Lecture Notes in Networks and Systems 639

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New Metropolitan Perspectives

Transition with Resilience for Evolutionary Development

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Contents

Transformative Urban Regeneration: Two Paradigmatic Examples in Boston and Paris

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Abstract. Cities play a fundamental role in the global challenge of climate change, but in most cases financial obstacles and lack of skilled human resources restrain the development of transformative actions. The recovery from Covid-19 pandemics brings a new stimulus for urban sustainable transitions, allocating a large amount of monetary resources for urban regeneration initiatives connected with the SDGs and the Green Deals objectives. Indeed urban regeneration emerges as a key mechanism to address both post-pandemics recovery and climate challenges, facilitating the implementation of urban mitigation and adaptation measures. District-scale projects can become enablers of city-wide sustainable transition, allowing the experimentation of innovative technical solutions to activate multi-systemic transformations. A large literature has been produced over the last 20 years over the topics of Urban Resilience and Sustainable Transition. Nevertheless a multi-sectoral approach to district-scale transformations is just emerging and needs to be integrated through evidences from best practices. This paper aims to identify a portfolio of measures able to transform existing neighborhoods into zero-carbon and climate-resilient systems. With this purpose, two case studies have been explored as paradigmatic examples of sustainable district redevelopment, and namely the Clichy-Batignolles eco-district (Paris) and the Talbot-Norfolk Triangle Eco-Innovation District (Boston).

Keywords: Urban Regeneration · Sustainability Transition · Urban Resilience

1 Introduction

The role of cities in the global challenge of achieving a climate-proof post-carbon society is well discussed by scientists and international policy-makers. Consuming over two-thirds of global energy and leading a large part of global carbon emissions, cities are considered as one of the main drivers of climate change [1]. At the same time, as urban areas have also traditionally been the centers of economic growth and innovation, cities are also regarded as a "powerful lever" for sustainable transitions, especially referring to the capacity of activating innovative public policies and smart transformations of the built environment [2, 3]. Nevertheless, as most of the world population is concentrated in

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urban areas and most of cities present aging and inefficient infrastructural systems, cities are also particularly vulnerable to the effects of climate change. Climate-related extreme events hit urban areas with increasing frequency and intensity, periodically putting urban infrastructures in crisis and compromising urban functions with cascade effects involving different interconnected sectors. The morphology of urban built environment has significant implications on the local/global climate alterations, and cities' response to extreme events varies according to the context and its resilience capacity. However negative impacts can be reduced through strategic urban planning and design, and new tools and instruments are emerging in urban planning for addressing solutions to enhance urban resilience and manage urban transition toward climate-neutrality (e.g. Resilience Strategies and Transition Management). The UN Agenda 2030 emphasizes the importance of activating urban transformations in order to "Make cities and human settlement inclusive, safe, resilient and sustainable" (SDG11) [4]. New transformative development pathways are gaining momentum, integrating SDGs with climate mitigation and adaptation objectives. Such transformations regard not just the built environment, but the whole asset of urban systems, implying structural changes on transport, energy, water and land-use regimes, and involving multiple interconnected domains, such as socio-economics, technology, environment, governance and market structures [5]. As today, many cities struggle with financial obstacles and lacks on skilled human resources, undermining the implementation of urban mitigation and adaptation measures. As the objectives of pandemic recover have been aligned with Green Deal targets, new economic opportunities are opening up for cities, with significant monetary resources allocated for supporting urban regeneration initiatives [6]. In this context, the mechanism of urban regeneration emerges as a key tool for addressing both the post-pandemic recovery and urban climate challenges. In this regard, the scale of district is widely considered by experts and practitioners as a "sweet spot" for activating urban transition, providing the opportunity to experiment and implement different innovative solutions, which could possibly be replicated in other parts of the city [7]. A large literature has been produced around the topic of Urban Sustainable Transition, with enormous improvement in the field of technological innovations, and a fast-growing body of work on socio-technical and socio-ecological transformations. Nevertheless the gap between research findings and their effective applications to urban realities still persists, and many international institutions call for further research efforts to discover successful practices to learn, replicate and scale up in accordance with different contexts: "The necessity for inter and transdisciplinary co-create knowledge to support urban transitions has been widely recognized by city and municipality networks and the R&I community, e.g. in: IPCC (2019) Global Research and Action Agenda on Cities and Climate Change Science; JPI Urban Europe (2019) Strategic Research and Innovation Agenda 2.0; ICLEI (2018) The ICLEI Montréal Commitment and Strategic Vision 2018–2024; United Cities and Local Government (2019) The Durban Political Declaration" [8].

Basing on these assumptions, the paper explores the mechanism of urban regeneration intended as a catalyst of urban transformative changes toward climate resilience and sustainable transition. The aim is to identify a portfolio of measures for transforming existing cities through district-based interventions oriented to low-carbon transition. For this purpose, two case studies have been analyzed as paradigmatic examples of district

sustainable redevelopment, and namely the Clichy-Batignolles eco-districts in Paris and the Talbot-Norfolk Triangle Eco-Innovation District in Boston. The paper is structured into two main pain parts: in the first paragraphs a literature review has been provided for framing the emerging paradigms in the field of Urban Transition, emphasizing the role of district-scale transformations in the process of urban decarbonization; the second part of the paper provides the case study analysis. The two case studies have been investigated through the framework proposed by the EU DUT partnership (Driving Urban Transition) [8], simplifying urban complexity through the interconnectedness of three main transition sectors (energy, mobility and circularity). Each case study provided a set of measures for district transformations, mutually contributing to activate urban transition through the models of 'Positive Energy Districts', 'Circular Urban Regenerative Economy' and '15 min cities'. The research results highlight the importance of addressing urban regeneration initiatives through strategic urban planning processes, based on multi-scalar policies and multi-systemic approaches, and built upon strong participatory co-design processes.

2 Literature Review

2.1 The Role of Cities in the Global Challenge of Climate Change

Climate Change has been long discussed in both the academic and political environments, with a broad production of scientific literature stating the correlation between human enterprises, greenhouse gas emissions, and global warming. Elaborated in 2004 by the professor Will Steffen and his staff, the *Great Acceleration* graphs show "the holistic, comprehensive and interlinked nature" of major global changes simultaneously occurring across the socio-economic and the biophysical spheres since the 1950s [9]. One of the most significant trends emerging from the graphs regards the rapid rate of urbanization, strongly connected to a drastic rise on global GDP, from the one side, and relevant increases in terms of energy use and resources depletion, from the other. These trends parallel closely other alarming changes interesting the environmental parameters (e.g. the atmospheric composition, the water cycles, the marine and terrestrial ecosystems, and the world surface temperature), demonstrating a temporal correlation between the two phenomena, but not proving a cause-effects relation (Fig. 1). However the *Great Acceleration* graphs early became the manifesto of the Anthropocene, emphasizing the rapidity of the "collision course" occurring between human activities and the Planet Earth [10]. Several other terms have been coined over the last two centuries to describe the role of humans in the dramatic changes affecting the Earth System (the Anthropozoic era by Stoppani, 1873; Psychozoic era by Le Conte, 1877; Technocene by Ter Stepanian, 1988; Anthrocene by Revkin, 1992; Homogenocene by Samways 1999; Capitalocene by Moore, 2014; Chthulucene by Haraway, 2014, etc.). Some of them explicitly refer to urban areas as primary drivers of the current unsustainable trends triggering global warming and climate change (e.g. Urbicene by Swyngedouw, 2017; Urbanocene by Wes, 2017). In effect, if in terms of size cities cover only the 2% of the world landmass, in terms of climate impacts they have a considerable footprint, consuming over two-thirds of the world's energy and producing more than 70% of global CO2 emissions, primarily through the consumption of fossil fuel for building and transportation [3]. Particularly

significant is the contribution of large cities, where the extent of build environment, the high population density and the large amount of businesses have a pronounced impact on the local and regional energy balance, as well as on resource depletion and waste production [11].

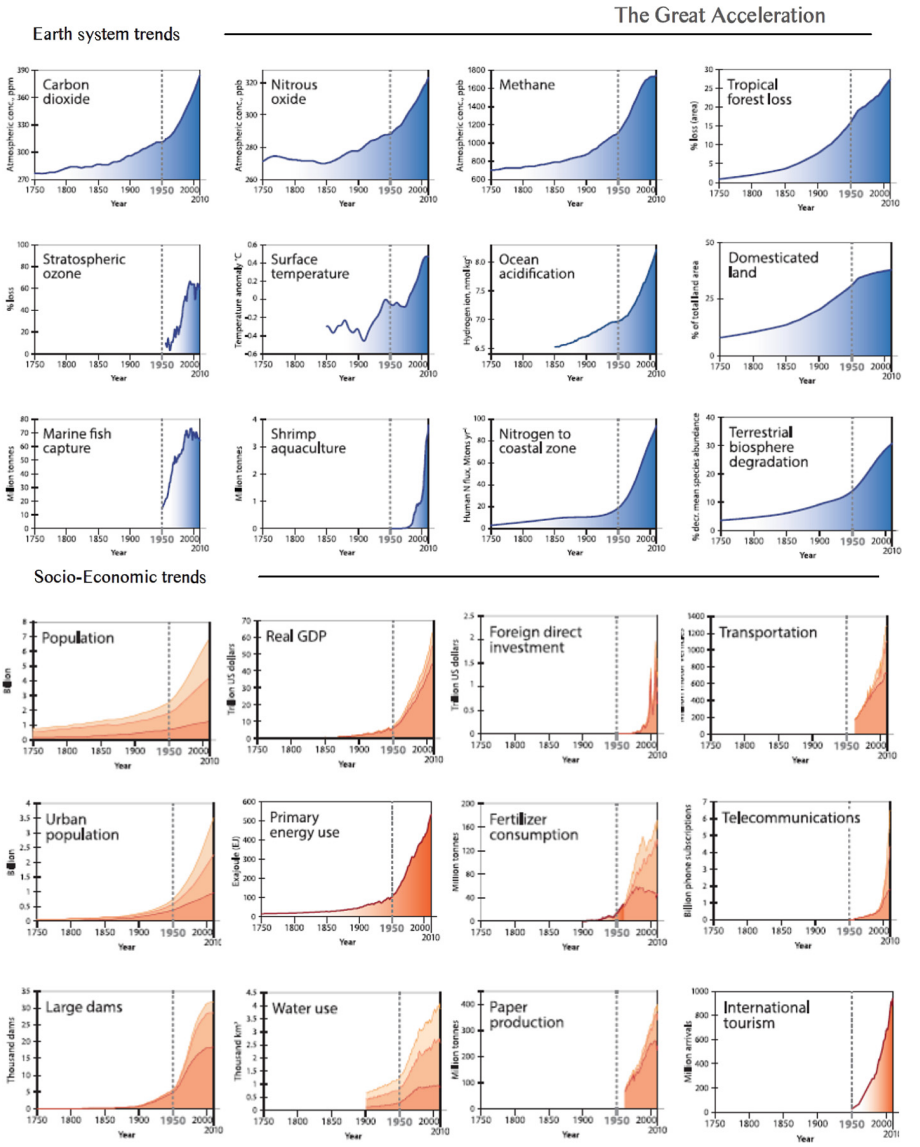

Fig. 1. The Great Acceleration: Trend over time (1750–2010) of Earth System parameters and Socio-Economic human activities [9]

Urban greenhouse gas emissions (GHG) reflect the structure of a city and its urban metabolism, including resources use, energy sources, and resident's lifestyle [12]. Inadequate spatial organization, inefficient services, declining infrastructures, lacking on transport system, and citizens' car-dependent life-styles intensify urban GHG emissions and air pollution, leading as well major impacts related to climate-related extreme events.

At the same time, cities are particularly exposed to the negative effects of climate change. The Intergovernmental Panel on Climate Change (AR5, 2014) assessed that "much of key and emerging global climate risks are concentrated in urban areas" [13]. Indeed, cities of all sizes, economic conditions, and site characteristics are already experiencing the stressor effects of climate-related extreme events: phenomena as heat waves, droughts, heavy precipitations, flash floods, hurricanes and snow storms are becoming more and more frequent in urban areas, constantly putting urban infrastructures in crisis and threating people health and well-living [13]. Factors as density, urban morphology, quality of the built environment, and services efficiency can influence the local impacts of climate change. Urban morphology and building materials properties can also exacerbate local weather, altering surface air temperature and ventilation and creating localized warming phenomena known as 'urban heat islands' (UHI) [14]. Moreover, socio-economic inequalities and spatial segregation of low-income citizens even worsen the risks connected with climate-related extreme events, intensifying the risk-exposure of the most vulnerable population [15]. Future predictions forecast the global urban population to grow more than 70% by 2050 [3] with an increasing percentage of global urban land cover [16]. Business-as-usual approaches to urban development are not adequate to face the challenge of global warming, boosting the unsustainable trends related to land consumption, resources depletion, air pollution, loss of biodiversity, etc., and thus destroying the green infrastructures that help cities to adapt to climate change effects [17]. As stressed by the International Panel of Climate Change (AR5), "action in urban centers is essential to successful address global climate change adaptation" [13], and fundamental transformations are needed not only in the built environment, but also in the economic, social, and political spheres in order to reduce climate risks and vulnerability and contribute to global sustainability.

Grounding on the necessity to "meet the needs and aspirations of the present without compromising the ability to meet those of the future" [18], new climate-oriented development pathways are emerging for cities, taking into account the complex dynamics occurring between climate and socio-economic systems, and combining together the Sustainable Development Goals of the Agenda 2030 [4] with local adaptation and mitigation measures. On one side the concept of Sustainable Urban Development provides "an integrated approach to urbanization based on a holistic view of its social development, economic development, environmental management (at the local, national and global levels) and governance components [that] entails the coordination of objectives and programs among different city stakeholders (e.g., citizens, government and the business sector), as well as the development of linkages between and within socioeconomic sectors and activities" [19]. On the other, mitigation and adaptation concepts respectively address the challenges of "keeping climate change moderate rather than extreme" (namely reducing or cutting anthropogenic GHG emissions in the atmosphere), and "anticipating and

coping with impacts that cannot be avoided" (e.g. strengthening and adapting infrastructural systems and enhancing community resilience) [13]. The integration of adaptation and mitigation measures in urban policies can generate multiple co-benefits for urban development, increasing cities attractiveness by providing the double opportunity to redesign high-quality public spaces while reducing climate risks exposures. Nevertheless, these new climate-resilient pathways require both incremental and transformational changes, involving "significant transformations in economic, social, technological, and political decisions", as well as a strong integrated multi-system approach across the involved sectors [13]. The distinction between incremental and transformational change is important, as the first refers to "extensions of actions and behaviors that already are in place" while the second "includes actions that change the fundamental attributes of a system in response to actual or expected impacts of climate change" [13]. Along the concept of sustainable development, the new climate-oriented approach introduces the concept of transformative capacity, where the term "transformability" overcomes the concept of adaptability ("the capacity to deal with change and stay within a regime"), referring to "the capacity to cross thresholds into new development trajectories" as well to "enable shifts from one regime to another" [13]. Transformations are thus intended as "a change in the fundamental attributes of natural and human systems [that] reflects strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation that supports sustainable development, including poverty reduction" [13].

2.2 Sustainable Transition and Urban Resilience

Since the First World Climate Conference (Geneva, 1979), the necessity of phasing out fossil-fuels dependency in favor of more sustainable development pathways has been at the center of international negotiations, but so far real efforts toward decarbonization have appeared quite inadequate to limit global warming below the Paris Agreement's threshold of 1.5 °C [10]. Despite huge improvements in renewable energy and low-carbon technologies, little progress has been made and still far from sufficient. Indeed, the problem of carbon dependency is so deeply rooted in the global socio-economic system that experts converge in thinking that the 'technological innovation approach' [20] alone does not address the required structural changes [21]. It encompasses not just a shift from one set of fuels to another, but a much complex multi-level and multi-system transformation, involving different actors from the civil society, and entailing major changes also in individual lifestyles. 'Socio-technical transitions' are well discussed in literature, defining systemic changes in the fields of energy, transport, agri-food, and other interrelated systems insisting in technology, policy, markets, consumer practices, infrastructure, culture and scientific knowledge [21–23]. However the lock-in mechanisms occurring in the economic and institutional spheres make it difficult to dislodge existing (unsustainable) systems to activate the structural changes needed for a complete decarbonization [21], and thus radical shifts sound quite difficult to be achieved in a short run. Sustainable transitions toward low-carbon are therefore intended as complex and long-term processes of multi-dimensional macro-changes comprising multiple actors and multi-level approaches. The Transition Management emerges as a new approach to dealing with the complex nature of low-carbon transition. Defined as "a form of intelligent long-term planning through small steps based on learning and experimenting"

[24], the TM framework provides specific practical instruments and methods for developing transition processes through meta-governance approaches, seeking "to overcome the conflicts between long-term imperative and short-term concerns" [25]. Applying the practice of TM to the urban context, climate adaptation actions combined with mitigation co-benefits become "a powerful resource-efficient means to realize sustainable development goals", providing as well opportunities for both incremental and transformative changes toward resilience and sustainability transition [13].

With the rise of the Covid19 crisis, the importance of preventing and being prepared for other future shocks grabbed world leaders' attention to the point of putting urban climate actions, local resilience-building initiatives and zero-carbon transition at the forefront of the US and EU recovery plan discourses and funds allocations. Both the topics of Urban Resilience and Sustainability Transition were already mainstreamed in the academic and political debates, but now more than ever they became mandatory issues to be simultaneously addressed in the logic of a "build back better" post-pandemic recovery. From one side, the Covid19 emergency has been a test-bed for urban resilience, pointing out different context-specific urban responses with a common denominator, which is the aggravation of social vulnerabilities [26]. On the other, as many countries are aligning their recovery plans with the Green Deals' objectives, the Covid19 crisis can become a trigger for new "waves of innovation" and accelerate the process of sustainable transition [27]. According with the 100 Resilient Cities network, enhancing urban resilience means improving "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kind of chronic stresses and acute shocks they experience" [28]. Building upon the evolutionary theories [29] and the adaptive cycles of the panarchic model [30], the concept of urban resilience has significantly evolved over time, shifting from the reactive approach based on the shock therapy and the frameworks of emergency management and post-disaster recovery, to a pro-active approach where communities play a vital role, cultivating preparedness through learning capacity, and seeking potential transformative opportunities through adaptation and innovation [31]. In this perspective, "change" is the key factor: the "bouncing back" paradigm of resilience has transformed into a "bouncing forward" vision [32].Over the last 10 years, around 100 global cities from different countries developed their resilience strategy, with the support of the 100 Resilience Cities network, pioneered by the Rockefeller Foundation [28]. Based on a strong participatory process that involves citizens and stakeholders for the assessment of local stressors and opportunities, resilience strategies emerge as innovative instruments for cities to design new urban visions, and to define resilience-oriented goals, initiatives and actions. The Resilience City Index developed by Arup for the 100RC network, provides a holistic framework that identifies the main drivers (or universal factors) of urban resilience, to helping planners and decision-makers evaluate results and implement resilience practices in synergies with other city-plans. Four main axes have been identified to categorize the urban-resilience drivers, and namely: 1. Leadership & Strategy (effective leadership and management; empowered stakeholders: integrated development planning); 2. Health & Wellbeing (Minimal human vulnerability; Diverse livelihood and employment; Effective safeguards to human health and life); 3. Economy & Society (Sustainable economy; Comprehensive security and rules of low; Collective society and mutual support); 4.

Infrastructure & Ecosystems (Reliable mobility and communication; Effective provision of critical services; Reduced exposure and fragility).

While the resilience-building approach put urban vulnerabilities and risks reduction at the core of the action-design process, transition management strategies define short, medium and long term targets for addressing zero-carbon objectives through integrated actions across different and interconnected urban sectors. As today many leader cities around the world have provided to build their climate action plans, also defining transition-oriented actions and objectives in accordance with national and regional long term targets [2]. Nevertheless, small urban centers face serious difficulties in implementing their local policies with climate measures, due to the lack of financial and human resources which affects the local capacity to act [8]. In many cities the success of such practices is undermined by institutional fragmentation and non-participatory governance structures: incoherence in policies and strategies, uncoordinated planning and decision-making, and lack of shared visions regarding urban transformations lead to ineffective measures and inefficient use of resources [8]. In this context, the role of local governments is crucial, as climate actions have to be integrated into local investments, urban policies and existing regulatory frameworks. Coordinated support from different levels of government, horizontal learning through networks of decision-makers and city experts, the involvement of the private sector for local investments, and the engagement of civil society through participatory processes are all factors that can facilitate the success of urban transition processes [13].

2.3 Transformative Urban Regeneration: District-Scale Transformations for Activating Urban Transition

On December 2021, an Expert Group Meeting had been organized in Bilbao within the UN Human Settlements Programme (UN-Habitat) focusing on how to 'build-back-better' cities after the Covid-19 pandemic. The EU recovery package provides cities with a new economic stimulus to foster sustainable urban transformations, in accordance with the EU Green Deal objectives. Experts from different disciplines agreed in considering Urban Regeneration as "one of the most comprehensive and effective tools that government can adopt to recover from economic crisis, while achieving sustainable and inclusive cities" [33]. As stressed above, the paradigm of sustainable urban transition involves multiple changes across interconnected sectors, and integrated approaches are needed to address synergies and dilemmas emerging from urban complexity. Intended as an "integrated and inclusive process that combines physical, environmental and socio-economic measures" [33], the mechanism of urban regeneration emerges indeed as a key lever for activating the transformative capacity of the city, as it enables urban transformations from district-scale up to city-level, involving city leaders, planners, policymakers, together with civil society, investors and the private sectors to co-design and co-create urban changes. In this context, new paradigms of urban re-development are emerging, encompassing climate objectives with SDGs, and emphasizing the transformative role of urban regeneration initiatives toward the complex objective of carbon neutrality: as spaces for experimenting innovative solutions, local transformations can incrementally change the fundamental attributes of the urban system [34].

Peter Roberts defines Urban Regeneration as a "comprehensive and integrated vision and action which seeks to resolve urban problems and bring about a lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change or offer opportunities for improvement" [35]. Building upon the evidence from the history of urban change, he explored the mechanism of Urban Regeneration in relation to the evolution of urban policies over times, catching the differences among development models, flagships and objectives in relation to the patterns of social values, political attitudes, and economic power of the day. Fixing the period from the early 1990s to 2008 as the 'golden age of regeneration', he argued that the new model of Urban Regeneration "moves beyond the aims, aspirations and achievements" of Urban Revitalization (1960s), Urban Renewal (1970s), Urban Redevelopment (1980s), shifting from 'a process of essentially physical change' (Couch 1990) to more strategic long-term visions of urban development, with a growing focus on social equity, environmental quality, and sustainable transition [35]. Also the way in which regeneration has been financed changed over time, shifting "from the dominance of public sector funding in the 1970s and early 1980s, through public-private partnership in the 1990s and 2000s, to a new private-public paradigm in the 2010s", where the private sector assumes a leadership role in addressing urban transformation [35]. Today new models of partnership are emerging, involving not only local governments and private stakeholders, but enlarging the decision processes to no-profit organizations, citizens and research communities.

A fundamental issue to address is the scale of intervention. If some problems need to be addressed through a city-regional approach (e.g. the provision of links to the international transport system), for others –as neighborhood concerns- the local scale seems to be more appropriated. In this contest, the district emerges as a key scale to activate urban transformative changes and city-wide climate action goals, as it offers a manageable dimension for integrating urban planning with technological, spatial, regulatory, financial, legal, environmental, social and economic issues. The district-scale also offers a manageable size for local experimentation: district-size projects can become test beds for innovative policy approaches and technical solutions, and –according with the local context-successful practices can be replicated and scaled-up in other parts of the city. Many practitioners look at the district as "the *sweet spot* between the building scale and the city scale in achieving sustainability, community development, and climate action goals" [7]. Indeed, the scale of the district offers greater advantages over single-building solutions, allowing at the same time the implementation of technologies that are not physically or economically viable at the city level (e.g. infrastructural systems for storm-water management, district heating, Community Renewable Energy projects, etc.). As the director of the Capitol Hill EcoDistrict (Seattle) explained in the project proposal: "It is widely recognized that the prospects for sustainable development are greatly improved when design is approached from a systems perspective. In the case of the built environment, this means thinking beyond a single isolated building and tapping into synergies with the surrounding buildings, infrastructure, and community" [36]. In term of energy transition, the district emerges as the most adequate scale to develop community-based energy systems based on renewable technologies, and Energy Neutral Districts and Positive Energy District emerge as novel models where the amount

of energy produced is equal or bigger than the amount consumed. These paradigms involve not only a shift in the energy source, but also fundamental changes related to the mobility system and the use of resources, as both contributing to district energy balance. Another emerging paradigm for sustainable districts is provided by the model of the 15-min city. Introduced by Carlos Moreno and popularized by Paris Mayor Anne Hidalgo, the concept of "chrono-urbanism" grounds on the idea that residents should meet most of the daily needs within a fixed time-frame by food or bicycle. Primary focusing on the transformation of the urban mobility system, the model of the 15-min city has the transformative capacity to encourage major changes on citizen's behavior by improving green areas, public space quality, services accessibility and mixed use development [37].

2.4 Three Pillars for Driving Urban Transition

Over the last 20 years, many international trans-municipal networks and organizations have emerged to support city-leaders and decision-makers for activating resilience-building process and transition-oriented programs (e.g. Covenant of Mayors for Climate and Energy, Carbon Neutral Cities Alliance, ICLEI, C40, 100RC, Transition Towns, etc.). One of the most recent programs promoted by the European Commission to stimulate urban low-carbon transformations is called 'Driving Urban Transitions toward a Sustainable and Livable Urban Future' [38]. Launched in 2020, it builds upon the Strategic Research Innovation Agenda 2.0 (SRIA 2.0) of the Joint Programming Initiative (JPI) Urban Europe (2019), with the aim to foster knowledge-exchange among the main actors of member cities and co-create evidence about successful practices of urban transition. Grounding on the principles of the Leipzig Charter (2007), the program promotes integrated urban planning by focusing on place-based approaches "from neighborhood scale up to functional areas", emphasizing as well the importance of multi-level governance and participatory processes: "We enable local authorities and municipalities, business and citizens to make global strategies into local action. We develop the skills and tools to make urban change happen and boost the urgently needed urban transformations [8]."

In order to address the overall complexity of the process of urban transition, the DUT partnership identifies four priority themes to be considered for developing an integrated approach to multi-sectorial transformations:

- **Digital transition and urban governance:** Digitalization is one of the key elements for innovating the Public Administration and empowering citizens to take part in the decision processes. At the same time, the digital transition may also address inequalities, as disadvantaged groups of population could be have not access to digital services. Moreover, with the emerging of big data, digitalization also offers potential to develop urban planning practices.
- **From Resilience to Robustness:** with the increasing frequency of adverse effects of climate change, urban systems require response paradigms built on 'safe to fail' adaptability principles as a baseline for urban resilience. This means implementing infrastructural robustness, as well promoting mitigation and adaptation measures. Urban regeneration processes as key enabler to improve urban robustness.
- **Sustainable land use and urban infrastructure:** Integrated urban planning supported by participatory processes can address wicked problems around congestion,

accessibility, transformation of the built environment and the energy system or waste of natural resources. Spatial inequalities between different areas may be exacerbated by increasing economic polarization, social segregation and gentrification dynamics.

- **Inclusive public space:** Urban development can provide improved spatial quality for public places accessible to all, increased green spaces, innovation of public transport, as well as promote walkability and cycling.

The DUT approach lies on possible dilemmas emerging from the analysis of these four key areas, with the intent to identify synergies and conflicts across various contexts and sectoral strategies. With this purpose, The DUT partnership mainly focuses on three main prioritized sectors along the Green Deal, and namely: urban energy, mobility and circularity. Each of these sectors is presented in the DUT framework as a pillar for district transformations and is strongly interconnected with the others. Developing these three pillars through an integrated multi-dilemma approach, districts could become regenerative hotbeds for urban transformation and global sustainability (Fig. 2).

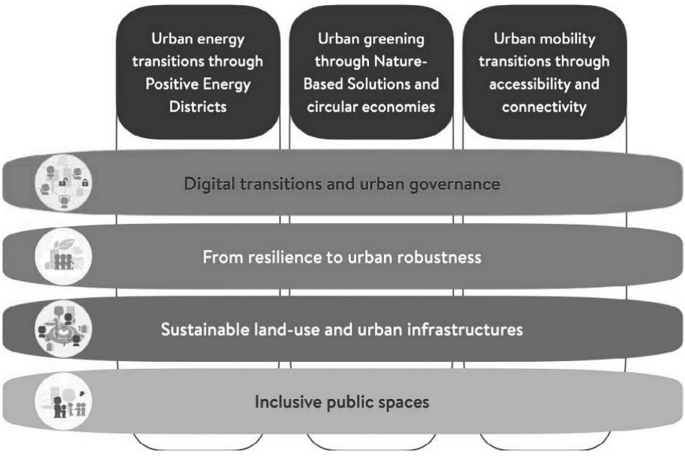

Fig. 2. The DUT's dilemma approach [38]

The three pillars proposed by the DUT framework for activating urban transition through district-based inter-systems transformations are thus synthesized as follows (Table 1):

Positive Energy District (PED)

The pillar has the objective to transform existing urban energy systems through the development of Positive Energy Districts and Neighborhoods. Innovative low-carbon technologies drive for new business models and have to be combined with a change in citizens' behavior (social innovation). Positive Energy Districts are thus defined as "energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional

energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability" [8]. PED implementation has to address three main issues, which are: improving the use of renewable energies (energy production); improving energy efficiency (energy consumption); improving and diversifying energy supply (energy flexibility).

Downsizing District Doughnuts: Circular Urban Regenerative Economy (CURE)
The pillar aims to facilitate regenerative urbanism at different spatial scales by fostering a circular use of resources, including major changes in the local economy and consumers' behavior, innovative approaches to food production, reuse of abandoned spaces, and restoration of the natural capital. This encompasses the use of innovative tools for resource management, a new design approach for the processes related to production of goods, logistics and distribution, as well as a new approach to buildings construction through recycled materials. Moreover the development of urban Green-Blue Infrastructures (GBI) and Nature-Based Solutions (NBS) provides diverse benefits related to climate mitigation (improving the tree canopy cover helps to capture part of urban CO2 emissions), climate adaptation (reducing the effects of urban heat islands; reducing the effects of excessive storm-water; etc.), public health and wellness (reducing air pollution; reducing stress on city's users; improving public space quality; etc.) and local economy (creating new business opportunities). The Doughnuts paradigm represents the role of the city within the nine planetary boundaries and "hinges on the three Rs of Reduction, Regeneration, and Redistribution in order to break the unsustainable linear economies of make-sell waste" [8].

15-min City
The pillar focuses on the transformation of the urban mobility systems, with the aim to reduce car-based mobility and improve walkability, cycling and innovative low carbon technologies for public and private transport. "The 15-min city is characterized by compact, integrated city or neighborhood structure with a high degree of self-sufficiency and local sustainability, though tightly interlinked with adjacent neighborhood and integrated in an effective interregional transportation network and sustainable supply chain" [8]. New technologies based on real data can improve traffic management and encourage citizens to use public transport and shared mobility systems. Nevertheless, it is fundamental to rethink space distribution for ensuring equitable, inclusive and accessible public services to all. Improving mixed-use and polyvalent offer for employment, education, local supply, shopping, and cultural facilities can satisfy community needs in the district perimeter, discouraging the use of car.

Table 1. The three DUT pillars for regenerative districts

PED	CURE	15 min C
Objective		
Transformation of the urban energy system	Urban greening and circular transition	Transforming urban mobility and improve urban services
Principal sector		
Energy system	Circular economy and green development	Mobility system
Main issues to address		
Renewable Energy Energy Efficiency Energy Flexibility	Reduction Redistribution Regeneration	Walkability Accessibility Mixed-use
Connected Challenges		
Energy Poverty Energy Security	GBI & NBS Climate Adaptation	ITC services Public Transport and Shared Mobility
Connected Systems		
Heating Waste Management Water Management Public Lighting Transport	Waste Management Water Management Food production Building Constructions Cycling and Walkability	Health care Housing Education Employment Shopping Leisure
Governance		
Policy framework Regulatory framework Incentives Citizens engagement Digitalization Data Management	Shared visions Citizens' Participation Waste Taxation Incentives	Co-design with local actors Change in citizens' habits Avoid socio-economic segregation Incentives ITC and Data Management

3 Methodology and Case Studies Analysis

This research explores the field of low carbon transition, focusing in particular on the role of district-scale transformations to foster urban and global climate-neutrality. As first step, a literature review has been produced to investigate the role of urban areas in the global challenge of climate change, particularly focusing the concepts of Urban Resilience and Transition Management as innovative tools to design and implement urban mitigation and adaptation measures. District-scale transformations have been investigated through the lens of urban regeneration, as it emerges as the most adequate instrument to enable transformational changes toward climate neutrality while achieving sustainable development goals. The second step is based on two explorative case studies,

and namely the Clichy-Batignolles eco-district from Paris (EU), and the Talbot-Norfolk Triangle (TNT) eco-innovation district from Boston (US). The case studies analysis is aimed at identifying a portfolio of measures able to transform existing districts into low-carbon systems. The case studies have been selected from two leader cities in the field of climate action, as the literature review highlighted that the commitment of local governments is essential to implement urban transformations. Both Paris and Boston have a long history on climate actions, often anticipating the targets of the stale level and being leading cities in international networks promoting urban resilience and sustainability, such as the Global Covenant of Mayors, 100RC, C40, and ICLEI. Defined as "new models of urban development based on public-private partnership, that emphasize innovation and deployment of district-scale best practices to create the just, resilient and resource efficient neighborhoods" [39], eco-districts emerge as Urban Living Labs, as the scale dimension allows local actors to experiment innovative solutions in terms of low-carbon technologies and policy practices. A key distinction between the two kinds of development has been further considered for the selection of the case study projects: while the Clichy-Batignolles can be considered a "blank slate" as it was developed on a regenerated brownfield site, the TNT eco-district has been planned on an existing neighborhood where most property is already developed, and thus it can be thought as a "patchwork" product [7]. The case study methodology relies on the DUT framework, analyzing district transformations under three main pillars focused on energy transition (PED), circular transition (CURE) and mobility transition (15min City).

3.1 The Chicly-Batignolles Eco-District, Paris

The Clichy-Batignolles eco-district is a redevelopment project started in 2002, with the intention to create a village in occasion of 2012 Olympics (occasion that Paris finally lost out of London) and implemented in 2015 through the EU CoRDEES project (Co-Responsibility in District Energy Efficiency) [40], that provided a further funding of 4.3 million euros. Key elements of the project's ecological design are: urban renewal of formerly polluted site, centrally located public green space, passive buildings, energy efficiency, rain water collection for maintenance of green areas, urban density and mixed use development. Located in the 17th district of Paris, the site of intervention covers a surface of 54 hectares, which has traditionally been occupied by logistic activities and heavy transport infrastructures such as the Saint-Lazare rail track and the ring road. The district is organized around a 10-hectar park -the Martin Luther King park- that is easy accessible and easy to cross and has become the meeting place for the people living in the surrounding areas. Moreover, the district is provided with an excellent public transport service, with two metro lines, two commuter train lines and a tramway. Based on the existing topography, the project aims to reconnect the surrounding neighborhoods with a mixed quarter of residential and commercial buildings, containing 3400 homes plus offices and business space for more than 12000 people. On the ground floor of the buildings, shops, schools and recreational facilities have been created to serve the neighborhood and the surrounding areas. Buildings are designed to meet Passivhaus standard, as well to maximize natural heat and light. Solar panels cover around 35000 m^2 on rooftops and facades, producing nearly 3,500 MWh per year, and all the buildings

are connected to heating grid supplied with geothermal energy, covering almost the 85% of the heat energy with renewable sources. Furthermore, an innovative system of waste management based on underground pneumatic tubes reduces greenhouse gas emission by 42%. The project has been designed to prevent urban heat islands and mitigate the impacts of extreme heat waves on the population. Hosting a large amount of vegetation, the park contributes to reduce air temperature thanks to the shade of the trees and the evapotranspiration generated by the greenery. Alongside the park more than 6,500 m^2 of private green space and 16,000 m^2 of green roofs contribute to enhance urban cooling, while improving biodiversity and containing the runoff rainwater. Rain gardens and drainage solutions are displayed inside the park: the collected rainwater fulfills 40% of the park' watering needs, while the surplus is recovered in an open wet ditch and stored in an underground tank that supplies the biotype pond. Moreover, the type of vegetation living in the pond enables natural water purification. Ground permeability helps to collect and reuse runoff-water, thus reducing the volume of rainwater that drains into the sewer system: only the 12% of the eco-district is covered by impervious roadways and the rainwater going on the sewer system is limited to 50% in public areas and 70% on private plots (Fig. 3 and Tables 2, 3).

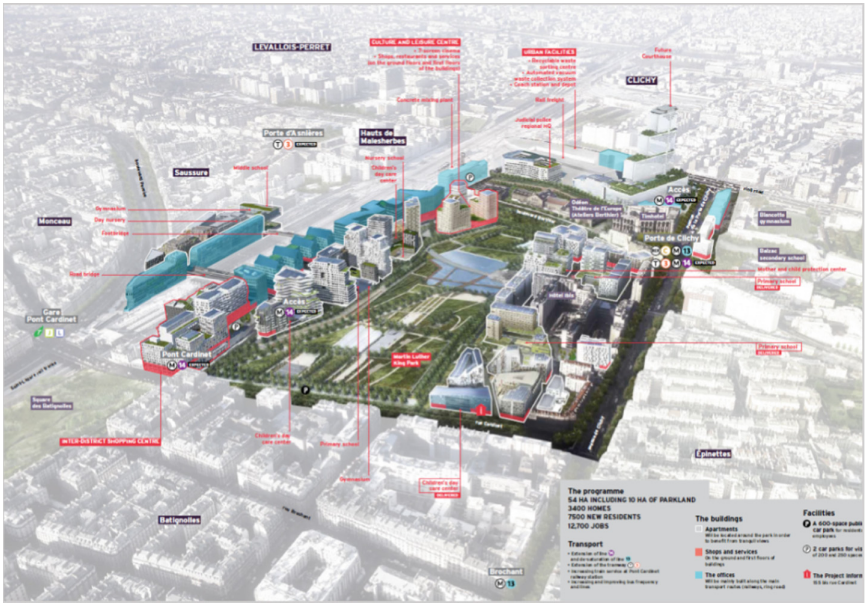

Fig. 3. The Clichy-Batignolles eco-district masterplan [41]

3.2 The Talbot-Norfolk Triangle Eco-Innovation District, Boston, MA

The Talbot-Norfolk Triangle Eco-Innovation District (TNT ID) is a sustainable development initiative in Codman Square, a historic district in the Dorchester neighborhood

Table 2. Context Analysis

The Clichy-Batignolles eco-district	
Context Analysis	
Site Location	17th district, Paris
Area of intervention	54 hectares
Year of the Project Further implementation	2002–2020 2015 (CoRDEES project)
Project Designers	François Grether, Jacqueline Osty, OGI
Type of Development	Brownfield Redevelopment
Program:	Park, offices, housing, public facilities
Inhabitants prevision:	6,500
Partners:	City of Paris, Paris Batignolles Aménagement, EMBIX, Une Autre Ville, Armines/ParisTech
Co-funding:	4.3 million euros from EU
Synergies with other Urban Programs:	Paris Action Plan, Urban Resilience Strategy, 15 min Paris, Circular Paris

(Boston, MA). Dorchester is one of the most underserved and economically disadvantaged neighborhoods of Boston, with a degraded and unsafe residential housing stock and a big number of abandoned commercial buildings. Out a population of more than 1500 residents, the 30% was under the poverty line and more than 33% was just at the poverty line. However, Codman Square was one of the major civic centers of Boston, holding historical buildings including school, churches and public facilities dating the early 19th century. In 2009 the Codman Square Neighborhood Development Corp. (CSNDC) launched an extensive community-based planning process called Millennium 10, engaging over 1000 residents to define goals and objectives for a transit-oriented redevelopment of the neighborhood, without displacement and with a focus on job creation. In June 2014, the district was recruited into the two-year EcoDistricts Target Cities pilot program, expanding its projects portfolio. The initiative involves 252 homes and 13 blocks distributed in an area of 46 acres and the project is still ongoing. The expected results are targeted to enhance equitable transit-oriented development, renewable energy generation, open space, walkability, urban agriculture, green infrastructure, public health and safety and local job creation. The transit-oriented redevelopment of the area has been projected pointing to the retrofitting of Talbot Ave Station. The district is provided with a commuter rail line, which parallel runs with the main greenway line. Moreover it is partially fueled by a new transit corridor, the Fairmont Commuter Rail Line, and is indicated by Boston's Vision Zero Plan to pilot the Slow Street initiative, which includes signage, speed humps, chicanes, crosswalks, bike lanes and green infrastructures. In term of green spaces, the district is equipped with one passive park, one active park and one community garden. Additionally, an urban agricultural site enables local food production, providing low/no cost fresh product for communities and improving local

Table 3. Three pillars analysis for the Clichy-Batignolles case study

The Clichy Batignolles Transformative Measures	
Transformations:	Mitigation/Adaptation/Social Benefits
PED – *Positive Energy Districts*	
Low Energy Buildings: • Passivhaus standards for new buildings • Bioclimatic Design • Maximize natural heat and light for new buildings: dual exposure • Solar panels (incorporate in the architecture, Façade panels, Courthouse) • Geothermal energy for district heating system • Heat recovery from grey water • Thermal Slab • Sensor and meters for monitoring energy consumption • Adiabatic cooling • Smart grid	• Mitigation • Mitigation/Adaptation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation
CURE – Circular Economy and Green Regeneration	
• Green spaces • Green roofs • Green walls • Wetlands • Ground Permeability • Storage tank for collecting rainwater • Reuse of the rainwater for green watering and ground cleaning • Underground pneumatic tubes for delivering waste to a sorting centre	• Mitigation/Adaptation/Social • Mitigation/Adaptation • Mitigation/Adaptation • Adaptation • Adaptation • Adaptation • Mitigation • Mitigation
15 min City – *Urban Mobility System*	
• Extension of the line New metro-station • Green pedestrian lines • Bike lines • Commercial spaces • Training and education • Leisure	• Mitigation/Social • Mitigation/Adaptation • Mitigation • Social • Social • Social

farmers market. Green bus shelter roofs, rain barrels, solar panels, trees and other green infrastructures are projected to be implemented across the district. Home energy retrofits, financed through grants and programs, have improved the energy efficiency of over 40% of the district's home and apartments (Fig. 4 and Tables 4, 5).

Fig. 4. The Talbot-Norfolk Triangle eco-district masterplan [42]

Table 4. Context Analysis

The Talbot-Norfolk Triangle eco-district	
Context Analysis	
Site Location	Dorchester Neighborhhod, Boston
Area of intervention	46 acres; 13 city blocks; 520 resident units;
Year of the Project Further implementation	2007- in progress Eco-District
Project Designers	François Grether, Jacqueline Osty, OGI
Type of Development	Neighborhood Redevelopment
Program:	Transit-oriented development, certifiable green affordable homeownership and multifamily rentals; open space; green infrastructures; retail; walkability and bikeablility; renewable energy; water conservation;
Residents:	1500 residents, around 525 families

(*continued*)

Table 4. (*continued*)

The Talbot-Norfolk Triangle eco-district	
Context Analysis	
Demographics:	African-American (78%); Latino (20%); Caribbean and Hatian (8%); Adults (74%); Youth (26%); Residents under the poverty line (30%); Residents at the poverty line (33%)
Partners:	Codman Square Neighborhood Development Corporation; Talbot Norfolk Triangle Neighbors United; City of Boston; LISC Boston; Enterprise Community Partners; Barr Foundation
Co-funding:	Grants for home retrofitting
Synergies with other Urban Programs:	Boston Carbon Free, Climate Action Plan, Resilient Boston, Zero Waste Boston, Open Space and Recreational Plan, Greenovate Boston, Boston Housing 2030, Boston 15 min, Slow Street initiative (Boston's Vision Zero Plan), Soak Up the Rain Campaign for green roofs at the bus stops
Certifications:	LEED ND, Eco-District Certification

Table 5. Three pillars analysis for the Talbot-Norfolk Triangle case study

The Talbot-Norfolk Triangle Transformative Measures	
Measures	Mitigation/Adaptation/ Social Benefits
PED – *Positive Energy Districts*	
• Home energy Assessment	• Mitigation
• Home weatherization	• Mitigation
• Home retrofits for energy efficiency (insulation)	• Mitigation
• Low energy new buildings	• Mitigation
• Renewable energy (solar panels)	• Mitigation
• Anaerobic digestion for local energy generation	• Mitigation
• Smart grid	• Mitigation
CURE – Circular Economy and Green Regeneration	
• Green Parks	• Mitig./Adapt./ Social
• Community gardens	• Mitig./Adapt./ Social
• Urban agriculture co-op and local farmers markets	• Mitigation/Social
• Green walls and roofs	• Mitigation/Adaptation
• Green bus shelters	• Mitig./Adapt./Social
• Rain gardens	• Adaptation
• Wastewater treatment	• Mitigation
• Building reuse	• Mitigation

(*continued*)

Table 5. (*continued*)

The Talbot-Norfolk Triangle Transformative Measures	
Measures	Mitigation/Adaptation/ Social Benefits
15 min City – *Urban Mobility System*	
• Commuter rail line	• Mitigation/Social
• Bus connections	• Mitigation/Social
• Fronting tree lined sidewalks	• Mitigation/Adaptation
• Bike lanes	• Mitigation
• Wayfinding	• -
• Traffic calming through textured sidewalks	• Mitigation
• Parking	• Adaptation
• Rain barrels for storm water retention	• -
• Green Zones	• Mitigation/Adaptation
• Commercial spaces	• Social
• Training and education	• Social
• Mixed-use hub of innovation	• Social
• Career training canters	• Social
• Community spaces	• Social
• Local produced art in within the public realm	• Social

4 Findings and Conclusions

The paper is aimed at investigating district-based urban regeneration initiatives as drivers of urban transitions toward sustainability and climate-oriented goals. The existing literature is mostly focused on innovative technical solutions designed to transform single urban sectors, but further efforts in research are stressed by municipalities and international organizations to develop integrated approaches for inter-systemic urban transformations. With this purpose, the paper explored two case studies selected from best-practices on district-based urban redevelopments: the Clichy-Batignolles eco-district in Paris and the TNT eco-innovation district in Boston.

The two case studies present substantial differences in terms of size and project context. The Clichy-Batignolle eco-district is extensive project of brownfield redevelopment, aimed at transforming a railway area into a mixed-use residential district and reconnecting surrounding neighborhoods. Brownfield redevelopments can be considered as “blank slate” and have a large space to experimenting advanced solution in term of smart grid, energy-efficient buildings and open public spaces. In the Clichy-Batignolles eco-district, buildings are designed through bio-climatic approaches and Passivhause standards to foster energy efficiency; energy is provided by solar panels, and the heating is provided by a geothermal system. The big park at the center of the district has an important impact in terms of mitigation and adaptation, as its variegated vegetation contributes to capture CO2 emission, preserve biodiversity, reduce runoff water and improve urban cooling, proving citizens tree shadow during the extreme heat-waves events. On

the other hand, the project of the Talbot-Norfolk Triangle can be considered as a "patchwork" development, as it is aimed at transforming an existing neighborhood, where most property is already developed and residents have constrained economic capabilities. The key for the success of the project was the strong participatory process conducted through the Millennium 10 project, that involved more than 1000 citizens to co-design the district transformation. The two case studies have been examined under the DUT framework, and namely through the three pillar sectors for urban transition (energy, mobility and circularity), analyzing the main transformations promoted by the projects in term of mitigation and adaptation measures. For each pillar, a set of transformative measures to implement through district based initiatives has been identified (Table 6).

Table 6. Measures for driving urban transformation

DUT		
PED	CURE	15 min C
Objective		
Transformation of the urban energy system	Urban greening and circular transition	Transforming urban mobility and improve urban services
Measures		
Renewable energy: Solar panels; Geothermal energy for district heating system; Anaerobic digestion for local energy generation; Smart grid; Energy efficiency: Passivhaus standards for new buildings; Maximize natural heat and light for new buildings; Home retrofits for energy efficiency (insulation); Heat recovery from grey water; Sensor and meters for monitoring energy consumption; Home energy Assessment; Home weatherization;	Urban Greening: Parks and community gardens; Green walls and roofs; Green bus shelters; Urban agriculture co-op and local farmers markets; Wetlands; Circularity: Building reuse; Wastewater treatment; Underground pneumatic tubes for delivering waste to a sorting centre; Rain gardens; Storage tank for collecting rainwater;	Mobility: Improvement of public transport; Bus connections; Green pedestrian lines; Bike lanes; Green Zones; Way-findings; Traffic calming through textured sidewalks; Parking; Rain barrels for storm water retention; Mixed Use/Services Commercial spaces; Training and education; Mixed-use hub of innovation; Career training centers; Community spaces; Local produced art;

Despite the context differences, both the case study evidenced the importance of strategic urban planning, where district transformations are aligned and facilitated by other synergic city plans. The research highlighted the logic of district regeneration as a key mechanism to activate the transformative capacity of the city toward carbon

neutrality. District-scale sustainable projects emerge as "sweet spot" for letting citizens experience innovative solutions and co-create changes through participatory processes. A strong local commitment, multi-scalar policy approaches and international cooperation among city-leaders are all factors that facilitate the implementation of transformative action at local areas.

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Lecture Notes in Networks and Systems 639

Carmelina Bevilacqua · Pierre-Alexandre Balland · Christina Kakderi · Vincenzo Provenzano *Editors*

New Metropolitan Perspectives

Transition with Resilience for Evolutionary Development

This open access book conveys attention to the theme of transition towards resilience and sustainability and its evolutionary perspective that emphasizes the complexity and uncertainty that governments and society are called to address in response to the ongoing challenges. "New Metropolitan Perspective Post COVID Dynamics: Green and Digital Transition, between Metropolitan and Return to Villages' Perspectives", 25–27 May 2022, Reggio Calabria, Italy. The papers included in the book are grouped around the following main topics: the envisaged transition towards resilience and sustainability; the relevance of the planning dimension for defining sustainable development pathways and managing complexity; and the green and digital transition by glimpsing at approaches, experiences, and cases that outline innovative solutions in cities and inner areas. The book primarily targets the academic and policymaker communities involved in managing the complexity of the transition for regions and cities.

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