeply intertwined with socio-cultural factors. Designers must recognize the unique needs, values, and aspirations of diverse communities. For example, a resilient housing project should align with the cultural preferences and lifestyles of its residents. Sensitivity to local customs and traditions ensures better adoption and longevity of interventions.

Other times, designers can spring this dualism leveraging on data-informed solutions. Designers today have access to a wealth of tangible data related to urban environments, ranging from climate patterns and infrastructure performance to social dynamics. They can leverage this information to propose resilient design solutions. For instance, understanding flood-prone areas based on historical data allows designers to create flood-resistant buildings or implement green infrastructure to absorb excess water. Of course, this role has deep implications: producing artifacts with the primary objective of coping against a negative effect on a city environment poses critical ethical responsibilities. Therefore, design decisions have far-reaching consequences. Urban resilience demands that designers consider not only immediate impacts but also long-term effects. When designing public spaces, for example, they must weigh the trade-offs between short-term convenience and long-term sustainability. For instance, choosing resilient materials for sidewalks or parks ensures durability and minimizes maintenance costs.

Finally, the ethical role of designers can be expanded to promotion of importance and urgency. As the knowledgeable part in the discussion, designers can serve as advocates for resilience. They can disseminate knowledge about the significance of resilient design interventions. Through public engagement, educational campaigns, and community workshops, designers can raise

awareness about the urgent need for resilient urban planning. This includes addressing climate change, natural disasters, and social equity. Now we can understand why some practitioners are called 'teacher', as this position poses designers as educators by example. Their projects become teaching tools for the broader community, and can greatly influence both experts and common people, sometimes producing true manifestos. By showcasing successful resilient designs – whether it's a green roof, a flood-resistant park, or a pedestrian-friendly street - designers inspire others and encourage replication.

The true success of design strategies for urban resilience, such as those listed within this volume, is determined by the crucial role of various cultural backgrounds and expertise involved in their definition. Given the complexity level in which cities worldwide find themselves today, it would be limiting to think that a single professional could have an overview and propose effective solutions regarding the considered issues. In this regard, the promotion of professional and research approaches aimed at interdisciplinarity and multidisciplinary is crucial to ensure accurate and effective management of problems and the promotion of adequate solutions. From a practical standpoint, among the profiles most considered useful in supporting resilient design, certainly emerge profiles from scientific backgrounds such as physicists, climate experts, as well as urban ecologists, supplemented by experts in sustainable economic development and evaluation of the social conditions of a specific intervention site.

In connection with the theme of urban complexity that has been the guiding thread throughout the entire volume, another fundamental aspect highlighted by the research presented is the sense of responsibility that designers have towards the environments they design. The excessive use of resources, as well as the disregard for the impacts that each intervention can have on the environment and its balance, which have characterized the activity of designers for too many years, even centuries, have been among the main causes of the environmental issues that today's population and future generations are forced to face. It is therefore evident that, now more than ever, designers can and must take

action to increase the resilience of ecosystems, starting with urban ones, to ensure a reversal of trends, promoting not only greater adaptability of systems to climate and environmental changes but also a reduction of their causes.
Finally, as highlighted in the previous sections, aiming at designing resilience requires a holistic perspective on the topic, by considering in parallel environmental, but also social, and economic aspects. Within these three broad categories, numerous research areas worthy of attention can be identified. It can also be observed that, in most cases, certain areas that are primarily explored in relation to one aspect (for example, the environmental aspect) actually have a very close relationship with other areas. An example that is already widely studied but still the subject of research is the phenomenon of the urban heat island, which is mainly analysed from an environmental perspective. However, it raises significant social issues related to the level of risk for the population and the socio-economic categories of the exposed population, as well as from a health perspective, which indirectly affects the economic system of the area of interest. Many other examples could be listed, and possible new research areas identified, and this is precisely the purpose of this volume. This book set the ground for future research on the definition of more efficient and comprehensive design solutions for more resilient, adaptive, and livable cities.

Collana ***ADDDOCS Documents***

1. *ADD. PhD Program in Architecture & Design*, a cura di Raffaella Fagnoni, Giovanni Galli, Manuel Gausa Navarro, 2019; ISBN 978-88-94943-90-0, e-ISBN (pdf) 978-88-94943-91-7.
2. *Draw the Map. La mappatura come strumento di sperimentazione indisciplinato*, a cura di Giovanni Amadu, Linda Buondonno, Daniele Rossi, Simone Setzi, 2025; e-ISBN (pdf) 978-88-3618-313-5.
3. *Designing Resilience. Strategies for the sustainable development and understanding of urban complexity*, a cura di Francesca Mosca, Gabriele Oneto, 2025; e-ISBN (pdf) 978-88-3618-337-1.

Francesca Mosca, architect and Post-Doc at the Department of Architecture and Design of UNIGE. Obtained the EU PhD label in Architecture cum Laude. She was visiting researcher at the Technical University of Munich, and she contributed to National and International research projects. Her research focuses on nature-based solutions for climate change adaptation to improve urban environmental conditions.

Gabriele Oneto, PhD student at the Department of Architecture and Design of UNIGE, holding a PNRR PhD research grant. He visited the Technical University of Munich (Germany) and at CIMA Foundation (Italy), contributing to International and National research projects. His research interests range from urban form and spatial analysis, landscape and urban ecology, and applied machine learning.

The European Union defines resilience as the ability to withstand and undergo transitions in a sustainable, fair and democratic way. For an urban system, resilience represents the ability to adapt and transform in response to stress while maintaining its essential functions and identities. The designer is therefore called to guide this movement, conducting innovative analyses and validating and experimenting with new ways of designing cities. Designing resilience involves adopting a holistic and systemic approach that considers the interdependencies and interactions between different urban components. Only by addressing urban habitats in their entirety can designers truly understand the changing kinetics of cities and their populations.

e-ISBN: 978-88-3618-337-1