Lecture Notes in Networks and Systems 639

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New Metropolitan Perspectives

Transition with Resilience for Evolutionary Development

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New Metropolitan Perspectives

Transition with Resilience for Evolutionary Development

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Preface

This book conveys attention to the theme of transition toward resilience and sustainability and its evolutionary perspective that emphasizes the complexity and uncertainty in which governments and society are called to take action in response to the ongoing severe and pressing challenges and find shared visions and pathways for an alternative future.

Therefore, the book aims to bring together scholars from a wide range of disciplines to creatively engage with the current debate on how the recovery and resilience plans will shape the future of cities and regions in Europe. It primarily targets the academic and policymaker communities involved in managing the complexity of the transition processes that regions and cities are called to address in facing the pressing and severe current challenges they are exposed to.

The book reflects the results of the ongoing research activities of the Transition with Resilience for Evolutionary Economic Development (TREnD) project, funded by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska Curie Actions—RISE 2018. The TREnD project sheds light on new approaches to facilitating the regional and urban transition to sustainability while reinforcing resilience to the shocks induced by transition dynamics. Specifically, the project investigates how "resilience-building" strategies can strengthen regional capabilities to activate, deploy, and manage transition processes toward sustainability. TREnD research activities are oriented toward the identification and comprehension of the factors which is able to enable or hinder transition strategies from the governance perspective, the assessment of the context-specific characteristics which is able to activate resilience-building processes, and the unveiled of the unleashed local potentials that external shocks—cities and regions are exposed to—can reveal in favor of reshaping development trajectories.

In this framework, the focus of the book appears timely and relevant. Inequalities and disparities related to the current globalization dynamics, the pressing need to face climate change through mitigation and adaptation processes, the severe consequences of the Covid-19 pandemic, and the recent geopolitical events impose the revision of last decades' development patterns. In a few words, the transition toward a more sustainable future is no longer an option. Addressing the energetic transition by protecting natural ecosystems and ensuring sustainability, boosting digitalization processes toward the knowledge society, and ensuring social inclusion and equity are just a few of the main issues to address. The European Commission, national, regional, and local governments, civil society, and the private sector are called to an unprecedented effort to define a better future for the Union. Therefore, transition, resilience, and sustainability are the keywords to descend for responding to the transforming socio-ecological and socio-technical dynamics at the core of evolutionary development. Harnessing globalization, addressing industrial change, embracing innovation and digitalization, managing migration in the long run, and fighting climate change define the global challenges across distinctive features and conditions of places which is able to respond according to local needs. Policy packages need to be integrated and coordinated, delivered at a national, regional, and local level while adapting to different territories' needs. In this direction, the role of regions and cities appears crucial in formulating adequate responses to pressing and severe challenges.

The recent Covid-19 pandemic has struck territories and communities, exacerbating cross-generational gaps already present in the pre-Covid era and bringing to light the increase of economic and social disparities, which have grown since 2008 with the last economic downturn, generating a geography of discontent that paved the ground for the increase of populism and nationalism in late 2018.

In Europe, the response to such a "perfect storm" conveyed in a new policy framework oriented at the just, green, and digital transition to increase the resilience and sustainability of the Union. The reforms of the investment plans launched with the unprecedented initiative of the NextGenerationEU and implemented with the Recovery and Resilience Facility including the Cohesion Policy (ESI funds) require effective multilevel governance in which multiple governments, national, regional, and city councils are autonomous but interdependent in the complementarity of planning strategic solutions based on mutual learning and negotiation. At the same time, data-driven resilience and transition frameworks back the strategies to accelerate the adoption of essential community resilience and climate adaptation plans. In light of a new scenario of urban/territorial development, which strongly emerged from the pandemic but needs to be planned to facilitate the transition toward sustainability, the traditional approach to managing local phenomena can no longer guide political choices in response to the speed of change. In this direction, the book drives the reader to a better theoretical and practical comprehension of resilience and transition, and the need to develop proper and adequate metrics through data analytics tools, arguing for a holistic approach around the territorial and social cohesion pillars in combining urban-regional science with research-innovation dynamics, and bringing into focus an array of controversial issues that the concentration of innovation, produced by knowledge complexity, may generate in peripheral areas.

The transition concept and its management are gaining relevance in the scientific and policymakers' arena. However, translating transition concepts and principles into practice is difficult. Transition is a long-term process open to unpredictable events that can affect its path but not change the final objective.

In this book, we argued that in light of the complexity and uncertainty of these times, designing, planning, and managing the transition are critical for increasing the resilience ability of territories and reaching the overarching objective of sustainability.

It is interesting to notice how—despite the relevance of the transition concept in the last decade—the understanding of "where" transition occurs and its spatial configuration has been neglected. The spatial configuration of transition dynamics, the understanding of their triggering mechanisms, as well as the management of their complexity are critical elements that should characterize planning processes for the facilitation of the envisaged transition, which has to be green and digital but grounded on a more important pillar: social justice.

Despite the multilevel policy efforts—from the EU to the local level—the last two decades have shown how social and economic vulnerabilities, as well as territorial imbalances, persist. In the early 2000s, the European Commission set the ambitious goal for the transition to a knowledge-based economy and society placing knowledge and innovation dynamics at the core of the development pattern to pursue. In this direction, the pre-Covid EU policy efforts in the programming period 2014–2020 focused on knowledge and innovation dynamics as central elements in leveraging public policy to reduce the gap between advanced and less advanced regions. Such an effort materialized in the Smart Specialization Strategies (S3) to discover the entrepreneurial potential of places supposed to activate territorial dynamics and stimulate local innovative potentials based on context innovation areas determined by regional actors. One of the main concerns raised during its implementation was related to the effectiveness of this policy setting in reducing disparities between advanced and less advanced regions. Many scholars and policymakers agreed on the ability of innovation to concentrate and cluster in specific localities and on the difficulty of rebalancing the complexity of knowledge and innovation dynamics in favor of less advanced regions and cities.

In order to address the challenges of the post-Covid recovery with the aim to reduce socio-economic and territorial disparities, the EU budget for the programming period 2021–2027 has been topped with additional funds contained in the NextGenerationEU financial package, a temporary instrument to facilitate the recovery while fostering the transition toward a sustainable future for the Union. The pillar of the NextGenEU is the Recovery and Resilience facility, whose main aim is to address the vulnerabilities emphasized by the pandemic effects, prepare the Union for the opportunities of green and digital transition, and reach the overarching objective of effective sustainability. Accordingly, each Member State has developed a National Recovery and Resilience strategy with the clear objective of addressing inequalities and disparities and exploiting local potentials for facilitating the transition. In this framework, addressing territorial imbalances among more and less advanced regions and between urban and rural areas is critical as it questions the strategy's effectiveness in reducing socio-economic differences. Each Member State presents territorial imbalances (north–south, urban–rural), which cannot be simply solved by channeling financial resources in most distressed areas. Given the persistent vulnerabilities and the lack of institutional ability to manage these resources, the gap with advanced regions will widen, increasing territorial imbalances. Furthermore, the recent geopolitical events, which also show the potential side effects of transition, can contribute to the revision of these national strategies distracting resources for distressed areas toward sectoral and thematic national contingencies. The risk of not addressing persistent vulnerabilities and increasing disparities is real. These overall context conditions open the floor for outlining a set of crucial elements for the definition, design, and management transition toward sustainability. The central question which to find an answer is how to facilitate the transition toward sustainability by favoring at the same time the resilience of economies—and territories—and ensuring equity and inclusiveness.

For this purpose, the book is grounded on the relevance of the planning dimension. It pays attention to the perspectives, approaches, experiences, and practices that can provide the ground for a fruitful debate around transition and resilience. It looks at regions and cities' efforts in planning transformative processes by casting light on the ongoing experiences in boosting multilevel governance and bottom-up processes for supporting local transformative dynamics that can increase territories' resilience. Moreover, it emphasizes the role of new technologies and data-driven approaches to facilitate such processes.

The recent development of new technologies and the rising relevance gained by data-driven approaches are turning points in the knowledge of social, economic, and environmental phenomena. The increasing relevance of computational science (artificial intelligence, machine learning, big data) also pervades the planning dimension. The availability of data and the increasing development of tools and techniques for their analysis is providing—and could provide—valuable support to inform decision-makers in the planning of the transition toward resilience and sustainability. Data-driven planning processes can offer flexibility, adaptability, and facilitate transformative development in defining sustainable development paths for cities and regions by detecting the co-evolution of the socio-ecological and socio-technical demand. Therefore, knowledge, research, and innovation dynamics coupled with innovative approaches in planning and governance are crucial for developing suitable solutions for resilience and sustainability. Furthermore, a better comprehension of these dynamics for ensuring equity and inclusiveness is the main challenge for facilitating the envisaged just, green, and digital transition toward resilience and sustainability. Data-driven planning processes can detect the transition dynamics and facilitate the deployment of their positive effects, but also provide the instruments for managing contemporary complexity. The continuous interaction between humans and technological devices shapes and modifies socio-technological dynamics provides the ground for exploiting data oriented at a better comprehension of social phenomena and addresses current issues. In this direction, pathways are emerging regarding research-based, policy-oriented actions and citizens' daily life that already exploit new technologies and instruments for the transition toward resilience and sustainability.

The push toward an open-data society, in which civic digital ecosystems at the local and national level can activate open-based research and innovation processes, oriented at the improvement of people's life by reshaping the citizens–institutions relationship. It is not a surprise that new approaches linked with computational sciences are shaping the emergence of the so-called urban science and developing approaches such as urban informatics that have clear direct and indirect implications for planning and governance processes. Such implications, directly and indirectly, affect how public authorities design and plan the future transition. The availability of real-time data and the speed of data processing due to technological improvements allow the generation of constantly updated pictures of phenomena (from pollution levels using satellite data to mobile phones for improving public transportation options) at the macro- and microlevels. Data can be used to improve the decision-makers' processes and constantly monitor and eventually adapt the implementation of plans and initiatives. Also, they can contribute to new forms of civic engagement and participation and improve the ability of public authorities to deliver timely and efficient public services. Most importantly, data and data analytics are valuable sources of information to better understand how to address climate change's side effects and reduce vulnerabilities and risks.

During the last decade, many higher education institutions and research institutes and centers have focused their activities on the relevance of data to address local issues. Such processes have generated civic data/digital ecosystems nurtured by three main veins. The first is the multidisciplinary contamination of research activities in computational science. The advancement of new technologies in the definition of artificial intelligence and machine learning processes is opening new windows of opportunity for developing better solutions to current issues through the potential deriving from the contamination with other disciplines: biology, chemistry, medicine, and last but not least, planning. As a result, multidisciplinary and interdisciplinary educational programs focused on the potential implications of computational science are being developed in many countries. Furthermore, the re-definition of societal relationships, intended as the complex dynamics among public, private, and civil society actors, is evolving into new forms. New public–private partnerships are arising worldwide for the development of approaches which is able to find solutions to contemporary problems and define new opportunities for a better future.

Following this rationale, the book is structured around three specific thematic areas emphasizing the role of planning for managing the complexity of the challenges to face. The first focuses on the envisaged transition toward resilience and sustainability, which outlines the increasing relevance of complexity related to the ongoing socio-ecological-technical transformative processes. Therefore, attention is posed to the new EU perspective for the transition that merges innovation policies and territorial perspectives. The EU Strategic Agenda for 2019–2024 is grounded on four main priorities: protecting citizens and freedom, developing a strong and vibrant economic base, building a climate-neutral, green, fair, and social Europe, and promoting European interests and values on the global stage. Such priorities are the drivers for the Commission's guidelines focused on the just, green, and digital transition of the Union toward resilience and sustainability. However, the current challenges imposed by the globalized dynamics call for multilevel efforts in sustaining the recovery and reacting to the continuous shocks that may hamper the development of suitable solutions toward such ambitious goals. These aspects are investigated through the contributions focused on transition, its governance, economics and innovation policies, European digital technology, and the sustainability dimension for a renovated Smart Specialization Strategies (S3) approach under the lens of the territorial perspective. Such a policy shift formulated in response to the recent pandemic lends relevance to the role of regions and cities in implementing tailored actions to boost the transition toward resilience and sustainability.

Considering that transition is based on transformative processes that will deploy their effect in the mid- and long term, the planning dimension becomes crucial for defining suitable development pathways to reach the ambitious—but necessary—goals of increasing resilience and achieving sustainability. This aspect is at the core of the second thematic area that focuses on complex processes in cities, which catalyze the immediate deployment of mitigation and adaptation actions. For a long time, cities have attempted to address their vulnerabilities in a rapidly changing context shaped by socio-ecological and socio-technological transformations, too dynamic to be absorbed timely by institutional processes. Although most of the side effects related to global dynamics come to the fore in cities, it is in cities that experimentation and innovative solutions are deployed to face the complexity of such challenges. Therefore, this book section houses contributions that outline the importance of planning in boosting resilience and sustainability-oriented processes in cities. These contributions focus on the urban dimension of transition regarding cities' ability to deploy adequate and timely responses from the policy-planning perspective. This part of the book explores approaches, cases, and experiences that emphasize the role of cities in planning the transition by adapting their planning tools.

One of the recent examples of policy frameworks for managing the complexity of urban transition processes is offered by the Driving Urban Transition program, developed thanks to a joint European research-based initiative. Built over a multidilemma approach, the DUT framework aims to manage the complexity of the urban transition processes by emphasizing the importance of district-based multisectoral initiatives to facilitate cross-system transformative processes through innovative technical solutions. For this purpose, the DUT framework identifies three main pillars for achieving low-carbon cities: the positive energy district, the circular economy, and the "15 min city". These three pillars are strongly correlated to each other, as the overall objective of a carbon neutral city can only be achieved through an integrated and multisectoral approach. This new vision can be deployed in cities where the transition toward resilience and sustainability is supported by planning processes that boost adaptation and transformative development.

The third thematic area explored in this book is related to the green and digital transition by glimpsing at approaches, experiences, and cases that outline possible pathways for a bottom-up development of innovative solutions in cities and inner areas. The development of new technologies is pervading vertically and horizontally the ability to find solutions to local challenges and issues. It affects how local communities auto-adapt and self-organize in response to the side effects of global dynamics. It helps in the implementation of innovative solutions for making cities more sustainable. Moreover, it boosts social innovation practices for local communities' empowerment and sustainable exploitation and valorization of local resources. The contributions guested in this section of the book outline a clear orientation for taking advantage of new technologies and digital solutions, suggesting possible bottom-up approaches to face the challenges of transition. Such an effort should prioritize the exploitation of knowledge and innovation dynamics placing urban innovation ecosystems as central elements in driving the transition toward resilience and sustainability. They are characterized by nonlinear development, adaptation and self-organization processes, and transformative dynamics, all properties that, if supported by public policies, can effectively drive the envisaged transition. From one side, they can channel knowledge and innovation dynamics into developing new technologies and solutions to face the challenges of the green and digital transition. From the other side, the support provided by public policies—both in terms of innovation and economic-oriented measures and in regional, city, and urban planning—can ensure the concrete materialization of the transition by exploiting this potential to address local challenges and ensuring social equity and inclusiveness in the effective transition toward sustainability.

The contributions of this book point out that the complexity of the current challenges is not only remarking on our vulnerabilities but also the limits and controversial effects—for the environment and humanity—of the development paradigm pursued in the last decades, that is no longer sustainable and must be rapidly corrected or reversed. A renovated relationship between nature and humans is needed, in the awareness that we do not have a planet B, and therefore without the preservation, restoration, sustainable exploitation, and regeneration of natural resources, as well as the complete decarbonization of our economies/societies, the opportunities—but more important the rights—of current and future generations will be seriously compromised. These elements provide a renovated centrality to planning processes for dealing with the complexity of these times and designing a better future for people. This new perspective paves the ground for the development of data-driven planning processes able to ensure a sustainable transition in all its three main pillars: social, by addressing the widening disparities and inequalities; economic, by promoting circularity as the main development paradigm for sustainable economic growth; and environmental, by reducing the pressure on natural ecosystems and mitigating the side effects of climate changes.

The contributions collected for this book have been presented at the sixth International Symposium "New Metropolitan Perspective Post COVID Dynamics: Green and Digital Transition, between Metropolitan and Return to Villages Perspectives", scheduled from May 25 to 27, 2022, in Reggio Calabria, Italy, in the specific focus sessions "TREnD", as part of the research activities conducted within the "TREnD" research project. The sessions saw the participation of high-quality international academics and experts from an international network of higher academic institutions by guesting significant contributions to stimulate a fruitful debate on global challenges among academics and policymakers. The themes discussed in these sessions followed the critical elements of the debate on a shift in policy design and implementation to drive transition-oriented structural changes in regions and cities. In this direction, this book offers the chance to navigate the complexity of transition and resilience by outlining possible policy agenda priorities, new approaches, cases, and experiences that enrich the flourishing academic and policymakers debate on the green and digital transition.

The design and organization of the specific sessions is the result of the synergetic activity of the TREnD and ZES (opportunity Zones for innovation EcosystemS governance) projects, which have received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreements No. 823952 (TREND) and No. 846144 (ZES), and the Smart Open Urban-rural iNnovation Data (SOUND) project that has received funding from the Italian Minister of University and Research (MIUR) under the PRIN—Progetti di Ricerca di Rilevante Interesse Nazionale Bando 2017 grant No. 2017JMHK4F.

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Carmelina Bevilacqua

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Contents

The Transition Toward Sustainability and Resilience: Innovation and Territorial Perspective for the EU Transition

A New Vision of Governance for the European Less Development Regions? Sustainability and Transition Management for a Modern Approach to Policy

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Abstract. The challenge for the future of Europe and the entire planet is to direct development towards sustainability trajectories. The current period is a time of change in the direction of Ecological Transition. Managing these changes requires innovative governance models, a challenge identified by the 14 European Megatrends. Europe recognizes the need for multilevel governance that always involves a more significant number of actors. The article identifies the governance approach of Transition Management (TM) as a model that responds to the challenge of new governance models inclusive of the sustainable vision. Especially for the lagging areas, the TM could be a methodology that supports the institutional capacity, often strictly correlated to the development conditions.

Keywords: Ecological Transition · Transition Management · Sustainability · Governance · Lagging Regions

1 Introduction

A profound change characterized contemporary society. The Covid-19 pandemic crisis has accelerated this transformative development and highlighted modern economic systems' fragilities. It confirmed the urgency of interventions aimed at protecting and reconstructing nature, the indissoluble link between the well-being of humanity and that of ecosystems. The European Sustainable Development Report [1] underlines that investing in protecting the European environment will also be essential for the economic recovery after the Covid-19 crisis. It is, therefore, necessary to redefine the areas of competence between the economy and the environment with a vision in which there are no fundamental dichotomies. We are experiencing the historical period as a new transition phase. The Transition defines the passage from an initial state of equilibrium to a new dynamic condition, which arises from the interaction and speed of structural change processes [2]. The Ecological Transition, in particular, is a process of structural change indispensable for the European Union, a fertile ground for new economic possibilities [3]. The challenge for the future of European territories is to direct development towards

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sustainability that concerns various elements and implies a future free from destructive conflicts [4]. Citizens support the EU's ecological ambitions, but the traditional governance systems are not more suitable for this scope. Above all, it is highlighted that for the less developed European Regions, and poor institutional capacity compromises virtuous development paths. A reflection, therefore, appears appropriate on the type of governance ideal for a path towards sustainability.

The Sustainable Development Agenda indicates the opportunity to use new governance models and identifies the Transition Management (TM) model as an approach that can benefit Europe's future [5]. Indeed, the Transition Management approach put together frontrunners from economics, policy, business, and society to develop a shared comprehension of the common complex transition challenge having a common strategy. This paper is structured as follows. The next paragraph highlights a general picture of the non-linear interpretation of Transition and Sustainability issues. The third paragraph underlines that one of the significant challenges identified as European Megatrends is the influence of new governance models. The following paragraph discusses what today appear to be the policies with the most significant impact on growth. Paragraph 5 emphasizes the need to resort to new governance models, especially for the less developed European regions. Paragraph 6 illustrates the characteristics of the Transition management model and the "Arena" operating model. Finally, the last paragraph expresses conclusions and references for new insights and future developments related to a new development approach to the European lagging regions.

2 Transition and Sustainability as a Complexity Framework

The last decades have seen different studies, in an inter and transdisciplinary field, on sustainability transitions [6] with fundamental concepts that describe contemporary transformation processes. It is necessary to break down the concepts of Transition and sustainability to have a more analytical picture, given the complex structure of the Ecological Transition that incorporates into the concept of sustainability. The Transition is the consequence of the interplay of signs of progress supporting and reinforcing each other. The conditions for change are the transformations that result from developments in various ambitions or dimensions such as technology, economy, institutions, behaviour, culture, ecology, and image/paradigms [7]. The transition process is not linear but gradual and inter-temporal in its evolution [2]. Shock events such as war, pandemics, and economic crises accelerate it. The Transition results from endogenous and exogenous developments with cross effects and autonomous consequences that interact and influence social and cultural change. The various modifications of change that occur during the Transition can be divided into phases [2]. Furthermore, the nature and speed of change differ in the steps identified in the pre-development stages, take-off, turn, and stabilisation. Specifically, the Transition's phases are summarised as follows:

- The pre-development phase does not detect visible changes in society but is characterized by experimentation processes;
- The take-off phase initiates the change process and the initial reception of the change;

- The turning point reflects visible structural changes resulting from an accumulation of socio-cultural, economic, and ecological resources combined with institutional changes. During this phase, collective learning, diffusion, and innovation processes continue to be triggered;
- Finally, in the stabilisation phase, the speed of social change reaches a new dynamic equilibrium but is stable in a short time.

One cannot notice that the illustrated transition phases are comparable to the classical neo-Schumpeterian logic of innovation and the development cycle of a new product in its various steps, from its introduction to the stabilisation phase. In addition, some similarities with Kondratieff's long wave theory [8] with Schumpeter's economic development theory indicate a revised concept of dynamic change where the Transition is very close to the turning point phase above.

Transition results from the interaction of different processes, many of which escape a unitary and hierarchical control, such as cultural change, characterized by its spatial and temporal autonomy. However, it is possible to influence the direction and speed of a transition, changing the probability of its occurrence. Several mechanisms are available whereby the macro-result depends on the fulfillment of different micro-decisions.

The Transition offers significant environmental benefits by developing more environmentally friendly systems. The hydrogen economy, industrial ecology, and personalised mobility are examples of system innovation and its sectoral links.

The definition of sustainability is not unique but open to different positions with multi-dimension aspects. Several studies underline the complexity of the conceptualisation of sustainability in the literature, highlighting the link with the concept of sustainable development. The multidimensionality of sustainability has become established, considering the complexity of real systems (Fig. 1). It needs to consider all dimensions of social, political-institutional, economic, and ecological interrelatedness. In addition, the spatial and temporal horizons are highlighted in the search for inter-and intra-generational equity [9, 10]. The fundamental challenges for sustainability appear in several different domains, such as the depleting natural resources constituting a limit on energy supply, air pollution, greenhouse gas emissions are an alarm for climate change, nuclear risks represent a threat to human survival, and even the security of food supply is a source of uncertainties in short and in the long term [11]. So, sustainability transitions are long-term, multidimensional, and fundamental transformation processes through which socio-technical systems are established and shift towards more sustainable modes of production and consumption [12]. A transition to sustainability is intentional. In a guided transition, political actors and regulatory and institutional support play an essential role.

The concept of sustainability derived from the "Brundtland Report" [13] has triggered a reflection on the development paradigm shift. The first approach to sustainable development, defined as "weak," combined the principles of neoclassical economics with environmental sustainability. A later "strong" approach to sustainable development sets the environment at the core of development. It emphasises the role of regulation and public policies in inducing compatibility with sustainable development [14–16]. "*Transforming our World: The 2030 Agenda for Sustainable Development*", with the identification of 17 Sustainable Development Goals (SDGs) [17], is the post-2015 United Nations vision of the path that global development should follow and has found strong support from the EU, even with the adoption of the European Green Deal. In this way, regional governance plays a significant role in achieving the SDGs, ensuring directionality towards sustainable development, and directly involving local stakeholders.

Furthermore, the closeness between planning and implementing policies allows observing measurable results in a more transparent, flexible, and inclusive process. A good governance model must support the Ecological Transition required by sustainable development. The below "triangle" clarifies some critical factors such as the economic, social, and ecological dimensions for the multifaceted aspects of sustainable development.

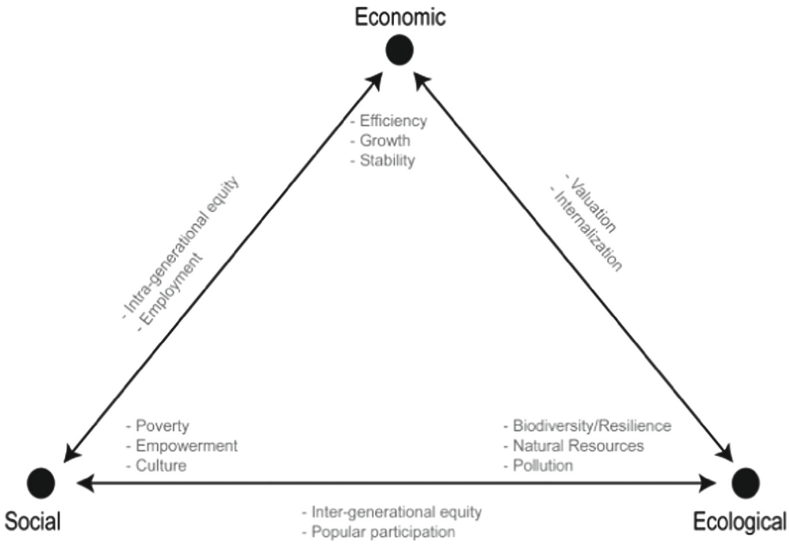

Fig. 1. Graphical representation of sustainable development [10, 18]

3 Megatrends: Greater Influence of New Governance Systems

The Ecological Transition is a change in the making, which policy strategies can guide with a medium and long-term vision. It needs structural changes in society. Current changes are defined as Megatrends [19]. Megatrends are long-term global driving forces that are observable in the present and are likely to exert significant influence for a few decades. In short, *a* Megatrend is a long-term driving force that is observable now and will continue to have a global impact on future generations. In Fig. 2, we can see several trends from non-state actors to automated decision-making.

Megatrends appeal for strategies for adaptation rather than plans for effecting change to the trends themselves. Europe has decided to monitor the 14 Global Megatrends relevant to the upcoming of the world. One of the European trends of particular interest is the "Greater influence of new governance systems." Non-state actors, global consciousness, social media, and the internationalisation of decision-making are forming new multilevel governance systems. Different elements influence the Megatrend "Greater influence of new governance systems," indicated in the timeline (Fig. 1), suggesting values determined in the vision of new stakeholders.

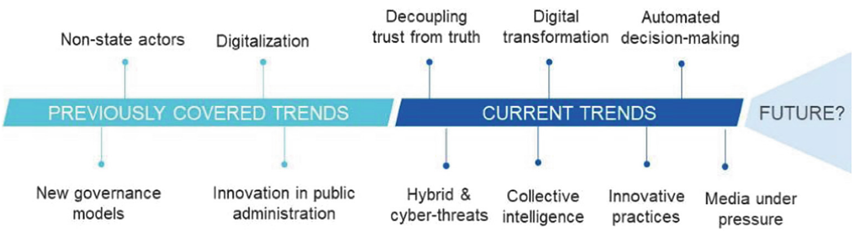

Fig. 2. Timeline. The driving forces of the Megatrend change over time. This timeline indicates that more established and newer trends are influencing the Megatrend's future direction. Source: https://knowledge4policy.ec.europa.eu/increasing-influence-new-governing-systems_en.

Identifying trends affects the long-term scenario. Observing local, regional, and global societal trends might be the primary tool for forecasting studies. Comprehension of these trends is particularly relevant to human development in economics, agriculture, energy, urban planning, and resource planning.

Managing the Ecological Transition requires new governance and management models. It requires insight into how governance systems can perform roles in new ways of working the challenges of this time. The Ecological Transition needs a holistic approach and the presence of new organisational actors, such as innovation brokers and meta-organizations that comprise networks of firms or individuals not bound by authority based on employment relationships but characterised by a system-level goal [20]. Participatory Governance is significant in the multi-stakeholder approach because it integrates different actors with various interests, knowledge, and capacities. A mindset change is required, and new decisions must be made cooperatively and involve all concerned actors.

Furthermore, the governance model must include self-regulation mechanisms achievement from accordance and control of collectively decided. Therefore, a non-linear approach to Governance appears necessary to evolve, adapt, and thus present a dynamic vision. One theoretical side that addresses Governance's complex and non-linear nature is the Evolutionary Governance Theory (EGT) [21]. Evolutionary Governance Theory links up with the literature on social-ecological and complex-adaptive systems, emphasising the processes and mechanisms that drive social evolution.

The EGT recognises the co-evolution of systems and investigates territorial stakeholders' interactions. The coordination of policies and practices regarding the organisation of the territory evolves as a process of spatial Governance. It identifies planning systems as configurations of actors and institutions involved in space organisation. The EGT perspective highlights a planning system conceptualized as an evolving configuration of actors, institutions, and attitudes. Today, a broad consensus indicates the need for an evolution of territorial Governance that leads to spatial coordination capable of addressing socio-environmental challenges such as urban and development ones. EGT offers a perspective on how institutions, markets, and societies evolve and how TM is closely related to managing the actual structural change.

In other words, Transition Management is part of the theoretical framework of Evolutionary Governance; it allows incorporating normative objectives in evolutionary processes in "*a reflexive way*" [2]. Modern social complexity requires new, democratic, and participatory visions of Governance. The goals to be achieved are many and include new ways of development, where the concept of sustainability is central. The Transition Management model leaves room for the inclusion of sustainability. Indeed, the Transition Management approach put together frontrunners from economics, policy, business, and society to develop a shared comprehension of the common complex transition challenge having a common strategy.

4 The Policy Approach to Economic Growth

Ecological transition-oriented public investments involve strategic decisions on the type of change to pursue. Regions are specific ecosystems where economic development emerges from increased interactive, dynamically adaptive, and integrated activities. There is not a unique theoretical model for regional economies being complex systems. The ambition to achieve a particular type of economic growth, such as smart, inclusive, and sustainable change, implies giving it a precise direction [22]. The policies of growth mainly align with two strands of regional growth theories. Policies that follow a spatially blind approach that focus on successful agglomeration and efficiency models aim to stimulate overall growth but neglect problems of declining and lagging areas and try to solve them only in a compensatory way [23].

Policies with a universal approach have been adopted based on the traditional assumption that natural forces of workers' geographic mobility and knowledge spillover would act as a counterbalance mechanism for agglomeration, leading to income equalization and the diffusion of innovation territorial convergence [24]. The theory of economic geography and the empirical evidence has shown that labor mobility and the diffusion of innovation polarize the economy and limit the equity-enhancing effects by adopting spatially blind policies [24]. On the other hand, place-based policies [25] have been promoted under the assumption that less developed areas can always catch up if equipped with the right tools. However, the lack of connectivity with poor physical infrastructure hinders place-based policies. Iammarino et al. [24] addressed the problem of policy approaches under the dual aspect of efficiency and equity. The authors highlight how the achievement of efficiency (using spatially blind policies) can increase territorial disparity (which, in turn, undermines efficiency) while excessive attention to equity (place-sensitive policies) undermines efficiency. Pursuing efficiency and fairness simultaneously with a territorial dimension is necessary. Both dimensions should be considered simultaneously, addressing both the causes of territorial discomfort and, at the same time, maximizing the potential of each territory. The authors mentioned propose the fusion of these two principles with a definition that they identify as "place-sensitive distributed development policies" (PSDDP) [24]. The PSDDP model provides a "mission-oriented" top-down approach and a "diffusion-oriented" bottom-up approach for strengthening territorial-specific capabilities. The PSDDP model to avoid a trade-off between efficiency and equity indicates three fronts: a) pushing more and more regions towards more non-routine (innovative) functions in their economic mix; b) expanding the sources of creativity and satisfaction that are good in and of themselves on human grounds, and c) stimulating more significant investment in basic capabilities that are essential to a dignified and creative life".[24]. This work does not aim to analyze the PSDDP model but only to consider the TM capable of supporting an approach that, by enhancing the mission, also considers territorial peculiarities. Above all, those regions that demonstrate inadequate governance capacity could use a governance model based on TM to compensate o reduce a certain degree of low quality.

5 The Less-Developed European Regions and the Low Institutional Capacity

The Eighth Report on Economic, Social, and Territorial Cohesion of the European Commission [26] highlights improved EU governance in recent years. Despite these results, gaps between and within the Member States remain (Fig. 3).

The regional policy of the European Union is a program based on a place-based vision [25] for the redistribution of wealth between European regions. A policy place-based is a long-term strategy to address the persistent underutilization of potential and reduce social and economic gaps in specific places through external interventions and multilevel governance actions.

The Cohesion Policy, implemented through the Structural Funds, has had both strong consent and various criticisms. Supporters believe it is necessary to bridge the disparities between the most developed and the most backward regions, and so be it adequate to make the weaker areas grow. Detractors highlighted critical points concerning the waste of resources, with high costs in terms of efficiency.

Despite the over thirty years of Cohesion Policy, there are still profound economic disparities between countries and between the regions of the countries that make up the European Union. The Report [26] highlights how cohesion policy is helping to reduce territorial and social disparities between EU regions. Still, in the Member States of Europe, southern (Italy and Greece) and southwestern (Spain and Portugal), improvement is lacking in competitiveness and growth, the suffering stagnation and economic decline. Southern Italy, for example, is confined in a "*development trap*," the risk of being locked in a low growth rate of GDP per capita, productivity, and employment. The quality of local governments, in particular, seems to influence economic development and shapes the efficiency and return on public investment. Lagging regions lack institutional capacity, and the local institutional environment follows a passive implementation of a predominant growth model. Institutional capacity has a long-term impact on economic growth, contributing to investment effectiveness and higher levels of innovation and entrepreneurship.

Good administrative ability is essential for the management of policies and, consequently, for the effectiveness of public investments. Regions with good institutions,

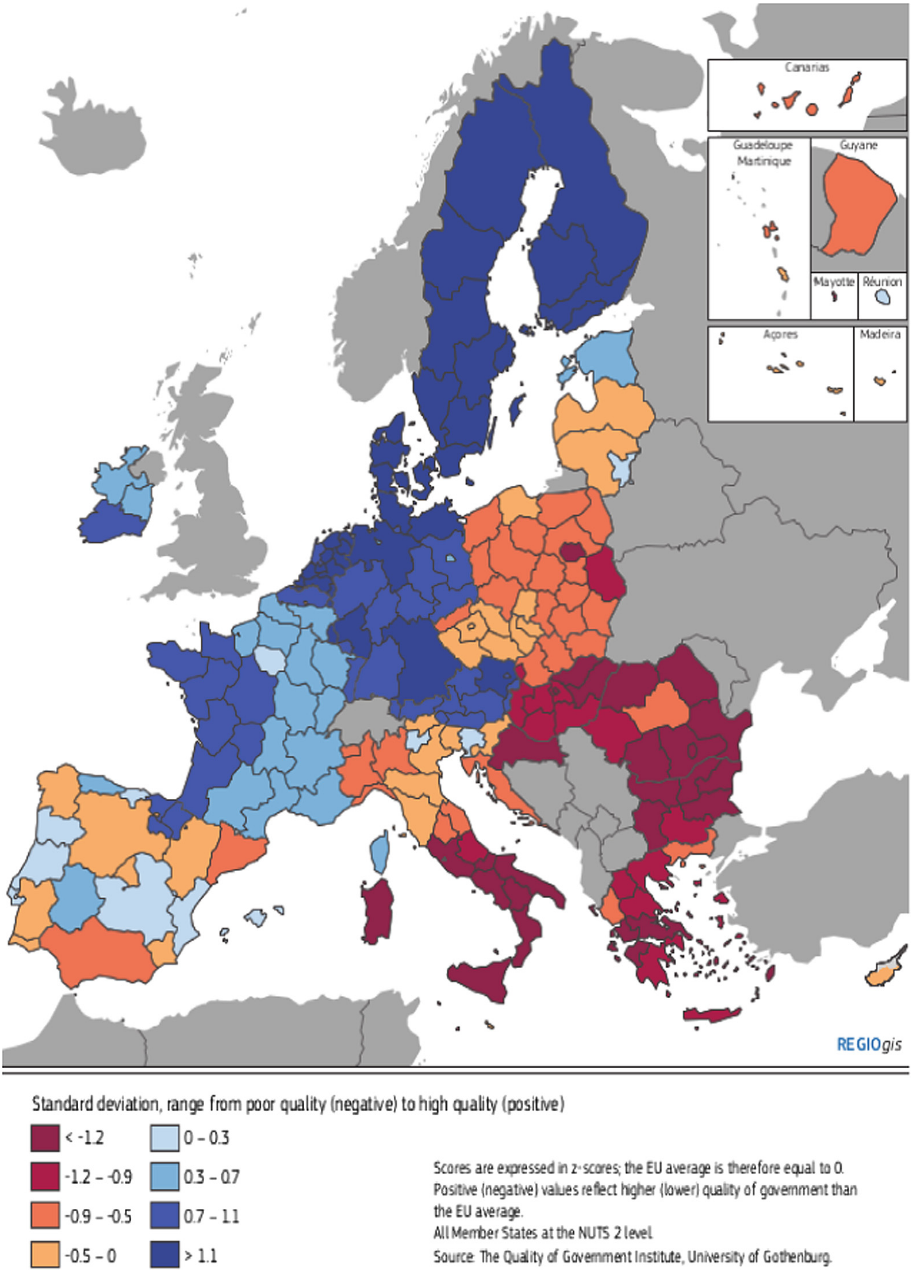

Fig. 3. European Quality of Government Index, 2021

significant accountability, and low corruption tend to perform better in the production and services of public goods, thus helping to create a favourable environment for economic growth and social development. Good governance requires well-functioning institutions and transparent procedures [23, 27, 28]. The weaker the institutional set-up, the more significant the difficulties involved in transforming investments into growth and development. The importance of governance quality has been underlined in the literature [28–33]. Institutions drive economic interactions by creating essential determinants for the economic results in the territories that, in the long term, are often the result of institutional conditions rather than alternative economic factors [33]. The regional and local governance is crucial to determine the rules and capacity building of different public and private stakeholders locally. Transparency and accountability are two prerequisites for high-quality governance. Governance open to stakeholders increases public satisfaction and promotes accountability and understanding of processes leading to greater trust in government. At the same time, trust is instrumental for active public involvement in policy-making. The role every more relevant of sub-national governments in the management of public investment assumes even a broader significance in relationship to Ecological Transition. Thus, for an improvement in the quality of government, new models such as that of the TM appear especially suitable for regions suffering from economic stagnation. Encouraging new approaches to policy management with models that simultaneously give direction and co-participation becomes essential for a break from ineffective past models.

6 Transition Management: Governance for a Sustainable Development

The field of sustainability transitions is relatively new and emerged out of a fusion between various disciplines, including innovation studies, science and technology studies, complexity theory, and governance theory [6]. Underlying these different backgrounds and perspectives lies a shared focus on transitions: processes of long-term change that society intends to transform structurally. At the same time, the original focus of the field was on socio-technical systems (i.e., transport, energy, agriculture), but recently seen increasing attention to urban transitions [34, 35] and the more social and political aspects of transformative change. This factor includes explicit attention to topics of power and politics [36] and grassroots innovation, as well as links with other emerging fields such as social innovation research [37–40].

A territorial governance model of Transition Management guides development dynamics toward sustainability objectives. Rotmans et al. [21] indicate a theoretical governance framework based on Transition Management. Studies on transitions towards sustainability followed [5, 12], which focused on technology and innovation with a transdisciplinary vision [6] and identifying the suitable model in the governance framework of the TM [41]. For example, the Dutch Government has already used the Transition Management model to manage four transitions: transitions to sustainable energy, sustainable mobility, sustainable agriculture, and transition biodiversity and natural resources, having already been on the path of a broader Ecological Transition for several decades.

In addition, The Dutch government uses the TM model one in the 4th Integrated Environmental Policy Plan and the Dutch Energy Transition Project [42]. Based on a double strategy, the TM improves the system (changing an existing trajectory) and innovation (new development or transformation course). The TM, therefore, departs from the old planning and implementation model aimed at achieving particular results. A process-oriented approach reformulates objectives and intermediate targets (see Fig. 2) (Fig. 4).

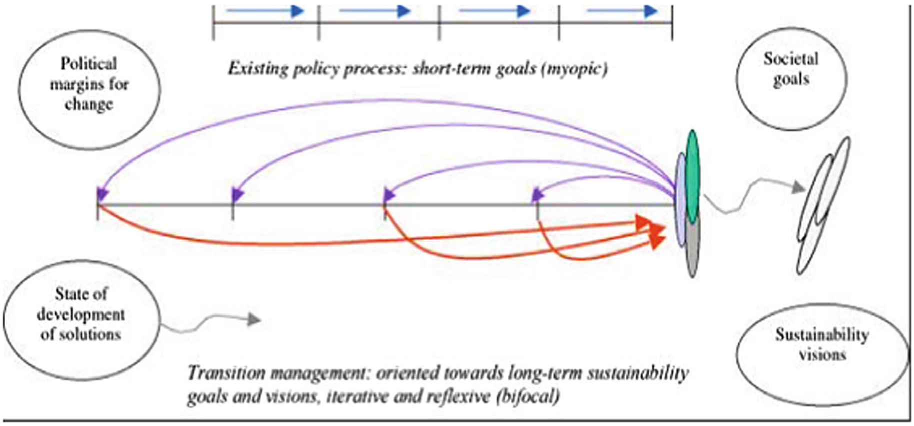

Fig. 4. Transition Management towards the classic intervention scheme [2].

Transition Management as a procedure management concerns objectives defined at a particular time. In particular, the Sustainable Development Goals [17] are well suited to apply the TM approach. An uncertain environment, such as a new model of sustainable development, urges companies and governments to predict evolutionary directions to plan development strategies. The TM offers elements to mutation and assists in enabling condition change. It is a reflective and evolutionary governance model that identifies systems or sectors of the economy as complex adaptive systems [36]. The governance instruments of TM, such as visioning, experimentation, and social learning, help to better prepare for change through transformative actions. TM's participatory process and interventionist approach support mobilizing actors and building networks for sustainability transformations. Transition Management is a meta-governance and policy-design framework for allowing and leading sustainability transitions. The ability to undertake a path of sustainability occurs through practical actions in the short term aligned with a medium and long-term focus [5, 34, 35, 41]. The European Ecological Transition indicates a profound mutation in the global system and includes all sectors; the energy system, moving from fossil fuels to renewable, or transport with the ever more increasing growth of shared mobility. Transitions occur over a long time that involves different generations leading to a change in the physical structure and the associated legislation, regulation, and societal expectations.

Transition Management presents a systemic approach to governance, which on a large scale offers the possibility of guiding and coordinating system innovations that move towards greater sustainability. Sustainability trajectories identify by building creative processes for future scenarios [43]. The most prominent function of the transition scenarios is to obtain an irreversible reformulation of the current paradigms [44]. The participatory and democratic involvement of local actors with different backgrounds in the strategic governance process makes it possible to identify the nature of the problems and the underlying causal mechanisms, finding new directions for solutions to persistent problems. The TM leads to improvements in performance through specific interventions [45]. Scenarios can provide guidance and focus on evolving into structural societal changes, developing long-term representations of sustainable worlds. The scenarios that apply the TM model should integrate different aspects of the problems, recognize uncertainty, and involve a broad public audience on sustainability and development issues [46]. The change is a prerequisite for a transition, and the different innovations must be reinforced in a joint project [43]. The solicitation of several specific innovations aims to cultivate sustainable alternatives to existing practices, triggering structural transformations in a long-term perspective. Thus, transition scenarios assume the configuration of participatory explorations of possible development trajectories that incorporate a mechanism of change towards a desired future state of the system. Niche innovations arise in different domains of society, each of which has its own internal pace of change. Economic developments, for example, are characterized by relatively rapid times, but the different domains need their synchronization, and the TM has the right incentives for their modulation [2, 22]. The modalities, therefore, become "*learning by doing and doing by learning*" when the interrelationships between the different trends are explored. In this sense, the future is not an empirical reality but a set of partially visible alternatives with large spaces of possibility. The table below resumes the characterizing elements of Transition Management.

6.1 The process of Transition Management

The Transition Management approach allows an innovation network of actors of various backgrounds who compare and integrate the different perceptions of structural problems at a strategic level. This vision of reality manifests itself in a shared and integrated perception of the issue [23]. The development of the scenario lies in the perception of the intermittent signals that herald political, economic, or social changes in society. These processes indicate the gap between the present and the future and the desired development direction. In particular, the TM assumes relevance in the Ecological Transition process because of the long-term sustainable co-evolutionary strategies. Policymakers, therefore, are not detached observers of change but active participants in the direction of innovation.

Kemp and Loorbach [2] describe the processes iterative of TM as follows:

- Problem structuring and identifying the transition arena;
- Developing a transition agenda, sustainability visions and pathways;
- Initiating and executing transition experiments;
- Undergoing processes of evaluation, monitoring and learning.

The model (Fig. 5) allows reflection upon the integration of sustainability in the policy of different European Regions where institutional characteristics and capabilities differ widely.

Table 1. The Transition Management characteristics. Authors' elaboration on Malekpour et al. [41]

Transition	**Management**
General Characteristic	Long-term focus Acknowledge significant, irreducible uncertainties Acknowledge the multi-objective, multi-actor nature of policy issues The impact is difficult to measure, especially in the short-term
Context	The starting point is a societal problem
Application Boundary	Considers the broader societal problem, although application could be at different scales Systemic societal change is the ultimate goal Proposes an alternative governance process
Process	A vision is co-created as part of the process The process is open-ended and essential on its own for social and policy learning It has its explicit theory of change Is methodologically pragmatic Irreducible uncertainty is addressed through experimentation and learning Future scenarios are used in a normative way and as a mobilizing tool (ideation) The process proceeds in a participatory process through organizing and mobilizing actors and developing partnerships
Output	The aim is to mobilize actors to realize transformative pathways

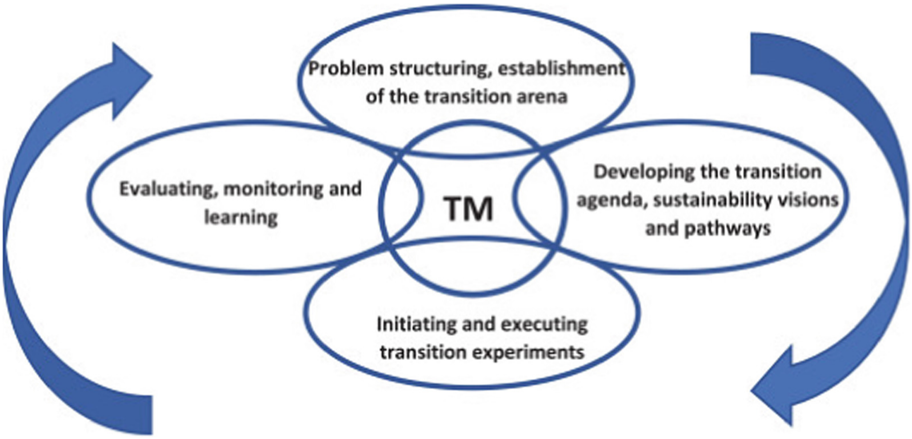

Fig. 5. Activity clusters in Transition Management [2]

The actors of a change scenario participate in a cyclical process. The Transition Management Cycle [50, 51] defines the problems, strategies, and transition paths developed, the networks mobilized, the experiments carried out, and the results monitored by reflecting the different learning points. Theoretical elements, reflections, and practical experiments are at the base of the TM-Cycle. The structure of the model is cyclical, and the phases can follow without a sequential order. The following four phases of the TM-Cycle operational systems are strategic, tactical, operational, and reflexive.

The strategic phase includes developing the vision, defining goals, and defining norms through collective discussion and a long-term perspective. Strategic activities will lead to changes in the social system. The tactical phase concerns the interaction between the actors' driving development. Tactical activities focus on interpreting the visions created by strategic actions at the system level and in the various networks, organizations, and institutions involved. Tactical activities seek to identify the barriers encountered (such as economic regulation conditions) when interpreting these views at the system level. The operational phase constitutes the learning process through experimentation and implementation at a specific level, focused on radical innovation. Finally, the reflective step allows us to evaluate social change. Reflective activities are incorporated both within politics and regulation and as a function of society's expectations and the "consensus" created through the media and modern information technologies.

The stimulating idea is that the stakeholders are involved in the entire process and all phases, including problem definition, coalition formation, experimentation, and evaluation.

The four phases of interventions are described below [49, 52] (Fig. 6):

1. Orienting: understanding, analysing, exploring the challenges, and reframing the problems.
2. Agenda setting: envisioning alternative futures that are more just and sustainable, developing a transition agenda, and identifying transition pathways.
3. Activating: conducting transition experiments and mobilizing networks.
4. Reflecting: monitoring, evaluating, learning from the transition experiments, and adjusting vision, agenda, and coalitions.

The most appropriate sequence of these phases depends on the operational places involved. Stakeholders start with analysing the new challenges, but also they evaluate accomplished projects and move to new orientations and possibilities.

Orienting indicates a prospective of change affecting the entire system. It has a long-term vision and operates in a strategic framework. The activating represents the operational level. It evolves in the short term (up to five years) and builds accurate results with projects or experiments and the vision of the quality of solutions. The Agenda-setting is at the base of the tactical level, with an interval lasting between 5–15 years of institutional and infrastructural changes. The Agenda must build on creating a shared sense of ownership of a sustainable future across society. Finally, the monitoring and evaluating of the transition process and learning from experiments concern the reflecting intervention.

The tools of the TM are different and come from various fields but appear valuable and adequate for governance that includes the concept of sustainability within its strategies.

A central operative instrument of TM is the "Arena" [49]. The Transition Arena facilitates interaction, knowledge exchange, and exchange learning among actors. An Arena is a group (networks) of actors engaged in the transformative goal of implementing future practices. The *'Transition team'* usually comprises the problem holder (e.g., the government department commission and a research team) who determine the framework and encourage the process [6].

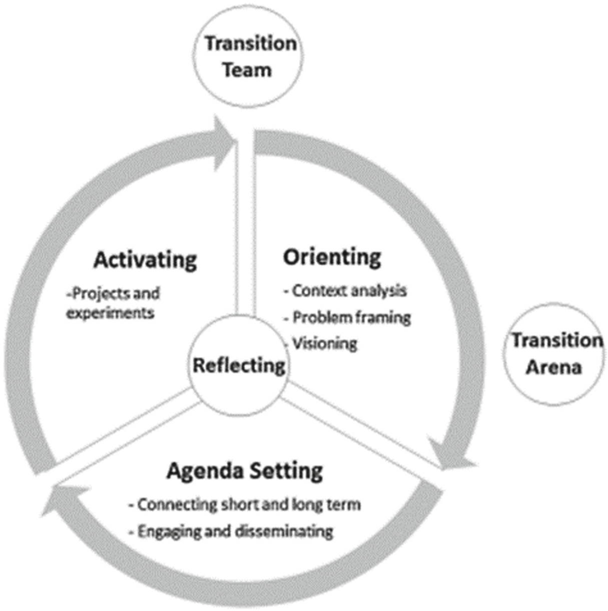

Fig. 6. The Transition Management Dynamics [6]

A critical element in TM is the set-up of a transition arena: a time constraint space and network in which participants co-create knowledge, critically analyse and develop new ideas, visions, and practical actions. Arena participants are involved in a collective process. The initial group should not be too large, with the selection of relevant actors based on competencies, interests, and backgrounds. A critical element is a representative participation from stakeholders such as governmental bodies, businesses, NGOs, and knowledge institutes. The arena participants need to be innovative in their thinking and open-minded toward new ideas. In addition, the arena is an open network, so new actors may enter the arena subsequent, such as others could leave the transition arena [53].

The Transition Arena has a first problematic step. The beginning of the process is the most delicate moment because it requires a mutual understanding and agreement about the vision proposed and planned for the other paths. The different opinions may generate conflicting perspectives of the actors involved and their various interests. However, an integrated assessment of the problem can achieve a certain level of agreement [53]. Different actors are confronted with the '*boundaries of the system*' prospecting innovation and change in the pre-development phase. Establishing the transition arena could facilitate precisely those regions struggling to trigger a process of change and a virtuous growth path. Therefore, the Ecological Transition management appears less abstract through new governance mechanisms and follows a mutual agreement.

7 Conclusion

The TM model radically changes planning techniques by implementing a model oriented to the dynamic change process. It is a model that combines growth, innovation, and the environment; themes currently at the center of the political debate in Europe in a post-Covid-19 era, reflecting economic, social, and cultural changes. Furthermore, it provides transversal tools for solving specific issues with a dynamic vision of social phenomena and a multilevel approach. Environmental, social and economic issues are closely connected. The Ecological Transition recognizes the environment as a constitutive element of the economy and the society. The policies are not linear, following continuous backward induction processes with high flexibility. Therefore, the governance model of the TM reflects the indication of territorial management, capturing dynamism and local complexity of all environmental elements. The multi-layered structure of the TM involves different social actors. It generates the democratic and participatory process, a necessary condition for its successful application. Therefore, the goal is to bring together drivers of change and sources of knowledge to create strategic visions that lead to an expansive definition of sustainability. Democratic citizen participation does not replace the role of government guidance; it persists and is necessary. Politics should recognize territorial needs and transform them into new opportunities for development. Collective participation should generate public support and increase the legitimacy of policies, helping reduce the risk of conflict and offering ideas, information, and knowledge. The TM model can trigger new processes for those regions blocked inside in a development trap with an evident correlation with a low institutional capacity. It makes it possible to broaden the responsibility for political choices, build long-term scenarios, and directly involve those who live in the area. Therefore, the Transition Management model appears in line with the broader framework of the Greater influence of the new governance system, i.e., a Megatrend.

The cohesion and economic gap have not diminished in Europe's economically less developed regions. The TM analysis opens up new possibilities for intervention in the context of the sustainable development strategy and the current Ecological Transition, which in Europe assumes particular strategic importance for the area's new and future geopolitical aspects.

The move towards a sustainable ecological transition indicates that TM's economic and social innovation is still in an evolutionary phase. In particular, if the institutions are potential innovators or backward actors, the results TM scheme will reveal what categories deal with them.

However, there is a risk of excess abstraction and difficulty applying Transition Management. The basis is the reconsideration of democratic participation processes for developing policies of complete economic, social, and environmental sustainability. Several contributions have already analysed the capacity of multilevel management of the European regions' economic, social, and territorial cohesion processes. The quality of the institutions is a watershed between advanced regions and regions included within a development trap. The quality of the institutions, however, is not the only condition that causes the economic gap in an area. Given its dynamic and induction logic, which continuously revises intermediate and final objectives, the TM presupposes a significant and widespread human capital endowment. The multi-layered structure of the TM involves different social actors, creating the democratic and participatory process, a necessary condition for its application.

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Assessing the Role of the Blue Economy in the Comprehensive Development of Lagging Coastal Areas. A Case Study of Calabria

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Abstract. Global warming has been having profound and wide-reaching consequences on the environment. Marine ecosystems have been at the nexus of these crises. Furthermore, the Covid-19 has exacerbated existing global inequalities across Marine sectors. Over the recent decade, Blue Growth has been considered a call for holistic management of the complex marine social-ecological system. Furthermore, it has shown the potential to coordinate efforts to combat the effects of climate change. Blue Growth industries could help accelerate recovery towards inclusive growth over the post-COVID-19 in the lagging coastal regions. Considering these premises, this study focuses on highlighting the characteristics of Blue Growth industries in Calabria – one of the lagging coastal in Southern Italy – to sustain the region's economic development. It investigates the regional characteristics and intersectoral linkages within the Blue Growth industries. Cluster-based analysis allows us to better understand the interconnections between different sectors within the industries. The paper's results offer new insights into Blue Growth industries' size and specialization in Calabria. The analysis in this paper detects the gaps and potentials in the exciting sectors in Blue Growth and therefore constitutes a practical first step in a series of more comprehensive examinations of Blue Growth patterns in Calabria.

Keywords: Clusters · emerging industries · Blue Growth · Calabria · regional analysis · community-based · network analysis

1 Introduction and Context

The currently observed changes to the earth system are unprecedented in human history. Since World War II, the world's population has soared and a conflict between economic growth and environmental protection has emerged [1]. The population has a tremendous impact on water, energy usage, agricultural lands, and the environment [2]. Cities grapple daily with issues related to the management of water systems and water scarcities [3], electricity shortages (by the impact on hydropower and plant cooling), and water-related diseases (through the use of contaminated water) [4]. As human pressure

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on the Earth system accelerate, unexpected critical global, regional, and local impacts are likely to appear [5, 6]. Hence, Sustainable Development Goals (SDGs) were born in 2015 to protect our planet, end poverty, and ensure that all people enjoy peace and prosperity. Additionally, the adaptation of Paris Agreement is another step to keeping global warming under two degrees Celsius and strengthening countries' ability to cope with the impacts of climate change [7]. The question, however, remains; can economic growth be reconciled with environmental sustainability? Although the Sustainable Development trajectory can be achieved, there is the risk of pursuing one at the expense of the others [8]. In other words, some goals could be easily achieved while disregarding the environment.

A sustainable ocean economy can play a crucial role in keeping 1.5 degrees within reach while providing jobs, reducing inequality, supporting food security, sustaining biodiversity, and boosting resilience [9–11]. Oceans are the Earth's largest natural carbon sink [12]. They absorb roughly 93% of the heat that comes from any greenhouse gas emissions. The oceans have already absorbed 30% of total anthropogenic CO2 emissions since the 1980s [13]. Thus, they are an essential regulator when it comes to global warming. However, this continued warming has led to rising acidification, ocean warming, and damage to its critical ecosystem [14]. It, therefore, places some management emphasis on resilience as an essential design feature in an uncertain world that is not only about bouncing back but is to be prepared [15].

Oceans cover around 71% of our planet, and areas in the coastal waters around the margins of the continents are considered the most productive areas [16]. These areas encompass 66 naturally occurring large marine ecosystems[1], which together produce 75% of global marine fish catches and contribute more than 12 trillion US dollars annually to the global economy [18]. However, these rich coastal seas face increasing threats from impacts like climate change, overfishing, and marine pollution, undermining the services humans require from healthy marine ecosystems [19]. Thus, there has been a very narrow focus on managing most marine activities [20]. The aim is to sustain the production potential for ecosystem goods and services, rather than managing single commodities without regard to the impacts on other parts of the ecosystem [21]. This means that multiple spatial scales need to be considered, and the perspectives need to be long-term rather than more typical short-term views that influence sectoral interests. So, from here, the globe started to shed light on the so-called "Blue Growth" and those interconnections between different sectors. Scholars and activists started looking for achieving win-win efficiency for all sectors. As to measure the efficiency of one sector and achieving its growth, it has to be measured with at least one more sector.

Blue Growth is a relatively new framework for ocean management [22–24]. The roots of its concept can be traced back to the concept of Sustainable Development (SD). SD started in the 1960s as a challenge to start achieving sustainable use of natural resources while at the same time securing social and economic developments. Since then, there have been three milestones in the development of SD. First, at the first United Nations (UN) conference on SD in Stokholm in 1972, the environmental dimension was defined.

[1] The world's oceans have been divided into 66 Large Marine Ecosystems (LMEs). These are defined as near coastal areas where primary productivity is generally higher than in open ocean areas [17].

Then, the economic dimension was the spot in Rio 1992 at the second UN conference on SD. Lastly, in 2002 in Johannesburg, the social dimension was defined at the third UN conference on SD. At Rio+ 20 that held in Rio in 2012, Blue Growth as a new concept was first conceived and took centre stage. This concept was a start to push governments to begin thinking about how to use the natural resources in oceans by combining the aspects of economic growth and environmental sustainability. Blue Growth implies making better use of the oceans via improved natural resource management across different sectors [25]. After the Blue Growth concept was introduced at the Rio+ 20 conference, it has been widely used and become necessary in aquatic development in many countries, regionally and internationally [23].

Smith-Godfrey identified Blue Growth as "the sustainable industrialisation of the oceans to the benefit of all" [26]. It connects the different ocean industries [22], for instance, fishing, shipping, tourism, and marine ecosystem services such as coastal protection and carbon storage [22]. Understanding such interactions (e.g., shipping impacts on the fishing industry) helps manage all components together, which tends to produce optimal outcomes at the system level [27]. However, this imposes challenges rooted mainly in complexity and scale [28]. Although these challenges are surmountable, they demand a pragmatic approach [29]. Such an approach explicitly recognises the existence of underexplored potentials.

Before the COVID-19 pandemic hit, Blue Growth industries such as fishing, energy, shipping, and tourism had been estimated to contribute 2.5% of world gross value-added; that value was predicted to double by 2030 [30]. However, the pandemic has hit hard the ocean sectors and global supply chains [31]. For example, the maritime tourism sector was one of the first sectors affected by the outbreak, with global reporting of COVID-19 cases among crew members and passengers on cruise ships [32]. Moreover, the linkages between blue sectors and land-based industries mean that the pandemic has broader impacts beyond these individual sectors but across the entire economy [31]. Therefore, a sustainable and holistic recovery strategy is critical for the well-being and resilience of communities and economies at large.

For this reason, the European Union has made great efforts to successfully implement the principle of cohesion by investing in infrastructure and aiding regions [33]. In 2014, the European Maritime and Fisheries Fund (EMFF) was adopted for the 2014–2020 period to support the objectives of the Europe 2020 strategy for smart, sustainable, and inclusive growth. More recently, European Commission proposed to renew the EMFF in order to continue supporting the implementation of the Common Fisheries Policy (CFP), the EU Integrated Maritime Policy, and increase territorial cohesion in the field of ocean governance [34]. As a result, the fund was renamed European Maritime Fisheries and Aquaculture Fund (EMFAF) 2021–2027. It aims to unleash the growth potential of a sustainable Blue Economy toward a more prosperous future for coastal communities [35]. The fund supports the European Green Deal's goals and helps achieve goal 14 of SDGs [36]. It aims at stimulating the growth of Blue Economy through; 1) assisting fishers transitioning to a sustainable fishery capture; 2) encouraging coastal regions in diversifying their economies; 3) increasing job opportunities through financing European coasts projects; 4) enhancing sustainable aquaculture developments[2].

[2] https://aac-europe.org/images/EC_EMFF.pdf.

In this research, Calabria is used to assessing regional economic growth through Blue Growth industries. Our primary research question is: can Blue Growth be the potential for a sustainable and inclusive transition in Calabria? We tackled this question by analysing the Blue Growth industries' performance by measuring their size and specialisation. The following section focuses on defining the case study and its blue economy. Section 3 provides the methodology, defining the extent of Blue Growth in Calabria and the tools used. Section 4 presents the gaps and specialisations in the exciting sectors in Blue Growth. Finally, Sects. 5 and 6 raise some issues that emerge when framing the Blue Economy within regional development and therefore constitute a useful first step in a series of more comprehensive examinations of Blue Growth patterns in Calabria.

2 Methodology

2.1 Area of Study

Our area of study is Calabria region in Southern Italy. The region has long been one of the poorest in Italy. The disparity in Italy is huge; Lombardy region, for example, has the highest regional GDP - roughly 400 billion euros – which accounts for more than one-fifth of the Italian GDP, while all eight Southern regions as whole produce less than Lombardy[3]. Italy is considered the only country in Europe with the most substantial and persistent territorial inequalities with an extraordinary degree of geographical concentration; among 173 European regions, the five poorest are in Southern Italy [37]. In OECD report for 2018 on Italy's regions and cities, it stated that "Italy has the largest regional disparities among OECD countries in unemployment rates, and the second largest in terms of safety" [38]. In 2020, the six regions with the lowest unemployment rate were in Southern Italy, with around 19% of Calabria's population unemployed [39]. "In 2019, almost one in four women in Calabria were without a job, whereas the share of unemployed males was of 20.2%"[4]. Therefore, in this study, we try to focus on this lagging region and assess its economic growth and the potential that could help it develop.

Regarding Blue Economy, on the one hand, Italy is one of the most significant contributors to the EU Blue Economy employment. It is specialised in labour-intensive sectors such as Coastal tourism or Extraction of living resources [40]. The Italian Blue Economy is dominated by the coastal tourism sector and Maritime transport. The Mediterranean Sea has been crucial to the economy of coastal cities [41]. Its traditional sectors (aquaculture, fisheries, coastal and marine tourism, shipping, shipbuilding/repair, and ports) and new maritime economy sectors (such as blue biotechnology, ship recycling, and ocean energy) have enormous potential for prosperity and inclusion growth[5]. There are several projects in the Mediterranean Sea in which Italy has participated to promote its Blue Economy transition [42]. On the other hand, Calabria is a coastal region that occupies the southernmost tip of Italy with an area of 15,081 km^2 with a total of 1,877,728 inhabitants in 2021 and presents a population density of 124.5/km^2 (Eurostat, 2020). Calabria is a statistics NUT III Region and integrates 5 provinces (NUTS III): Catanzaro, Cosenza,

[3] https://www.statista.com/statistics/793266/gdp-in-italy-by-region/.

[4] https://www.statista.com/statistics/778264/unemployment-rate-in-italy-by-region/.

[5] https://www.unep.org/unepmap/resources/factsheets/blue-economy.

Fig. 1. Map of the 45 Local labour Market Areas (LMA) in Calabria

Crotone, Reggio di Calabria, and Vibo Valentia that contain 44 Local labour Market Areas (LMA) (See Fig. 1). It is bordered by Basilicata to the north, the Gulf of Taranto to the east, the Ionian Sea to the south, the Strait of Messina to the southwest, which separates it from Sicily, and the Tyrrhenian Sea to the west. The Blue economy's potential has emerged in recent years in the Calabria, even though a coordinated effort has yet to emerge. The Mediterranean Sea is a development space that, if used sustainably, may lead to economic prosperity and contribute to the region's stability by creating jobs and innovative business opportunities in the maritime sectors [42]. Nevertheless, information about how the marine system works in Calabria is scarred. In the following section, we will give an in-depth examination of the Blue Growth industries in Calabria in terms of its size and specialisation.

2.2 Methods

In order to understand a system and evaluate the economic growth of a given region, the inter-sectoral relationships should be examined [43]. By dividing the economic system into interrelated sectors, clusters show exactly which sectors are closely related [44, 45]. Porter introduced the concept of industry clusters as groups of interconnected firms, suppliers, related industries, and specialised institutions in particular fields that are located in particular locations [46]. Industry cluster analysis facilitates revealing the spatial configuration of innovation and understanding of the performance factors and innovation flows, which will emphasize the potential elements of a regional innovation eco-system [47]. Porter focused on how the mutual transparency and knowledge exchanges in spatial proximity can enhance the competitiveness of a region by encouraging local innovation processes [48]. In times of crisis, clusters prove capabilities to ensure quick information flow and technological capacities. Therefore, they are crucial in playing a pivotal role in Europe's recovery from the crisis. In the beginning, clusters were defined in the US by proposing 51 traded clusters [49]. From the 51 traded clusters, ten Emerging Industries were defined based on employment growth and overall size [50]. The selection of the sectors in the emerging industries reflects the strong competitiveness potential of these sectors [51]. European Panorama of Clusters and Industrial Change analysis showed that emerging industries stood their ground better during the economic crisis, unlike traded clusters [52]. Blue Growth industries is considered one of the emerging industries. Emerging industries were shaped and affected by a number of megatrends [53] which are defined as "sustained forces on a global and macroeconomic level that influence the developments of business, environment, economy, society, cultures, and citizens' lives on a local and global scale" [54]. As for Blue Growth industries, it was affected by the changing mobility paradigm, driven by automation, green and circular economy, and smart mobility trends [55]. These industries cover traditional and new, and high-growth sectors [52]. It consists of 33 sectors (Table 1) that evolved from 15 clusters (Fig. 2).

Our study focuses on selected characteristics depicting the Blue Growth industries' current and past dynamics. We follow the European Observatory for Clusters and Industrial Change (EOCIC) methodology for measuring the Blue Growth industries' performance existing in Calabria region. The EOCIC shows the extent to which clusters have achieved this specialised critical mass by employing measures such as (size, specialisation, and productivity). This study examined the industries' size and specialisation by measuring the employment, establishments, and Location Quotient (LQ). The size is measured by the number of employees within the industry. On the other hand, LQ provides insights into the employment specialisation of the region. We then added a few additional calculations based on EOCIC 2020 report. The new LQ additional formulas consist of the number and size of plants, represented by the Plant and Size Quotient respectively. We retrieved our data from the Italian National Institute of Statistics (ISTAT). After data collection, the next step was to check the internal consistency of the indicators as appropriate for our study. Our focus is on LMA, it is "*a geographical area surrounding a central city (or cities a few miles apart) in which there is a concentration of labour demand, and in which workers can change their jobs without changing their residences*" [56]. Labour markets are crucial for the performance of the cluster and one

Table 1. It shows the sectors in Blue Growth industries as was classified in the Statistical Classification of Economic Activities in the European Community (NACE), which are cutting across different clusters

Blue Growth industries	NACE Code	Sectors' names	Cluster
	35.12	Transmission of electricity	Electric power generation and transmission
	35.11	Production of electricity	
	79.11	Travel agency activities	Hospitality and tourism
	77.32	Renting and leasing of construction and civil engineering machinery and equipment	Distribution and electronic commerce
	52.10	Warehousing and storage	
	46.14	Agents involved in the sale of machinery, industrial equipment, ships and aircraft	
	77.34	Renting and leasing of water transport equipment	
	42.91	Construction of water projects	Construction products and services
	73.11	Advertising agencies	Marketing, design, and publishing
	72.19	Other research and experimental development on natural sciences and engineering	Education and knowledge creation
	52.22	Service activities incidental to water transportation	Water Transportation
	33.15	Repair and maintenance of ships and boats	
	50.10	Sea and coastal passenger water transport	
	50.30	Inland passenger water transport	
	50.40	Inland freight water transport	
	30.11	Building of ships and floating structures	
	30.12	Building of pleasure and sporting boats	
	50.20	Sea and coastal freight water transport	
	25.99	Manufacture of other fabricated metal products n.e.c	Downstream metal products

(*continued*)

Table 1. (*continued*)

	22.19	Manufacture of other rubber products	Vulcanized and fired materials
	28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	Production technology and heavy machinery
	28.22	Manufacture of lifting and handling equipment	
	36.00	Water collection, treatment and supply	Environmental services
	03.11	Marine fishing	Fishing and fishing products
	03.12	Freshwater fishing	
	10.20	Processing and preserving of fish, crustaceans and molluscs	
	52.24	Cargo handling	Transportation and logistics
	52.23	Service activities incidental to air transportation	
	52.29	Other transportation support activities	
	49.41	Freight transport by road	
	71.12	Engineering activities and related technical consultancy	Business services
	71.20	Technical testing and analysis	
	09.10	Support activities for petroleum and natural gas extraction	Oil and gas production and transportation

of its distinct constituent elements. It represents the local labour pool in which the transfer of knowledge and technology is easy between firms [57]. Therefore, the data were transformed from more than 400 local administrative units to 45 Local labour Market Levels and from NACE 3-digit level to NACE 4-digit level (Table 2).

Table 2. Data Frame Structure

	Year (2012–2019)	
Data type	**Number of establishments**	**Average number of employees**
NACE code	**Sector's code (4 digits)**	**Sector's code (4 digits)**
Italy		
South		
Calabria		
LMAs		

The retrieved data was for eight years, 2012 to 2019; however, the analysis shown in this article is only for 2019 to try to get the most recent picture of the system. We adopted size and specialisation measures. These measures are described as follows:

2.3 Size

Employment

We calculated the size by measuring the LMAs' share of the total Italian employment in Blue Growth industries. It is calculated using the following formula:

$$Size_{r,b} = \frac{e_{b,r}}{E_{b,i}} \tag{1}$$

where

$e_{b,r}$ is the employment in Blue Growth industries b in LMA r

and $E_{b,i}$ is the employment in Blue Growth industries b in Italy i

Establishments

As for the number of establishments, we used only the network visualisation to analyse the region's data. Nevertheless, the number of establishments was used later in the calculations of LQ.

Specialisation

Location Quotient (LQ)

The Location Quotients method is adapted to identify the extent to which clusters have achieved their specialisation. LQ compares the proportion of employment in Blue Growth industries in Local Labor Market Areas over the total employment in Italy to the proportion of total Italian employment in that Blue Growth industries over total Italian employment. The equation is as follows:

$$LQ_{b,r} = \frac{e_{b,r}/E_r}{e_{b,i}/E_i} \tag{2}$$

where

$e_{b,r}$ is the employment in Blue Growth industries b in LMA r

$e_{b,i}$ is the employment in Blue Growth industries b in Italy i

E_r is the total employment in LMA r

and E_i is the total employment in Italy i

Moreover, we added to the standard calculation of LQ, the EOCIC new measures of LQ. The additional measures of LQ help reveal large firms, SMEs, or both have a high contribution to the employment share in Blue Growth industries. It is calculated by Plant and Siza Quotient. It is as follows:

$$\begin{gathered} LQ_{b,r} = \tfrac{e_{b,r}/E_r}{e_{b,i}/E_i} = \\ Plant\ (Concentration\ SMEs) = \tfrac{f_{b.r}/E_r}{f_{b.i}/E_i} \end{gathered} \tag{3}$$

$$\begin{gathered} multiplied\ by \\ Size\ (Concentration\ large\ firms) = \tfrac{e_{b.r}/F_r}{e_{b.i}/F_i} \end{gathered} \tag{4}$$

where

$f_{b,r}$ is the number of firms in Blue Growth industries b in LMA r
E_r is the total employment in LMA r
$f_{b,i}$ is the number of firms in Blue Growth industries b in Calabria/Italy i
E_i is the total employment in Calabria/Italy i
$e_{b,r}$ is the employment in Blue Growth industries b in LMA r
$F_{b,r}$ is the total number of firms in Blue Growth industries in LMA r
$e_{b,i}$ is the employment in Blue Growth industries b in Calabria/Italy i
and E_i is the total number of firms in Calabria/Italy i

Other elements that were introduced by EOCIC are Beta Size and Beta Plant. They measure the influence of large firms and the influence of SMEs, respectively.

$$Plant\ Beta(influence\ SMEs) = \frac{\begin{matrix} covariance \\ (plant\ formula; LQ\ formula) \end{matrix}}{\text{Variance(LQ formula)}} \tag{5}$$

$$Size\ Beta(influence\ large\ firms) = \frac{\begin{matrix} Covariance \\ (size\ formula; LQ\ formula) \end{matrix}}{\text{Variance(LQ formula)}} \tag{6}$$

The point of this second measure is that the employment in Blue Growth industries might be made up for the most part by large companies in a region. However, the industries within the same region might experience high levels of influence by SMEs. If the number is higher than 0.55 that indicates strong influence or dominance by either large companies, SMEs or both. In particular, "A strong influence by number and/or size is seen if the value of beta is above 0.55. In other words, SMEs are said to exert influence on emerging industries in a region if Plant Beta is above 0.55 and Size Beta below 0.55. Large firms are seen as key influencers if the Plant Beta is below and Size Beta above the stated threshold. Both Betas can be above 0.55 as well, meaning both SMEs and large firms strongly influence emerging industries in a region" [52]. In this step, we measured the influence of large firms vs SMEs at both scales – within the region and on the national scale. To do so, the first step was to calculate Plant and Size of each LMA with respect to Calabria. Then calculate the covariance and variance to get the Plant Beta and Siza Beta. After that, the same steps were taken but with respect to Italy. The only difference between the two steps is whether we take the number of firms and employees in Italy overall or only in Calabria region.

In addition to that, Social Network Analysis (SNA) was applied to analyze Calabria industries' networks. SNA is one of the promising tools for analysing and helping in a deep understanding of the system's complexity in terms of its inter-sectoral linkages and sectors' influence [58]. It maps the network structure of the regional Blue Growth industries and describes the intersectoral linkages and their relative size in each LMA. We use network analysis to build a relationship graph in which nodes are bipartite and represent LMAs and sectors in the Blue Growth industries, and edges are links between them. In the network, 'ties' resulted from the existence of the industrial sectors within LMAs. Networks allow us to describe the relations between the location and the sectors and evaluate the strength of connections [59]. Besides ECO methodology, two metrics were extracted from the network graph, eigenvector centrality and betweenness centrality [58]. Eigenvector centrality shows the degree of strength of a node by measuring its direct connections to other connected nodes. Betweenness centrality is a measure of centrality based on the shortest paths. We chose these two metrics because they complement each other, with eigenvector centrality measuring the value of a node in the overall network and betweenness centrality within the network [60].

3 Results

First, we started by grasping an image of the structure of Blue Growth industries in Calabria. Figure 3 depicts the Blue Growth sectors and the clusters that link them. Fifteen clusters (shown in a circle layout) are the connection between the industries. Some of these connections are relatively narrow, based on only one sector. Others are broader, with 100% of the cluster being part of Blue Growth industry (e.g. "Fishing and fishing products" cluster).

Blue Growth sectors are formed in the vertical line on the left, and the colour of the nodes reflects the parent cluster. The horizontal line at the bottom of the figure shows the 45 LMAs in Calabria. It gives us an initial image of the most robust nodes for LMAs, clusters, and Blue Growth sectors. For LMAs, it shows that Cosenza, Catanzaro, and Reggio Calabria are the most powerful zones in Calabria. Furthermore, the pie charts in the LMAs' nodes show that the highest number of establishments in these LMAs are from "Distribution and electronic commerce" and "Business services" clusters. Moreover, "Fishing and fishing products" and "Electric power generation and transmission" clusters are 100% part of Blue Growth industries. Additionally, "Water transportation", "Distribution and electronic commerce", and "Transportation and logistics" clusters have the highest share of sectors in Blue Growth industries, 7, 4, 4 sectors, respectively. However, "Engineering activities and related technical consultancy" sector from "Business services" cluster contributes to the highest number of establishments for Blue Growth industries in Calabria for 2019. Although the European Commission already made this classification for Blue Growth industries, network visualisation helps us understand the linkages with the sectors and the associated clusters.

3.1 Employment

According to our results, Blue Growth industries in Calabria appears to have a minimal size compared to the rest of the country (Table 3). However, that does not mean there is no hope for these industries to grow. Possibilities and sustainable development for coastal communities will be attained but with challenging normative concepts and representations of economics [61]. The growth can be achieved by establishing a coherent and direct understanding of the industry and relationships in economic sectors. Therefore, it is essential to establish the proper and coherent network for Blue Growth industries by understanding that the place and its economies are unique.

Table 3 shows the LMAs with a high size percentage. These LMAs are Cosenza, Lamezia Terma, Reggio Di Calabria, Gioia Tauro, Catanzaro, and Vibo Valentia with the size of Cosenza (19.19%) more than the double size of the other LMAs. However,

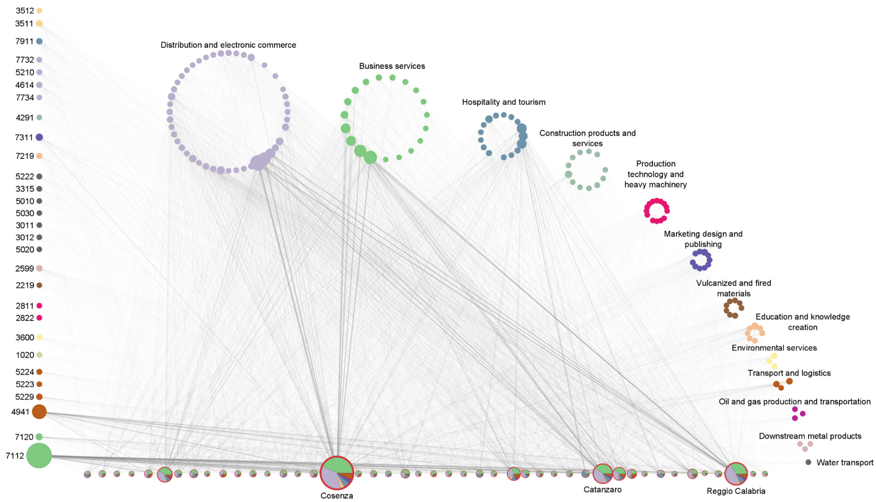

Fig. 2. Linkages between Blue Growth industries sectors and the parent clusters for the number of establishments in Calabria for 2019. **Legend:** Circles: clusters. Horizontal line: Local labour Market Areas. Vertical line: Blue Growth sectors

contradictorily, the size of Calabria's LMAs is almost nothing compared to Italy, with Calabria making up only 1.44% of the Blue Growth industries.

Betweenness centrality captures the nodes' role in allowing information to pass from one part of the network to the other. It indicates sectors and LMAs that act as bridges to others—in other words, having the most considerable effect on connecting the network as a whole. Our analysis shows that the highest sectors are "Engineering activities and related technical consultancy", "Freight transport by road", and "Travel agency activities", respectively. While the most dominant LMAs are, Crotone, Reggio Di Calabria, and Lamezia Terme. Interestingly enough, Cosenza comes in sixth place. Betweenness centrality also shows that "Sea and coastal freight water transport" sector has no control over the network. On the other hand, Eigenvector centrality dedicates the node's influence on the whole network. The numbers from the network showed the exact same tops as in Betweenness centrality. Engineering activities and related technical consultancy", "Freight transport by road", and "Travel agency activities" for sectors, and Crotone, Reggio Di Calabria, and Lamezia Terme for LMAs.

A deeper look at the internal distribution of the strengths and weaknesses of Blue Growth clusters is pivotal for fully understanding how the region is positioned for expanding its Blue Economy. Economic network visualisation played an essential role in our analysis. It helped in understanding regional economics and economic geography. As Fig. 4 shows, Freight transport by road sector acts as a "hub". It has the highest number of employees among all LMAs in Calabria, 6646.6 average number of employees. The highest proportion of that sector is in Cosenza, Lamezia Terme, and Cortona, with 903.3, 647.1, and 641.6 average number of employees, respectively. The second-highest number of employees is in Engineering activities and related technical consultancy sector, 4013.8 average number of employees, a quarter of that is in Cosenza with 965.9 average

Table 3. Employment size in Calabria's LMAs for 2019

LMA	Average employment in Blue Growth industries (2019)	Size of LMAs compared to Calabria	Size for Italy
Italy	1305084.25		
Calabria	18755.54		1.44%
Acri	195.53	1.04%	0.01%
Amantea	210.95	1.12%	0.02%
Belvedere **Marittimo**	138.21	0.74%	0.01%
Cariati	70.2	0.37%	0.01%
Cassano All'ionio	231.36	1.23%	0.02%
Castrovillari	571.2	3.05%	0.04%
Cetraro	62.7	0.33%	0.00%
Cosenza	3599.4	19.19%	0.28%
Mormanno	71.9	0.38%	0.01%
Paola	138.1	0.74%	0.01%
Praia A Mare	168.18	0.90%	0.01%
San Giovanni In Fiore	85.9	0.46%	0.01%
San Marco **Argentano**	342.7	1.83%	0.03%
Scalea	189.7	1.01%	0.01%
Catanzaro	1475.08	7.86%	0.11%
Chiaravalle Centrale	60.7	0.32%	0.00%
Sellia Marina	268.2	1.43%	0.02%
Soverato	359.07	1.91%	0.03%
Lamezia Terme	1679.82	8.96%	0.13%
Bianco	85	0.45%	0.01%
Bovalino	124.65	0.66%	0.01%
Delianuova	17.5	0.09%	0.00%
Gioia Tauro	1590.38	8.48%	0.12%
Locri	224.91	1.20%	0.02%
Marina Di **Gioiosa Ionica**	127.21	0.68%	0.01%
Melito Di Porto Salvo	146.46	0.78%	0.01%
Oppido Mamertina	32.62	0.17%	0.00%

(*continued*)

Table 3. (*continued*)

LMA	Average employment in Blue Growth industries (2019)	Size of LMAs compared to Calabria	Size for Italy
Polistena	535.5	2.86%	0.04%
Reggio Di Calabria	1606.01	8.56%	0.12%
Roccella **Ionica**	81.2	0.43%	0.01%
Rosarno	551.44	2.94%	0.04%
Sant'eufemia D'aspromonte	43.28	0.23%	0.00%
Stilo	86.8	0.46%	0.01%
Taurianova	146.45	0.78%	0.01%
Cirò Marina	165.41	0.88%	0.01%
Crotone	1225.32	6.53%	0.09%
Mesoraca	26.2	0.14%	0.00%
Petilia Policastro	185.2	0.99%	0.01%
Serra San Bruno	42.86	0.23%	0.00%
Soriano Calabro	61.66	0.33%	0.00%
Tropea	162.57	0.87%	0.01%
Vibo Valentia	1403.25	7.48%	0.11%
Corigliano-Rossano	152.47	0.81%	0.01%
Nova Siri	26.53	0.14%	0.00%

number of employees. The highest number of employees are in Cosenza, Lamezia Terme, Reggio Di Calabria, Gioia Tauro, and Catanzaro, with 3599.4, 1679.8, 1606.0, 1590.4, 1475.1 average number of employees, respectively. However, the lowest is in Delianuova, Mesoraca, Oppido Mamertina, Serra San Bruno, and Sant'eufemia D'aspromonte, 17.5, 26.2, 32.6, 42.9, and 43.3, respectively, because they are landlocked LMA. Although Cosenza is dominant in Blue Growth industries employment, it has almost no employment in "Renting and leasing of water transport equipment" and "Building of pleasure and sporting boats" sectors. As for Lamezia Terma, the highest number of employees are in "Freight transport by road", "Engineering activities and related technical consultancy", and "Service activities incidental to air transportation" sectors, 647.1, 299.9, 287.5 average number of employees, respectively. Reggio Calabria is supposed to be a major economic centre for regional services and transport on the southern shores of the Mediterranean. The highest number of employees is in "Sea and coastal passenger water transport" sectors, 195.7. Gioia Tauro has an important port; Port of Gioia Tauro is one of the largest seaports in southern Italy. It is situated on one of the busiest maritime corridors in the world, Suez to Gibraltar. Gioia Tauro has the highest employment in

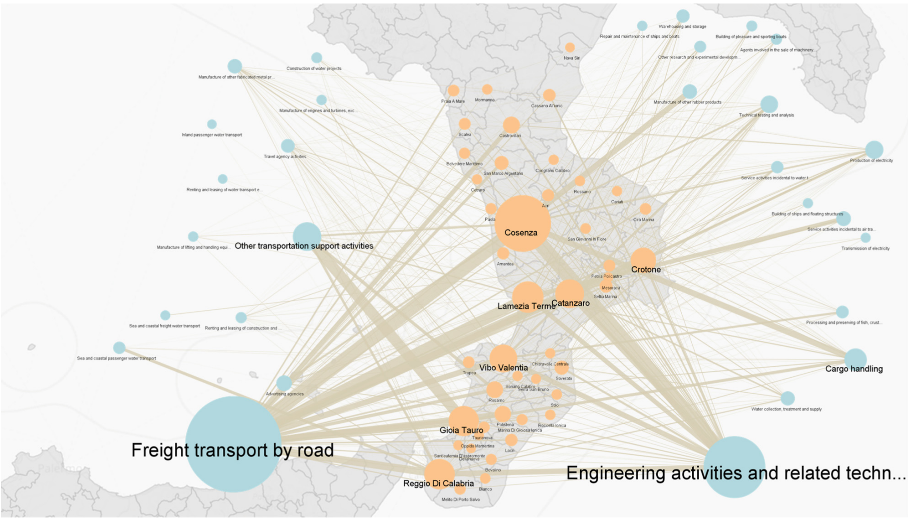

Fig. 3. Network of the employment in Blue Growth industries in Calabria for 2019**. Legend:** Orange nodes: Local labour markets. The size of the orange node: average no. of employees in all sectors found in that LMA. Blue nodes: Blue Growth sectors. The size of the blue node: average no. of employees in that sector. Edge width: average no. of employees in each sector in the connected LMA.

"Other transportation support activities" sector, which consists, for example, of forwarding of freight services and customs activities. Catanzaro is the second-highest LMA in "Production of electricity" sector with 107.6 average number of employees. On the other hand, 4 out of 33 sectors did not exist in Calabria in 2019, "Freshwater fishing", "Marine fishing", "Inland passenger water transport", and "Support activities for petroleum and natural gas extraction" sectors.

3.2 Number of Establishments

For the number of establishments, "Engineering activities and related technical consultancy", "Freight transport by road", "Technical testing and analysis" sectors show the highest Betweenness centrality. While Crotone, Reggio Di Calabria, and Vibo Valentia are the highest LMAs. Regarding eigenvector centrality, it shows the exact same order.

Graph 4 shows "Engineering activities and related technical consultancy" sector has the highest number of establishments in Calabria (3419 units), while "Freight transport by road" sector has 1592 units only. The highest number of "Engineering activities and related technical consultancy" establishments is in Cosenza, Catanzaro, and Reggio Di Calabria, 806, 339, and 310, respectively. The graph shows that the biggest LMAs in terms of the number of establishments are Cosenza, Reggio Di Calabria, Catanzaro, Lamezia Terme, and Vibo Valentia, 1373, 588, 582, 435, 420. Although Gioia Tauro is dominant for employment in "Other transportation support activities" sector, it has only eight establishments for that sector. Meanwhile, Cosenza and Reggio Calabria have a higher number of establishments, 23, and 21, respectively. "Advertising agencies" sector and "Technical testing and analysis" sector are in the third and fourth places in terms of the number of establishments after "Freight transport by road" and "Engineering activities and related technical consultancy". The weakest sectors in Blue Growth industries are "Inland passenger water transport" and "Sea and coastal freight water transport", with two establishments each. Vibo Valentia has an important industrial area, "Vibo Marina". It is an important commercial and tourist harbour for petrol distribution and fish selling (especially tuna). It has 193 establishments for Engineering activities and related technical consultancy sector and 99 establishments in Freight transport by road sector. The weakest LMAs are Delianuova, Sant'eufemia D'aspromonte, and Nova Siri, with 12, 16, and 17 establishments, respectively. In a nutshell, Freight transport by road and Engineering activities and related technical consultancy sectors are the "dominants" of Blue Growth industries in Calabria for 2019.

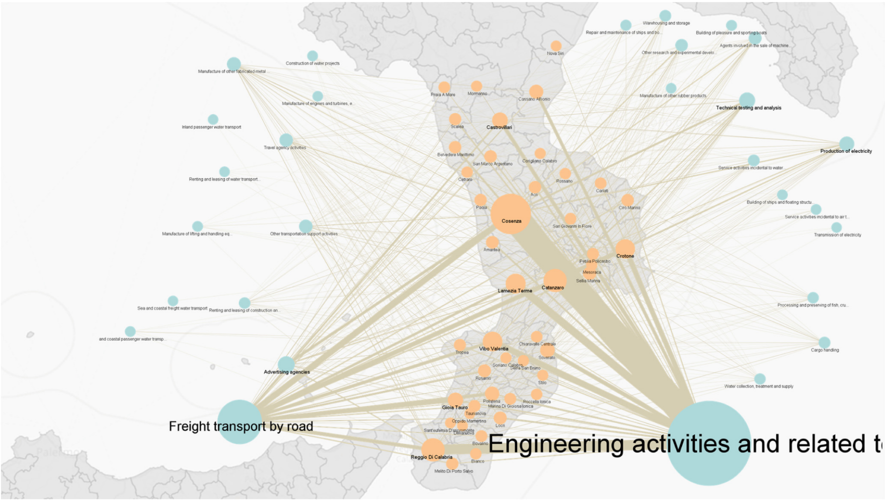

Fig. 4. Network of the number of establishments in Blue Growth industries in Calabria for 2019. **Legend:** Orange nodes: Local labour markets. The size of the orange node: no. of establishments in all sectors found in that LMA. Blue nodes: Blue Growth sectors. The size of the blue node: no. of establishments in that sector. Edge width: no. of establishments in each sector in the connected LMA.

3.3 Location Quotient (LQ)

In order to identify to what extent clusters have achieved their specialisation, Location Quotients method is adapted. LQ compares the per cent of local employment in a specific industry to the per cent of national employment in the same industry.

In Italy, there are almost 200 thousand activities in this Blue Growth that employ almost 900 thousand people (equal to almost 3.5% of the country's employment rate). The Blue Economy generates an added value of 134.5 billion euros: 8.5% of the total economy. However, in terms of specialisation, 4 out of 5 provinces in Calabria, compared to the rest of Italy, are not yet specialised in these industries. Although seas surround Calabria from most of its frontier and it is famous for its beautiful beaches, it still lacks utilising one of its critical assets. Table 4 shows the degree of specialisation for each LMA. The LMAs that specialise in Italy are Gioia Tauro and Rosarno. Gioia Tauro was no surprise as it has one of the largest seaports in southern Italy, Port of Gioia Tauro. Gioia Tauro was ranked the second port operating in the Mediterranean Sea [62]. Rosarno shows specialisation in "Freight transport by road" and "Other transportation support activities" sectors that include, for example, forwarding of freight and arranging or organising of transport operations by rail, road, sea or air.

Table 4. Location Quotient for LMAs in Calabria Region for 2019.

LMA	**Average employment in all industries (2019)**	**Average employment in Blue Growth industries (2019)**	**LQ for Calabria**	**LQ for Italy**
Italy	23214.949	1305084		
Calabria	484269	1293184		0.600
Acri	7311	19553	0.792	0.476
Amantea	7697	21095	0.812	0.488
Belvedere **Marittimo**	5691	13821	0.719	0.432
Cariati	537	702	0.387	0.233
Cassano All'ionio	14403	23136	0.476	0.286
Castrovillari	16649	5712	1.016	0.610
Cetraro	3422	627	0.543	0.326
Cosenza	77555	35994	1.375	0.826
Mormanno	4762	719	0.447	0.269
Paola	8321	1381	0.492	0.295
Praia A Mare	3499	16818	1.424	0.855
San Giovanni In Fiore	6265	859	0.406	0.244
San Marco **Argentano**	8768	3427	1.158	0.695
Scalea	6469	1897	0.869	0.522
Catanzaro	44425	147508	0.984	0.591
Chiaravalle Centrale	3979	607	0.452	0.271
Sellia Marina	7606	2682	1.045	0.627
Soverato	11548	35907	0.921	0.553
Lamezia Terme	3996	167982	1.245	0.748

(*continued*)

Table 4. (*continued*)

LMA	Average employment in all industries (2019)	Average employment in Blue Growth industries (2019)	LQ for Calabria	LQ for Italy
Bianco	4075	85	0.618	0.371
Bovalino	8251	12465	0.448	0.269
Delianuova	1761	175	0.294	0.177
Gioia Tauro	1668	159038	2.824	1.696
Locri	983	22491	0.678	0.407
Marina Di **Gioiosa Ionica**	5245	12721	0.718	0.431
Melito Di Porto Salvo	9665	14646	0.449	0.270
Oppido Mamertina	2248	3262	0.430	0.258
Polistena	12096	5355	1.311	0.787
Reggio Di Calabria	61639	160601	0.772	0.463
Roccella **Ionica**	494	812	0.487	0.292
Rosarno	6874	55144	2.376	1.427
Sant'eufemia D'aspromonte	2078	4328	0.617	0.370
Stilo	246	868	1.045	0.628
Taurianova	5671	14645	0.765	0.459
Cirò Marina	7691	16541	0.637	0.383
Crotone	28834	122532	1.259	0.756
Mesoraca	1783	262	0.435	0.261
Petilia Policastro	4669	1852	1.175	0.706
Serra San Bruno	4211	4286	0.302	0.181
Soriano Calabro	3802	6166	0.480	0.288
Tropea	5984	16257	0.805	0.483
Vibo Valentia	29184	140325	1.424	0.855
Corigliano-Rossano	27685	15247	0.163	0.098
Nova Siri	4529	2653	0.174	0.104

Furthermore, the Beta measurement with respect to Calabria shows the internal structure in Calabria for Blue Growth industries. The results show that Plant Beta is 0.34 and Size Beta is 0.62 which reflects the stronger influence of large firms within the region. The first conclusion to be drawn is that the specialization of some LMAs in Calabria is driven by the firms' sizes not the number of firms. The Beta on the national scale shows the same feature which is size driven. When we took the number of firms and employees on the national scale and measure it with the same variables but on the LMAs scale, we got that Plant Beta is 0.53 and Size Beta is 0.74. This might reveal that the concentration of firms is low. However, the number of firms is still important when considering the absolute size [63].

Overall, from 2012 to 2019, the trend in LMAs in Calabria appears to be relatively stable. There is no significant increase or decrease in those areas. However, as considered one of the main LMAs in Calabria, Reggio Calabria had been experiencing a decline throughout these eight years. Additionally, "Support activities for petroleum and natural gas extraction" sector has 0 employees and establishments in all years and the same for "Inland freight water transport" sector. "Manufacture of engines and turbines, except aircraft, vehicle and cycle engines", "Transmission of electricity", "Sea and coastal freight water transport", and "Inland passenger water transport" sectors display low levels of economic activity within the region (only 0.16% of the total establishments for all the region in 2019) and low labour specialisations. Finally, higher productivity levels in "Engineering activities and related technical consultancy" and "Freight transport by road" sectors, 50%, and 23% of all sectors in Calabria for 2019, respectively).

All LMAs in Calabria are involved in Blue Growth industries. However, they differ based on the number of connections each one has to all the sectors. For instance, Reggio Calabria, Crotone, Lamezia Terme, and Vibo Valentia have connections with 24, 24, 23, and 23 sectors, respectively. On the other hand, although Cosenza is the largest LMA in terms of the number of employment and establishments, it has only 22 sectors from Blue Growth industries. Mesoraca, Nova Siri, Delianuova, and Sant'eufemia D'aspromonte have the least sectors with 3, 4, 5, 5 sectors, respectively.

4 Discussion

The primary aim of this paper was to provide a better understanding of the Blue Growth industries' performance in Calabria and focus on the heterogeneity of the industries in the region. Their economic performance is a combination of very different levels. The specialisation of the industries is not the only driver of regional development; the size of economic activity, however, is another variable recommended in the literature [64–66]. The evidence from quantitative research across several countries and regions demonstrates a positive relationship between employment in strong clusters and economic performance [66–68]. Blue Growth industries are one of the largest among emerging industries in the total employment in Europe. It is ranked 3rd out of 10 in total employment in Europe, consisting of 13.3 million employees [52]. The total employment in Blue Growth industries in 2012 is 11825652 [51], while the average number of employees in Calabria for the same year is 51782.96. Calabria has a very high labour shortage, consisting of roughly 1% of Europe's total employment for Blue Growth industries. The labour shortage could be for a lack of market-oriented management skills, lack of financial and controlling knowledge, increase in costs, few incentives, or restructuring of some activities. One of the reasons that Calabria might have is low employment because of low wages as Blue Growth industries is ranked 9th for the average wage in 2019 [52].

Furthermore, the COVID-19 pandemic has created new circumstances and unemployment might increase. The results have revealed general lessons for understanding Blue Economy in Calabria.

"Freight transport by road" and "Engineering activities and related technical consultancy" sectors are the main sectors in Blue Growth industries. However, there is miss information about the role of marine and freshwater fishing in Calabria. The dataset we used does not provide information regarding these sectors, which raises questions about whether the capture fisheries in Calabria are just small-scale fisheries or artisanal fisheries. Hence, there is a need for qualitative data to measure the performance of the small scall and the importance of regional stakeholders to support these small industries.

It was claimed that "…. Similarities between systems often allow data from one system to carry information that has value in others" [22]. However, the system is complex and has complicated interconnections within many sectors. For example, one cannot know if the depletion of some fish species is from overfishing or pollution or other reasons [22]. Hence, in this paper, we use illustrated economic networks as a tool to absorb this complexity. In this project, we show a structural analysis of the inter-sectoral linkages and main sectors of the Blue Growth industries in Calabria. Such analysis employs suitable network metrics to measure the centrality and influence of each sector on the other ones and the possibilities for clustering of related activities [69]. The Blue Growth industries shows an appreciable dynamic in cross-sectoral linkages. It "… include all sectors and industries related to a maritime environment as well as sectors producing, making use of, and treating fresh-water sources" [52]. The networks introduced in this paper demonstrate that the marine system has very complex social-ecological systems exposed to several cross-scale interactions affecting critical ecological and socioeconomic processes and their interaction. This means that when the future Blue Growth potential is discussed, one should be aware of which processes and at which scales, or levels, are likely to drive change in fisheries. The ocean potential is primarily estimated based on the interactions between the different sectors, which, if well addressed, can result in too high expectations for growth. The study of Blue Growth in a specific city has to be oriented to that city's system, as the system is comprised of several different, but connected, sub-systems, which are exposed to different combinations of drivers and have different governance systems.

5 Conclusion

This study has sought to identify the characteristics of Blue Growth in Calabria. The results show the cross-sectoral linkages within the region and give us a holistic view of the current structures, which is essential for initiating an inclusive transition. Nevertheless, the situation of Calabria within the country is also crucial to evaluate the extent of the region (physical and economic). In doing so, we, on the one hand, have evaluated the system through 2 measures: size and specialization and also the influence of either large firms or SMEs on the Blur Growth emerging industries in Calabria. On the other hand, we extracted two metrics from the network graph, eigenvector centrality and betweenness centrality. We found that there are powerful zones within Calabria that act as the dominants for Blue Growth industries. For sectors, "Engineering activities and related technical consultancy", "Freight transport by road", "Travel agency activities", and "Technical testing and analysis" are the dominant ones. Crotone, Reggio Di Calabria, Cosenza, Vibo Valentia, and Lamezia Terme are the strongest LMAs in Calabria. However, Calabria is very weak compared to the rest of the country. The industries there are small, and it is not specialised in these sorts of sectors although it is a coastal region and washed with water from 3 sides. Therefore, our study is meant to be a start point to reveal the characterises of the industries in the region and hence aim to overcome the inertia of an undesired business as usual development. We try to establish a clear image of the sectors and their relationships, thus, establishing an oriented paradigm for a sustainable and inclusive transition through Blue Growth industries. Especially after the recent evolution of the COVID-19 global pandemic that has further increased uncertainty around future trajectories. People are looking at Blue Growth as a way to save countries from poverty and declining GDPs and to segregate warring parties. Using the Blue Growth concept in the right way that aims to respond to the natural resource use challenge in oceans by combining the aspects of economic growth and environmental sustainability could help lagging regions ramp up [70]. Identifying significant cross-scale interactions that influence natural resource production is vital to understanding how and at what spatial or temporal scale and organisational level should be managed. For future studies,

One of the limitations of this study is the difficulty in measuring the impacts of the sectors' economic activity and therefore quantifying the environmental impacts. Therefore, it would be interesting to conduct studies that can provide solid arguments to support it. For the future of this research, the empirical analysis presented here will be extended by the addition of qualitative, not only quantitative, indicators on innovative behaviour in the estimation of the impact of absorptive capacity in the case of regional clusters. Local ecological knowledge can provide a valuable means of accessing new data. Moreover, we need to investigate if the absolute size plays a more important role than the level of specialization in Calabria or the other way around. There is still a lot more to be investigated regarding other indicators for the performance of Blue Growth in Calabria. Thus, the questions arising around 'scale' extend further to the level of regional management required to govern the Blue Economy in Calabria. Blue Growth can create millions of new jobs, but it must be exploited and managed sustainably.

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Data Availability. Publicly available datasets were analyzed in this study. This data can be found here: [http://dati.istat.it/Index.aspx?QueryId=21147].

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S4 + and the Sustainability Dimension for a New Territorial Perspective

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Abstract. The European Commission has made sustainable development a central element of its growth strategy for the next few years. From an all-encompassing perspective, the European Green Deal (EGD) represents the EU's contribution to the Sustainable Development Goals (SDGs), the "Smart Specialization Strategy" (S3), and the attempt of the EU at a position of global leadership in sustainable development. This paper states that an effective innovation-oriented policy, including a sustainable dimension, requires an adequate division of labour between the EC, national and regional/local governance levels, and the shift from S3 to S4 +, a smart specialization sustainable strategy. It also underlines how a territorial approach to policies is suitable for incorporating a five-helix innovation model and is well suited for implementing S4 +. Therefore, the Ecological Transition, illustrated in the EGD, requires a new governance design and management attitude. This contribution proposes a framework for implementing the new EGD strategy and the consequent implementation of the sustainability dimension. Numerous challenges focus on the sub-regional level highlighting the Community-Led Local Development (CLLD) as a tailored governance model that can include Sustainability and innovation in a complete democratic setting.

Keywords: S3 · S4 + · Quintuple Helix · Sustainability · Territorial Governance · CLLD

1 Introduction

The COVID-19 pandemic emergency has involved the entire planet and, in addition to having had severe repercussions for the health of humanity, has caused severe social and economic difficulties. The European Union (EU) has undertaken a wide range of policy initiatives and health measures to mitigate the economic and social crisis of COVID-19. Still, the pre-existing production capacity and the previous market logic are no longer a feasible task, and we are dealing with a new scenario based on a sustainable recovery. It becomes essential to discover and start new and innovative activities that can provide high-quality growth opportunities and deal with our time's environmental and social challenges. The main objective is to guide the EU toward a development path focused on ecological Sustainability the territorial and social cohesion. The EU looks at

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a transition towards economic carbon neutrality, using digitalization, and fostering technological change in the context of globalization. In this context, the Smart Specialization Strategy [1] can be central to supporting innovative activities that help the territories discover new opportunities for more sustainable and inclusive economies. On the path towards a more inclusive and sustainable society, the European Union has made conscious and long-term choices. First, the UE has embraced the Sustainable Development Goals (SDGs), an urgent call for action by all countries, outlined in the 2030 Agenda. In a few words, a model of progress based on economic, social, and environmental Sustainability was adopted by the United Nations (UN) General Assembly in September 2015. The 2030 Agenda for Sustainable Development and its seventeen Sustainable Development Goals (SDGs) bind the 193 Member States to ensure sustainable and inclusive economic growth, social inclusion, and environmental protection, thus promoting peace, just, and inclusion through a broad global partnership. In addition, in December 2019, the European Commission presented the communication on the European Green Deal [2, 3]. The European Council indicated the new "Green Growth Strategy" in December 2020. It committed itself to the EU's green transition, providing political guidelines on EU policies to achieve zero climate impact by 2050. Therefore, the European Transition for the next decades is to embrace the dimension of Sustainability with a holistic and omnipresent vision within future investment strategies and choices. Through a suitable governance approach, the work looks at innovation policies under the sustainability dimension and their potential effectiveness in European territories.

This contribution proposes a reference framework for achieving the European sustainability objectives. In the following, we outline the main elements of each section. The following paragraph presents the European Ecological Transition as a challenge and opportunity for the near future. The third paragraph highlights the relative evolution of innovation policies, which led to the transition from S3 to S4 + [4]. In a concrete effort to include the environment in the development strategy, the fourth paragraph connects the new S4 + to the Quintuple Helix innovation model [5], an excellent theoretical basis for implementing innovation with a systemic vision. The fifth paragraph explicitly references the territorial transition of governance necessary for implementing innovation policies with an idea of Sustainability. The sixth paragraph describes and proposes how community-based local development [6] is suitable for managing innovation in various European territories. Finally, the conclusions summarize the logic of the structure used in this work and propose reflections for further investigations on the subject.

2 The European Ecological Transition

The European Green Deal (EGD) approved 2020 is a set of policy initiatives by the European Commission to make the European Union (EU) climate neutral in 2050. The European Green Deal contemplates a series of different measures - including new laws and investments - designed for the next thirty years in the way of a sustainability view. The EGD started Europe into a climate-neutral, just, and prosperous society. Implementing these goals involves evolving from a linear to a circular economy, farm-to-consumer Sustainability, building a global food and agricultural system, a clean and resilient energy sector, and regulated social investment, including education, health, gender equality, and rural education development [2, 3]. An innovation policy is necessary to implement the objectives of the EGD, which calls for a type of systemic innovation in which new solutions emerge from the combination of technologies, infrastructures, skills, and entrepreneurship, which involves citizens and local administrative capacity. In addition to new technological solutions, the European Ecological Transition requires significant changes following a new operational mindset. Besides pertinent upper system-level changes, a successful Ecological Transition requires a deep regional and local engagement. The European Green Deal statement framework indicates that the focus in research and innovation policy should be to achieve the necessary change, where innovative solutions can accelerate the shift towards Sustainability [4]. The object is to ensure a more sustainable development path.

Furthermore, the Green Deal underlines the importance of diversity within the EU. The Strategy's success will depend on recognizing local territories' diversity, places' cultural and social diversity, and the different characteristics present in urban and rural environments. Therefore, attention to territorial peculiarities can lead to a sustainable development path that respects these differences and develops the most relevant innovative potentials through innovation processes. In these aspects, the Smart Specialization Agenda provides an ideal platform for an EU journey towards implementing the Green Deal goals. Indeed, it already constitutes the combination of innovation-driven and entrepreneurship-driven activities linked to locally consolidated governance capacity on an urban and regional scale. In addition, in the new approach of European Cohesion Policy 2021–2027, a clear policy trajectory is required to improve Sustainability, entailing that the dimension of Sustainability is included within the essential S3 programming elements. The Ecological Transition marks a step toward transformative development, where research and innovation policies support the necessary innovative change in the direction of Sustainability. Therefore, the role that regional smart specialization strategies can play in this phase of evolution is of significant importance for repositioning Europe as a leader of a new growth model that follows the rules of environmental Sustainability. Through the Regional Innovation Strategy, Europe's diversities can take on value and turn into resources. Sub-national areas can identify and make the most of the industrial opportunities of the European Green Deal, engaging and co-creating with citizens. The European Green Deal can have very different regional implications, depending on the region's starting situation. Therefore, the challenges will be diverse within the European territory. At the local level, policymakers will have to deal with all the problems of alignment, stability, and coordination between various stakeholders, often contradictory or related to monopoly positions. The European Union needs a radically new political stance at the regional and local level compared to the previous traditional S3 policy, with policymakers facing problems of incentive alignment and horizontal and vertical coordination [4].

3 From S3 to S4 +

The Smart Specialization Strategy (S3) [1, 7] was conceived based on fundamental ideas such as minimizing the risk of dispersion of investments in research and innovation (such as training R&D expenditure) and the capacity to enhance existing knowledge and innovation potential in a region. These paths included relaunching existing clusters in innovation and the “discovery” of new possibilities. The implementation of the Smart Specialization Strategy has initiated integrated actions contemplating a plan for a specific and place-sensitive economic change, focusing on the strengths of the reference territory and its competitive advantages [7]. The S3 has set itself the goal of focusing on all types of innovation, not just the technological one, with the involvement of a wide range of actors in developing the regional innovation strategy and defining priorities specific to the territories. The Strategy aims to promote an authentic chain of innovation and competitiveness, capable of transforming research and innovation, resulting in a competitive advantage for the production system and an effective increase in the well-being of citizens. The regional strategies formulation was an ex-ante conditionality for activating the interventions of the Structural and Investment Funds. In addition, it was the opportunity for the European regions to build a framework of coordinated actions to outline the specializations most suited to one’s potential for innovation and to design coherent, targeted, and accompanying selective paths. The initial logic of the Strategy stems from an aspatial concept of innovation [1], but it evolves to the regional and spatial aspects that influence innovation [8]. The Smart Specialization Strategy has adapted to the logic of a place-based approach [9], where the different levels of government share the implementation of the policy with particular attention to performance and results and the mobilization of local actors [10]. The S3 underlines how the innovation process is an open system in which different actors collaborate and interact to promote an open and inclusive governance system that supports the participation of traditional and new innovators. Smart specialization is a policy framework in the EU policy portfolio that combines top-down directionality with bottom-up activities involvement. According to Boschma [11], Smart Specialization has positive characteristics, such as a place-based and location-sensitive regional innovation policy strategy. Smart specialization has mobilized new forms and modalities of sub-national decision-making and coordination focused on collaborative engagement and policy formulation in public, private and civil society spheres. In the new programming period for 2021–2027, Smart Specialization Strategy should continue to play a significant role in regional development and cohesion inspired via an innovation paradigm that respects the dimension of Sustainability. The first generation of Smart Specialization has stimulated knowledge-based growth through better use of resources oriented to research and innovation. However, we are going through a phase of post-S3 change that considers new aspects of development and collective well-being essential. The new Smart Specialization Strategies 2021–2027 must incorporate the Ecological Transition. A reorientation and updating of the logic of Smart Specialization towards the objectives of the European Green Deal can provide a basis for a path towards sustainable development. In particular, making the most of the entrepreneurial and innovative spirit of the EU economies, interconnected to sustainable and inclusive growth, a structural shifting towards the S4 + [4]. The S4 + provides an ideal platform for achieving the Green Deal objectives. The transition from S3 to S4 + changes the logic behind regional development strategies in Europe. The programming elements of the S3 remain the same but, at the same time, added, at the EU level, an explicit and unambiguous focus on the required trajectory of locally driven innovation toward Sustainability and inclusiveness [4]. The entrepreneurial discovery process

(EDP) in the S3 is a core element, but with a lacking standard definition from the begin. It reflects learning process-oriented to a territory capable of setting the priorities on which the area of research and development of innovation should focus [12]. The EDP is a central element in regional endogenous growth. In other words, EDP combines creative methods of using the opportunity derived from possessing endogenous territorial assets [13–15]. Entrepreneurial discovery is an inclusive process in which the relevant stakeholders detect new and potential activities and notify the government. The government assesses this information and empowers those actors most capable of realizing the potential. This process mainly distinguishes Smart Specialisation from traditional industrial and innovation policies. In the broader context of the Smart Specialization Strategy, the entrepreneurial discovery process assumes different meanings. A well-specified summary appears to be that of Gianelle et al. [16], which define EDP as the result of an inclusive and evidence-based process driven by stakeholder engagement and attention to market dynamics, which drives investments. The scenario underneath S3 indicates that the right priorities for a given territory should engage territorial stakeholders, such as businesses, government, universities, and civil society, who possess the necessary knowledge to develop strategies suited to a given context [17]. However, after years of implementation is a challenging concept for most European regions and countries, probably due to a lack of territorial analysis and EDP contextualization. However, new elements can improve past results and missing targets. Today, this interaction contemplated in the Quadruple Helix Model related to Universities, Industry, Government, and civil society see the natural environment (fifth helix) as an essential element of the S4 +, a cornerstone for a development-oriented toward Sustainability [5, 18].

S4 + indicates bottom-up collaborative governance structures and multi-actor collaboration in a regional context to frame and inform the support structure for innovation and growth by seeking the distinctive elements of the territory. It, therefore, reflects a territorial governance approach, which supports regional specificities with a place-based vision. Through the EDP, the interested stakeholders identify the essential domains or those areas of research and development or innovation that characterize or can characterize a given geographical context. The goal of the smart specialization is for regions to identify opportunities to build competitive advantages in high-value-added activities [19]. All this presupposes that each area has a diversified economy and institutional structures that can determine the potential for future development, rejecting, in fact, universal policies applicable to each specific context [20, 21].

4 The S4+ and the Quintuple Helix Innovation Model

The concept of innovation has different meanings over time and is constantly evolving [22]. Considering innovation as a process that involves diverse cooperating actors, an ecosystem fits well an innovation system. The Helixes Models develop an approach to innovation considering an ecosystem where territorial actors play an essential role [18, 23, 24]. The Helixes refer to actors in relationships with each other favoring knowledge production in a given context. Identifying innovation as a process involving different actors, government, institutions, industry, civil society, and the natural environment requires acknowledging the factors influencing each helix or actor in innovation.

Innovation is a process that involves several phases [22]. It requires the cooperation of subsystems involved with varying intensity in the various stages of the overall activity [25–27]. The role of each subsystem becomes decisive in the innovation system, reflecting a synergistic process with non-linearity characteristics.

The basic model of the three-Helix [28] highlights the ability to generate innovation through the interactions between universities (higher education), industries (economy), and public authorities (government). The addition of the fourth helix represents civil society's bottom-up actions and opinions. It indicates how social networking capabilities increase the probability and impact of knowledge [23]. The nonlinear innovation model of the Quintuple Helix combines knowledge, know-how, and the natural-environment system into one interdisciplinary and trans-disciplinary framework. The Fifth Helix Model approach can enhance civil society participation and connect ecosystem value creators, i.e., users of innovation who can become innovative co-creators and do so in an Eco-sustainable way.

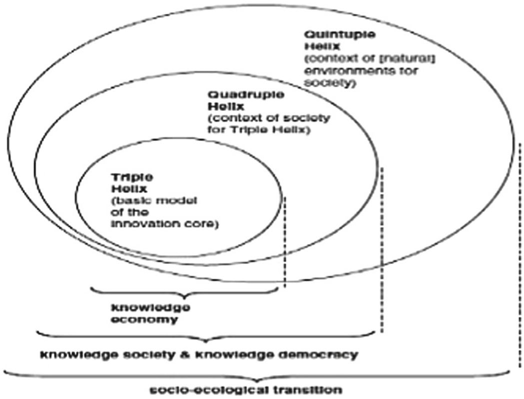

Fig. 1. Quintuple Helix Innovation Model [5]

The environmental helix represents the European Green Deal's crucial objectives concentrating on sustainable development for the future of European growth. The logic of the Quintuple Helix allows it to tackle existing environmental challenges and deal with the Ecological Transition. Adopt a Quintuple Helix Approach in the Smart Specialization Strategy means understanding the roles of innovation actors in a regional or sub-regional system in a sustainable way. An evolution of the policy logic from S3 to smart specialization strategies for sustainable and inclusive growth (S4 +) [4] implies a policy change where regions may contemplate setting policy priorities to drive innovation and the same time, response to societal challenges, including Sustainability. The Quintuple Helix Model can indicate a suitable model in theory and practice to understand the link between knowledge and innovation, forwarding sustainable development.

The Quintuple Helix is complete, with the environment becoming an essential element in the innovation and knowledge system. [26].

Fig. 2. Quintuple Helix Model [26]

5 The Transition to Territorial Governance.

The Green Deal involves a multilevel governance (MLG) framework and different governance levels between European, national, and regional/local policymaking. Therefore, the success of multilevel governance in achieving the Sustainable Development Goals will depend on how each governance level will contribute to the mission [4]. A solid governance configuration is a critical enabling condition for effectively implementing Sustainable Smart Specialization Strategies. An S4 + approach changes policy implementation structurally because innovation becomes systemic, focusing on synergies between innovation, Sustainability, infrastructure, and skills [8]. An intervention policy concerning a specific geographic context must consider all elements indicated. Therefore, implementing the Smart Specialization Strategy should refer to a territorial governance (TG) model that considers the peculiarities of a specific geographical area. The MLG examines policymaking across different levels of governance. Alongside the MLG, the territorial governance approach imposed itself. Implementing and forming policies based on local knowledge require territorial attention, and the TG focuses its reach at the sub-national level. In European policy, the concept of TG first emerged in spatial planning studies as a holistic instrument for backing spatial planning work [27, 28]. In the last years, the concept of TG has gained traction among EU and OECD representatives [29].

The TG is considered crucial both for implementing significant European policies, including the EU 2020 Strategy, the EU Territorial Agenda 2020, and EU Cohesion Policy [30, 31], and also for gathering the Sustainable Development Goals (SDGs) [32].

Territorial governance is an organizational model of collective territorial action, where emerging openness and transparency process, cooperation, and coordination, both horizontally and vertically [33]. Specific elements characterized the TG, such as the bottom-up approach, allocating power to the lowest levels of governance, and creating an open, transparent, and democratic political process. Furthermore, the TG allows the development of strategies and solutions for territorial challenges [29, 30, 34, 35]. The territorial dynamics can be managed with significant flexibility, making consistent the processes and tools and evolving the monitoring and assessing territorial impacts; so even delineating different territorial boundaries for dealing with changeable policy questions or problems. Therefore, the spatial aspect becomes crucial to developing and managing specific strategies with a place-based approach. The main characteristics that identify and distinguish the TG concern managing territorial dynamics, monitoring and assessing territorial impacts, and delineating boundaries for dealing with different policy questions or problems [28]. Table 1 overviews five crucial dimensions of the TG concept specified in the academic literature [33–36] and adopted in the table by Moodie et al. [29].

Table 1. Critical dimensions of territorial governance (TG) [29]

Dimension	Key features
Coordinating actors and institutions	TG strengthens links between sub-national authorities and other public and private actors, with policymaking agencies devolved to the lowest level, vertically embedded in multilevel governance structures
Integrating policy sectors	TG creates horizontal synergies between public, private, and civil society actors, enabling the development of new-networked ecosystems that add to territorial cohesion
Mobilizing stakeholder engagement	TG approaches provide a voice to all relevant and interested actors, allowing them to shape the policymaking process and enhance regional autonomy and accountability in public administration
Adaptive to changing contexts	TG is reflexive and adaptive to changes in a territorial context, with actors able to review and revise territorial policies in light of new information and learning
Place-based/territorial specificities	TG is a bottom-up process driven by local knowledge creation that focuses on finding solutions to territorial challenges through focused visions and strategies

The S3 model accurately reflects and aligns with the concept of TG because it proactively involves the sub-national dimension in developing bottom-up policies guided by local knowledge and skills [29].

A relational approach allows for interpreting the most complex territorial relationships and identifies competitiveness in trust, sense of belonging, creativity, relationality, and local identity. Therefore, the concept of innovation in adherence to a territorial approach identifies the territory's ability to trigger innovative mechanisms and invest in resources linked to the territorial context through spatial relations. Material aspects such as infrastructures, the presence of large companies, and intangible aspects such as knowledge, creativity, entrepreneurship, and social capital are all elements of the development of sub-regional areas. They are generated by endogenous processes (development of local knowledge and creativity) and via exogenous operations (investments by multinationals and the public sector). In short, a combination of traditional elements of development and the local territorial capital [37].

Table 2. Smart Specialization Strategy and Territorial Governance (Authors' elaboration)

	Smart Specialization Strategy (S3)	**Territorial Governance**
The structural pattern of interaction	Bottom-up territorial governance (TG) approach: regional stakeholders working in collaboration with public authorities to frame policy direction	Network: polycentric
Functional scope	Narrow (domain-specific)	Narrow (task-specific)
Geographical scope	Sub-national level	A core focus on the sub-national level: congruent boundaries
Jurisdictions	Limited and non-intersecting	Limited and non-intersecting
Institutional stability	Fluid and flexible in time and space	Fluid and flexible in time and space

Territorial development policies (policies with a territorial development approach) must primarily help regions to build their territorial capital. All or part of territorial capital elements results from a specific context's history. It determines the productive vocation and the development path to build local development strategies. Several empirical studies [38–40] on the endowment of territorial capital show that it is not the presence of all the relevant elements in the development path but the presence of different complementary or synergistic components, and from one of them, balanced development. Thus, also, econometric analyses [41] indicate the presence of knowledge and a high social and relational capital as determining factors in the growth trajectory of European regions. Therefore, it is necessary to focus on governance initiatives directly involving local actors, with a place-based approach [9] to foster development. The local development paradigm assumes that each territory has a set of assets and values. Local actors should recognize and grasp them to exploit them as sources of local development [42]. The joint action of several actors from the public, private, and non-profit sectors creates relationships capable of strengthening the territory's identity and enhancing its strengths [43, 44].

Furthermore, the positions of the territorial actors and their communication flow within the governance network strongly influence the ability to adapt and learn [45, 46]. The Smart Specialization Strategy represents a multilevel challenge, and the local level is crucial for capturing places' distinctive and constantly evolving needs, facilitating concrete territorial challenges. In addition, the regional level is essential to ensure quality and coherence in the management and evaluation of the process and to coordinate a learning network around the locally activated projects. Finally, regional and local levels must share some actions, such as developing the connection of the local innovation ecosystem with the outside world. Acquiring relevant knowledge from local stakeholders, usually incorporated and tacit [47], is essential to recognize the potential for innovation in a specific context and, consequently, obtain a practical implementation of the S4 +. Accomplish that acquisition is the result of a participatory governance attitude, which represents an opportunity to incorporate the perspectives and priorities of the local population [48].

6 Which Governance Apparatus is Suitable for the Sustainability Dimension of the Smart Specialization Strategy?

Institutional quality is an essential element for achieving development. In the tradition of Veblen and Commons, [49, 50] institutions are a particular type of social structure with the potential to change agents, including changes to their purposes or preferences. The definition is precise concerning an operational explanation such as the game's rules in a society. However, behind any theoretical aspects, institutions play an essential role in determining the potential of a territory to be developed. Empirical measures of institutions are difficult to determine, but different European regions which are lagging seem to have weaker institutional constructs than their more developed counterparts [51]. Poor institutions affect essential growth-promoting factors, such as the returns on European Cohesion policies competitiveness, weakened entrepreneurship, and the local capacity to innovate. Poor institutions – ineffective local governments, limits in voice and accountability, and corruption – have often directed infrastructure investment towards large projects with dubious economic and social returns. This has led to a rise of extensive projects that may have responded to short-term gains but, in the medium-term, have contributed little to improving the economic performance in lagging areas. If institutional quality cannot be improved, regions will not capture waves of economic possibilities and any innovation process. Even with its solid foundation, this kind of reasoning looks weak. We need, probably, a piece of better knowledge about why the capacity building of institutions does not work correctly in lagging areas, and we look at the strengthening of collaborative relationships according to a multilevel approach [52]. Local governance and development projects typically refer to complex phenomena involving different actors representing diverse interests and importance. The involvement of various stakeholders and the activation of their knowledge are generally considered aspects of "good governance" [36, 53, 54]. However, a recurrent problem is how to mobilize and include these actors and their knowledge in adequate strength for territorial development. Over the years, the European Commission has introduced several new policy instruments designed to enhance the role of the sub-national level in EU regional policy. Community-led local development (CLLD) is a specific tool for sub-regional use and mobilizing and involving local communities and organizations. The LEADER experience of community-based local development is the basic concept founded at the beginning of 1990. CLLD is a tool to strengthen synergies between local, public and private actors to respond to the territory's specific needs. The CLLD approach is community-driven because Local Action Groups implement it (LAGs) and represent the local public and private actors. The LAGs are local socio-economic interests deriving from the public and private sectors. A voluntary process defines the administrative spatial delimitation concerning the territories' needs. We do not have the typical administrative delimitation of Municipality, City, Province, or Region but a voluntary aggregation of different municipalities with similar socio-economic characteristics. The LAGs develop and implement integrated and multi-sectoral local development strategies. The mission of the CLLD is to support local actors in rural areas in planning and designing development strategies capable of unlocking the unexpressed potential of these territories. The European Commission encourages a Community-Led Local Development approach (CLLD) [6] that focuses on integrated area strategies. CLLD reinforces the communities' strength, transforming local actors from passive beneficiaries into drivers of local development [55]. The CLLD is a method that conforms to policy implementations with a place-based and participatory vision. This approach allows for the integration of different EU funds based on the substantial involvement of local actors in both process phases: planning and delivering. The 2021–2027 Cohesion Policy framework, in addition, supports the development of regional growth strategies by urban, local, or other territorial authorities, which should now be in charge or at least involved in the selection of EU-funded projects. Indeed, the CLLD model has had excellent results in rural development across Europe. The application of CLLD in Europe enumerates about 3000 Local Action Groups, which highlights this policy instrument's capacity to address local development within a renewed support of integrated territorial initiatives of the EU policymaking [56]. However, the implementation of the CLLD initiative shows a different and articulated pattern in Europe. These different implementation approaches, of course, presuppose careful investigation and open up to in-depth research and comparison in search of the weaknesses and strengths of the CLLD policy tool. The following table 3 highlights the evolution from the Leader program to CLLD in the EU, the constant increase in the number of LAGs, and the growing amount of funding.

The CLLD local initiative, as indicated in Servillo [56], indicates the following connected dimensions:

- The spatial-institutional design occurring between LAG and functional territory;
- The LAG's design of a policy agenda;
- The community's cultural adherence with the territory;
- The societal process casts the community's role in the policy-agenda implementation.

This perspective of the CLLD framework allows for a deeper understanding of the local dynamics and their evaluation. It, therefore, appears to be a governance pattern suitable for implementing some aspects of the Quintuple Helix Model and leading to the search for the innovative capacities of specific territories. Furthermore, this approach allows for a longer-term vision of regions by directly involving those who live there. The elements that distinguish the CLLD tool overlap the logic underlying the Smart Specialization Strategies. The CLLD encourages local communities to develop "bottom-up" integrated approaches to respond to local challenges requiring structural changes, enhances the capacity to stimulate innovation, and promotes entrepreneurship by encouraging the discovery of potential in specific territories. The possibility of sharing and co-integrating the fragmented knowledge held by each interested party allows for reaching a shared vision in the design of policies. It allows for achieving the value added to the needs of the interested private and public stakeholders [47].

Table 3. Evolution from LEADER to CLLD in the EU Source: Miller [57] for the period 1991–2013; own elaboration for 2014–2020 data

Stage	**Duration**	**Funds**	**Budget**	**Number of Local Action Groups (LAGs)**
LEADER1	1991–1993	EAGGF, ESF, ERDF	€450 million	217
LEADER2	1994–1999	EAGGF, ESF, ERDF	€1.7 billion	821
LEADER +	2000–2006	EAGGF	€2.1 billion	893 in EU15 (+ 250 LEADER + type measures in 2004–06 in 6 Member States)
LEADER axis	2007–2013	EAFRD	€5.5 billion (6% EAFRD funding)	2,200 in EU27
CLLD	2014–2020	EAFRD,ERDF,ESF,EMFF	Min. 5% of EAFRD	3134 in EU27

Recent studies [58] analyze the cost-effective cooperation among CLLD agents in a game theory setting. The number of entities involved (citizens, local businesses, and authorities), the degree of independence in the decision-making process, and their access to information were all crucial to finding a high degree of cooperation and fairness achieving better results in the case study analyzed in the overmentioned work. Applying a decision support system clearly shows that CLLD's apparatus as an instrument of public policy support local economic and sustainable initiatives. The European top governance level towards policy tools such as CLLD triggers sustainable territorial development and local innovation processes.

Figure 3 summarizes the multilevel innovation governance implementation of the sustainability dimension required by the Green Deal strategy. The evidence shows how the Green Deal goes directly to the local, regional layer where the combination of s4 +, Quintuple Helix approach, and local community governance play a crucial role in a spatial development policy.

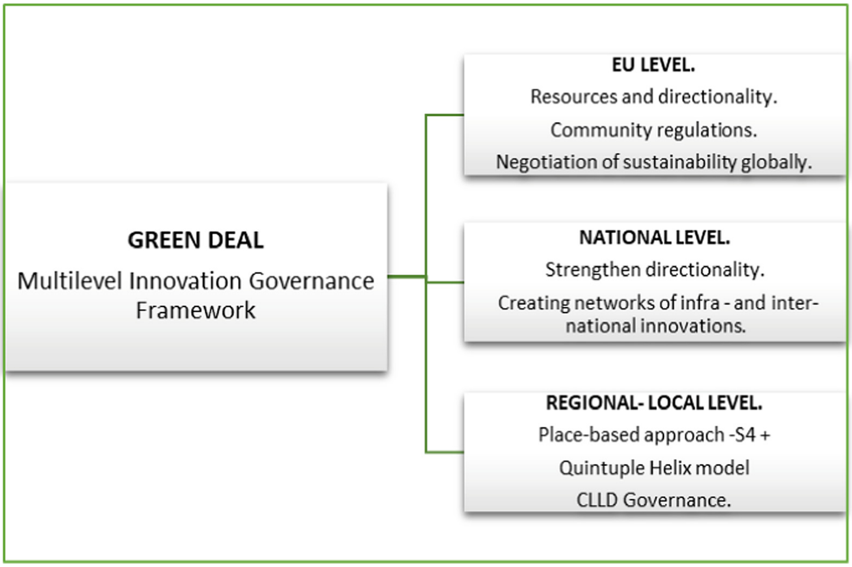

Fig. 3. Multilevel Innovation Governance Framework for the dimension of Sustainability (our elaboration)

7 Conclusion

The European Commission has made sustainable development and the digital agenda the core elements of its overall growth strategy for the following years. From an all-inclusive perspective, the European Green Deal represents the EU's contribution to the Sustainable Development Goals (SDGs) – and the new EU's "Smart Specialization Strategy" – Europe's attempt to develop at the world level a leading position in sustainable development. Players who were partially at the centre of the European integration process, such as regions, cities, and communities, will receive a significant boost in terms of activities and capacity to decide their destiny.

The underneath aspect of this paper is to offer new insights about reaching some balancing elements between the efficiency versus regional disparities conundrum considerably amplified in Europe. While, on the one hand, there is the need to reduce the technological gap with the US and China, enhancing the "champions" of innovation in Europe, on the other, economic theory still has no answer why growth differentials among regions did not decrease in these decades. A multi-governance strategy is therefore necessary, allowing a better understanding of the different territorial structures.

This paper claims that an effective innovation-driven policy requires a proper division of tasks between the EC, national, and regional/local governance levels within a particular transition period to develop a real territorial governance.

The innovation model of the Quintuple Helix appears suitable for Ecological Transition and conforms to the new challenges of the S4 +. Therefore, implementing new strategies for the territories also requires territorial governance with a place-based, democratic, and participatory approach. The Community-Led Local Development support, already present in the implementation models of European policies, could be helpful in the changing path of significantly less developed regions. It aims to increase employment, skills, and enterprise and ensures local people are involved in developing projects.

Entrepreneurial discovery, a prerequisite of S3, can be facilitated by the same stakeholders they should be planning the territory, being themselves protagonists of a vision of their future. The dimension of Sustainability becomes an integral part of the path because it could naturally be included in the planning, as the territories' inhabitants are more sensitive to the well-being of the place where they live and the quality of life. Regional, National, and European policies must accompany this process by encouraging the ambitions of a green and sustainable economy with adequate resources. The paper aims to link together some concepts that, in our opinion, can strengthen the path of the Green Deal strategy. The work is a first starting point to deepen different ideas, identifying and analyzing in the continuation in the deep. The implementation of CLLD represents a motivating research topic. First, to find this approach's effectiveness, analyze its characteristics and usefulness from different perspectives. The democratic participation in the preparation of the territory certainly offers a wide range of reflections and research ideas stimulating. Identifying new qualitative and quantitative methods capable of supporting and analyzing a new territorial governance approach also lends itself to a significant research challenge.

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The Development of Social Impact Finance and the Post-COVID-19 Transition

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Abstract. This paper investigates new financial instruments within the aggregate of social impact finance, which has developed particularly following Covid-19. In particular, the focus is on Social Impact Bonds (SIBs) and the Italian Social Fund. The multi-stakeholder logic of SIBs and Social Fund are well suited to finance social innovation projects that are fundamental for revitalizing local communities and urban areas. These new financial instruments can play a crucial role in simplifying the launch of local development processes and placing environmental sustainability and biodiversity as crucial variables of the new EU Sustainable Development Strategy.

Keywords: Impact Investing · SIBs · Innovative Social Fund · Sustainability

1 Introduction

This paper intends to investigate the new forms of financing that have been the protagonists of rapid growth in recent years characterized by an unexpected shock that has hit the world economy, namely Covid-19.

In Italy, since the beginning of the pandemic, there has been a severe phase of economic recession (with a contraction of 12.8% of the gross domestic product), [1] a fall in employment (−841 thousand employed compared to 2019), and a more significant climate of mistrust towards the search for job opportunities that causes an increase in inactive people. In this scenario, the pandemic has widened inequalities, increased poverty, weakening the welfare systems. New forms of poverty emerged, just as happened after the financial crisis of 2008. The difference from the previous shock is that at the end of 2019, the poverty level is significantly higher. For the first time, the "new poor," i.e., those experiencing material deprivation, have increased by over ten percentage points (from 31% to 45%). They are almost 450 thousand people. These include families with minors, women, working-age people, odd jobs, employees, and precarious workers. The year before the pandemic outbreak, ISTAT data [2] show that the absolute poor are 7.7% of the population (4.6 million). The weakest group are the families in the South, particularly the larger ones with five or more members, those with minor children, the families of foreigners, and the less educated and the under 34 years old. Data from the

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Bank of Italy show that in April-May 2020, 15% of Italian families reported a decrease in their income of more than 50%. These percentages increase dramatically for the self-employed category (80%).

Covid-19 has widened inequalities, increased poverty, weakening the welfare systems. The effects of Covid-19may hinder the achievement of the Social Development Goals (SDGs) of the 2030 Agenda [3].

Furthermore, Covid-19 is modifying the allocation of private and public funds toward the healthcare, financial inclusion, and food security sectors.

In this scenario, the models and tools of Impact Investing can address complex needs, both related to the health sector and connected to social projects combatting poverty and social exclusion.

To allow greater dissemination of these financial instruments, the Global Impact Investing Network (GIIN) published a roadmap for the future of Impact investing, identifying 18 actions referring to six areas:

- Strengthen the identity of impact investing;
- Change the paradigm that governs investment behavior and expectations;
- Extend products with a social impact;
- Design tools and services that support the incorporation of impact into the analysis, allocation, and deal-making activities of investors;
- Improve training via targeted professional education;
- Introduce policies and regulations that both remove barriers and incentivize impact investments.

In May 2020. GIIN and the R3 Coalition, the Response Recovery and Resilience Investment Coalition have facilitated new initiatives for the development of Impact investing,

The main networks in this market collaborate with the initiative, such as Aspen Network, a nexus of the organization (ANDE, AVPN, B Lab, Confluence Philanthropy, EDFI, US Impact Investing Alliance).

Several authors [4–10]) use the terms such as “finance for social impact,” “impact finance”, “impact investing”, “sustainable finance”, “social finance”, “impact revolution”, “green finance” to indicate these instruments, financial alternatives to traditional bank credit.

Impact investing, starting at a meeting of the Rockefeller Foundation in 2007, represents a challenge that involves various players in the economic system and not just financial intermediaries. It requires adopting new tools, activities, models, and intermediaries [11].

Impact investing represents an innovative way through which the financial systems support the sustainable development of the economy, with particular attention to the even complex needs of operators and individuals. Even according to Global Impact Investing Network (GIIN)[1] - proposes the following definition of Impact investing: investments in companies, organizations, and funds made to generate a measurable social and environmental impact and capable, at the same time, of producing a return economic for investors. Therefore, this new approach to finance offers financial solutions (with

[1] The network that includes the major international players in Impact investing; www.thegiin.org

returns in line with or below market returns) to social and environmental problems/needs. The social impact is present in Italy. For example, Social Impact Italian's investment is a new platform of CDP (Cassa Depositi e Prestiti) to stimulate innovative business initiatives.

According to the Italian Report of the G8 Social Impact Investment Task Force [12] (2014), Impact investing: "supports investments linked to measurable social objectives capable, at the same time, of generating an economic return for investors. Social impact finance actively places financial resources in projects, companies, and investment funds that generate social benefits compatible with the economic return to be ensured for the investor".

All the studies that investigate finance for social impact highlight two features that unite the various financial products within this financial sector (see Fig. 1):

- The purpose of achieving a social (and environmental) impact related to the expectation of the financial return for investors
- The measurement of the social, economic, and environmental impact by recalling the concepts of accounting and transparency

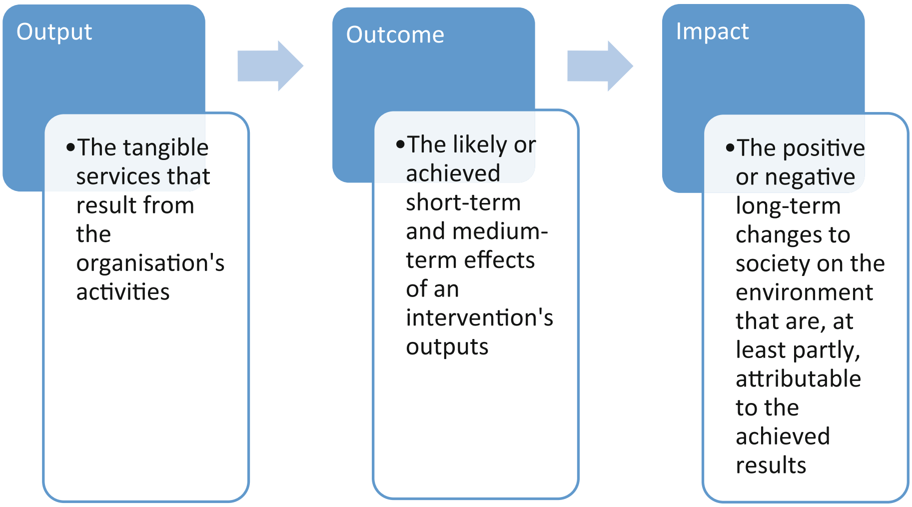

Fig. 1. The financial scheme for social Impact. Adapted: Trotta [13]

This contribution presents a structure divided into three sections. The first paragraph proposes a short literature review to provide a conceptual framework of the distinctive features of social impact finance compared with the already known forms of financing. The second paragraph focuses on a particular financial product: the social impact bonds (SBIs). SIBs are an innovative financing mechanism in which governments or other authorities enter into agreements with social service providers, such as social enterprises or nonprofit organizations, and investors to pay for the delivery of pre-defined social outcomes. The third paragraph intends to propose a potential use of social impact bonds to foster local development via specific stakeholders, centered on the logic of the Quintuple Helix [14]. The real connection between financing, long-term return, and outcomes of local sustainability indicates new ways for a new form of capitalism.

2 Finance for the Social Impact in Scientific Debate and the Future Challenges for Its Development

2.1 A Short Review

Porter and Kramer [15] emphasize the greater complexity of social impact finance. They define Impact investing as an approach to finance that aims to achieve financial and broader objectives according to a shared logic value.

Impact finance has specific characteristics [16] that differentiate it from traditional financing

1. forms and mainly produce and measure social Impact;
2. with an adequate return.

In this regard, Gimpel [17] emphasizes the importance of finance and the intention to achieve a social impact that differentiates them from traditional finance and, therefore, the need to review conventional classic financial theories. These financial innovations draw much inspiration from behavioral finance, representing a different economic modus operandi to the neoclassical approach.

For other authors [4, 18, 19], the definitions of Impact investing focus on two elements such as the "financial return" and the "non-financial return."

The complete implementation of social innovation projects, thanks to the availability of financial resources conveyed through the products/instruments of social impact finance, would allow for a "democratization of finance" and, therefore, a more equitable society [5].

Loagarde-Segot [20], Carè, et al. [10] The Manifesto "From Crisis to viability: Finance reconsidered" has indicated a post-crisis financial movement focused on the necessary intertwining between real economy and finance for environmental and social well-being.

According to multi-stakeholder criteria, Rizzello, Migliazza, and Carè [4] identify four common aspects: sustainable finance, impact entrepreneurship, public policy in the social sector, and a new cooperative approach to creating public-private partnerships.

Jackson [21], Joy and Shields [22], Berzin, Pitt-Catsouphes, and Peterson [23] underline the need to initiate partnership forms between different local players. According to these authors, to successfully implement projects oriented to social needs, it is necessary to enhance the synergies and partnerships between stakeholders operating in public, private, and nonprofit sectors. Logic-based financing schemes are the base of these forms of cooperation. With achieved results in social projects, the capital invested acquires the projected payoff. This different view suggests a revision of the traditional financial theories. [5, 24].

The development of impact finance represents a challenge for all operators. The financial sector should be more aware of the need for social capital, while on the demand side, the private and public actors need better skills and capacity to capture project sustainability. Salamon [25] uses the expression “Big Bang,” Cohen [26] speaks of “impact revolution.” Walker Kibsey and Crichton [27] affirm how impact financing is a “revolutionary way.”

JP Morgan [6], Clarkin and Cangioni [7], Alijiani and Karyotis [8] underline how impact investing must determine a positive effect, unlike what happens in the case of socially responsible investments (SRI), where the logic is to minimize assets that produce a negative impact. Both financial approaches adopt the long-term vision of cooperation and trust rather than individualistic behavior. Weber and Duan [9] and Carè et al. [10] highlight the focus on positive results in promoting sustainable development circuits for society. However, these authors define impact finance as a new form of social finance, and Phillips and Johnson [28] define social impact finance using the expression Green Finance.

Social Impact Bonds (SIBs) have attracted much attention after the last financial crisis. The post-Covid-19 scenario seems to be an attractive proposition for financing the delivery of social services.

2.2 The Future Development of Impact Finance

This section of the work proposes a reflection on the main challenges that all the players involved in the impact finance market will have to follow to allow for more rapid development of this different approach to finance.

These challenges will involve both the supply and demand sides, the orientations of financial intermediaries, and the environmental context in which the social innovation projects are financed.

Some challenges make the country’s entire environment unattractive for developing IIS (see Fig. 2). A first criticality is undoubtedly the government’s lack of attention to the SII. Most EU countries do not have comprehensive national strategies presenting SII guidelines and objectives in their countries. The lack of strategies explains the occasional nature of policies in favour of the growth of SII. The second general challenge is the lack of a unified and precise definition of SII. For example, the monitoring of the SII market appears increasingly tricky and increasingly frequent not to fully grasp the benefits of the SII because investments that satisfy the logic of the SII are confused with other types of investments. The final problem is that some providers have started labelling their products as SII products due to tighter regulations on sustainable investment criteria, even though their funding sources do not adhere to SII standards.

The legislation adopted in the various countries does not provide an unambiguous definition of the actors on the demand side. For example, there is a wide heterogeneity between the meanings of social enterprises in the EU Member States. In addition, most EU Member States lack a specific policy framework to support the development of social enterprises. Furthermore, 10 of 27 EU Member States have not introduced any specific organizational legislation to recognize and regulate social enterprise activity. Other regulatory barriers harm the supply of funds. Some regulatory obstacles prevent the mobilization of private funds toward impact investments. Finally, impact measurement methodologies are underdeveloped in most EU Member States.

Furthermore, there is no consistent, standardized approach to measuring Impact. Outputs (activities) rather than results are at the base of impact measurement systems.

On the supply side, there is still an overall funding gap for SII in Europe. This gap exists because private investors primarily attribute transaction costs and risks to higher SIIs than traditional commercial investments. For this reason, these entities will make their capital available to finance social innovation projects only in the presence of adequate guarantees. The implementation of the IIS is still in the infantry phase. Therefore, the demand for project funding cannot be satisfied. Another critical issue on the supply side is the scarce presence of investors who have significant funds. One area for growth to be further developed is the role of institutional investors (including pension funds) in directing existing funds toward Impact investing.

The demand-side challenges in Europe are even more daunting. Few beneficiaries can receive SII investments. There is a lack of social enterprises. The legal status of social enterprises varies from country to country, leading to the exclusion of many who could receive SII. Third, many social enterprises and demand-side actors have limited organizational capacity to receive SII.

Effective intermediaries can help overcome many obstacles to developing the SII market. They can create liquidity, reduce risk, lower transaction and information costs, and facilitate payment mechanisms'. The success of the SII market relies significantly on the capacity of financial intermediaries 'to sustain long-term projects by minimizing the cost of running them.'

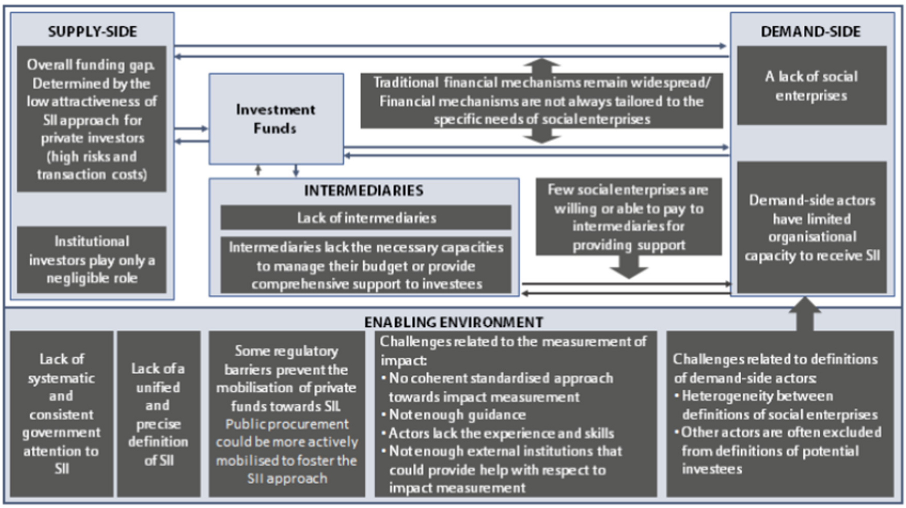

Fig. 2. The challenges to the development of the SII market. Source: European Parliament [29]

After framing the issue of impact finance, two examples of impact finance in Italy are the Social Impact Bonds and the Social Innovation Fund.

3 Social Impact Bonds and the Social Innovation Fund: Two Examples of Financing for Social Innovation Projects

3.1 SIBs

The Social Impact Bond (SIBs) is a particular example of an impact finance product that shares the operating mechanism of the "Payment for Results" (PFR) or Pay for Success (PFS) type with other contractual forms), which are well-known in the USA. The return for the investor is the positive impact generated by social activity. The SIBs are not bonds *strictu sensu.* In financial terms, they are future contracts on social outcomes. Bonds, equity, or hybrid financial instruments can finance a SIB in which the term bond indicates the link between the investment and the social Impact.

Social Finance UK was the first intermediary to create a SIB, which defines this financial product as an agreement between the various stakeholders and the Public Administration (PA).

Social impact bonds are justified because PA cannot manage social problems with preventive actions due to the scarcity of resources. Third-sector operators could play a key role in overcoming these difficulties of the public administration. Social enterprises and nonprofit organizations can demonstrate substantial experience in this financial sector.

The PA, interested in improving its service and reducing its costs, verifies the potential of these preventive interventions as alternative welfare methods and estimates the savings that would ensue if implemented at a specific scale.

The idea is that preventive services can be more effective and efficient than traditional care programs, usually based on interventions carried out only ex-post in response to an emergency or social hardship. The consequent saving of resources can be the leverage to align the interests of investors, administration, intermediaries, and service providers.

The SIB provides a partnership between different actors, sanctioned by bilateral contracts, and raises private capital to promote innovative public policies.

The essential elements of its structure are the following:

- a program of social interventions capable of generating a social impact (outcome) and saving on public spending;
- a loan/loan with repayment of capital and remuneration only in case of success of the Program.

Barclay and Simons [30] define the SIB: as "*a contract with the public administration, in which the latter undertakes to make a payment for the improvement of social results. Based on this contract, resources are collected from socially oriented investors. This investment is a mix of interventions that aim to improve social results. The goal's achievement is the requisites for investors to receive public financing. The return is commensurate with the degree of improvements obtained*".

Mulgan et al. [31] define the SIB as a new financial model:

1) Channeling resources from the financial system towards social issues,
2) Favoring an expansion of overall resources (public and private) in favor of welfare,
3) Transferring risks from the public sector to financial operators more capable of assessing and managing the risks associated with these instruments.

PIRU [32] identified three distinct social impact bond models: 1) Direct Provider, 2) SIBs with SPV, and 3) Social Investment Partnership (SIP). In the first model, investors directly financed the project, directing the financial resources to the provider. The supplier has a central role and manages an ample variety of risks.

The Special Purpose Vehicle (SPV) receives the investments and counterparty in the various contracts. The objective of this second model is to isolate risks and reduce information asymmetries between the parties, defining SIBs with an intermediary or SIBs managed by funds [33–35]. In this case, an intermediary intervenes between the SPV and the service providers. Based on a management agreement (a contract not included in the first model). The "Social Investment Partnership" model envisages the involvement of specialized operators (social enterprises, nonprofit organizations) capable of carrying out the project in the best possible way.

It emerges that the SIB is a sophisticated financial instrument; not created to encourage speculation but capable of creating a new social innovation framework. The complexity of the SIB lies in the network of relationships between stakeholders. An important proxy variable of the network is the Trust, which, together with the usual financial risk of investment, constitutes the total return of the investment.

The constituent of the SIB is the Social innovation performance. The investor does not bet on the random trend of a specific value (share, currency) but on the ability to generate social and economic value. The standard structure of the SIB foresees the interaction between five subjects (see Fig. 3):

- Public Administration (local, regional, national authorities);
- Service providers (typically nonprofit organizations);
- Corporate investors;
- Specialized intermediary;
- Independent evaluator who certified the outcome achieved.

The intermediary plays the role of promoter of the SIB with the PA and other actors. The PA and the intermediary contract provide a payment conditional on achieving specific objectives. Suppose the funded program does not reach the goal. In that case, costs for the administration do not incur. Social service providers use the capital from investors to implement the program and, in part, used for management and evaluation costs borne by the intermediary. The service provider that implements the service is not required to incur additional fees if the social project does not achieve the expected results. In practice, it assumes an obligation of means and not of results. The operating mechanism of the SIBs allows us to highlight some advantages and shortcomings.

Among the advantages, the transfer of the risk of failure to the private investor allows the public sector not to expose itself and not compromise the relationship with taxpayers due to inefficient public spending. Administrations can guarantee the possibility of experimenting with innovative tools compared to traditional intervention strategies

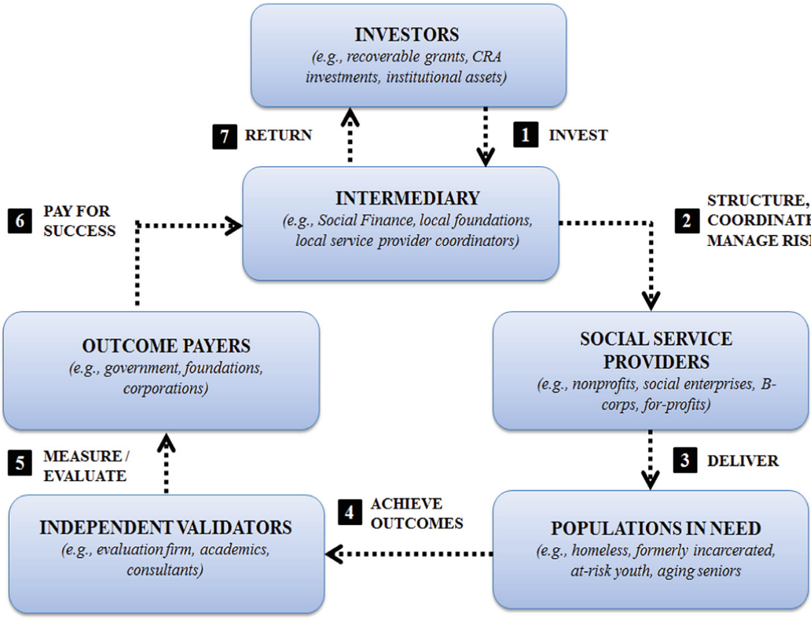

Fig. 3. The structure of social impact bonds. Source: OECD [36]

without assuming the risk of failure. The promoter must have in-depth knowledge of the social issues to intervene and build a SIB partnership. A solid actor-network is at the base of a Sibs' capacity to limit information asymmetries and facilitate investment in social activities. These actors must also include third sector entities (social enterprises and nonprofit organizations) sufficiently structured, with experience in providing preventive interventions and innovative services.

The success of social impact bonds requires the definition of a program well supported by a clear identification of the target population, large enough to generate meaningful results. The selection of the beneficiaries must also be compatible with the methodology used to evaluate the results. In any case, there must be a reliable system for measuring the results achieved.

A further condition for implementing a SIB is the existence of a PA determined to tackle social problems with new tools and a long-term programming orientation, independent from a short-term political cycle.

The main benefit of using SIBs is that the total cost of the service provided by social enterprises or nonprofit organizations must be lower than the PA's savings from the reduction in spending on existing programs.

The market of impact finance, particularly social impact bonds in the EU, has been the protagonist of consistent growth in recent years by exploiting its peculiar characteristic of the mix between financial returns and social impact. However, even today, it does not have its maximum potential, and there are significant differences in its diffusion among the Member States. The social impact investment market started growing in 2011, with a sharp increase from 2013 to 2015 (see Fig. 4).

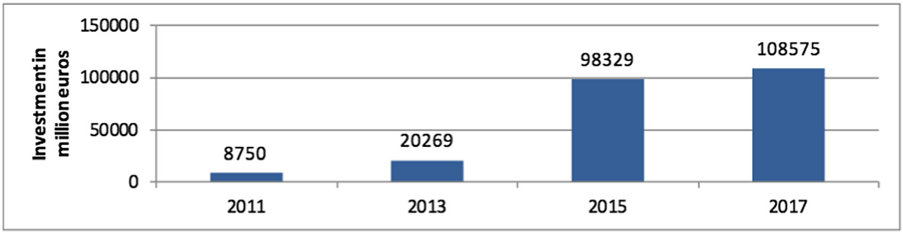

Fig. 4. The trend of social impact investments in Europe. Source: European Parliament [29]

The Social Impact Investment (SII) market's development levels are not homogeneous among the EU Member States. Germany, France, Portugal, Italy, and, although it is no longer members of the EU, the UK has already reached relatively high SII market maturity levels. The less developed markets of western, southern, and northern Europe have been showing constant growth in social impact investments. The Central and Eastern European (CEE) countries have a weak SII market. In particular, they lack SII intermediaries, incubators, and investment-readiness support and rarely use innovative SII financial instruments. According to the different maturity levels, Fig. 5 illustrates the different European dynamics of the SII market.

Segments	Nº EU Member States	% EU Member States	Colour
Performing market	4	15%	
Infant market	10	37%	
Incipient market	13	48%	
	27	100%	

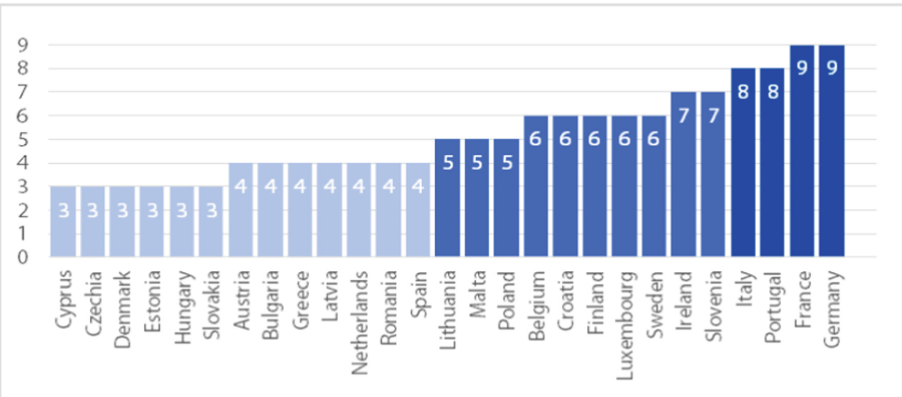

Fig. 5. The different maturity of SII in Europe. Source: European Parliament [29]

The social dimension is at the base of the Italian experience. Memorandum 2121 indicates a social and urban innovation tool, one of the recent initiatives of shared value in Italy, a specific approach based on Realtors and regional institutions [38]. The Program aimed to encourage the work inclusion of those detained in the prisons of the Lombardy Region. The project, whose name originates from a specific Article of Italian Law, considers the penitentiary system regulating the possibility of inmates to carry out work outside prisons (Article 21). This project represents the first case of collaboration between public bodies and private companies. Among the private companies involved, Lendlease, the Australian operator, has promoted two important urban redevelopment projects in the Milan area (MIND, i.e., the site of Expo 2015, and Milano Santa Giulia).

3.2 The Social Innovation Fund: An Analysis of Some Financed Projects

The following two paragraphs describe the main characteristics of the Social Innovation Fund's ongoing projects. The second paragraph proposes an in-depth analysis of the role the Fund mentioned above can play in achieving objectives such as environmental and economic sustainability, and social inclusion, for cohesive economic growth in Italy. The more effective forms of diffusion of social innovation that produce impacts, not only economical, are fundamental above all following the outbreak of the Covid-19 pandemic. This pandemic has caused a widening of development gaps, penalizing the South of Italy more.

The Social Innovation Fund was established through the Notice of the Presidency of the Council of Ministers and mainly financed social innovation interventions. The Fund is entirely part of the logic of social innovation processes having four key elements:

- Orientation to social needs and the generation of collective outcomes;
- Co-creation of value as the foundation element of participants;
- New forms of coordination;
- Appropriateness in resource allocation choices.

This Fund finances intervention as part of a three-year program aimed at strengthening "the capacity of public administrations to carry out social innovation interventions aimed at generating new solutions, models and approaches for the satisfaction of social needs, with involvement of private sector actors. Caulier-Grice et al. [37] have introduced of social innovation concept (see Fig. 6), providing a framework divided into six moments that describe, from the beginning to the last systemic change, the mode of Fund's operation. The following three types of interventions are:

a. A feasibility study and an executive plan to design a potential social innovation project that responds to an identified need. This intervention in the first two phases, defined as Prompts and Proposals;
b. The experimentation of social innovation idea with the application of models for measuring and evaluating social Impact, occurring in the Prototypes and Sustaining phases 3;
c. The categorization of social innovation idea as a new public policy centred on a mixture of public and private resources, promoting multi-stakeholder governance with a public and private dimension. The Scaling and Systemic Change last steps.

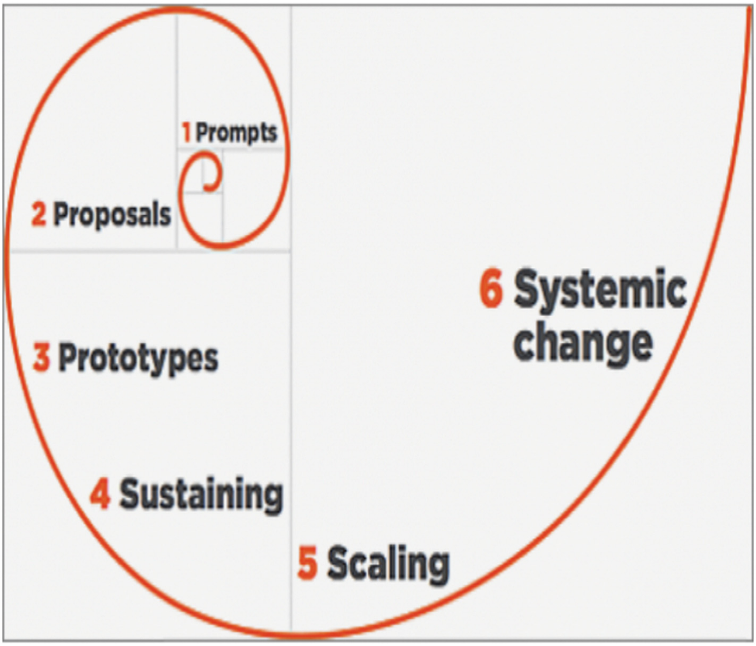

Fig. 6. The Social Innovation Spiral – Source: Caulier-Grice, Mulgan, & Murray [37]

In Italy, 15 million euros were allocated from 2018–2020. About 109 provincial capital municipalities and 14 metropolitan cities were the primary beneficiaries of the Fund. The funded projects mainly concerned three areas of intervention: social inclusion, cultural animation, and the fight against early school leaving. Social inclusion concerns people with disadvantaged or vulnerable situations (Women victims of violence, minors, disabled, unemployed). The "Cultural animation" involves initiatives in the cultural and training sphere, especially regarding the suburbs' marginal areas. The "Fighting early school leaving" discusses the prevention and fight against school dropouts. In 2020, the total financial resources disbursed amounted to € 21,250,000. Of the 79 projects, only 21 have had access to the second phase. The projects mainly concern the area of Social Inclusion (76%) distributed in Northern and Central Italy (13) and the South (8). In particular, seven projects are located in the Northern regions (Piedmont, Veneto, and Lombardy), six projects in the central areas (Marche, Umbria, Tuscany, and Lazio), and eight in the Southern regions (Puglia, Calabria, Campania, Molise, and Sicily). Social inclusion is the only macro-area that includes funded interventions in all three macro-regions. In particular, the primary social needs identified are social Exclusion (28%), work exclusion (26%), school dropout (17%), housing emergency (13%), elderly frailty (11%), and urban decay (4%). (See Fig. 7).

The Third Sector Entities (ETS) have a predominant role in managing these projects (53%), mainly in Southern regions. In addition, 24% are profit companies, universities represent 13%, and nine percent include other public authorities (See Fig. 8).

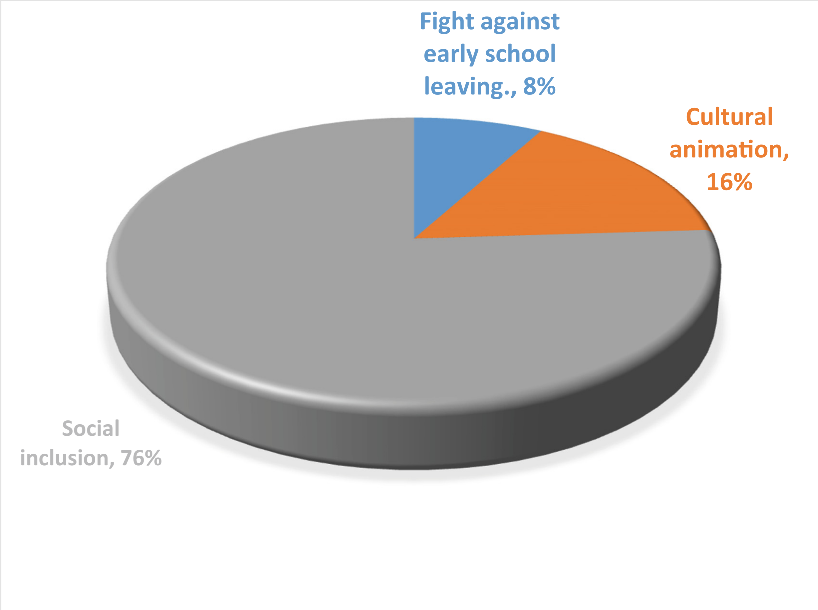

Fig. 7. Social Innovation Fund and projects funding. Author's elaboration on data from the Italian Government Department of Public Administration https://www.funzionepubblica.gov.it/innovazione-sociale

Different financing instruments (see Fig. 9) are at the base of the Fund, and the banking sector is the principal provider of the resources (57%). The outcomes refer to promoting an enhancement in several well-being aspects of individuals and the community in the medium-long term. The expected results are related to social relations, improvement of personal well-being, increased skills, social inclusion, attractiveness, territorial competitiveness, job placement, and strengthening of administrative capacity.

In general, we distinguish three types of outcomes:

- Hard outcomes: changes whose measurement takes place through quantitative and objectively verifiable methods;
- Soft outcomes: those changes whose measurement takes place through qualitative methods, often difficult to measure;
- Cashable outcomes: both hard and soft changes generating social values transformed into financial proxies (in terms of lower costs / higher revenues)

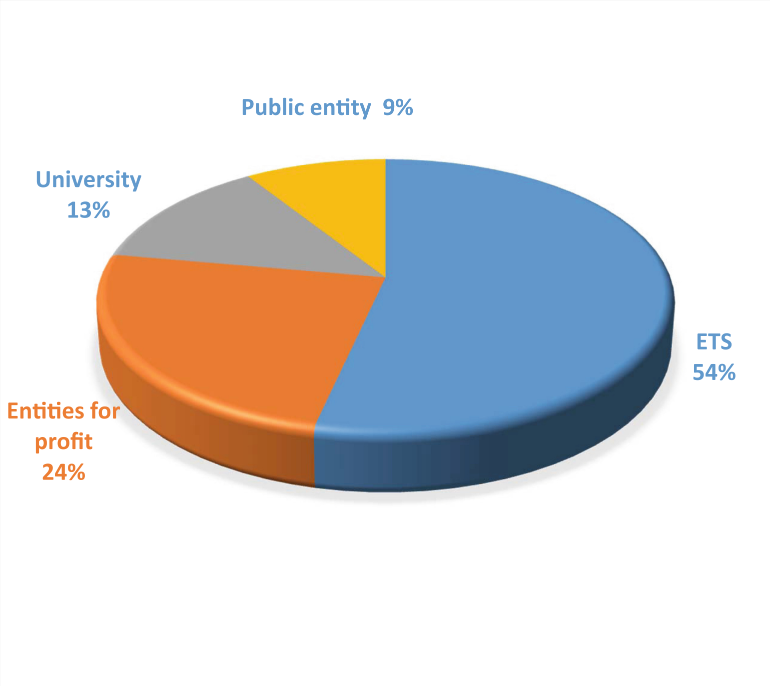

Fig. 8. Partners typology and Social Innovation Fund. Author's elaboration on data from the Italian Government Department of Public Administration https://www.funzionepubblica.gov.it/innovazione-sociale

Indeed, quantitative measurement is still experimental and represents 29% of the total outcomes. The Social Innovation Program's monitoring system aims to represent the most relevant data collected by analyzing the projects presented and monitored. The critical element is to build a joint analysis of the project's social, economic, and financial sustainability. In particular, the current evaluation looks at the capacity to build specific metrics to comprehend outcome payers and the returns of the generated impacts. The outcome payers, the stakeholders who will benefit from the economic outcomes deriving from the achievement of the outcomes, take the form of direct and indirect outcome payers. Regions, Chambers of Commerce, Ministries, the National Agency for Active Labor Policies (ANPAL), and Employment Centers are among them.

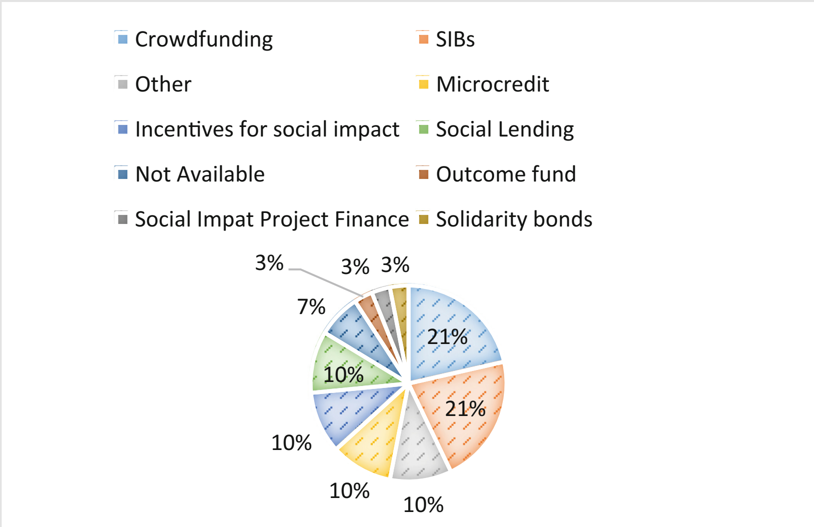

Fig. 9. Financial sources and the Innovation Social Fund (2022). Author's elaboration on data from the Italian Government Department of Public Administration https://www.funzionepubblica.gov.it/innovazione-sociale

3.3 The Innovation Fund and the Link with the Sustainable Development Goals of Agenda 2030: Some Descriptive Results

The development of these new financial instruments works in connection with the United Nations Sustainable Development Goals, i.e., the new 17 objectives for 2030, a new agenda to analyze trends of the world market relating to the automation of work, finance for digital innovation, the democratization of data, the transfer of wealth to the fragile segments of society.

Following the just expressed considerations, this paragraph intends to propose an initial assessment of the potential impacts of the Social Innovation Fund through an analysis of the data provided by the Monitoring Committee. The primary beneficiaries of the Fund mentioned above are mainly the Municipalities, Regions, and Metropolitan Cities.

In particular, three lines of the analysis are:

- Distribution of ongoing funded projects that refer to the sustainable development goals of Agenda 2030;
- The link between the sustainable development goals and the Fair and Sustainable Well-being (BES);
- The local authorities involved in the projects

Of the 17 sustainable development goals (SDGs abbreviation "Sustainable Development Goals"), 29% of the ongoing programs related to Objective 11, "Sustainable cities and communities." This objective intends to improve air quality and waste management and allow a building design that satisfies more participatory, integrated, and sustainable logic. The 2030 expected goal is to ensure access to safe and affordable housing. This objective is related to 5 dimensions of Fair and Sustainable Well-being (BES) Social

Relations (58%), Quality of Services (27%), Landscape and Cultural Heritage (7%), Economic well-being (4%), Subjective Well-being (1.49%), Safety (1.49%).

Seventeen Italian municipalities presented social innovation projects with this objective. 67% of the projects submitted are located in the Municipality of Syracuse and Prato.

Goal 3 is the second objective that benefited from more resources "*To ensure a healthy life and promote the well-being of all citizens at all ages.*" As many as 18% of the resources went to projects for Goal 3. The country's governing authorities will have to face several crucial challenges by 2030, such as:

- Reducing the number of children born orphans, the maternal mortality rate to below 70 cases for every 100,000 children born alive;
- To reset the causes of deaths in infants and children under five. This second challenge requires that all countries must commit to reducing neonatal mortality to at least 12 for every 1,000 live births and infant mortality under five years of age to at least 25 per 1,000 live births;
- Fighting the spread of epidemics such as AIDS;
- A constant commitment to the prevention and treatment of non-communicable diseases, the promotion of mental health and well-being, the prevention and treatment of drugs and alcoholic beverages, better road safety, more accessible access to sexual and reproductive health care services;
- Promotion of universal health coverage following a logic of inclusiveness;
- Improve the quality of the environment to reduce the number of deaths and diseases caused by air, water, and soil pollution problems;
- Strengthen the implementation of the Regulatory Framework of the World Health Organization Convention on Tobacco Control;
- Reinforce the investment in research and development of vaccines and drugs to combat communicable and non-communicable diseases;
- Design a diversified offer of training services aimed at health personnel.

The fulfillment of this objective is linked to four dimensions of the BES: subjective well-being (62%), health (19%), social relations (17%), and work and lifetime balance (2.38%). Eight municipalities in the South have presented projects aimed at this objective. The dimensions of well-being 0are 4: Subjective well-being (62%), health (19%), Social relations (17%), and Work and lifetime balance (2.38%). In the South of Italy, the municipality of Campobasso has presented projects most oriented towards this objective (67%). The projects presented by this joint leader also favour subjective well-being as a dimension of equitable and sustainable well-being.

Objective 4 covers 17% of the programs is the "Quality Education." This goal, drawing on the previous Millennium Development Goals (WHO), intends to promote higher quality for all levels of education and all possible opportunities between primary education and professional training. Therefore, lifelong learning paths receive emphasis. In this way, all people will have the opportunity to lead a quality of life consistent with the peculiarities of the territorial area where they live in a safer, more sustainable, and interdependent way. The evidence shows various challenges by 2030:

1. Ensure that all girls and boys complete accessible, equitable, and quality primary and secondary education leading to relevant and effective learning outcomes;

2. Ensure that all girls and boys have access to quality early childhood development, care, and pre-primary education so that they are ready for primary education
3. Ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university;
4. Considerably increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship;
5. Eliminate gender inequalities in education and ensure equal access to all levels of education and vocational training for the most vulnerable;
6. Ensure that all youth and a substantial proportion of adults, both men, and women, achieve literacy and numeracy;
7. Ensure that all learners acquire the knowledge and skills necessary to promote sustainable development, including through education aimed at sustainable development and lifestyle, human rights, gender equality, the promotion of a peaceful culture and non-violent, global citizenship, and the enhancement of cultural diversity and the culture's contribution to sustainable development;
8. Build and strengthen education structures through education for sustainable development that are sensitive to the needs of children, disabilities, and gender equality and provide learning environments that are safe, non-violent, and inclusive for all.

Many municipalities in Southern Italy, Campobasso, Naples, Bari, Brindisi, Lecce, Catanzaro, Catania, and Palermo, have privileged dimensions of the BES as Education and Training, Social Relations, and Subjective Well-being. In particular, Catania municipality prefers the quality of services (67%).

The fourth SDG that gathers 15% of the projects presented to the Fund is Goal 10, "Reduction of inequalities" between states and within them through promoting social, economic, and political cohesion among citizens.

To achieve this goal, the activation of global social protection policies and targeted planning and management of migratory flows is necessary. By 2030, the target is to increase the population's income in the most economically disadvantaged conditions by 40%. Indeed, demanding challenges for the European countries. In Italy, following the outbreak of the Covid-19 pandemic, poverty levels considerably increased.

In addition, the various States have identified a 3% reduction in the transaction costs of migrant remittances. This objective involved the projects presented by 13 Italian municipalities, of which 5 in the South (Campobasso, Brindisi, Lecce, Palermo, and Catania) and 8 in the North (Cuneo, Turin, Bergamo, Padua, Treviso, Perugia, Fermo, Rome). The dimensions of the BES connected to the projects related to this objective are essentially 4: subjective well-being (39%), social relations (33%), economic well-being (19%), and quality of services (8%).

The fifth sustainable development corresponds to goal 8, "Decent work and economic growth," which includes 12% of the total projects. Growth and youth are interconnected, and the young cohorts find full and complex access to the labour market. More than 200 million people currently have no work income. Therefore, creating a green economy and a much more dynamic labour market ready to enhance the potential of the young are two crucial challenges for the growth of both developing countries and emerging and industrialized ones. The realization of development must not take place at the expense of the natural environment, and environmental enhancement is necessary for new forms of growth. Governments have identified some challenges, such as:

- Improve levels of economic productivity by investing in diversification, technological progress, and innovation, with particular attention to high value-added and labor-intensive sectors;
- Promote policies aimed at development, job creation, and entrepreneurship, especially for small and medium-sized enterprises;
- Ensure more efficient and sustainable use of resources to avoid environmental degradation;
- Ensure full employment and decent conditions of decent work for all;
- Reduce the share of unemployed young people and "NEETs);
- Abolish all forms of forced labour and all forms of slavery and exploitation of child labour;
- Improving the working environment in compliance with safety standards for all workers, including immigrants, especially women, and precarious workers;
- Promote policies to promote sustainable tourism with essential repercussions on local territories;
- Develop and implement a global youth employment strategy and the Global Employment Pact of the International Labor Organization.

All other objectives of The Social Innovation Fund indicate a low level of importance (less than 4%) (Fig. 10).

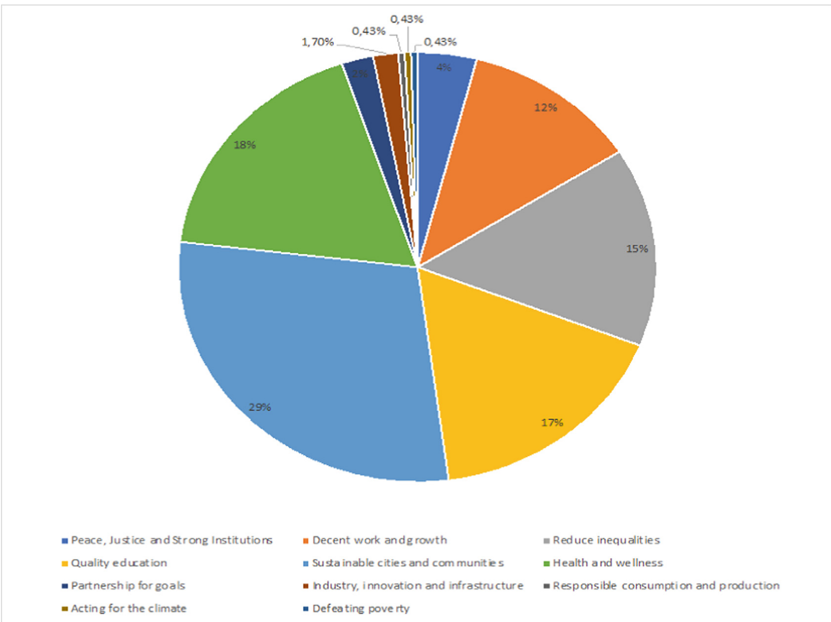

Fig. 10. Social Innovation Fund and BES (2022). Author's elaboration on data from the Italian Government Department of Public Administration https://www.funzionepubblica.gov.it/innovazione-sociale

4 Conclusion

New forms of financing such as SIBs and the Social Innovation Fund represent new opportunities for growth in recent years. The logic of the multi-stakeholder partnership indicates how impact finance indicates a new trend partially exploited in the current times. In our opinion, the strong ties between environmental sustainability and the new forms of financing explain why the environment, trust, and financial instruments during the current ecological transition a challenge ahead of us is global and systemic. Therefore, social innovation assumes strong links with the environment and the economy. Financial instruments represent new forms of these critical relations.

The different dimensions of Sustainable Well-being (BES), indicated in the first project cycle of the Italian Innovation Fund, demonstrates that some communities and cities require an increasingly precise financial design to intervene and solve local problems. In recent years, however, the applications of SIBs probably demonstrate their partial beneficial capacity for two main reasons. The first lies in the complex components of the financial structure, and the second issue is the difficulty of constructing reasonable quantitative metrics for evaluating results.

Conversely, "The Covid-19 crisis has created an urgent need for a just, impact-led recovery that serves all people and preserves our planet. It presses us to change our ways to address the tremendous social and environmental challenges better ahead of us." [26].

This manifesto is clear: to save billions of people from more significant hardship. We must bring impact finance to the core of our economies by defining different actions. This comment is not a wish, but it requires immediate ability to intervene. First, introducing incentives to accelerate impact investment, which pursues social and financial returns to create sustainable jobs, advance education, better health care, and supply the expansion of nonprofit organizations more capable than classical organizations to support the most vulnerable. Also, the growth of investment levels into small and medium-sized impact-driven businesses and high-growth impact ventures to create new activities. Another issue is the impact of transparency on companies. These actions will reinforce the collaboration level of several stakeholders such as private companies, public enterprises, universities, and the public the own mutual trust.

In addition, Impact Finance opens a new way of financing at a territorial level. The 380/2020 EU strategy "Communication on Biodiversity Strategy for 2030 Bringing Nature back into our Lives" represents the starting point for a new reflection on the importance of environmental sustainability in designing local development models for the coming years. The European Commission has identified the socio-ecological transition as one of the main challenges for current and future societies and economies.

However, new steps are necessary to accelerate the ecological transition towards a social economy. A financial dimension of the innovation model requires a better understanding. The Global Impact Investing Network (GIIN) envisions a future world in which social and environmental factors are integrated into investment decisions. To realize this vision, the GIIN Roadmap has presented six categories of action that the impact investing community needs to take on to ensure the industry achieves its potential. Understanding how to effectively measure and manage impact is critical to ensuring investors achieve their desired results to address the world's most pressing social and environmental challenges. We envisage an extensive use to enable the EU to achieve a continuous long-term improvement of quality of life through the creation of sustainable local communities and cities able to manage and use resources efficiently, i.e., an innovation that respects the principles of environmental sustainability related to new financial instruments. The logic of the multi-stakeholder partnership promoted is well suited to environmental protection and biodiversity in the direction of a sustainable and social economy where all actors are involved and responsible for formulating local development strategies.

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Innovation Policies in Germany: An Analysis of Tools and Impacts

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Abstract. This work proposes an analysis of the main financial and political instruments adopted in 2012–2019 in Germany to support the various forms of innovation (startups, clusters, technology transfer, university-industry partnerships, etc.). In this way, we will try to understand whether these examples of industrial innovation policy have managed to play a crucial role in reducing the development gaps between West Germany and East Germany, thus facilitating acceleration of convergence between these two territorial areas.

Keywords: startup · technology transfer · entrepreneurship · cluster

1 Introduction

This paper, descriptive in nature, intends to offer a review of the main policies and tools adopted by Germany to support innovation, above all the digitization of production activities, and the creation of new entrepreneurship.

To satisfy this objective the paper proposes an analysis of the reports of the German Federal Government in recent years (2012–2019) with particular reference to innovation policies.

Through this analysis we will try to provide an answer to the following questions:

- What was the role of the Central Government in the management of these policies? and what was that of the individual regional governments?
- Was there an equal distribution of these initiatives in the territories of West Germany and East Germany?
- Which sectors benefited most from these initiatives?

The main objective of these policies should have been to reduce the development discrepancy between the two areas of Germany (East and West) by making the entire territory more cohesive. This convergence process initially witnessed marked acceleration, starting from the 1990s thanks to the increasing role of the industrial sector as a driving force of economic growth. On the other hand, since the end of the 1990s, this convergence process has slowed down considerably.

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https://doi.org/10.1007/978-3-031-34211-0_5

The theme of innovation and digitalization of the economy has assumed central importance in the context of the PNRR (National Recovery and Resilience Plan) presented on April 27, 2021, in Germany. The composition of the German PNRR and the percentage incidence of the different strategic areas are described in detail in the Table 1 and Figs. 1, 2. However, it is much smaller than in other EU countries (27.9 billion euros).

Over 50% of the planned resources, or 14 billion, were allocated to the challenge of digitization, while 11.3 billion to the challenge of the environmental and energy transition. The government plans to spend over 90% of NGEU (NextGenerationEU) resources on digitization and ecological policies. A part of the resources allocated for digitization will benefit schools (overall 1.3 billion) and health facilities (overall 3 billion).

A significant portion of the resources will be allocated to the strengthening of the public administration to eliminate all the bureaucratic constraints that slow it down and often prevent it from meeting the needs of citizens. In this way, all public and private investments will be made faster. To this end, 3 billion will be allocated to finance the Online Access Act project, a centralized system designed to offer administrative services quickly and make it easier for citizens and businesses to access public administration documents.

According to the economic research institute DIW, 61.7% of the resources will be used to finance public investments and incentives for private investments. The latter will cover almost half of the total resources disbursed. The remainder is made up of current expenditure (20.5%), subsidies to businesses (15.3%), and transfers to households (2.5%). The use of resources will be highest in 2021, and about half of the expenditure will be concentrated in the two years 2021–22.

Table 1. PNRR and strategic areas. Source: Bundesfinanzministerium

Elements	Billion	Quote for digital (Billion)	Quote for envinroment (Billion)
Environmental and energy transition policies	11.26		11.26
Digitization of the economy	5.90	5.90	
Instruction	1.44	1.44	
Incentives to participate in social life	1.26	0.03	
Modernization of public administration and incentives for private investments	3.52	3.81	
Health	4.56	3.47	
Total	27.95	14.65	11.26

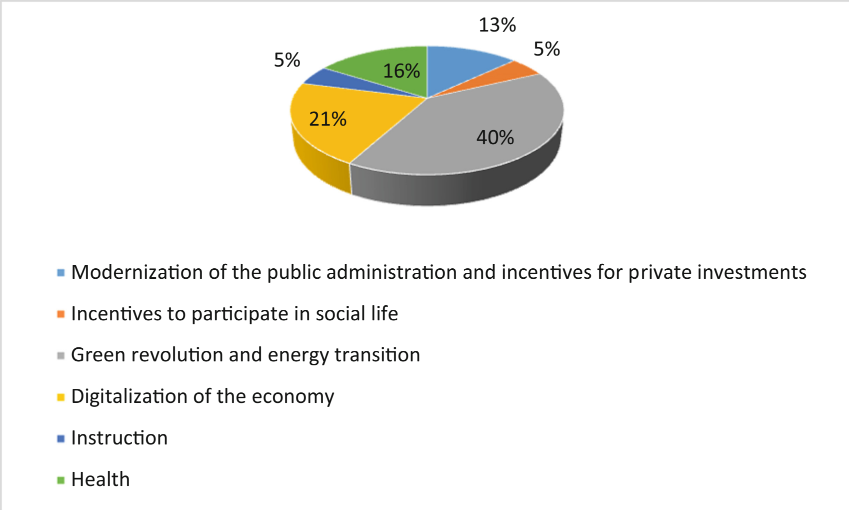

Fig. 1. Distribution of funds between EU strategic areas. Source: Authors elaboration based on PNRR data

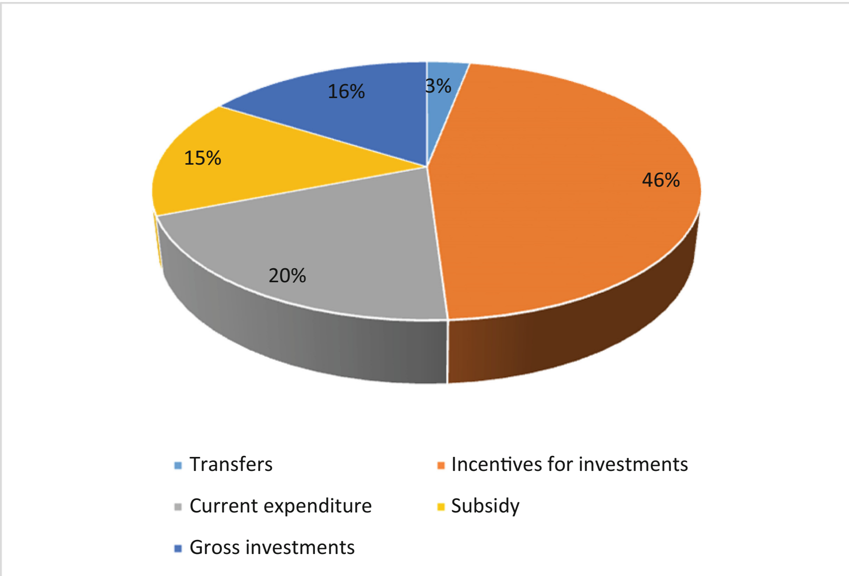

Fig. 2. Distribution of resources among expenditure components (estimated values)

In addition to previous resources, Germany has received € 12 million from the REACT-EU (Recovery Assistance for Cohesion and the Territories of Europe) program to support those most affected by the coronavirus pandemic, for example by hiring additional teaching and assistance staff in early childhood education in financially weaker municipalities. The additional REACT-EU funds are primarily channeled through the European Regional Development Fund (ERDF) and the European Social Fund (ESF) (including the Youth Employment Initiative - YEI). Some of the new resources will also be used to top-up the European Fund for Aid to the Most Deprived.

At 31 May 2022, the headline figures on the volume of REACT-EU resources mobilized are as follows;

- EUR 42.2 billion total EU amount allocated through ERDF and ESF (with a further EUR 512 million allocated to FEAD)

This amount includes the thematic investments below:

- EUR 6.4 billion of ERDF allocated in support of the green transition, of which EUR 5.6 billion specifically target climate action;
- EUR 3 billion of ERDF allocated for digital economy;
- EUR 7.2 billion of ERDF allocated in support of enterprises and business development;
- EUR 7 billion of ERDF allocated in support of healthcare systems;
- EUR 15.3 billion of ESF allocated in support of labor market measures, social inclusion and education and training.

The new funds provided to Germany will also support the vocational training of 700 people aimed at improving skills for the digital and green transformation of the economy. They will also support the exchange between universities and SMEs to apply research results in enterprises to contribute to the digital transformation of the economy.

The issue of ecological transition has also been an essential focus in the context of the NRP in Germany. Other financial resources earmarked for this issue come from the Deutscher Aufbau- und Resilienzplan-Darp recovery plan, financed by the Recovery and Resilience Facility (RRF), also part of the EU Next Generation aid package. Green policies attracted 39% (11 billion out of a total of 28 billion) of the resources provided through the Recovery and Resilience Plan. This percentage gives Germany primacy in the promotion of green initiatives, surpassing Italy (31%) but maintaining an evident detachment from Spain (44%) and France, with over 50% of its "Plan de reliance" dedicated to green investments. By evaluating the amounts disbursed, in absolute terms, Germany is positioned in last place compared to Italy, France, and Spain. Italy is the country that has received the most significant amount of resources to be allocated to green investments, over 59 billion, against Spain (31 billion), France (21 billion), and Germany (11 billion).

Concerning energy transition, Germany is implementing a series of initiatives aimed at modernizing the industry by making it less dependent on greenhouse gas emissions and also massive interventions on the transport front, both public and private. Among the most significant investments, 3.3 billion has been set aside to decarbonize the economy, promoting the introduction of new hydrogen technologies to be implemented in production chains. Another 5.4 billion will be used for the construction of hybrid and electric means of transport, as well as the purchase of sustainable buses and trains, in line with the climate objectives of the Paris agreement. Germany, together with Spain, is the country that has invested the most in electric transport (respectively (5.4 and 13.2

billion). In addition, 2.5 billion will be invested in sustainable construction to increase the energy efficiency of new or existing buildings. Germany and Spain are focusing heavily on energy production from hydrogen (investing 3.2 and 2 billion respectively), trying to reduce as much as possible the production of electricity from nuclear power plants and to decommission coal-fired plants.

Thanks to the analysis conducted in this paper, it emerges that the economic structure of East Germany is rather fragmented, representing an essential constraint for the growth of investments in R&D by industry. The entrepreneurial fabric of Germany is made up of large companies operating mainly in the medium-high technology manufacturing sector (automotive and chemical) and some small, highly specialized companies characterized by a high degree of openness to international markets.

Creating new companies (spinoffs and startups) of both university and a non-university matrix is particularly widespread in Germany. In this regard, Daimer et al. [1] underline that, in recent years, there has been a shift from individual cooperation projects towards more strategic forms of cooperation with long-term interactions between business management and university researchers. These partnerships are prevalent in the high-tech sectors, but the humanities and social sciences sectors represent a potential future that is still not fully explored.

Germany can be considered a best practice case in the context of policies to support the creation of startups. Its startup ecosystem has therefore become a qualitatively unique model in Europe. Almost 10% of the founders of German startups and 22% of employees come from abroad. From a study conducted by I-COM [2], Germany is one of the European countries considered as having the highest market capitalization of successful innovative startups (about 7% of the 150 companies evaluated on the stock exchanges of Frankfurt and Xetra).

Furthermore, public financing in Germany is highly diversified and is essentially structured on four pillars: direct grants, public loans, public guarantees, and equity. In Germany, the relevant venture capital partners (VC) can be targeted through the Bundesverband Deutscher Kapitalbeteiligungsgesellschaften. e.V. (BVK - German Private Equity and Venture). Conferences and special events such as The German Equity Forum provide many opportunities for young companies to contact potential VC partners directly. Honttenrott and Richstein [3] demonstrated that joint funding consisting of government subsidies and soft loans positively impacted the startup of startups specializing in knowledge-intensive sectors.

The University of Lüneburg has set up an incubator concept, awarded over € 80 million in funding from the European Structural Funds and regional financing of Lower Saxony.

The paper is divided into three sections. The first section proposes a review of the literature to highlight how the way of thinking about industrial policy has changed over the years. In the second, a longitudinal analysis is proposed of the main initiatives adopted to guarantee support for innovation in all its forms (business creation, technology transfer, business-university partnerships, research clusters, and innovation poles) trying to define the objectives, the instruments adopted, and the significant repercussions at the national level and, where possible, at the regional level. The third section concludes the work.

2 Changes in the Conception of Industrial Policy: A Review of the Literature

Writing a literature review on the effects of industrial policy in advanced and developing economies is a rather daunting task for several reasons. First of all, there has been no sharing of the crucial role that industrial policy can play in territorial development processes. The manifestation of the repercussions of industrial processes has been highly heterogeneous globally. Furthermore, there is a problem of a lack of information on good performance and, above all, on the criticalities that may condition the success of any industrial policy both in its design and implementation phase. The lack of these data hinders the identification of best practices as models to follow to identify the changes to be made, especially for the benefit of the territorial areas falling furthest behind. It also makes it more problematic to conduct solid empirical checks. Among the countries that may be considered successful models to follow in implementing industrial policies, we may certainly include China.

The lack of data, making it difficult to carry out qualitative analyses, i.e., according to a case study approach, has also hindered over the years the conduct of econometric analyses aimed at investigating the impact of industrial policies. This criticality has diminished in intensity in recent years, and there have been many empirical analyzes. Lane [4] analyzed the fallout of the industrial policy known as "Heavy Chemical Industry (HCI)" under the Chung-Hee dictatorship (1973–1979). The economic activity of South Korea towards capital-intensive industry, generated an increase in productivity of 80% (compared to the manufacturing industries not affected by this policy). Furthermore, there are strong positive long-term effects of this industrial initiative on other sectors linked to those targeted, and weak adverse effects on industries with backlinks to the sectors targeted by HCI.

There has been a succession of empirical investigations that focused on the economy of China as a geographical area. For example, Nunn and Treffer [5], analyzing the tariff structures of 63 countries, identify a positive correlation between this protection mechanism of knowledge-intensive industrial sectors and the GDP growth rate over the long term. Concerning the economy of China, public subsidies are among the most investigated industrial policy instruments. The attention given to these tools can be explained by the fact that subsidies can significantly reduce the incidence of the barriers to innovation built by leading companies to the detriment of potential competing followers ([6–8]). Thanks to the first-mover advantage, leading companies have a whole range of skills that allow them to benefit more from the revenues associated with innovation. First of all, these companies, which have greater knowledge of the genesis of innovation and the factors necessary to develop it, exploit a more accentuated division of labor in order to manage production costs more efficiently, and may decide whether they need to transfer low-skilled tasks to another developing country willing to offer better conditions. Since the emerging industries globally are all high-tech, enterprises in China have more potential for productivity growth than enterprises in catching-up or maturing domestic industries. These tangible and intangible assets, which represent the strengths of Chinese companies in the management of innovation and in addition, their greater propensity to invest in R&D, are not sufficient to guarantee the success of innovation policies. The probability of successful innovation for companies in emerging sectors on a global level is always strongly conditioned by the existence of market demand ([9–12]).

The development of market demand could be slowed down by the existence of information asymmetries between leading companies anticipating innovation and potential buyers. To reduce such asymmetries and avoid market failure on the demand side, several industrial policy instruments on the demand side, such as demand subsidies and tax reliefs and direct public tools for the procurement of innovation, can play a crucial role. Therefore, the joint action of supply-side subsidies and instruments to stimulate market demand would allow companies operating in emerging high-tech industrial sectors and located in developing countries to overcome the critical issues, which characterize these sectors for competing firms from OECD countries ([13]). Among the most recent studies are those by Guo et al. [14] and Boeing [15]. The former estimates the impacts of the INNOFUND government program supporting small and medium-sized enterprises, finding a positive correlation between the subsidies provided through this fund and the ability to produce innovation. For Boeing (2016), the subsidies granted by the Government to research and development produce a displacement effect in the sense that, in the short term, they replace (and do not add to) the corporate investments in research and development, and this effect tends to disappear over the long term. For Boeing et al. [16], this displacement effect is not prevalent for companies that repeatedly benefit from subsidies, companies specializing in high-tech sectors, and companies with minority state participation. Howell [17] examines the effect of public subsidies on different levels of innovation by businesses, and concludes that public subsidies promote innovation in higher-tech industries but hinder economic performance in both lower and higher-tech industries. Kalouptsidi [18] also investigates government subsidies as an instrument of industrial policy, limiting his attention exclusively to the shipbuilding industry. Thanks to disbursements of between 1.5 and 4.5 billion dollars (in 2006–2012), the Chinese shipbuilding industry achieved significant market shares from Japan and South Korea. Chen et al. [19] analyzed the cut in income taxes allocated to investments in research and development by companies as an industrial policy tool. Firms that benefited from this cut and thus double their real income for R&D could increase productivity by 9%. Aghion et al. [20] mainly focuses on trade policies such as tariffs, export subsidies, FDI policies, and tax exemptions.

A relatively recent definition of industrial policy is that provided by Schot and Steinmuller [21] and by Warwick [22]. The former introduced the expression "transformative innovation policies," those whose effects must be evaluated with respect to the ability to solve specific problems, primarily the fight against poverty, the aging of the population and climate change, rather than producing more innovation. According to Warwick, industrial policy is “any kind of government intervention or policy that attempts to improve the business environment or to alter the structure of economic activity towards sectors, technologies or tasks that should offer better prospects for economic growth or social well-being compared to what would occur in the absence of such an intervention.“ This definition is broader and shows greater horizontal impacts than the definitions previously provided by other authors, for example, Chang [23] and more recently Mao et al. [24], who prefer a vertical approach. For Chang, the effects of industrial policy are not vertical, and fall exclusively on specific sectors. Also, for Mao et al., industrial policy intends to achieve objectives that identify a specific sector, for example, the expansion of entrepreneurial capacity, support for internationalization, technological change, strengthening of investments in research and development, increased productivity, etc. This heterogeneity of objectives is perfectly consistent with this broad definition of industrial policy, which includes all interventions supporting science and technology (tax breaks, tariffs, subsidies, export credits, FDI, and technology transfer) as strategic levers for greater competitiveness in targeted sectors.

This extension, proposed with a view to strengthening the possible synergies between industrial policy and S&T policies, represents a step forward compared to previous studies that investigated traditional and new types of industrial policies separately ([25–27]). For Mao et al., the productivity growth of an industrial sector depends on three factors: (1) the timing of a policy, (2) the attributes of a policy, and (3) industry attributes. The starting point for this argument is found in the reflections proposed by Lee and Malerba [28] and Pellegrino and Savona [11]. The former pointed out that within each specific sector, three sets of factors (technological, demand, and institutional/political) influence its recovery cycles. At the same time, the latter argued that both financial and non-financial factors played a role such as, for example, knowledge and factors on the demand side. Technological limitation is perhaps the most obvious non-financial factor limiting innovation, and the three types of industries in developing countries such as China face different incentive-related and technological constraints.

The difficulty of understanding the nature of the problem to be solved and the urgency with which solutions must be offered represent some of the causes of the failure of any industrial policy, regardless of how it is interpreted. In this regard, no socially desirable goal is the same for all territories ([29, 30]). Actors implementing policies "on the ground" are also more likely to possess the skills and practical knowledge necessary to understand specific problems of the place and context in which their solution is to be implemented ([31, 32]). All of this suggests the need for a more bottom-up or place-sensitive approach to innovation policy, something generally missing from the challenge-oriented innovation policy agenda. ([33]).

The attention to local specificities, as a starting point in the promotion of technological diversification strategies, is also taken up by the agenda of the European Commission with its smart specialization strategy ([34]). In this perspective, innovation policies should be selectively based on a place's unique and specific characteristics and resources ([35]). As tools for implementing the smart specialization strategy, many scholars have focused on public procurement, illustrating examples of procurement-driven innovation and providing estimates of the relationship between innovation outcomes and procurement ([36–41]). However, their effectiveness is severely weakened by several problems, primarily the lack of technical expertise on the part of the contracting authorities, poor coordination, and poor incentives. Innovation through public procurement requires policy change, in particular new meaningful capabilities and institutional change ([42–44]).

Despite a Great Deal of Interest in the Barriers and Challenges Associated with the Use of Procurement ([45]), Little Attention Has Been Paid to the Impacts that Public Procurement-Driven Innovation Can Produce at the Regional Level ([46]) and the

Institutionalization and Mainstreaming of This Political Innovation. There is a Lack of Practices that Can Be Considered *Best* Practices. Uyarra et Al. [47], Considering the Case of the Spanish Region of Galicia, Question the Effectiveness of Procurement as an Innovation Policy Tool.

3 Policies for Innovation

This section aims to analyze policies implemented in Germany to encourage business creation, the greater digitization of production activities, and the supply of broadband.

The management of policies and financial instruments in support of businesses and innovation is highly centralized and does not involve private entities outside the Federal Government. The two main actors which formulate the innovation policy are the Ministry of Education and Research and the Ministry of Economy and Energy. In particular, the latter has gradually seen the strengthening of its competency relating to programs supporting businesses, especially start-ups and small and medium-sized enterprises, and policies for promoting more excellent applied research.

Coordination between federal and national government decisions has also been ensured through the Joint Science Conference (Gemein-same Wissenschaftskonferenz-GWK) established in 2007 and made up of federal and state finance and research ministers. A particularly significant role in achieving greater cooperation between the federal government and local governments was played by the signing of three pacts. The first, the Hochschul pact for Higher Education, was signed in 2007, with financial coverage until 2020, and aimed to promote an expansion of the educational offer of German universities and to increase the propensity to internationalize their research activities. The second pact, the Pakt fur Forschung und Innovation - Research and Innovation, was signed in 2005 and funded until 2020 to strengthen the main research institutions. The third pact, the Exzellenzi (Excellence) initiative, was signed in 2007 to channel financial resources in favor of clusters and universities of excellence.

Since 2006, the Federal Government has been supported by institutions with a federal structure, made up of illustrious players from the worlds of economy and science, such as the Council for Innovation and Growth and the Union for Research between Science and Economics. More recently (2015), two other important groups of experts were set up: the High-Tech forum and the Platform for Industry 4.0. The first was made up of twenty exponents from the world of science and business, while the second represented a virtual platform aimed at facilitating multidisciplinary interaction and the greater sharing and dissemination of knowledge, especially in the digitization of business processes.

All these institutions working alongside the Federal Government to simplify bureaucratic and administrative issues that could hinder the implementation of innovation policies take the legal form of partnerships ("Projekttrager") of a public, semi-public or private nature.

The instruments described in this section are direct financing instruments since Germany differs from France, for example, in its absence of indirect financing for businesses through tax incentives.

As highlighted by Eickelpasch [48] and by Sofka [49], the areas of intervention of these various financial initiatives are essentially attributable to three categories: support for technology startups, strengthening innovation in small and medium-sized enterprises, and business advisory services. As we will see from the description of these tools, the second area of intervention is characterized by a much more diversified offer of financial instruments and initiatives.

Table 2 summarizes the projects and financial allocations of the INNOKOM project since its launch (2009) in East Germany.

Table 2. The INNOKOM project in East Germany

	2009–2014	2009–2015	2009–2017
Projects	1,080	1,434	1,789
Amounts (million euros)	312	421	522

At the end of 2014, as part of the "Business Regions" initiatives, more than 170 "Innovation Forums" had received or would receive funding of up to € 85,000. By May 2017, out of 181 projects, 45 had been approved. At the end of 2018, the projects financed by non-profit research bodies reached 2,002 with funds of approximately 578 million euros. The share of East German forums was disproportionate, over 40%. The portfolio of topics ranged from technological development (e.g., flexible electronics or cross-reality [XR]) and social innovation in nursing, to the environment and sustainability (including the development of plastic-free packaging and new types of foods created from algae).

Table 3 represents the total amounts granted to support the creation of startups in Eastern Germany provided by the various European Resource Planning (ERP) programs: the ERP Start-Up Loan - Start-up Money program, the ERP Start-up Loan - Universal program, and the ERP Capital for Start-up program. In 2017, the total amount allocated by ERP to startups was 528 million euros, divided as follows: 43 million (approximately 18%) by ERP Start-Up Money, 459 million euros (approximately 13%) by ERP Universal, and 26 million euros (about 23%) by ERP Capital for Start-up. At the end of 2016, around 53 million euros (and therefore around 20% of the volume of commitments) had been granted by the ERP Start-up Loan - Start Money program, around 352 million euros (11%) by the ERP Start-up Loan - Universal Program, and 24 million euros by the ERP Capital for Start-up program (approximately 20%). As a demonstration of the growing interest in the startup phenomenon, this figure was far superior to that disbursed by the end of 2015, of approximately 51 million euros (approximately 19% of the volume of commitments) to enterprises in East Germany. The ERP startup loan-universal program was about 360 million euros (about 11%), and the ERP capital for the startup program about 35 million euros (about 26%).

Table 3. The project Enterprise Resource Planning for startup (ERP) in East Germany

	2016	2017	2018
Amounts (million euros)	429	528	483

The ERP Fund, specifically dedicated to the digitalization of businesses, expanded its budget in 2017 by financing 47 loans, amounting to resources of approximately 135 million euros to the new federal states. To benefit from these resources, companies had to qualify as “digital” or “Innovative” and to have been present on the market for at least two years.

About 31% of the young and innovative companies, which between 2013 and June 2016 were classified as eligible for support by the INVEST program, were based in the new federal states, with 21.9% in Berlin. In 2016 alone, 108 innovative companies from the new federal states received funding. This program was subsequently extended until 2017.

During the years 2014–2016, the EXIST program (Existenzgründungen aus der Wissenschaft), created in 1998 and consolidated in 2014 to fund the start-up of businesses and the process of transferring research, saw a redefinition of the prerequisites for funding. Above all, the primary intent of this program was to alleviate the start-up costs of academic spin-offs for a maximum period of 12 months.

In recent years, the section of the EXIST business start-up program has disbursed over 17 million euros, while the area of the EXIST program dedicated to the transfer of research accounts for over 23 million euros. About 20% of the total resources was granted to start-up teams in universities in East Germany. In 2017, the EXIST Start-up Grant and EXIST Research Transfer programs maintained and in some areas expanded the high level recorded the previous year. This is reflected in the number of projects, with 348 in the EXIST Start-up Grant program and 151 in the EXIST Research Transfer program (1 + 2 programs). For both the EXIST Start-up Grant (over 22 million euros) and the EXIST Research Transfer (over 30 million euros), approximately 18% of the total volume was awarded to start-up teams in East German universities.

Since 2015 the High-tech Founder Fund (HTGF), a seed-stage investor, has been operational, providing 21 loans for a total of around 10 million euros in the eastern federal states. This corresponded to commitments of around 54% of HTGF’s 40 overall first-time financing commitments in 2015. In 2018, this amount was lower but still constituted a significant form of financial support for companies in East Germany (6.5 million euros, corresponding to commitments of approximately 15% of the 59 loan commitments). In 2017, € 3.65 million had been granted, or approximately 19% of the 34 loan commitments.

The 2,661 participations provided by the Micro-Mezzanine Fund from its inception in autumn 2013 to the end of 2018, amounted to approx. 107.8 million euros. Of this, 989 investments (959 at the end of 2017 and 917 at the end of 2016) for a value of approx. 39.8 million euros (38.4 million euros in 2017 and 37.7 million euros in 2016) went to the new federal states. This fund also disbursed 88 individual loans in 2018 to companies specializing in the ICT sectors operating in the new federal states for a total of approximately 264 million euros.

Smaller businesses, especially micro-businesses, were the preferred target of the new Microloan Fund, which disbursed 2,360 loans of approximately 15.04 million euros from 2010 to 2015 in the new federal states (excluding Berlin), and from May 2015 to February 2018, 811 loans of approximately € 7.3 million in East Germany (excluding

Berlin). This corresponded to 22% of the total funds for microloans. In 2018, 303 micro-enterprises (330 in 2017) in the new federal states (including Berlin) received loans for a total of over 2.8 million euros (3 million euros in 2017). This corresponded to 26% of all micro-entities receiving support.

Micro and small enterprises are also the subjects of another "SME-NetC" initiative, launched in August 2016 with a budget of approximately 18 million euros, particularly focusing on R&D in their innovation processes. Among the sectors most concerned are biotechnology, maritime technology, energy, environmental technology, and information and communication technology.

From 2001 to 2022, over 50 growth centers and 39 growth potential centers were supported with over 484 million euros thanks to the Innovative Regional Growth Cores or Growth Core Potential Program. A significant share of these funds (120 million euros) went to projects in Saxony. As part of this program in Lusatia, 15 partners set up a network to build the "house on the Bergheider See", a futuristic houseboat capable of satisfying its own needs for electricity, heating, and drinking water.

The budget for the "Centers for Innovation Competence" program up to 2021 amounted to at least 335 million euros. This budget continues to grow, and will reach 400 million euros by the end of 2022, with 14 Research Centers benefiting from these financial aids.

The "InnoProfile-Transfer" Program earmarked 123 million euros, with a deadline of 2019, to support 23 market-oriented collaborative projects, seven young research groups, and 21 research groups originating in university-business partnerships. In 2018, a total of around 300 million euros was approved. For the previous "InnoProfile" program, referring to the period 2006–2013, 157 million euros was allocated. Together with this previous project, 296 million euros would have been disbursed by 2019. One of these research groups was the FunGene ZIK of the University of Greifswald, which led to the foundation of an interdisciplinary center for genome research and the creation of the Northern Germany center for microbial genomics.

The "Priority for SMEs" Program, since it was launched in 2007, has supported over 1,500 individual and collaborative projects, granting a total of over € 1 billion and involving over 2,300 small and medium-sized enterprises across Germany. About a quarter of these funds have gone to research stakeholders in the eastern federal states.

The "Research Campus" initiative has allocated approximately 45 million euros in funding (from 2013 to 2020) for research and development projects in the new federal states and Berlin. Overall, the initiative is involved in 183 cooperation projects across nine research campuses, and 89 of these are participating in research campuses in eastern Germany. These partnerships can play a crucial role in revitalizing the East German regions, since more than half of the partners involved are SMEs. Among the most emblematic examples are the Berlin MODAL and Mobility2Grid campuses, researching new methods of mathematical optimization and coupling of mobility solutions with intelligent power grids, and the campuses in Magdeburg, focusing on medical technology (STIMULATE), as well as in Jena, with a focus on the diagnosis of infections and pathogens (InfectoGnostics).

The central innovation program for SMEs, "ZENTRALES INNOVATIONS PROGRAM MITTELSTAND-ZIM," launched in 2008, intends to promote the development of technologies (of any kind) and leaner bureaucratic processes. Loans of up to 350,000 euros can be granted to companies with 500 employees. To meet this aim, support for all forms of cooperation between research and businesses and the increase in technology transfer is essential. The companies' projects are mainly focused on the technologies of the future: digitalization, energy and resource efficiency, health research and medical technology, smart mobility, and renewable energy. This program has been providing support for ambitious research and technology development projects by SMEs since July 2008, resulting in new products, processes, or technical services. It is significant for the regions of East Germany to which it has earmarked about 40% of the funding.

The Federal Government has repeatedly increased its budget for the ZIM program in recent years, which rose to 543 million euros in 2016 and 548 million in 2018. The planned budget for 2019 was approximately 555 million euros. From 2008 to 2014, over 31,000 loan applications were approved for over 4.2 billion euros to stimulate investments of over 8.4 billion euros in research and development.

As of 2016, as part of the Industry 4.0 Program, ten PMI 4.0 centers of excellence were established throughout Germany within the PMI 4.0 - Digital Production and Work Processes initiative. These centers offer companies practice-oriented digitization know-how and specific demonstration and testing opportunities to meet their regional priorities. Two centers of excellence in Berlin and Chemnitz are already operational. A third center will start operations in Ilmenau in autumn. In 2017, additional centers of excellence opened their doors, with the aim of filling regional and thematic gaps and providing assistance for economically less developed and industrially weak regions in East Germany.

Another key tool to assist SMEs and businesses in digital transformation is the Federal Mittelstand-Digital Program (digital SMEs), which in mid-2019 established a network of 26 SME 4.0 competence centers. Each of the nine federal states has 18 regional competence centers, which provide digitalization knowledge at different sites with various practical, and accessible demonstrators that SMEs can test for themselves.

Thanks to the "Go Digital" Program at the end of 2018, 113 consulting companies on innovative technologies were certified and located in the new federal states. More than a third of all project funding (38.4%) was paid to SMEs and specialist operators in East Germany.

Technological innovation received extensive financial support from the Federal Government during these years: 450 million euros in 2018 to East Germany, of which about 350 million euros for assistance in implementing projects that used innovative technologies and about 100 million euros within the scope of institutional funding. Six university-research centers-business alliances were completed by 2018, involving over 60 partners from the business world and the scientific/academic community. The eastern federal states benefited most from funding for information and communication technology (290 million euros for East Germany, or 57% of the funds provided nationally for this area), for nanotechnologies and materials (almost 60 million euros, 45% of the national funding), as well as optical technologies (for a total of 46 million euros, 38% of the total funding).

Also, in support of the development of new technologies, approximately 400 million euros were disbursed by the Federal Government in 2017, and of these, 250 million euros in the form of research grants to finance research projects in Eastern Germany. The new federal states received 36% of federal government technology funding in 2017. Grants focused on information and communication technologies (44%), nanotechnology and materials technologies (35%), and optical technologies (38%).

In 2018, the Max Planck Schools program was launched, a joint initiative of the Max Planck Society, German universities, and non-university research organizations. Its aim is to concentrate scientific excellence in Germany and optimize doctoral programs internationally. Three pilot programs will initially be funded for five years, for a total of € 9 million per year. Primary responsibility for two of these networks, some of them at a European level, rests with institutes in the new federal states: the Max Planck School of Cognition is run by the Max Planck Institute for Human Cognitive and Brain Sciences, and the Max Planck School of Photonics is managed by the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) in Jena. In addition, three of the nine major project universities are located in East Germany: Friedrich-Schiller- Universität of Jena (MPS Photonics), University of Leipzig (MPS Cognition), and Humboldt- University of Berlin (MPS Cognition). The Otto-von-Guericke University of Magdeburg and the Dresden University of Technology also participate in MPS Cognition.

4 Conclusions

The description of Germany's instruments for financing innovation allows us to state that public spending on applied research and innovation by small and medium-sized enterprises has been marked by a certain balance between private and public contributions. Private spending has accounted for two-thirds of total expenditure on research and development. The federal government has managed to ensure a significant increase in public resources, and the supply of resources by the state has remained stably heterogeneous.

After this analysis of the main initiatives taken to accelerate the process of economic convergence between West Germany and East Germany, it must certainly be said that the objective of reducing the research and innovation gaps between these two areas has been achieved. In particular, from 2006 to date, spending on research and development has grown by over 3% of the GDP target set by the Euro-pa 2020 strategy. This objective has been raised to 3.5% of GDP by the strategy for technological innovation by 2025.

To accelerate the process of economic convergence, the major contribution that the Structural Funds (European Regional Development Fund-ERDF, European Social Fund-ESF, and European Agricultural Fund for Rural Development-EAFRD) are making should be highlighted. In particular, in 2005–2019, recalling the Solidarity Pact II, East Germany obtained various forms of significant financial aid (over 200 billion euros) divided among the infrastructure, transport, and urban development sector (156) and other sectors, primarily innovation, research and development, education, environmental protection, and sporting activities (51). For the following programming period (2021–2027), the European Commission has proposed for Germany a sum of 17.7 billion euros at current prices (15.7 billion euros at 2018 prices) from EU structural funds. In this way, an attempt is made not to extend funding to regions of Germany with a GDP between 75% and 100% compared to the EU average also to areas of East Germany (in transition).

In addition to the structural funds, the penultimate federal government, as part of the Solidarity Pact II, devised a new national financing system for structurally weaker regions through a series of financial projects active from 2020: the BMWi INNO-KOM, the Joint Task To improve the regional economic structure and the WIR! (Wandel durch Innovation in der Region) of the Federal Ministry of Education and Research (BMBF). WIR! is a financial project, which became operational in 2017 and which, in a pilot phase, allocated 150 million euros for 32 initiatives in East Germany.

The way of thinking about the financial system is changing, increasingly favoring an open and systemic approach to financing that considers both technological and social innovation. The main idea of the new funding system is to expand, through an additional 22 funding programs, the Joint Task Improving Regional Economic Structure, currently limited to East Germany. These new programs include funding for innovation provided by the Innovative Skills Funding Program (INNO-KOM), the Central Innovation Program for SMEs (ZIM), and Funding for Innovation and Structural Change, funding for broadband coverage and programs for rural development, urban development, and the provision of essential community services.

As part of the High Technology Strategy, Germany has succeeded in responding to the demand for incremental innovation and investment in research and development that is developing above all thanks to relations between the public sector, large companies and research centers. These relations have been facilitated by the stability of the political system.

In the governance systems of innovation strategies, a central role is played by public development banks (KfW), and evaluation bodies (EFI) have been introduced. The presence of these evaluation agencies, totally independent from the central government, has made the evaluation system of innovation policies in Europe more effective (Borras and Laatsit 2019).

Innovation in universities has been facilitated by multilevel coordination between the federal government and the Länder.

Supporting the demand for innovation requires a revision of legislation as a necessary condition to ensure the effectiveness of the tools to support innovation. Better regulation translates not only into simplifying the procedures for disbursing loans to businesses but also into strengthening consultation practices and evaluating the effects of the measures introduced. Germany appears to have made significant progress towards this goal by shifting the focus from incremental entrepreneurial innovation to radical innovation through the adoption of the "transformative change" paradigm.

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A Composite Indicator to Describe Digital Technology in Europe

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Abstract. The "Digital Europe" program is a central element of the Commission's comprehensive response to the challenge of digital transformation and is included in the proposal on the Multiannual Financial Framework (MFF) for the period 2021–2027. Its aim is to provide a spending instrument adapted to the operational requirements of capacity building in the areas identified by the European Council, as well as to exploit the synergies between them. The program aims, among other things, to develop and strengthen basic skills in artificial intelligence, such as data resources and archives of artificial intelligence algorithms and make them accessible to all enterprises and public administrations; ensure that the essential capabilities needed to secure the EU's digital economy, society and democracy are available and accessible to the EU public sector and businesses, as well as improve the competitiveness of the EU cybersecurity industry; expand the optimal use of digital capabilities, in particular high-performance computing, artificial intelligence and cyber-security, in all sectors of the economy, in sectors of public interest and in society, including the implementation of interoperable solutions in areas of public interest, as well as facilitating access to technology and know-how for all enterprises.

To better understand the phenomenon, this study aims to analyse the use of digital technology among European enterprises through a composite index of artificial intelligence (AI) and information technologies (ICT) (using the Wellness Methodology Fair and Sustainable) to measure the territorial gaps and to know the European countries more or less inclined to use it.

For this purpose, this contribution develops with the following structure:

- description of the theoretical reference framework and the indicators used to regard "artificial intelligence" and "information technologies";
- description of the methodology for the construction of the composite indicator;
- description of the results, also through a geo-referenced map of European countries willing to use digital technology;
- conclusions

Keywords: Digital · Index · Europe

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1 Introduction

The "Digital Europe" program is a central element of the Commission's comprehensive response to the challenge of digital transformation and is included in the proposal on the Multiannual Financial Framework (MFF) for the period 2021–2027. Its aim is to provide a spending instrument adapted to the operational requirements of capacity building in the areas identified by the European Council, as well as to exploit the synergies between them. The program aims, among other things, to develop and strengthen basic skills in artificial intelligence, such as data resources and archives of artificial intelligence algorithms and make them accessible to all enterprises and public administrations; ensure that the essential capabilities needed to secure the EU's digital economy, society and democracy are available and accessible to the EU public sector and businesses, as well as improve the competitiveness of the EU cybersecurity industry; expand the optimal use of digital capabilities, in particular high-performance computing, artificial intelligence and cyber-security, in all sectors of the economy, in sectors of public interest and in society, including the implementation of interoperable solutions in areas of public interest, as well as facilitating access to technology and know-how for all enterprises [1].

To better understand the phenomenon, this study aims to analyse the use of digital technology among European enterprises through a composite index of artificial intelligence (AI) and information technologies (ICT) (using the Wellness Methodology Fair and Sustainable) to measure the territorial gaps and to know the European countries more or less inclined to use it.

The choice of a composite index is dictated by the fact that it has the advantage of avoiding the presentation and interpretation of many elementary indicators to perform simpler and faster analyses, especially in comparative terms, obviously preserving coherence between the individual elements and their synthesis. On the other hand, in the last decades, to respond to the ever increasing needs to have systematic information on complex realities, attempts have increased to create synthetic and complex indicators, in many sectors and in many areas of knowledge and knowledge, to integrate a large amount of information in formats that can be easily understood by a large number of people.

For this purpose, this contribution develops with the following structure:

- description of the theoretical reference framework and the indicators used to regard "artificial intelligence" and "information technologies";
- description of the methodology for the construction of the composite indicator; in particular, the robustness of the method identified will be assessed through the "influence analysis", which makes it possible to verify if and with how much intensity the rankings of the composite indices change following the elimination of an elementary indicator from the starting set and therefore the indicators that "weigh" more (COMIC software - Composite Indices Creator);
- description of the results, also through a geo-referenced map of European countries willing to use digital technology;
- conclusions

2 Background

Digital transformation is verticalizing industrial processes and public administration. European systems, especially those of countries characterised by high public debt, have identified PNRR as a fundamental tool to change their models without affecting the sustainability of their finances. But innovation both in the economy and in the management of public administration and, more generally, structural reforms in Italy have always been a process characterised by strong slowdown factors that have adversely affected development.

It therefore appears necessary, after becoming aware and conscious of the failures of some reforms in recent years, to identify a pragmatic approach and governance models capable of basing innovations and reforms on reality and data, leaving aside ideological and dogmatic positions. There is therefore a need to redefine the set of innovative public policies and reformulate a digital decision-making process that obviously cannot simply follow and borrow from traditional processes. One of the main objectives of the PNRR must be to incentivise innovative sectors and to invest to stimulate the innovative potential of territories and put it at the service of the regional and national economy. To do this, we need to change our approach from what has been done so far and embrace the paradigm of harmonious innovation, which aims to accompany companies and territories in the challenges of digital and technological, green and circular, social and economic transitions, in a logic of convergence between tech and social innovation and in the perspective of Super Smart Society 5.0 and Industry 4.0.

However, the point we want to start from is to consider harmonic innovation, i.e. innovation that is born and develops if all the agents involved interact positively with each other and with the external environment. Businesses, territories and institutions, thus become pieces of a larger puzzle that can only grow if all the actors cooperate and contribute to collective growth. "Innovation, in the broadest sense, can be identified as the most powerful agent of change in the history of mankind, intimately linked to the concept of progress, which is oriented and shaped by innovation itself [...] It is not a question of reasoning about the many innovations, the many actions, the many possible interventions: it would risk being a weak exercise if it lacked solid foundations. Rather, it is a matter of stopping to reflect on the very concept of innovation, rethinking its foundations. This effort takes on a precise formula: the Harmonic Innovation paradigm, i.e. the circular innovation that pursues the 'right relationship' and knows how to combine contrasting elements and tones in a logic of consonance" [7, 8].

Innovation must be harmonious, i.e. it must be an innovation that is born and develops in such a way that all the agents involved interact positively with each other and with the external environment. Businesses, territories, institutions thus become pieces of a larger puzzle that can only grow if all actors cooperate and contribute to collective growth. It is not a question of reasoning about the many innovations, the many actions, the many possible interventions: this would risk being a weak exercise if lacking a solid foundation. Rather, it is a matter of pausing to reflect on the very concept of innovation, rethinking its foundations. Through harmonious innovation, we can foster the formation of new skills, the enhancement of young talents and the construction of new generational leadership, the birth and support of start-ups, spin-offs and innovative SMEs of value, the construction of qualified and stable networks and networks for innovation, actions that become drivers of development for the territories. Measuring the innovation and innovation capacity differentials between different European countries is therefore an essential starting point in this process of building a new set of policies.

3 Methodology

The measurement of a complex phenomenon such as the digitality of a company requires a preliminary conceptual definition, conducted through the decomposition of the general concept into its main components of meaning.

By digital enterprise, also known as Industry 4.0, we mean a permanently connected enterprise that works actively thanks to the integrated use of a set of technological resources that manage and solve most of the procedures, helping to build and enhance business relationships. Business.

The values of the index consequently measure different degrees of predisposition of the company to conditions of digitality and the main dimensions that have been taken into consideration, based on the factors that can most determine a computerization condition, are artificial intelligence (AI) and information technologies (ICT).

The approach used involves the construction of 2 macro areas, artificial intelligence (AI) and information technologies (ICT) that is two pillars by aggregating elementary indicators. Both pillars and elementary indicators have been considered non-replaceable. To construct synthetic index, we adopted the following indicators all with positive polarity [2] where the 'polarity' (or 'towards') of an elementary indicator is the sign of the relationship between the indicator and the phenomenon to be measured (for example, in the construction of a synthetic index of development, the "life expectancy" has polarity positive, while "infant mortality" has a negative polarity). Therefore, it was necessary to bring the indicators to the same standard, reversing the polarity, where necessary, and transforming them into pure, dimensionless numbers:

The matrix relating to data on European enterprises was divided into four progressive steps:

a) Selection of a set of basic indicators on the basis of an ad hoc evaluation model hinging upon the existence of quality requirements;
b) Further selection aimed at balancing the set of indicators within the theoretical framework of the structure. Outcome indicators are impact indicators as the ultimate result of an action as a result of a stakeholder activity or process;
c) Calculation of synthetic indices (pillars), by making use of the methodology proved more appropriate to obtain usable analytical information;
d) Processing of a final synthetic index as a rapid empirical reference concerning the degree of digital technology of European enterprises.

Missing values were attributed via the *hot-deck* imputation (missing data is provided by a "donor", that is a case with no missing data, chosen, usually within the same database, within a set of cases similar to the case with data missing) and, where not possible, with Europe's average value.

The choice of the synthesis method is based on the assumption of a formative measurement model, in which the indicators are seen as the 'cause' of the phenomenon to be measured, so a change in the latent variable does not necessarily imply a change in all the observed indicators (the indicators are not interchangeable and the correlations between them are not explained by the model).

The exploratory analysis of input data was performed by calculating the mean, average standard deviation and frequency, as well as correlation matrix and principal component analysis. Since this is a non-compensatory approach, the simple aggregation of elementary indicators was carried out using the correct arithmetic average with a penalty proportional to the "horizontal" variability.

Normalization of primary indicators took place by conversion into relative indexes compared to the variation range (*min-max*): the value assumed by each unit is re-proportioned so that it oscillates between the lowest assumed value by the indicator set equal to 0 and the highest set equal to 1.

Attribution of weights to each elementary indicator has followed a subjective approach, opting for the same weight for each of them. Since, in some cases, the elementary indicators showed different polarity, it was necessary to reverse the sign of negative polarities by linear transformation.

For the synthetic indicator calculation, we used the *Adjusted Mazziotta-Pareto Index* (AMPI), which is used for the min-max standardization of elementary indicators and aggregate with the mathematical average penalized by the "horizontal" variability of the indicators themselves. In practice, the compensatory effect of the arithmetic mean (average effect) is corrected by adding a factor to the average (penalty coefficient) which depends on the variability of the normalized values of each unit (called horizontal variability) or by the variability of the indicators compared to the values of reference used for the normalization.

The synthetic index of the i-th unit, which usually varies between 70 and 130, is obtained by applying, with negative penalty, the correct version of the penalty method for variation coefficient (AMPI $\pm$), where:

$$AMPIi- = Mri - Sricvi \tag{1}$$

where *Mri* e *Sri* are, respectively, the arithmetic mean and the standard deviation of the normalized values of the indicators of the i unit, and $cvi = Sri\,/\,Mri$ is the coefficient of variation of the normalized values of the indicators of the i unit [5].

The correction factor is a direct function of the variation coefficient of the normalized values of the indicators for each unit and, having the same arithmetic mean, it is possible to penalize units that have an increased imbalance between the indicators, pushing down the index value (the lower the index value, the lower the level of digital technology).

This method satisfies all requirements for the wellbeing synthesis and related phenomena [4]:

– Spatial and temporal comparison
– Irreplaceability of elementary indicators
– Simplicity and transparency of computation
– Immediate use and interpretation of the obtained results
– Strength of the obtained results

An influence analysis was also performed to assess the robustness of the method and to verify if and with which intensity the composite index rankings change following elimination from the starting set of a primary indicator. This process has also permitted us to analyse the most significant indicators.

The analysis was conducted using the *COMIC* (Composite Indices Creator) software, developed by ISTAT. The software allows calculating synthetic indices and building rankings, as well as easily comparing different synthesis methods to select the most suitable among them, and write an effective report based upon results [6].

4 Results

Tables 2, 3 and 4 reveal a good variability, in particularly we can see a greater variability of the ICT macro area compared to the AI macro area ($\sigma = 11.49$) and among the indicators of the ICT macro area VAR 8 (Percentage of enterprises with e-commerce sales of at least 1% turnover), VAR 9 (Percentage of enterprises' total turnover from e-commerce sales) and VAR 10 (Percentage of enterprises provided training to their personnel to develop their ICT skills) show a greater standard deviation (respectively 7.73, 8.43 and 7.80).

Tables 5, 6 and 7 show significant correlations between AI e ICT macro areas (r = 0.683) and, in particularly, there are significant direct correlations between percentage of enterprises analysing big data internally using machine learning (VAR1) and percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) (r = 0.907), between percentage of enterprises analysing big data internally using machine learning (VAR1) and Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6) (r = 0.708), between Percentage of enterprises with a chat service where a chatbot or a virtual agent replies to customers (VAR4) and Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) (r = 0.714) and Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) and Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6) (r = 0.779), between Percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8) and Percentage of enterprises' total turnover from e-commerce sales (VAR9) (r = 0.651), between Percentage of enterprises provided training to their personnel to develop their ICT skills (VAR10) and Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills (VAR11) (r = 0.616).

The influence analysis describes the indicators that most influence the composition of rosters of European countries. In analysing Tables 9 and 10, we can see that the most significant macro area is ICT (mean = 2.862, $\sigma = 3.280$) and the most important indicators concerns percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8) (mean = 1.793, $\sigma = 1.864$), percentage of enterprises with a chat service where a chat-bot or a virtual agent replies to customers (VAR4) (mean = 1.621, $\sigma = 1.622$) and percentage of enterprises that employ ICT specialists (VAR12) (mean = 1.517, $\sigma = 1.567$).

Table 1. Macro areas and Indicators

Macro areas	Indicators
Artificial Intelligence [3]	Percentage of enterprises analysing big data internally using machine learning (VAR1) Percentage of enterprises analysing big data internally using natural language processing, natural language generation or speech recognition (VAR2) Percentage of enterprises using service robots (VAR3) Percentage of enterprises with a chat service where a chatbot or a virtual agent replies to customers (VAR4) Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6) Percentage of enterprises that use three AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR7)
ICT [4]	Percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8) Percentage of enterprises' total turnover from e-commerce sales (VAR9) Percentage of enterprises provided training to their personnel to develop their ICT skills (VAR10) Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills (VAR11) Percentage of enterprises that employ ICT specialists (VAR12)

Table 2. Mean, σ and frequency macro areas

	AI	ICT
Mean	100.969	101.903
σ	9.172	**11.49**
Frequency	29	29

Table 3. Mean, σ and frequency AI macro area

	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7
Mean	3.31	1.207	2.034	2.207	5.931	0.897	0.103
σ	3.892	0.94	1.052	1.424	3.909	0.724	0.31
Frequency	29	29	29	29	29	29	29

Table 4. Mean, σ and frequency ICT macro area

	VAR8	VAR9	VAR10	VAR11	VAR12
Mean	20.103	17.966	21.31	8.966	20.897
σ	**7.734**	**8.437**	**7.802**	3.438	5.115
Frequency	29	29	29	29	29

Table 5. Correlation matrix of the macro areas

Macro areas	AI	ICT
AI	1.000	
ICT	**0.683**	1000

Table 6. Correlation matrix of the AI's indicators

Indicators	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7
VAR1	1.000						
VAR2	0.216	1.000					
VAR3	0.215	0.173	1.000				
VAR4	0.497	0.180	0.495	1.000			
VAR5	**0.907**	0.305	**0.504**	**0.714**	1.000		
VAR6	**0.708**	0.452	**0.614**	**0.610**	**0.779**	1.000	
VAR7	0.475	0.169	0.098	0.273	0.418	0.208	1.000

Table 7. Correlation matrix of the ICT's indicators

Indicators	VAR8	VAR9	VAR10	VAR11	VAR12
VAR8	1.000				
VAR9	**0.651**	1.000			
VAR10	**0.552**	**0.531**	1.000		
VAR11	0.415	0.353	**0.616**	1.000	
VAR12	0.313	**0.503**	**0.570**	**0.611**	1.000

Table 8. Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of macro areas

Macro areas	Mean	σ
IA	2.621	2.833
ICT	**2.862**	**3.280**
Mean	**2.741**	**3.057**
σ	**0.121**	**0.223**

Table 9. Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of AI's indicators

Indicators	Mean	σ
VAR1	0.621	0.762
VAR2	**1.276**	**1.236**
VAR3	**1.034**	**1.066**
VAR4	**1.621**	**1.622**
VAR5	0.414	0.683
VAR6	0.345	0.603
VAR7	0.690	1.289
Mean	**0.857**	**1.037**
σ	**0.436**	**0.346**

Table 10. Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of ICT's indicators

Indicators	Mean	σ
VAR8	**1.793**	**1.864**
VAR9	1.448	1.567
VAR10	1.379	1.518
VAR11	1.379	1.324
VAR12	**1.517**	**1.567**
Mean	**1.503**	**1.567**
σ	**0.154**	**0.173**

5 Discussion

The values of the composite index of Artificial Intelligence (AI), information technologies (ICT) and digital technology are described in Table 11, Table 12 and Fig. 1.

As regards digital technology, the "best" performances are grouped in north-eastern Europe, in particular in Denmark (total index 125.7, AI index 110.8, ICT index 125.5), Finland (total index 122,2, AI index 114.3, ICT index 115.7), Belgium (total index 121.8, AI index 106.1, ICT index 126.2), Sweden (total index 111,4, AI index 103.8, ICT index 112.3) and Lithuania (total index 106.8, AI index 113.5, ICT index 97.1), but the most

Table 11. Synthetic European Index ranking of AI

Nations	Value	Rank
Ireland	124,24	1
Malta	120,90	2
Finland	114,36	3
Lithuania	113,50	4
Denmark	110,86	5
Belgium	106,11	6
Portugal	104,24	7
Sweden	103,85	8
Slovakia	103,52	9
Italy	103,35	10
Spain	102,87	11
Germany	101,87	12
Czechia	101,55	13
Norway	100,00	14
Austria	99,78	15
Luxembourg	99,56	16
Croatia	99,50	17
France	99,50	18
Netherlands	98,04	19
Estonia	97,65	20
Romania	95,16	21
Bulgaria	93,51	22
Poland	93,09	23
Slovenia	93,09	24
Bosnia and Herzegovina	92,03	25
Cyprus	91,77	26
Latvia	89,69	27
Hungary	89,68	28
Greece	84,86	29
EUROPE	**100,00**	

digital European nation is Ireland (total index 135.6, AI index 124.2, ICT index 123.9) followed by Malta (index 126.0) and Denmark (index 125.7). Italy ranks 24th (out of 29) in the ranking of digital technology (index 111.18), in particular 10th in the ranking of artificial intelligence (index 103.3) and 26th (index 85.9) for the use of ICT, a clear sign that AI is widespread in the few companies that use ICT.

Table 12. Synthetic European Index ranking of ICT

Nations	**Value**	**Rank**
Belgium	126,28	1
Denmark	125,53	2
Ireland	123,96	3
Finland	115,77	4
Malta	114,45	5
Sweden	112,36	6
Czechia	108,05	7
Netherlands	107,08	8
Spain	104,10	9
Norway	103,62	10
Croatia	103,21	11
Hungary	102,44	12
Germany	102,31	13
Portugal	101,71	14
Austria	101,23	15
Cyprus	100,96	16
Luxembourg	99,65	17
Slovenia	99,04	18
France	97,17	19
Lithuania	97,16	20
Poland	96,19	21
Estonia	94,40	22
Slovakia	94,36	23
Bosnia and Herzegovina	91,44	24
Latvia	91,30	25
Italy	85,97	26
Greece	85,75	27
Romania	85,31	28
Bulgaria	84,38	29
EUROPE	**100,00**	

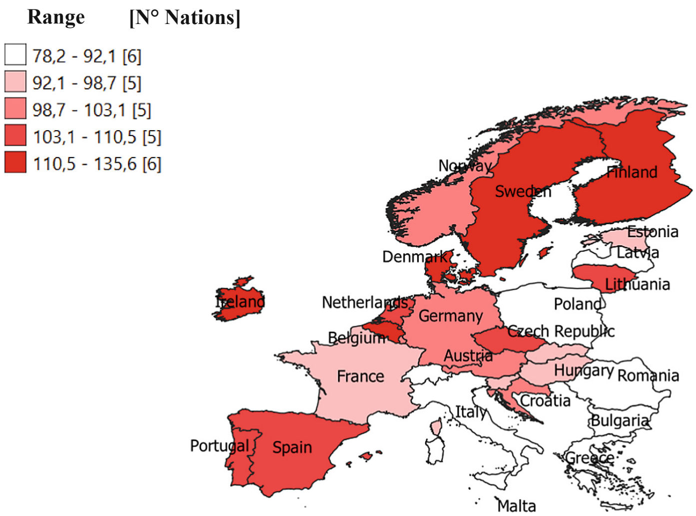

Fig. 1. Territorial distribution of the European synthetic index of digital technology

6 A Focus for Italy

According to the European Innovation Scoreboard 2019, Italy has a lower innovation rate than the EU average and is therefore considered a 'moderate innovator'. The regions as a whole have shown signs, albeit weak, of innovative capacity, but to date only Friuli Venezia Giulia is a 'strong innovator' in Europe. The 2021–2017 programming being implemented must therefore aim to incentivise innovative sectors and to invest to stimulate the territories' innovative potential and put it at the service of the regional and national economy.

European programming 2021–2027 must focus on research and development much more than 2014–2020. Italy currently spends 6.7 billion resources related to cohesion policies (4 billion from EU coffers, 2.7 from national ones) on research and innovation. The new programming will total EUR 272 billion. Of this, 226 billion for the ERDF and 46 billion for the Cohesion Fund. These investments are to be concentrated on five thematic objectives:

1) innovative, smart and inclusive development, connectivity, development of information and communication technologies, efficient public administration;
2) a greener, low-carbon and resilient Europe, energy transition, green and blue investments, the circular economy, climate change adaptation and risk prevention; and the circular economy;
3) a more interconnected Europe by improving mobility;
4) a more social and inclusive Europe implementing the European pillar of social rights;
5) a Europe closer to the citizens, promoting the sustainable and integrated development of cities and other non-urban areas through local initiatives.

The Regulation stipulates that region (according to their level of development) will have to concentrate a predefined percentage of resources on two of the five objectives: innovative development (OT1) and environment (OT2).

This means that the:

a) more developed regions will have to concentrate 50% in OT1 and 30% in OT2;
b) transition regions will have to concentrate 40% OT1 and 30% OT2;
c) less developed regions shall concentrate 30% OT1 and 30% OT2.

In the 2021–2027 programming, therefore, a fundamental principle is affirmed that investments in innovative, intelligent and inclusive development must constitute the prevailing part of the programmed investments, especially with reference to advanced regions, and in any case may not be less than 30% with reference to less developed regions. Translated into numbers, we are talking about EUR 100 billion.

To this must be added the PNRR resources. Next Generation EU has a budget of 208.6 billion euros, of which 191.4 billion for the Recovery and Resilience Facility. Regarding the Recovery and Resilience Facility (RRF), the resources available to Italy are estimated at 63.8 billion in grants and 127.6 billion in loans. Seventy per cent of the resources are to be committed in 2021–2022, the remainder in 2023. The Italian share of the grants is calculated for the entire period based on the data available to date. However, the actual amount of the remaining 30% of the programme will depend on the fall in GDP in 2020–2021 The amount of loans is calculated as the maximum that can be drawn given the expected level of Gross National Income (GNI) and the ceiling of 6.8% in relation to GNI.

There will be no shortage of resources, and the next five-year period could be an opportunity to increase research and development spending in Italy, which has always been the Cinderella of all investment spending. The fact that Italy is not a strong innovator denotes a fundamental failure of structural and regional development policies. Because a country that does not innovate or innovates little is a country that loses competitiveness, and loss of competitiveness is the antechamber to decline.

For Italy, therefore, spending the PNRR and Structural Funds resources well will be crucial. Today, the lack of innovation has caused us to lose our competitive capacity and pushed us into a situation of decline from which, if we do not take immediate action, it will be difficult to lift ourselves, also due to the government's ordinary policies that have privileged welfare spending over investment spending and the weight of public debt that constitutes a constraint on the very possibility of investing. It is necessary, then, to have the courage to invest in innovation through ambitious, coordinated and wide-ranging projects. It is necessary to think of major revolutionary projects to which sufficient resources can be allocated, avoiding the use of resources for patronage purposes by distributing them in a haphazard manner and scattering them in a thousand rivulets. The basic flaw of past Structural Fund programming has also been this, and the obvious result has been the poor quality and quantity of innovation produced by the Italian system.

Acknowledging past mistakes is certainly the first step to avoid making them again in the future, and it is therefore to be hoped that these analyses and programmes will be shrewder and more efficient.

Losing competitiveness and innovative capacity today is very dangerous. Thirty years ago, a loss of competitiveness produced delayed effects on GDP of up to decades. Today, the loss of competitiveness is reflected almost in real time on GDP. In fact, Italy is a country that grows little, one of the last in terms of speed of development in Europe and among advanced countries.

The 2021–2027 planning and the PNRR must be the opportunity to reverse the course and start a path of growth in innovation and growth in competitiveness. If this opportunity is not seized, Italy's future will be characterised by the word 'decline' [7, 8].

7 Conclusions

Composite indicators (CIs) which compare country performance are increasingly recognised as a useful tool in policy analysis and public communication. The number of CIs in existence around the world is growing year after year.

For a recent review see Bandura, 2006, which cites more than 160 composite indicators, even if the inventory presented in this paper is not exhaustive [10]. In fact, the research leading to the inventory was based on reports, websites, books, and academic papers. The inventory presents indices in alphabetical order, providing for each entry the author or organization responsible for it, a description of the index and its methodology together with the year of creation, frequency of issuance and the relevant sources, including websites. This information corresponds to indices found in publications or websites, which are either updated frequently or are "one-time events". Private firms offer online paid subscription services (for example, credit rating agencies or private consultancy firms) and sometimes do not disclose their methodologies to the public, thus only the limited information available in their websites is included in the inventory.

Such composite indicators provide simple comparisons of countries that can be used to illustrate complex and sometimes elusive issues in wide-ranging fields, e.g., environment, economy, society or technological development.

It often seems easier for the general public to interpret composite indicators than to identify common trends across many separate indicators, and they have also proven useful in benchmarking country performance (Saltelli, 2007). However, composite indicators can send misleading policy messages if they are poorly constructed or misinterpreted. Their "big picture" results may invite users (especially policy-makers) to draw simplistic analytical or policy conclusions. In fact, composite indicators must be seen as a means of initiating discussion and stimulating public interest. Their relevance should be gauged with respect to constituencies affected by the composite index [9].

The synthetic index which has been calculated in this paper can be useful to get an idea of the use of digital technologies at a territorial level, but above all it can constitute a support for the decisions of European policy makers who must encourage companies to develop them, as part of one of the 6 priorities of the European Commission 2019–2024, namely «A Europe ready for the digital age».

In this *scenario*, a type of "compensatory" or "add-on" regional development policy ends up accentuating the differences between regions, which are due to the different regional response to policies stimuli. Instead of fostering convergence, traditional policies create underdevelopment traps.

Peripheral regions are the ones most exposed to loss of competitiveness since the rules governing the economic system promote the aggregation of factors and "classic" regional policy is unable to counter this trend, despite generous financial compensation. An effective regional policy should work on two levels: modify the response function of regional economy and also provide an investment able to generate diffuse positive externalities [11, 12]. Moreover, interventions should be minimal and aimed at creating stronger connections between economic agents and, in particular, combining production activities with services, to foster the servitisation that probably influences "soft" factors inside the regional economy.

Appendix

Table 13. AI macro area indicators (percentage)

Nation	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7
Austria	3	2	2	1	4	1	0
Belgium	3	1	2	3	5	1	1
Bosnia and Herzegovina	1	0	1	3	3	0	0
Bulgaria	1	0	2	2	5	0	0
Croatia	2	1	3	1	5	1	0
Cyprus	1	1	1	1	3	0	0
Czechia	2	3	2	1	6	1	0
Denmark	5	1	5	3	9	2	0
Estonia	3	1	1	2	4	1	0
Finland	5	2	3	6	10	2	0
France	2	1	3	1	5	1	0
Germany	2	2	2	2	6	1	0
Greece	1	0	0	0	0	0	0
Hungary	1	0	1	1	3	0	0
Ireland	20	1	2	4	20	2	1
Italy	2	1	3	3	7	1	0
Latvia	1	1	1	0	2	0	0
Lithuania	3	3	3	3	7	1	1
Luxembourg	2	1	2	2	5	1	0
Malta	12	2	3	5	15	3	0
Netherlands	4	1	1	2	4	1	0
Norway	3	1	2	2	5	1	0
Poland	1	0	2	2	4	0	0
Portugal	3	1	3	3	8	1	0
Romania	1	1	1	3	5	0	0
Slovakia	1	1	3	4	6	1	0
Slovenia	2	1	1	0	2	1	0
Spain	4	1	3	2	7	1	0
Sweden	5	4	1	2	7	1	0

(*continued*)

Table 13. (*continued*)

Nation	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7
EUROPE	**2**	**1**	**2**	**2**	**6**	**1**	**0**

Legend:
VAR1: Percentage of enterprises analysing big data internally using machine learning
VAR2: Percentage of enterprises analysing big data internally using natural language processing, natural language generation or speech recognition
VAR3: Percentage of enterprises using service robots
VAR4: Percentage of enterprises with a chat service where a chat-bot or a virtual agent replies to customers
VAR5: Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)
VAR6: Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)
VAR7: Percentage of enterprises that use three AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)

Table 14. ICT macro area indicators (percentage)

Nation	VAR8	VAR9	VAR10	VAR11	VAR12
Austria	22	17	18	9	20
Belgium	26	31	33	18	30
Bosnia and Herzegovina	19	8	15	8	15
Bulgaria	8	6	7	9	16
Croatia	31	14	23	8	19
Cyprus	15	6	25	11	25
Czechia	30	30	25	8	18
Denmark	38	29	30	14	29
Estonia	17	14	17	7	17
Finland	19	20	38	13	28
France	14	23	15	9	18
Germany	18	18	24	10	19
Greece	8	4	12	6	19
Hungary	14	23	16	8	29
Ireland	33	44	27	10	30
Italy	12	13	15	4	13
Latvia	12	10	17	5	20
Lithuania	28	14	14	9	16
Luxembourg	10	15	21	12	22

(*continued*)

Table 14. (*continued*)

Nation	VAR8	VAR9	VAR10	VAR11	VAR12
Malta	25	15	28	14	29
Netherlands	19	17	24	12	24
Norway	22	19	33	8	17
Poland	14	17	18	4	25
Portugal	20	20	23	7	20
Romania	18	12	6	3	16
Slovakia	17	21	16	5	17
Slovenia	18	18	26	7	17
Spain	25	19	20	13	17
Sweden	31	24	32	9	21
EUROPE	**18**	**20**	**20**	**8**	**19**

Legend:
VAR8: Percentage of enterprises with e-commerce sales of at least 1% turnover
VAR9: Percentage of enterprises' total turnover from e-commerce sales
VAR10: Percentage of enterprises provided training to their personnel to develop their ICT skills
VAR11: Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills
VAR12: Percentage of enterprises that employ ICT specialists

Table 15. AI and ICT composite indices (range 70–130)

Nation	AI	ICT
Austria	99,8	101,2
Belgium	106,1	126,3
Bosnia and Herzegovina	92,0	91,4
Bulgaria	93,5	84,4
Croatia	99,5	103,2
Cyprus	91,8	101,0
Czechia	101,5	108,1
Denmark	110,9	125,5
Estonia	97,6	94,4
Finland	114,4	115,8
France	99,5	97,2
Germany	101,9	102,3
Greece	84,9	85,8

(*continued*)

Table 15. (*continued*)

Nation	AI	ICT
Hungary	89,7	102,4
Ireland	124,2	124,0
Italy	103,3	86,0
Latvia	89,7	91,3
Lithuania	113,5	97,2
Luxembourg	99,6	99,6
Malta	120,9	114,4
Netherlands	98,0	107,1
Norway	100,0	103,6
Poland	93,1	96,2
Portugal	104,2	101,7
Romania	95,2	85,3
Slovakia	103,5	94,4
Slovenia	93,1	99,0
Spain	102,9	104,1
Sweden	103,9	112,4
EUROPE	**100,0**	**100,0**

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Cities as Resilience Engines: Planning and Governance for Managing the Transition Towards Resilience and Sustainability

Planning for Sustainability: A New Unit of Spatial Planning for Driving Transition

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Abstract. The health and climate crisis are calling for an urgent re-evaluation of concepts such as resilience and sustainability and how we measure and implement them, sifting the debate towards the role urban design and planning play in driving urban transitions. Recent studies have been introduced to investigate the dynamics of the pandemic in urban areas and the ample literature on tools and methods for measuring vulnerabilities. The paper calls for a need to re-scale urban planning down to a human level by bridging space syntax attributes with measures of resilience. It introduces a data and evidence-based approach framework for driving urban transitions utilizing risk assessment (National Risk Index) and a vulnerability measuring index (City Resilience Index) to quantify spatial attributes which foster sustainable practices. A scenario testing method is proposed to make urban design more consistent with the strategic mission of urban planning driving resilience and transition.

Keywords: Resilience · District · Space Syntax

1 Introduction

The district is slowly establishing itself as the main unit in spatial planning due to the growing significance of community-based development strategies. The emphasis on the community in sustainable development practices is more than just a recognition that many low-income communities will bear the greatest cost of climate change due to vulnerabilities resulting from high levels of natural resource dependence [1, 2] or as a consequence of the inadequate provision of infrastructure in low-income urban areas [3]. It is also an acknowledgment of the frequent failure of economic growth policies based on western-style modernization and industrial growth [4, 5] in achieving sustainable community development [6]. Even during the recent COVID-19 pandemic the disproportionally greater impact on vulnerable parts of the society and the urban poor has only further exacerbated existing disparities [7, 8]. Calling into question how to objectively measure risk and vulnerabilities to have a policy commitment for a just allocation of resources to mitigate these negative impacts in the future. This prompted policy-makers

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to approach the discourse on "development" and consecutive policies tackling multi-dimensional inequalities, with greater caution. The shift towards place-based policies was a response to the limitations of previous policies promising to deliver "harmonious development" – such as the EU Cohesion policy – which instead fell prey to (i) space-ignorant one-size-fits-all approaches; (ii) passively accommodating agglomerations led by corporate decisions; and (iii) turning local elites into rentiers, rather than compensating lagging areas – only further strengthening existing inequalities [9]. The rejection of a top-down approach and working towards the utilization of indigenous strengths by harvesting the assets and capacities of the community has led to community-based and community-led development approaches becoming the fastest growing mechanism for driving development. As of June 2020, there were 327 active community-driven development projects in 90 countries promoted by the World Bank for total lending of $33 billion [10]. Neighbourhoods have thus become the centre topic of discussions on climate change and a target scale for driving urban transitions toward a sustainable and resilient future.

And while certain aspects of urban planning which have previously been suppressed by neoliberal practices, such as the quality of open public space, are now being brought back to the forefront of discussion [11]. Lockdowns and physical distancing mandates have underscored the significance of one's vicinity to essential resources as extremely valuable. On the other hand, urban density has come under fire as a potential weakness in a pandemic situation bearing the responsibility of increasing transition rates. The question of whether dense urban morphology contributes to the rapid spread of infectious diseases has been the subject of several studies [12–14]. At the same time studies have put forward social-distancing models [15] as an effective [16] spatially related non-pharmaceutical intervention for mitigating and controlling primary outbreaks. However, evidence of the toll social distancing has on mental health is rapidly growing [17–19]. And while social distancing can help in slowing down the spread of infections, the history of pandemic-influenced urban design can offer us insight into spatially based solutions for creating an urban space less susceptible to disease outbreaks. Thus, simultaneously lessening the necessity of social alienation and minimizing the negative mental health side-effects. Historically public health is intrinsically related to the quality and design of space [20] and is an important point in sustainable and resilient urban development. Hence the pandemic introduced an opportunity to constructively build upon lessons learned from this challenging situation and shift from a reactionary character of urban planning toward planning for transition. In other words, to reshape urban areas and cities to be transformed into regenerative and liveable places addressing the climate crisis while improving the quality of urban life for all residents equally [21, 22] scaled down to the human level. Research has shown an association between the physical configuration of the street network and the distribution of social activities. However, state of the art measures for resilience focus on a macro urban scale, failing to address the human scale of the urban fabric. In other words, they overlook the role urban configuration plays in fostering sustainable practices and boosting resilience. The paper introduces a framework for driving urban transitions and downscaling urban intervention to a neighbourhood level based on a process utilizing a policy commitment- (i) the National Risk Index; a robust assessment tool for mentoring the level of a city's vulnerability- (ii) City Resliced Index;

and a methodology for providing feedback by controlling for effects on a neighbourhood level through scenario testing - (iii) Space syntax approach.

The objective of this paper is to bridge this scale divide in measuring resilience and sustainability by introducing the Space Syntax approach which quantifies the performability of urban space by correlating spatial attributes, associated with the distribution of social activities, with indicators of resilience derived from the City resilience index. Utilizing different sets of data and evidence-based tools can help develop a pandemic and climate-resilient urban strategy through a progressive planning approach. The introduction of a scenario testing practice based on the space syntax methodology can promote sustainable urban planning by allowing adjustable district borders depending on different resilience goals and their diverse area size requirements (15-min city, positive energy districts, and circular urban economies).

2 Theoretical Background

2.1 Neighbourhood-A Unit of Urban Space

As cities work towards recovery from the COVID-19 pandemic, the '15-min' city concept is gaining momentum. With climate change still the focus of global concern, C40 Mayors' Agenda for a Green and Just Recovery encouraged a wider implementation of the 15-min concept [23] promoting the concept as a panacea. While this concept is not necessarily equally suitable for all cities the increasing digitalization of services followed by an accelerated systemic shift to remote working brought on by COVID serves as the impetus to apply the principle of neighbourhood unit regardless of the city size. The 15-min city was adopted by Carlos Moreno from the 'neighbourhood unit' concept, introduced by Clarence A. Perry. The urban model, a neighbourhood, was designed for a population of about 5,000–9,000 residents, with a school, place of worship, and recreational area at its centre. Commercial uses were shifted to the perimeter of the neighbourhood along arterial streets which defined the boundaries of the neighbourhood. The intention was to create a unit of urban morphology in which pedestrians were able to move freely along interior curvilinear streets without interference from high-speed vehicular traffic [24]. Similar to the neighbourhood unit, the 15-min concept offers a highly functional mixed-use, socially concentrated planning paradigm − an inclusive system promising higher resilience, particularly since lockdowns have forced people to re-think their lifestyles and opt for 'local'. The '15-min' city concept is a decentralised urban planning model, in which every neighbourhood contains all the essential amenities for living and working available within a 15-min walking or cycling distance. This basic notion of a walkable mix-use unit would reduce the need for frequent long-distance travel while strengthening a sense of community, and improving sustainability. The stimulated social interaction and cohesion among residents living in the same neighbourhood underpin the assumptions within urban planning that are associated with permeability, mixed uses, and high densities promoted by Jane Jacobs in 1961. Her concept 'eyes on the street' promotes not only vibrancy, via a diverse mix of land-uses, but more natural surveillance and the potential to reduce opportunities for crime [25]. In design terms, this means that residents potentially have increased opportunities to 'self-police' the streets in certain housing layouts, which are configured to face each other and the street. The underlying premise that spatial density and permeability facilitate social cohesion and cooperation will be further elaborated through case studies based on the space syntax approach.

2.2 Space Syntax Methodology and Space Sustainability

Space syntax method and theory enable us to describe the spatial properties of a sustainable city, and through an operational method analyse spatial relationships between built objects. It has introduced refined knowledge about the relationship between space and society [26]. The space syntax method analyses street networks and can shed light on the walkability qualities of a researched area or neighbourhood. Above walkability, space syntax can offer additional information on the spatial qualities relating to spatial resilience and sustainability.

Space syntax encompasses both a theory and a method constituted by a collection of analytical tools used to study urban morphology and uncover the logic of space that affects human behaviour [27]. Space syntax is based on a philosophy of design that puts forward architecture and urban design, in both spatial and plastic sense, as fundamentally configurational [28]. The theory argues that the universal statistical behaviour of space syntax measures uncovers the universality of the human-urban interaction mechanism and that the configuration of space itself is the main generator of movement [29] yielding attraction and privileging certain urban spaces over others regardless of land use.

The space syntax method quantifies the spatial network using axial maps presented by the least and longest set of axial lines (lines of sight) covering all open spaces in an urban environment [30]. These axial lines form a basis for network configuration analysis. Apart from axial maps, segment maps are used to perform segment-based analysis when small-scale research is needed. Segment maps are derived from axial maps in which axial lines are split at intersections to form segments [31]. Visibility graphs are derived from isovists-the area of space directly visible from a viewpoint located within the same space [32]. Visibility graphs are generated by superimposing a grid on a vector drawing of a space (e.g. a CAD drawing) using space syntax software. Syntactic measures can then be computed for each grid cell using space syntax measures for quantifying the proximity and inter-visibility of grid cells [33].

One of the basic ideas in measuring spatial relations is the concept of depth, meaning the distance between any pair of spatial elements. Three definitions of distance are used: (i) Topological distance-the number of turns from one space to another; (ii) angular distance-the angular change from one space to another; (iii) metric distance-the Euclidean distance in meters from one space to another. Different spatial patterns will be generated by utilizing the three types of distance. The axial representation is utilized to derive topological distance, whereas the segment map utilizes all three distance measures. However, all three concepts of distance can be applied to calculate different syntactic measures.

Integration (or Closeness). One of the basic syntactic measures is integration or mathematical closeness. Integration illustrates how close or how accessible each spatial element is to all others under each definition of distance, such as the least angular distance [28, 31].

Choice (or Betweenness). Another frequently used syntactic measure is choice or mathematical betweenness. Choice measures the degree to which each spatial element lies on the shortest paths, under each definition of distance, between any pair of spatial elements [31, 34, 35].

The difference between these two measures is that choice assesses the potential of the movements passing through each space (through-movement potential) whereas the to-movement potential is measured by integration. Therefore, through-movement patterns can be examined by producing a choice pattern.

Some of the other syntactic measures used are connectivity-number of spaces immediately connecting to a space of origin [28, 30]; total depth-the sum of the topological depth from any node to all the others [34]; centrality-a measure that quantifies the probability that a street segment will fall on a randomly selected shortest path linking any other pair of segments [31, 36]. The measures most commonly used in space syntax are angular choice and angular integration at various metric radii utilizing axial and segment visual maps, because these measures have been supported and verified by a large number of studies and practical applications [31]. Visibility integration is the most frequently used measure in visibility graph analysis [33].

To operationalize boundaries and gain understanding as to why the three different distance concepts yield different patterns the concept of Radius was introduced as a tool for selecting sub-systems. Topological radius is defined by a fixed topological depth from any given origin (e.g. 4 directional changes). On the other hand, the metric and angular radii refer to all aspects within a fixed metric distance from an origin (e.g. 5 m). In addition, angular distance can also be calculated by angular step. Generally, urban street networks that bring about movement and display higher visibility, encourage street-level use intensification over a period of time. A city's spatial form and configuration influence how people move – public transport, cars, bicycle, or on foot. An initial rapid scope literature review has uncovered various connections between syntactic measures and different social activities. Urban morphology has shown to correlate with the placement of (i) economic activities [37–40]; (ii) crime rates [30, 41–44], and (iii) research collaboration and exchange of ideas [45, 46]. This can be explained by the frequency of pedestrian movement – the more spatially integrated a street segment is, the higher the flow of pedestrians and the more the space along that street segment will attract economic and other activities [38], and the opposite the less an area is integrated the higher the segregation will be and therefore aggravate urban exclusion from essential services like education and health services [47]. Urban interventions, such as street links have been shown to influence this process [48]. This theory shows the authority a street network's spatial configuration has over movement, and subsequently social and economic activities [49].

2.3 Measuring Resilience

The question of how to measure vulnerabilities and resilience has resulted in several methodologies and indexes which aimed to assess the level and type of risk for governments to properly allocate resources where needed and help boost community resilience. Here two types of indexes will be discussed in detail: ARUP City Resilience Index which utilises both qualitative and quantitative data, and the FEMA National Risk Index which utilizes quantitative data.

The concept of resilience is not in conflict with sustainable urban policies [50] and therefore should be viewed as complementary approaches in urban planning – to design for true sustainability is to design for resilience. Resilience is the ability of a system to respond and recover from a shock quickly, while sustainability imposes the imperative of continuance. A sustainable model is usually defined as that which balances economic, environmental, and social issues equally well, but it may not by default accommodate change efficiently or recover quickly after a shock. Therefore, it is important to underline that while sustainability encompasses the three aforementioned categories, resilience is derived from the quality of their interlinkages and introduces new imperatives: (i) reflection-having monitoring mechanisms put in place in order to adequately adjust the system according to new altered conditions; (ii) robustness-implement physical assets which are in terms of construction and management conceived in a way to withstand impacts of hazards without a great loss of function; (iii) redundancy-the spare capacity porously created with an aim to accommodate disruption by mitigating surges in demand; (iv) flexibility-the capacity of a system to change, evolve and adapt in response to changing circumstances; (v) resourcefulness-the the ability of people and institutions to anticipate future conditions, set priorities and secure a system of coordinated response by mobilising wider human, financial, and physical resources; (vi) inclusivity-need for broad engagement and participation among communities, including the most vulnerable groups; (vii) integration-alignment and integration among city systems to promote consistency in decision making to ensure all investments are in synergy and supportive of common goals [51]. However, the efforts to develop more resilient and sustainable systems revealed the need for a methodology that would be able to develop a baseline relative risk measurement by leveraging available source data and community vulnerability factors. A comprehensive index that could measure the relative vulnerability of a community, or a city, could help inform planners, emergency managers, and the general public, but most importantly-policymakers and support their decisions regarding priority and allocation of resources, updating emergency operation plans, enhancing hazard mitigation plans, identify a need for a more detailed and refined risk assessment for specific areas, inform and educate residents and homeowners, encourage community-level cooperation and engagement, enhance and update codes and standards, and set up long-term community recovery. There is a plethora of literature dedicated to framing and understanding vulnerability [52–57]. Still, definitional discrepancies persist due to a myriad of climate change research and the diverse scientific communities involved [58]. Though the broad framework considers vulnerability as a function of sensitivity, exposure, and adaptability [59] it is also seen as a synthetizing concept that links the biophysical and social dimensions of climate change [60, 61].

National Risk Index (NRI). Before the National Risk Index, a plethora of tools and methods to assess risk have already been developed and utilized by a variety of different agencies across the US. The 2012 Disaster Resilience report by the Nation Research Council USA outlined 17 assessment tools and systems, and since the report was released there has been an explosion in the number of additional resilience measuring tools developed by government agencies, academia, NGOs, communities, and the private sector. These tools vary in range and purpose—quantitative to qualitative, bottom-up to top-down, hazard-specific to hazard-neutral, local to global, and pre- to post-event [62–64]. Beginning in 2016, FEMA's NHRAP (Natural Hazards Risk Assessment Program) started work on the National Risk Index by adopting an informed vision for a multi-hazard view of risk that combines the consequence and likelihood of natural hazards with resilience capabilities and social factors. The goal was to form a holistic, comprehensive view and create a nationwide baseline of natural hazard risk.

The NRI's purpose is to decrease human and infrastructure costs through smart pre-disaster investments. Studies have consistently shown FEMA hazard mitigation investments are cost-effective and result in communities that are safer and more resilient to natural hazards, including impacts from climate change. An analysis of the "American Recovery and Reinvestment Act showed that investments in community resilience generated 15 to 33 jobs per million dollars spent and an economic return of $2.40 for every $1 invested" [65]. Therefore, the National Risk Index promotes a systematic risk evaluation which can inform policy-makers of the most rational investments and resource allocation strategies [66]. In 2021 FEMA released a National Risk Index (NRI) as a baseline risk assessment application resulting from a collaboration with a variety of federal, state, and local governments, academic institutions, non-profit groups, and private industries. All data supporting NRI components were required to be nationwide in scope and able to be measured at the Census tract level. Hazard type data sources were also required to have location and time information. However, some data that met these requirements were simply not available for the Census tract level, unlike the County level-which is complete. For Example, Social Vulnerability scores are available for all counties but are absent for 292 Census tracts. Calculations are performed separately at two levels—County and Census tract—so scores are relative only within their level. The committee for NRI reviewed the strengths and weaknesses of different frameworks for measuring resilience, and identified four critical dimensions of a consistent system of resilience measures or indicators [64]:

1. Vulnerable Populations—factors that capture the needs of individuals and groups in relation to indicators such as minority status, health issues, mobility, and socioeconomic status
2. Environmental Infrastructure—the ability of infrastructure to recover from critical events—these include water and sewage, power, transportation, communications, and natural infrastructure
3. Social Factors—factors that enhance or limit a community's ability to recover, including elements such as social capital, language, education, financial structures, culture, and the quality of the workforce

4. Built Infrastructure—the ability of built infrastructure to withstand impacts of disasters, including elements such as public services, homes and businesses, bridges, and roads

The general National Index Risk Eq. (1) is as follows:

$$\text{Risk} = (\text{Expected Annual Loss} \times \text{Social Vulnerability})/(\text{Community Resilience}) \tag{1}$$

Social Vulnerability. The social vulnerability source data is provided by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) Social Vulnerability Index (SoVI). SoVI is a location-specific assessment of social vulnerability that utilizes 29 socioeconomic variables, which the literature research suggests contribute to a community's reduced ability to prepare for, respond to, and recover from hazards [67].

Community Resilience. Community Resilience is defined by the National Institute of Standards and Technology (NIST) as a community's ability to prepare for anticipated natural hazards, adapt to altering conditions, and recover rapidly from disruptions [68].

The community resilience index was provided by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) and is adapted from their Baseline Resilience Indicators for Communities (BRIC) index [69]. The community resilience score is a consequence reduction risk factor and represents the relative level of the community's resilience relative to all other communities at the same level. Consequently, a higher Community Resilience score results in a lower Risk Index score. Because Community Resilience is unique to a geographic location (county) it is a geographic risk factor. Since there are multiple ways to define resilience at the local level but no nationally available, bottom-up community resilience indices are available, and the key drivers of resilience vary between locations, the Social Vulnerability and Community Resilience chose to utilize a top-down approach. The source data is provided by the University of South Carolina's Hazards and Vulnerability Research Institute HVRI) and is only available at the county level. Therefore, Community Resilience scores were inferred from counties to Census tracts by assigning each Census tract the score of its parent county.

Expected Annual Loss (EAL). The EAL for each county or Census tract is the average economic loss in dollars resulting from natural hazards per year. EAL is computed for each hazard type and only quantifies loss for specific consequence types (i.e. buildings, population, or agriculture). The historic losses source data are provided by the Spatial Hazard Events and Losses Database of the United States (SHELDUS) Arizona State University's (ASU) Spatial Hazard Events and Losses Database. EAL is estimated for 18 hazard types: avalanche, coastal flooding, cold wave, drought, earthquake, hail, heat wave, hurricane, ice storm, landslide, lightning, riverine flooding, strong wind, tornado, tsunami, volcanic activity, wildfire, and winter weather.

The equation for Expected Annual Loss (2) is as follows:

$$\text{Expected Annual Loss} = \text{Exposure} \times \text{Annualized Frequency} \times \text{Historic Loss Ratio} \tag{2}$$

City Resilience Index (CRI). The City Resilience Index developed by Arup [51] is perhaps the most comprehensive holistic framework taking into account the economic, physical, and social disruption; and that is applicable at the city scale rather than to any individual system within a city. The index has been designed to enable cities to assess and monitor the multiple factors which contribute to their resilience. The Index provides a means to assess and measure the extent to which the city is achieving the 12 goals, based on 52 indicators according to the 4 dimensions (see Table 1). The aim of the City Resilience index is also to focus on assessing the performance of a system before a hazardous event, rather than to mitigate or prevent the loss of assets due to a specific event. It utilizes both a quantitative (when data is available) and a qualitative approach.

The CRI and NRI both reveal vulnerabilities and show the extent of an urban system's ability to respond to a disaster. They are confined within available data and promote analysis on a macro urban scale. The greatest difference is that NRI is US specific, in that it is calibrated according to data sets available for the US. The CRI is formed as a comprehensive basis of measurement based on research that revealed universal factors deemed to contribute to city resilience – although their relative importance varies according to contextual specificities. CRI was developed with the intent to be both relevant and accessible to cities globally regardless of their size, capacity, location, or availability of data-which is why its value lies in the addition of qualitative methods for data acquirement. However, both indexes overlook the role urban space plays in boosting resilience by way of spatial configuration. To scale down and facilitate effective implementation of the 15-min the proposed framework is enforced by the addition of a qualitative method that can examine the built environment and locate vulnerabilities on an urban fabric level – Space Syntax.

3 Research Design and Methods

This proposed framework (see Fig. 1) for driving urban transitions towards a sustainable and resilient future puts forward a multiscale framework based on an assessment of vulnerabilities through the quantitative tool (i) the National Risk Index-which dictates policy commitments; monitored through a holistic, more comprehensive, qualitative and quantitative (ii) City Resilience Index; while controlling for effects on a district scale through a set of analytical techniques for evaluating the syntactic properties of urban models with (iii) the space syntax method. The paper employs a structured literature review of space syntax publications in order to (i) detect; (ii) summarise; and (iii) reveal those studies that statistically correlate at least one syntactic measure with indicators based on the twelve goals from the City Resilience Index. The utilization of CRI is justified by its universality of indicators applicable to a global context. The hypothesis is that space syntax measures can serve as indicators for the aforementioned goals and enable or restrict the policy and subsequent investment from producing the desired outcome. To do so the paper sets out eligibility criteria to assess the eligibility of reported studies (referred to as primary studies). The included primary studies: (i) applied at least one of the two representations to conduct space syntax analysis: axial or segment; (ii) reported a quantitative association between any space syntax measure of spatial attribute and topics deducted from the twelve goals of the City Resilience Index; and (iii) presented valid regression model or correlation analysis; (iv) included primary data (not based on

Table 1. City Resilience Index, ARUP [51]

4 dimensions	12 goals	52 indicators
Health & Wellbeing	1. Minimal human vulnerability	1.1 Safe and affordable housing
		1.2 Adequate affordable energy supply
		1.3 Inclusive access to safe drinking water
		1.4 Effective sanitation
		1.5 Sufficient affordable food supply
	2. Diverse livelihood & employment	2.1 Inclusive labour policies
		2.2 Relevant skills & training
		2.3 Local business development and innovation
		2.4 Supportive financing mechanisms
		2.5 Diverse protection of livelihoods following a shock
	3. Effective safeguards to human health & life	3.1 Robust public health systems
		3.2 Adequate access to quality healthcare
		3.3 Emergency medical care
		3.4 Effective emergency response services
Economy & Society	4. Collective identity & community support	4.1 Local community support
		4.2 Cohesive communities
		4.3 Strong city-wide identity & culture
		4.4 Actively engaged citizens
	5. Comprehensive security & rule of law	5.1 Effective systems to deter crime
		5.2 Proactive corruption prevention
		5.3 Competent policing
		5.4 Accessible criminal and civil justice
	6. Sustainable economy	6.1 Well-managed public finances
		6.2 Comprehensive business continuity planning
		6.3 Diverse economic base
		6.4 Attractive business environment
		6.5 Strong integration with regional & global economies

(*continued*)

Table 1. (*continued*)

4 dimensions	12 goals	52 indicators
Infrastructure & ecosystems	7. Reduced exposure and fragility	7.1 Comprehensive hazard and exposure mapping
		7.2 Appropriate codes, standards & enforcement
		7.3 Effectively managed protective ecosystems
		7.4 Robust protective infrastructure
	8. Effective provision of critical services	8.1 Effective stewardship of ecosystems
		8.2 Flexible infrastructure services
		8.3 Retained spare capacity
		8.4 Diligent maintenance & continuity
		8.5 Adequate continuity for critical assets & services
	9. Reliable mobility and communications	9.1 Diverse and affordable transport networks
		9.2 Effective transport operation & maintenance
		9.3 Reliable communications technology
		9.4 Secure technology networks
Leadership & strategy	10. Effective leadership and management	10.1 Appropriate government decision-making
		10.2 Effective co-ordination with other government bodies
		10.3 Proactive multi-stakeholder collaboration
		10.4 Comprehensive hazard monitoring and risk assessment
		10.5 Comprehensive government emergency management
	11. Empowered stakeholders	11.1 Adequate education for all
		11.2 Widespread community awareness & preparedness
		11.3 Effective mechanisms for communities to engage with government
	12. Integrated development planning	12.1 Comprehensive city monitoring data management

(*continued*)

Table 1. (*continued*)

4 dimensions	12 goals	52 indicators
		12.2 Consultative planning process
		12.3 Appropriate land use and zoning
		12.4 Robust planning approval process

simulation); (v) reported findings in English; and (vi) have a study area at the level neighbourhood or district.

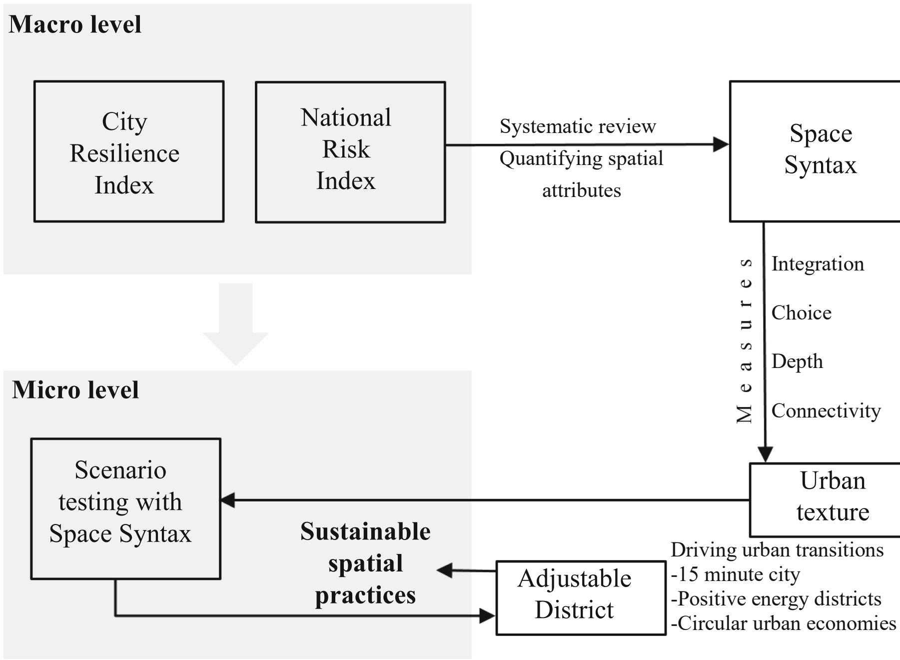

Fig. 1. Conceptual map of research methodology

3.1 Search Method for Deducting Relevant Studies

The systematic analysis was conducted according to a four-step process outlined below: First, comprehensive database searches were conducted within all major electronic publishing databases including SAGE (n = 686), Science Direct (n = 895), Tailor & Francis (n = 601), MDPI (n = 2), JSTOR (n = 108), Space Syntax Network (n = 7), SPRINGER Link (n = 11,437), and Wiley online library (n = 163). The following research strings were modelled according to the formula: “methodology” AND (objective) AND (indicator variable) AND (syntactic representation) AND (relevant connection). Because certain search engines do not support wildcards they were excluded from search strings.

Appropriate indicator variables for target objectives were derived from the first phase of the space syntax literature review. Only those found to be correlated with indicators listed in the City Resilience Index were chosen. For example, for the goal "minimal human vulnerability" the indicator "1.1 Safe and affordable housing": for safe residential areas, the indicator for safety is "burglary incidences" which are correlated with specific spatial layouts, and is, therefore, a syntactically measurable effect. The following research strings were used: "space syntax" AND (house OR residential) AND (crime OR burglary) AND (axial OR segment OR visibility) AND (correlation OR regression); "space syntax" AND (economy OR retail) AND (pedestrian OR mobility) AND (axial OR segment OR visibility) AND (correlation OR regression); "space syntax" AND (health OR well-being) AND (medical OR services) AND (axial OR segment OR visibility) AND (correlation OR regression); "space syntax" AND (community OR vitality) AND (pedestrian OR walkability) AND (axial OR segment OR visibility) AND (correlation OR regression); "space syntax" AND (policing OR crime) AND (sex OR drug) AND (axial OR segment OR visibility) AND (correlation OR regression); "space syntax" AND (infrastructure OR "land use") AND (segregation OR consolidation) AND (axial OR segment OR visibility) AND (correlation OR regression). Because Science Directs limits the number of Boolean operators to eight the search strings were repeated separately with 'axial' and 'segment' graph, and later with 'visibility' graph.

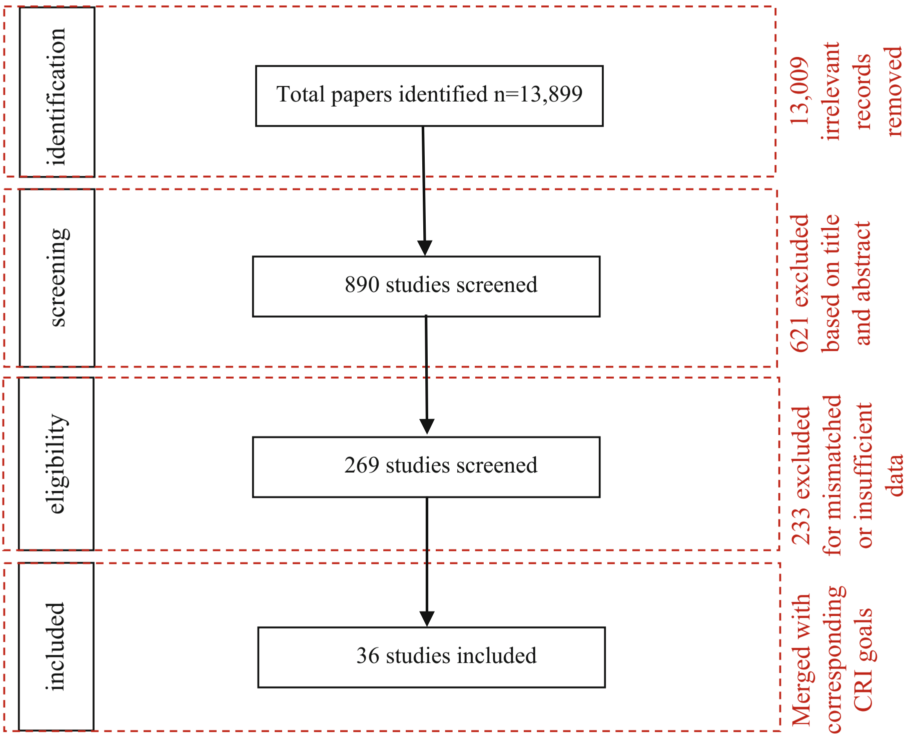

Fig. 2. Methodology for selection of primary studies

The above search process yielded 13,899 documents which were examined systematically as depicted in Fig. 2. The titles were initially checked for relevance and duplication which screened out 13,009 documents. The remaining studies were further screened based on title and abstract to further exclude those which failed to provide information that would render them relevant for this study. Based on this 621 additional document was excluded. The full text of the remaining 269 studies was examined for data, and 233 were eliminated based on insufficient data or mismatched data. Leaving 36 studies to be included and cross-referenced with indicators from the CRI and divided according to the goals (see Table 2).

3.2 Scenario Planning

Space syntax method and theory enable us to describe and evaluate the spatial properties of a sustainable city. *A posteriori* reveals the relationships between a built environment's spatial attributes and socio-economic patterns occurring within it. However, in line with the new tendency of pro-active urban planning Space syntax reveals itself as a valuable tool in that sense as well. In the *a priori* case, it can be applied as a tool in urban analytical design for scenario development and option testing in all phases of urban intervention to evaluate the spatial effects of various urban design proposals and how they can intensify human activities and movement. Thus space syntax can support a decision-making process for a well-functioning urban design, allowing the development of sustainable cities and communities.

Space syntax can offer an answer to the 'what if' question. A case study examining the likely effects of two different locations for a new bridge across the Nieuwe Maas River in Rotterdam illustrates the scenario testing capability of the space syntax approach. This scenario testing was originally conducted in 2012 for the municipality of Rotterdam [97] to improve the spatial integration of the southern part of Rotterdam. One bridge placement option indicated an increase in the spatial integration of the southern centre of Rotterdam. In doing so, the centre has the spatial potential to become the main centre of Rotterdam. The other indicates a shift of the main centre of Rotterdam towards the western part of Rotterdam south. The conclusions from this case study are rooted in the theory of the natural movement of economic process [49], however, it does not attempt to test and evaluate results according to spatial attributes found to be correlated with indicators for resilience.

For this reason, the methodology design is based on systematic analysis. The reproducibility stemming from the method design allows for further testing and additional case studies, and subsequently, an opportunity to refine the application.

4 Discussions and Conclusion

The notion of urban transition towards sustainability and resilience supported by various world organisations [23, 98, 99] promotes a holistic, comprehensive approach, one which encompasses land-use planning and spatial organisation at various scales per the current needs of societies and includes actions aimed at improving living conditions, stressing mobility, accessibility, and greening [21]. The overwhelming effect of COVID-19 has

Table 2. Space syntax case studies utilizing syntactic measures found to be correlated to the 12 goals of CRI

4 dimensions	12 goals	Attribute associated Space syntax case study	Space syntax measures
Health & Wellbeing	1. Minimal human vulnerability	Chang,2009 [43]; Knöll et al., 2017 [70]; Shu and Huang, 2003 [44]; Sohn et al., 2018 [71]; Wang et al., 2021 [72]; Ward et al., 2010 [73]; Wu, 2015 [74]	Choice, Depth, Integration, Connectivity
	2. Diverse livelihood & employment	De Filippi et al., 2020 [75]; Froy, 2016 [37]; Hillier and Sahbaz, 2005 [41]; Kawada et al., 2014 [76]; Matthews and Turnbull, 2007 [77]; van Nes, 2001 [40]	Integration, Angular choice, Connectivity
	3. Effective safeguards to human health & life	Garnica-Monroy and Alvanides, 2019 [47]	Integration
Economy & Society	4. Collective identity & community support	Hillier et al.,2000 [78]; Soares et al.,2021 [46]; Zaleckis et al.,2019 [79]	Centrality, Choice
	5. Comprehensive security & rule of law	di Bella et al., 2015 [80]; Hidayati, 2020 [81]; Jones and Fanek, 1997 [82]; Miranda and van Nes, 2020 [83]; Summers and Johnson, 2016 [84]	Depth, Integration, Connectivity
	6. Sustainable economy	Mohamed and van Ham, 2022 [85]; Salazar Miranda and Claudel, 2021 [45]; Sun et al., 2022 [86]	Centrality, Normalised choice
Infrastructure & ecosystems	7.Reduced exposure and fragility	Mouratidis and Yiannakou,2022 [11]; Watts et al., 2015 [87]	Integration, Intelligibility
	8.Effective provision of critical services	Santilli et al., 2021 [88]	Integration
	9.Reliable mobility and communications	Orellana and Guerrero, 2019 [89]; Sharmin et al., 2020 [90]; van Nes, 2021 [91]	Integration, Connectivity, Choice
Leadership & strategy	10. Effective leadership and management	Hidayati et al., 2019 [92]; McCormack et al., 2021 [93]	Angular integration, Normalised choice
	11. Empowered stakeholders	Greene and Greene, 2003 [94]; Scorza et al., 2021 [95]	Angular integration, Intelligibility

(*continued*)

Table 2. (*continued*)

4 dimensions	12 goals	Attribute associated Space syntax case study	Space syntax measures
	12. Integrated development planning	Ozbil et al., 2019 [96]	Integration

recently steered the discourse towards a human scale and a people-centred approach. Promoting the importance of the hyper-local environment [23] to support quality of life by adopting a 15-min city strategy means introducing an urban model that allows everyone, in every neighbourhood, to meet most of their daily needs within a short walk or bike ride from their home. However, the materialisation of policies and learned behaviour of people can be a make-or-break point in delivering desirable results. Therefore, the identification and analysis of factors that encourage specific patterns of behaviour concerning space as well as the resulting economic and social consequences: in other words, that which emerges from the interrelation between the built environment and its users; can be crucial in achieving urban transitions. The 'spatial turn', conceived by Lefebvre [100], wherein space is not the 'container' of events generated by people but a fully-fledged actor, actively influencing the societies functioning opened the door for socio-spatial dialectics, wherein the 'spatial' shapes the 'social' as much as the 'social' shapes the 'spatial' [101]. Spatial logic would seem to hold insight into why policy outcomes are enabled or restricted to perform efficiently and concerning conflicting groups of actors. In other words, space shifts the emphasis in favour of certain policy perspectives and thus reveals the bias of the public agency. Thereby stressing the need for a spatially analytical method that can quantify spatial attributes in correlation to social activity patterns and render adequate urban design solutions aligned with spatial planning strategies and subsequent urban policies.

The literature review has demonstrated that various spatial patterns can generate different outcomes in terms of economic and social activities, affecting residents' well-being, cooperation, sense of belonging to a community and perceived urban safety. The introduced cased studies based on the space syntax methodology may support this notion by establishing significant correlations between spatial attributes and real-world and historical data.

Therefore, this space syntax methodology can be an effective tool in helping policymakers and researchers evaluate favourable urban policies, strategies, and control for effects during the designing process of future developments and urban interventions with scenario testing. A top-down framework consisted of (i) the National Risk Index to locate vulnerabilities and assess the appropriate resource allocation and investment commitments; a broad comprehensive and robust (ii) City Resilience Index to diagnose the strengths and weaknesses of a community and monitor relative performance over time; and (iii) space syntax method as a scenario testing tool as a control-method used to render the most appropriate design solution in line with policy aims can help drive urban transitions.

A conceptual framework based on a top-down approach focused on the human scale would provide additional support to governmental policies in not only disease prevention and control, but promote sustainability practices complementary to resilience capacity building. Analysing and detecting vulnerabilities as the first step would provide an aim and targeted area for resource allocation. The next step of scaling down to a human scale would help resolve detected vulnerabilities on an urban texture level, and thereafter introduce a plan which will provide residents with all essential needs in a 15-min radius. Tailored strategies and urban design solutions are needed to provide an upgraded urban space and green infrastructure. Since not all solutions will provide the desired result, scenario testing of proposals should be conducted to render the most spatially sustainable and effective solution.

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Resilient and Transition Strategies for the Post-pandemic City: A Multi-criteria Analytical Approach for the Case of the Metropolitan City of Reggio Calabria

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Abstract. European cities face the challenges of planning their transition to achieve sustainable and resilient urbanization. However, operationalizing suitable urban strategies toward sustainability appears difficult, especially in the light of rising inequalities and disparities within and among EU cities and regions. Urban regeneration strategies appear to be a possible leveraging mechanism for cities' green and digital transition in the mutated policy context for recovery after the pandemic. In this context, the paper explores how intermediate cities effectively design and implement urban development strategies toward resilience and sustainability in response to the current pressing challenges. The Metropolitan City of Reggio is examined by assessing the city's ability to address context vulnerabilities in current urban development strategies through a multi-criteria analytical approach. Results point out priority factors that affect the case under investigation and should be prioritized in de-fining future development strategies and the potential role of urban regeneration in the city's future development strategies towards resilience sustainability.

Keywords: urban resilience · urban sustainability · urban transition · urban regeneration

1 Introduction

In the 21st century, climate changes, pandemics, and economic fluctuations are just a few of the challenges affecting cities and exposing populations to unpredictable and unforeseen risks [1]. Given the pace of urbanization processes, such challenges became remarkable for cities in scale, scope, and complexity [2, 3]. Cities are then called to deploy policy responses linked to local conditions and provide tools and instruments to achieve sustainable and resilient urbanization [4]. In this direction, the rising uncertainty and complexity, reflected from the global to the urban scale, are demanding new and radical approaches to achieve a transformation to sustainability [5] emphasizing the relevance of the urban dimension [6]. However, despite the efforts towards sustainable urban development in the last decades, socio-economic inequalities and environmental

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degradation issues in cities persist [7]. The increase in social, economic, and environmental vulnerabilities pushes adopting resilience thinking in planning [8]. As a result, cities are designing "workable governance instruments to support low carbon energy transition and stimulate urban transition and transformation to achieve sustainable and resilient cities" [9: 410].

In response to the pressing and severe challenges mentioned above, the European Union (EU) has deployed policy and financial efforts to develop transition strategies toward resilience and sustainability for the future of the Union. The Next Generation EU instrument, which makes available unprecedented financial resources for future resilient Europe, has been designed and implemented to foster the recovery phase of the EU [10]. Accordingly, each Member State has shaped a National Plan for Recovery and Resilience to access these resources and facilitate such transition.

Although the policy efforts, global dynamics and natural risks affect cities' ability to withstand shocks and stress [8]. In a recent contribution, Florida et al. [11] pointed out how, in macro-geographic terms, it is likely difficult that winner-take-all economic geography will be affected by extreme shocks. Hence, the attention should focus on intermediate cities with considerable and untapped economic potential, requiring a more territorially balanced, place-sensitive approach [12]. However, there is a difficulty in planning in response to the increase in urban systems vulnerabilities [8]. One of the worldwide socio-economic development strategies to address this gap is urban regeneration, which is gradually shifting from large-scale urban transformation projects "to address diversity, sustainability, equality and livability in the city" [13: 101].

In this context, the paper explores how intermediate cities address their vulnerabilities in the light of resilience and sustainability goals through their urban development strategies. Given the financial resources available, and the relevance of cities in facilitating the transition, we argue that cities should carefully identify their development priorities, starting from addressing their main vulnerabilities. By following an integrated perspective, urban regeneration offers the chance to implement suitable strategies to increase urban sustainability and foster urban resilience, given its ability to cover the social, economic, and environmental dimensions [14].

In the light of these premises, the paper seeks to answer the following research questions: given the pressing challenges to tackle and the robust response of the EU in terms of policy adaptation and financial resources, are cities effectively designing and implementing resilience-oriented strategies to address their persistent social, economic, and environmental vulnerabilities? Furthermore, which actions such strategies should prioritize to facilitate urban transition toward resilience and sustainability?

To answer these questions, this contribution explores and describes the case of the Metropolitan City of Reggio Calabria, Italy. It attempts to assess its ability to address context vulnerabilities through the analysis of the development strategies in place and the potential role of urban regeneration in the future development strategies of the city towards resilience and sustainability.

The paper is structured as follows. The following section discusses the connection between urban resilience, transition, and sustainability concepts from the urban planning and governance perspective based on the available literature on these topics. Specifically, it provides a preliminary list of urban resilience definitions, highlights urban transition management as a point of contact between resilience and sustainability concepts, and the relevance of (urban) planning and urban regeneration to achieve these two ambitious goals. This section also casts light on the policy context in which cities' resilience strategies are being implemented in Italy, namely the National Plan for Recovery and Resilience (PNRR) and the National Operative Programme – Metropolitan Cities. The methodology section presents the overall analytical approach to explore the case study selected, examined through secondary data and on-desk analysis of official documents. First, a multi-criteria analytical approach (adaptation of weighted product model) is applied to detect local context vulnerabilities. Then, the city development strategy is assessed against the vulnerability weight detected, and the Cities Resilience Index has been simulated to assess the resilience performance of the case under investigation against the current urban development strategy. Results point out priority factors that affect the case under investigation and should be prioritized in defining future development strategies to increase the city urban resilience and sustainability.

2 Background

2.1 The Urban Transition Towards Resilience and Sustainability

The recent and interconnected challenges exacerbated by the pandemic push cities to rethink and redesign their future development strategies. Therefore, cities must respond quickly and adapt to the continuous changes promoting urban resilience [4]. Fostering urban resilience in a time of uncertainties and complexity requires transitional processes, which are increasingly gaining emphasis due to the critical importance of local action for sustainability and climate change and the need for cities to take effective and efficient decisions in this direction [15]. Recently, the promotion of urban resilience related to the environmental, socio-economic, and political domains has attracted the attention of scholars and policymakers [16, 17]. A preliminary list of urban resilience definitions sheds light on the adaptive capacity of cities. Leichenko [18], defines *urban resilience* as the "ability of a city or urban system to withstand a wide array of shocks and stresses" outlining the relevance of adaptive capacity. Cities' adaptive capacity varies depending on several factors such as "governance, institutions, cultural habits, technology, wealth, urban planning, and their ability to respond to such challenges" [19: 382]. The level of cities' adaptive capacity is related with urban resilience, which "increases when cities have more adaptive capacity, and decreases when they are more vulnerable" [19: 382]. Meerow et al. [16: 45] define urban resilience as "the ability of an urban system - and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales - to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to transform systems that limit current or future adaptive capacity". The latter definition emphasizes a linkage between socio-ecological and socio-technical networks in time and space, shaping urban resilience [16]. Meerow and Newell [3:4]. Have emphasized how leading scholars on resilience argue that the resilience concept "is crucial for achieving sustainability in a world of transformations." Although urban resilience emerged as related to facing the challenges of natural disasters in the urban environment and climate changes, it can be applied to a more extensive set of sustainability challenges [20]. Such challenges (see Table 1) refer to three distinct resilience components: the resilience of urban structure and services provided, the resilience of urban metabolism, and the resilience of urban dynamics.

Table 1. Sustainability challenges and related resilience perspective (Source: author's synthesis from [20: 183].

Sustainability Challenges	Principle	Perspective
(urban) Built environment	Rapid urbanization processes call for a safe built environment for population in the face of natural risks and climate changes	Reduction of specific vulnerabilities, especially those experienced by the urban poor living in high-risk areas (p.183)
Urban metabolism	Inefficient and unsustainable resource use both at the city and at the global level	Long-term socio- technical transition toward sustainability (involving technologies, innovation, development patterns of production and consumption chains), along with social, political, and behavioral changes. (p. 183)
Urban dynamics	Globalization has increased inequalities which reflect in cities by affecting vulnerable groups	Short circuit economies as local responses to external stresses the empowerment of vulnerable groups so that they can manage the necessary transition and innovation for sustainability (p.183)

For Chelleri et al. [20], responding to these challenges requires an integrated framework for the deployment of urban resilience strategies that incorporate sustainability to deal with "cross-scale implications (trade-offs) among systems, capacities, vulnerabilities, and time periods" [20: 183]. Following Chelleri et al. [20], three different approaches related to timescale can be summarized as follows: recovery (short-term), adaptation (medium-term), and transition (long-term). While the first is related to the immediate response to a shock as it could be to a natural disaster, and the second is the adjustment process of the response, the third approach implies a longer-term structural transformation (transitions) [20]. This approach shifts adaptation towards transition through a critical and complex socio-political choice, which happens when the system is close to a dangerous threshold [20] as the phase we are going through after the pandemic. In this perspective, resilience is not conceived as a return to normality but rather as "the ability of complex socio-ecological systems to change, adapt, and, crucially, transform in response to stresses and strains" [21: 302]. This definition provided by Davoudi [21] – which focused on evolutionary resilience – opens the floor to the "transition" concept, which refers to the transition management approach that "tries to empower and mobilize the undercurrent of sustainable development by offering a coherent framework for systemic change" [15]. Specifically, urban transition focuses on "the ability of multiple actors to initiate, accelerate and facilitate transformative processes in cities by scaling, replicating and embedding in local practices and institutions, generating solutions that directly and effectively address sustainability in cities" [3]. The two concepts of urban resilience and urban transition are relevant in understanding and defining the adaptation and transformation processes that drive urban transformations towards sustainability. Although the literature keeps the two concepts separated, Redman [22] has highlighted how a possible point in common between the two approaches could lie in transition management, as both resilience and sustainability goals need transformative actions and strategies to be reached. Therefore, assessing urban resilience is becoming important for city planners, policymakers, urban transformation experts, and researchers [23], and how to achieve resilience is nowadays the main question to answer. Given the complexity of Cities, planning is crucial to increase their resilience – intended as the ability to be prepared for uncertainty [24]. Urban systems are affected by an increasing number of shocks and stresses that increase their exposure to vulnerabilities and hinder the sustainability of economic and social development [8]. Although the concept of resilience is not relatively new to the planning discourse, urban resilience is encountering difficulty being operationalized in the context of cities [20]. Davoudi [21: 306] emphasizes the relevance of evolutionary resilience for urban planning, given "its rejection of equilibrium, emphasis on inherent uncertainty and discontinuities, and insight into the dynamic interplay of persistence, adaptability, and trans-formability, provides a useful framework for understanding how complex socio-ecological interdependencies work". From this definition, it is possible to point out two main relevant elements for the resilience and sustainability-oriented planning process: adaptability (or adaptive capacity) and transformation. The first "provides the opportunity for self-organization, which is a process of attraction and repulsion in which the internal organization of a system is not guided or managed by an external source" [8:7]. The second is defined "as the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable" [8:7]. Some authors [25] argue that the first step to achieving resilience is to reduce the vulnerability of a system. Measuring its vulnerability contributes to defining a prioritization list for developing an urban agenda [25]. Indeed, reducing vulnerability to shocks and focusing on the assets that enable a system or community to maintain its functions and follow its paths is one of the main characteristics of resilience [26]. However, considering the vulnerability concept within the resilience debate can lead to some misinterpretation [25]. In this contribution, we are aware of the overlapping of these two concepts and their conceptual separation [3]. Measuring the vulnerability of an urban system in its components is a preliminary step to assess if the urban development strategies designed and implemented effectively address cities' vulnerabilities to achieve resilience and sustainability [25]. Indeed, as Eraydin and Tasan-Kok [8] pointed out, planning practice has difficulty elaborating a framework to address the increasing vulnerabilities of urban areas.

2.2 The European and the Italian Response to Foster the Resilient Urban Transition: Urban Regeneration for the Transition

The European Union has responded to the COVID-19 pandemic with unprecedented measures [27]. The long-term budget for the EU programming period 2021–2027 (1.211 BEUR) has been topped up with EUR 806.9 billion of the Next Generation EU (NextGenEU) package as a temporary instrument to power the recovery [28]. The NextGenEU aims to foster the recovery from the pandemic and prepare the Union for a more green, digital, and resilient future [10]. The central pillar of the NextGenEU is the

Recovery and Resilience Facility [27], which aims to "mitigate the economic and social impact of the coronavirus pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions" [27]. The Recovery and Resilience Facility funds are distributed "according to national recovery and resilience plans prepared by each Member State, in cooperation with the European Commission, and in line with an agreed allocation key" [10]. In addition, several existing EU programs will be reinforced by the financial resources made available by this tool. The Cohesion Policy (REACT-EU), the Just Transition Fund, the EU Agricultural Fund for Rural Development, InvestEU, RescEU, and Horizon Europe [10]. Furthermore, the REACT-EU (Recovery Assistance for Cohesion and the Territories of Europe) extends the EU response to the crisis (EUR 55 billion) making available additional funds to the 2014–2020 European Regional Development Fund (ERDF), the European Social Fund (ESF), and the European Fund for aid to Most Deprived (FEAD) [28].

The Italian response to the crisis generated by the pandemic has been set out in the National Recovery and Resilience Plan, which envisages investments and reforms to deploy using the EUR 191.5 billion of the Recovery and Resilience Facility and EUR 30.6 billion being funded through the Complementary Fund [29]. The Plan aims to face both the challenges that emerged after the pandemic and the structural weaknesses of the Italian economic system [29]. The Plan is built on three strategic pillars: digitalization and innovation, ecological transition, and social inclusion [29], which aim to address the economic and social side effects generated by the pandemic and the persisting structural weaknesses of the Italian economy by defining a transition path that will also contribute to reducing territorial, generational and gender gaps [29]. The Plan has been articulated in six missions (see Table 2).

Table 2 shows how the green and digital transition is the main priority of the strategy (Mission one, two, and three absorb most of the budget - BEUR 104). Italian cities can benefit from the National Recovery Plan (PNRR) through the Resilience and Recovery Facility and the React-EU within the NextGenEU stimulus package. The PNRR pays particular attention to rebalancing the inequalities across territories, specifically between the north and south of the country and urban and inner areas. Cities, then, are central elements to drive the envisaged transition, and urban regeneration is gaining relevance as a mechanism to activate it. Social inclusion, energy district, circular economy, and sustainable mobility are only a few specific actions that urban regeneration processes and projects can sustain. Many of the Italian PNRR missions refer explicitly to urban regeneration as a tool to characterize interventions in cities' urban and peripheral areas to facilitate the transition towards resilience and sustainability. Figure 1 shows the connection between the PNRR and urban regeneration by highlighting the component of each mission in which urban regeneration is mentioned as an implementation tool. It also shows the funds available for each action. Most resources are channeled into the Mission 5 Inclusion and Cohesion (MEUR 87.96) with a specific focus on employment policies (MEUR 38.97) and interventions under the family act (MEUR 30.5). The green transition mission (MEUR 79.7) pays particular attention to the energy efficiency of buildings (MEUR 37.39) and local sustainable mobility (MEUR 18.52). Despite the lower amount of resources (MEUR 18,91), the healthcare mission addresses two critical elements that

Table 2. Italian National Recovery and Recovery Plan (PNRR): Missions, aims and funds [29].

Mission	Aim	Funds (BEUR)
Digitization, Innovation, Competitiveness, Culture	promoting the country's digital transformation, supporting innovation in the production system, and investing in two key sectors for Italy, namely tourism and culture	49.2
Green Revolution and Ecological Transition	improving the sustainability and resilience of the economic system and ensuring a fair and inclusive environmental transition	68.6
Infrastructure for Sustainable Mobility	the development of a modern, sustainable transport infrastructure extended to all areas of the country	31.4
Education and Research	strengthening the education system, digital and technical-scientific skills, research, and technology transfer	31.9
Inclusion and Cohesion	facilitate labor market participation, including through training, strengthen active labor market policies and foster social inclusion	22.4
Health	strengthening local prevention and health services, modernizing, and digitizing the health system and ensuring equal access to care	18.5

emerged during the pandemic outbreak: the digitalization of medicine (MEUR 11.82) and community-based care (MEUR 7.9). The digitalization, innovation, competitiveness, and culture mission highlight important resources to deploy in urban, inland, and marginalized areas by leveraging cultural heritage and tourism funds (MEUR 5.45).

Urban regeneration mechanisms are receptive to flexibility and change [30] and gain relevance as a response to the global challenges related to socio-ecological and socio-technical dynamics. Such flexibility lies in the public-private partnership and in the support provided by the Mixed-use zoning approach [31], which allows for economic diversity [32] and acts as a catalyst for environmental sustainability [33]. Then, fostering the transition towards resilience and sustainability in cities can be facilitated by the urban regeneration approach. In the Italian case, cities can benefit from the available EU resources by exploiting the programs developed for 2014–2020, specifically the National Operative Programme for Metropolitan Cities [34], as a platform to coordinate the efforts for the transition of metropolitan cities towards sustain-ability and resilience. The National Operational Programme (NOP) "Metropolitan cities 2014 – 2020" supports the priorities of the National urban agenda within the framework of the sustainable urban development strategies outlined in the Partnership Agreement for the programming period 2014–2020 [34]. In addition, the Programme is aligned with the European Urban Agenda strategy, which identifies urban areas as crucial to fostering the smart, inclusive, and sustainable growth set out by the Europe 2020 Strategy.

Given this policy framework for the programming period 2021–2027, European cities now have the unique opportunity to re-design their development strategies accordingly

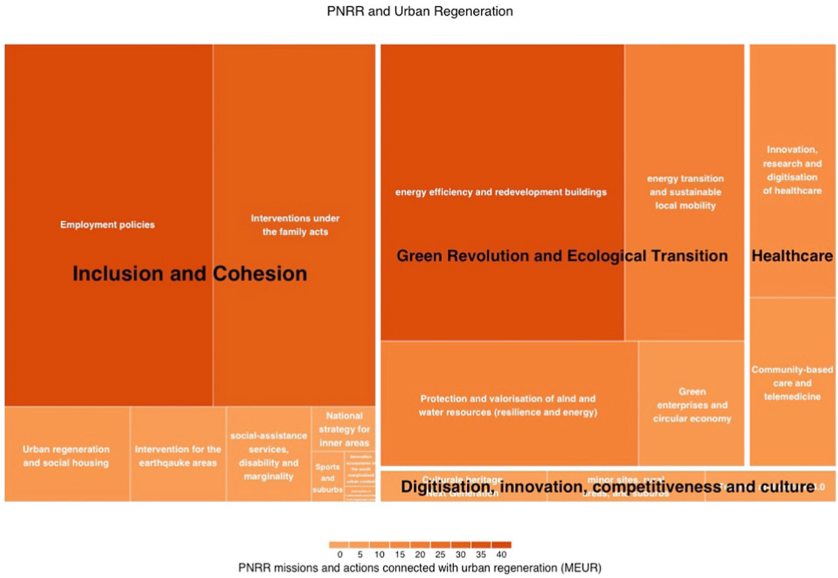


Fig. 1. Italian PNRR: missions and actions connected with urban regeneration.

and foster their resilience and sustainability. Indeed, the adopted Italian Partnership agreement has confirmed the PON METRO strategy for the programming period 2021–2027, expanding the reference target areas to the metropolitan area administrative context [35]. The PON Metro platform offers the chance to Italian metropolitan cities – and their entire metropolitan areas- to re-organize their urban development strategies built on transition-oriented processes to address climate changes and facilitate the transition toward a circular economy. In this direction, urban regeneration can act as a catalyst for such transition by creating the conditions for a more resilient and sustainable city.

With the rise of the pandemic and the mutated policy scenario, cities can exploit the resources made available by the NextGenEU within the existing plans and programs such as the PNRR and the PON METRO. The first (PNRR) makes available important financial resources for integrated interventions as the National Innovative Programme for housing quality – PINQUA (Programma Innovativo per la qualità dell'abitare), which is aimed at funding urban regeneration projects in Italian Municipalities - or the Integrated Urban Plans (PUI - Piani Urbani Integrati). For the PINQUA, the funded projects target housing issues by increasing public housing options, regenerating the socio-economic context in urban centers, and increasing the accessibility, functionality, and safety of neglected spaces and places often situated in the peripheries of cities. At the same time, the PUI, which rationale follows the new Italian Partnership Agreement for the programming period 2021–2027, extends the areas of intervention from the main municipality area to the metropolitan one. The investment aims to create new citizen services, requalify logistic infrastructures, and transform vulnerable territories into smart cities and sustainable realities [29].

The resulting policy framework offers attractive solutions for intermediate cities, triggering urban development patterns towards resilience and sustainability. Cities now have clear development goals (resilience and sustainability), drivers (green and digital transition), financial resources (NextGenEU and React-EU together with the existing instruments), and tools (i.e., PNRR, PON Metro). Given that urban regeneration embraces the social, economic, and environmental dimensions [14, 36], it can act as development framework under which cities can implement this strategy.

2.3 Towards Urban Resilience Sustainability: The Agenda 2030 and the 100 Cities Resilience Framework

The transition towards sustainability was deemed urgent in 2015 when world leaders agreed on adopting an ambitious agenda for fostering human well-being with the Paris Agreement and the sustainable development goals (SDGs) [37]. The Urban Agenda 2030 [38] core is represented by the seventeen Sustainable Development Goals (SDGs) and 169 sub-goals. Among the 17 SDGs, the Urban Agenda [38] has included a specific Goal related to cities, the SDG 11, "Make cities inclusive, safe, resilient, and sustainable", resulting from the growing emphasis on evidence-based policy, including urban policy [39]. The complexity of the challenges affecting cities requires efforts to increase their learning, adaptation, and transformation across ability sectors and levels [40]. Fostering urban resilience is a significant challenge for cities [41]. Over the past decades, inter-governmental agencies - UN Habitat, UN Office for Disaster Risk Reduction, and the World Bank – have developed tools, indices, and guidelines to support cities in this direction [41]. Recently the Rockefeller Foundation has worked on the urban resilience concept by developing practical tools for its assessment by promoting an international partnership, namely the 100 Resilience Cities network. The approach is based on planning and assessment tools developed by ARUP "to assess relative vulnerabilities and strengths in a city as a basis for developing a resilience strategy [41]. The ARUP approach [42] has two main pillars, the Cities Resilience Framework (CRF) and the Cities Resilience Index (CRI). Both pillars distinguish four essential dimensions: 1) health and well-being; 2) economy and society; 3) infrastructure and environment; 4) leadership and strategy (see Table 3).

Table 3. The Rockefeller Resilience Framework/index [42]

Dimension	Drivers	Actions
Health and Wellbeing	Minimal human vulnerability	The extent to which everyone's basic needs are met
	Livelihoods and employment	Access to finance, ability to accrue savings, skills training, business support and social welfare
	Safeguard to human life and health	Integrated health facilities and services, and responsive emergency services
Economy and Society	Collective identity & mutual support	Active community engagement, strong social networks, and social interactions

(*continued*)

Table 3. (*continued*)

Dimension	Drivers	Actions
	Social stability and security	Law enforcement, fair justice, and prevention of crime corruption
	Finance including contingency fund	Sound management of city finances, diverse revenue streams, and the ability to attract business investments, allocate capital and build emergency funds
Urban Systems and Services	Reduced physical exposure	Understanding of the hazards and risks to which a city is exposed, inform the development of integrated strategies to physically protect the city
	Continuity of critical services	Active management and maintenance of ecosystems, diversity, redundant capacity, maintenance of essential services and contingency planning
	Reliable mobility and communications	Diverse and affordable multi-modal transport systems and ICT networks and contingency planning
Leadership and Strategy	Effective leadership and management	Trusted individuals, multi-stakeholders' consultation, evidence-based decision-making and disaster risk reduction activities
	Empowered stakeholders	Education for all, access to up-to-date information and knowledge to enable people and organizations to action
	Integrated developed planning	Presence of a vision, integrated development strategy, and regularly reviewed plans updated by cross-department groups

The CRF is articulated in three layers: categories, drivers, and qualities [42]. The CRF can help stakeholders develop a shared understanding of resilience or identify the critical gaps where actions and investments are needed [42]. Dimensions contain drivers to reflect the specific characteristics of cities, and each driver contains sub-drivers to identify specific actions (see Fig. 2).

The final layer results in the City Resilience Index (CRI), enabling cities to reach their resilience level [42]. The City Resilience Index (CRI) follows the structure of the City Resilience Framework (Fig. 2): 4 main dimensions corresponding to the four main categories, 12 goals corresponding to the 12 drivers, 52 sub-indicators, and 130–154 variables considered [42]. The relative importance of indicators can depend on the urban context and provide a holistic picture of a city's resilience [42] (Fig. 2). Two main elements emerge from the Rockefeller 100 Cities Resilience framework. The first is the importance of assessing vulnerabilities to determine the resilience ability of a city. The second is the relevance of urban planning in fostering urban resilience strategies.

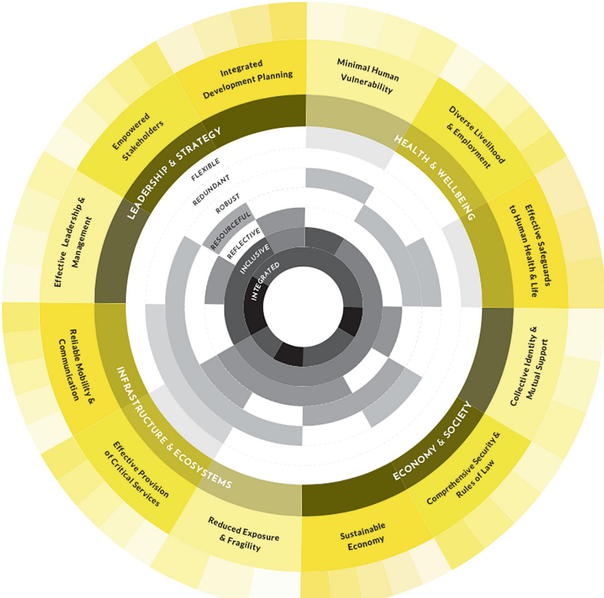


Fig. 2. City Resilience Framework (CRF) and City Resilience Index (CRI) [42]

3 Methodology

This section explores how cities effectively design and implement urban development strategies to address their persistent social, economic, and environmental vulnerabilities towards resilience and sustainability. It focuses on the case of the Metropolitan City of Reggio Calabria, one of the 14 Metropolitan Cities included in the Italian PON METRO.

The analytical approach is articulated in three main levels. The first introduces the case in the PON Metro context and program by examining the city PON Metro strategy. The second level focuses on the local context vulnerabilities detection. To assess the context vulnerabilities of the case under investigation, we propose a multi-criteria analytical approach based on the adaptation of the weighted product model - WPM). First, the most recent and available context-based statistical indicators are analyzed to detect local context vulnerabilities and match the city development strategy with the vulnerabilities detected. Second, indicators have been grouped in subthemes and associated with the three main pillars of sustainable development (social, economic, and environmental) [43]. Third, the WPM allows for weighting the vulnerability factors in the case under investigation. Such vulnerabilities have been used to assess the city resilience performance level and framed into the Cities Resilience Index [42] categories. By exploiting the CRI Rapid Resilience Review Toolkit, it has been possible to detect the main drivers for intervention for facilitating the resilience-oriented planning process.

Finally, the vulnerabilities detected, the Resilience drivers, and the PON METRO strategy's actions have been framed in a relational matrix to assess how the city is addressing the vulnerabilities detected.

4 The Case of Reggio Calabria

4.1 Reggio Calabria in the Context of the National Operative Programme: The Strategy

The Metropolitan City of Reggio Calabria is in the southern Calabria region. It is one of the 14 Metropolitan Cities selected by the government to be included in the PON Metro Programme [44]. The case strategy is examined considering the city administration designed and implemented the PON Metro strategy. The Programme "Metropolitan cities 2014 – 2020 aims to support the priorities of the Italian National urban agenda in line with the objectives of the European Urban Agenda, which identifies urban areas "as the key territories to take up the challenges of smart, inclusive, and sustainable growth set in the Europe 2020 Strategy [44]. Within the framework of the sustainable urban development strategies outlined in the Partnership Agreement for the programming period 2014–2020, fourteen Italian metropolitan cities have been identified as eligible for this Pro-gramme [44]: Turin, Milan, Bologna, Venice, Florence, Rome, Bari, Naples, Reggio Calabria, Cagliari, Catania, Messina, and Palermo.

As for the PON Metro Programme, the strategy adopted by the Metropolitan City of Reggio Calabria [44] is articulated in 5 strategic axes: Metropolitan Digital Agenda; Sustainability of public services and mobility; Social Inclusion services; Infra-structures for social inclusion; Technical Assistance. Furthermore, with the REACT-EU funding, three more axes have been added: Green, digital, and resilient recovery; Social, economic, and occupational recovery; and Technical Assistance (Table 4).

Table 4. City of Reggio Calabria refunding of the PON Strategy according to the React-EU resources [44]

Axis	Fund	Funds (MEUR)
1 Digital Agenda	ERDF	16.1
2 Sustainable Mobility	ERDF	36.3
3 Social Inclusion	ESF	24.2
4 Infrastructures for Social inclusion	ERDF	10.2
5 Capacity Building	ERDF	1.2
6 Green, digital, and resilient recovery (REACT-EU)	ERDF	63.2
7 Social, economic, and occupational recovery (REACT-EU)	ESF	4.5
8 Capacity Building (REACT-EU)	ERDF	6.9
Total	ERDF and ESF	162.6

In the initial PON Metro strategy, the City administration has channeled the financial resources into specific projects to be completed by 2023. In this pre-COVID vision, which includes only the axes from one to five, most of the financial resources were allocated for Sustainable mobility (36.3 MEUR) and social inclusion (24.2 MEU).

Table 5 shows a homogenous distribution of ongoing projects at the National level among all the axis of the Programme. On the contrary, most ongoing projects for the City of Reggio Calabria are related to social inclusion (31,91%) and sustainable mobility (29,79%). The actions completed – or still in place – are not related to the re-design of the strategy according to the REACT-EU as the former have been designed b.

Table 5. Number of projects activated by axes in total and for the City of Reggio Calabria [44]

Axis	Ongoing Projects in all Metro cities		Ongoing Projects in Reggio Calabria	
	n	%	*n*	%
1 Digital Agenda	104	20,15	6	12,77
2 Sustainable Mobility	132	25,58	14	29,79
3 Social Inclusion	124	24,03	15	31,91
4 Infrastructures for Social inclusion	112	21,70	8	17,02
5 Capacity Building	44	8,52	4	8,51
Total	*516*	*100*	*47*	*100*

5 Findings: Detecting Context Vulnerabilities and Leverage Resilience-Based Planning Processes

Given that cities are "complex, dynamic environments made of multiple inter-related systems that are competing with other cities for investment and resources" [1:10], a framework to organize the available data and understand interrelationships is needed [1]. "This is particularly true for multi-dimensional concepts such as resilience which cannot be readily measured [1:10].

In this direction, indicator-based measurement is the predominant approach to assessing urban resilience quantitatively and qualitatively [25]. Indeed, indicators constitute valuable tools for cities to follow their performance, detect weaknesses and deploy actions to improve them [42]. Indicators can serve as powerful tools to facilitate and support decision-making by policymakers because they can help in the identification of opportunities, helping in setting priorities, and comparing performance across different contexts [1]. Moreover, the case study methodology allows exploring a phenomenon in context, using one or more data collection methods to describe a case or cases [45]. Secondary data and on-desk analysis of official documents are the primary sources used for this study. We used two main datasets: the Sustainable Development Goals (SDGs), and the Italian well-being (BES) indicators made publicly available by the Italian National Institute of Statistics (ISTAT). Despite the specific SDG on cities – 11 Make cities inclusive, safe, resilient, and sustainable – we extended our inquiry to all the possible SDG indicators related to urban phenomena or connected with urban dynamics. Consequently, the SDGs should be used as a reference framework to design and deploy urban policies oriented at the transition towards resilience and sustainability.

In this study, SDGs and BES indicators were used and grouped in thematic areas according to the three widely accepted sustainability pillars (social, economic, and environmental) (see Table 6) with the overall aim to detect urban context vulnerabilities. Each dimension contains subthemes selected based on the available indicators in the original dataset.

Table 6. Sustainability dimension and subthemes. Source: authors' elaboration

Dimension	Sub-themes
Social Dimension	Health and Education; Safety; Services; Housing and urban quality
Economic Dimension	Economy; Employment; Digital and Innovation
Environmental Dimension	Waste; Water; Biodiversity

To detect local context vulnerabilities and understand which action should be prioritized, we have adopted a multi-criteria analytical approach by adapting the Weighted Product Model (WPM), a popular Multi-Criteria Decision Method (MCDM) [47]. The WPM evaluates "several alternatives to a set of attributes or criteria, where each attribute is independent of another" [46]. Compared to the WSM, the WPM applies a multiplication technique to relate the attribute rating [46] instead of a sum as in the weighted sum model (WSM). The choice of WPM is based on its ability "to provide optimal solutions in the ranking systems." The formula – adapted – of the WPM is the following:

$$P(A_K) = \prod_{j=1}^{n} \left(a_{Kj}\right)^{w_j}, \text{ for } K = 1, 2, 3, \ldots, m.$$

In this study, an adaptation of the weighted product model (WPM) is used to assess the vulnerability weight for each dimension and sub-themes and grasp the interconnections inside each dimension and across them [48, 49]. In this direction, the distance of each attribute from the Italian average is applied as a general criterion to rate vulnerability for building the decisional-making matrix [46].

5.1 Detecting Local Context Vulnerabilities

The adaptation of the WPM consisted of building the decision-making matrix in which the criteria system includes all indicators concerning the three dimensions of Sustainability: social, economic, and environmental. The weight processes have been handled in two steps. In the first step, the study considered the dimensions separately. However, all indicators have been normalized by considering the dimensions as alternatives to finalize the matrix. Tables 7, 8, and 9 report the indicators selected for Calabria related to the social, economic, and environmental dimensions.

Table 7. Social dimension – Indicators per sub-themes.

Indicator	*Reggio Calabria*	*Calabria*	*Italy*
health and education			
Life expectancy at birth (2020)	82,1	82,0	82,0
Participation in continuing education (2020)	5,1	5,6	7,2
Children 0–2 using childcare services (2018)	1,5	2,2	14,1
Presence of childcare services (2018) (%)	8,2	19,1	14,1
People at risk of poverty or social exclusion (2020) (%)	26		25,3
housing and urban quality			
Density of historic greenery and urban parks of considerable public interest (2019)	0,1	0,5	1,8
Housing crowding index (2020)	2,6	2,3	2,6
Safety			
Population exposed to flood risk (2020)	10,6	13,2	11,4
Population exposed to landslide risk (2020)	0,6	3,4	2,2

Table 8. Economic dimension – Indicators per sub-themes.

indicator	*Reggio Calabria*	*Calabria*	*Italy*
Employment			
Non-participation rate in work (2020)	39,7	38,0	19,7
Unemployment rate (2020)	15,4	20,1	9,2
Neet (2020)	34,5	34,6	23,3
Young unemployment rate (2020)	31,4	40,4	22,1
Occupational gender gap (2020)	-26	-26,4	-19,9
Young Non-participation rate in work (2020)	70,8	69,4	47,2
Income			
Percapita income	12911,5	12920,0	18690,3
Non-performing entry rate of bank loans to households (2020)	1,1	1,2	0,8
Innovation			
Municipalities with services for families entirely online (2018)	11,5	8,7	25,1
Innovation of the productive system (2018)	45,3	45,5	48,1
Fixed network coverage for ultrafast internet access (2019)	26,7	11,4	30,0

The result, visualized by the tree map charts (see Fig. 3, 4, and 5) for each dimension, defines an order of vulnerability factors highly affecting the Reggio Calabria context.

The main vulnerabilities detected are related to the health and education, housing and urban quality (social dimension), the employment and income (economic dimension), and waste and water (environmental dimension) sub-themes.

Table 9. Environment dimension – Indicators per sub-themes.

Indicator	***Reggio Calabria***	Calabria	Italy
Biodiversity			
Incidence of urban green areas on the urbanized surface of cities (2020)	4,8	4,4	8,5
Energy			
Irregularities in the electricity service (2019)	3,7	4,0	2,4
Water			
Leakage from the municipal water network (2018)	46,6	44,9	42,0
Efficiency of drinking water distribution networks (2018)	53,4	55,1	58,0
Waste			
Separate collection of urban waste trash re	33,5	36,3	39,6

5.2 For a Resilience-Based Planning Approach: Assessing Local Context Resilience Through the Rapid Resilience Review Toolkit

The application of the CRI based on the vulnerability assessment results allows for measuring the performance of the Reggio Calabria. Figure 8 shows the resilience index preview achieved by using the Rapid Resilience Review toolkit derived from the CRI work. Starting from the vulnerabilities selected, we attempted to simulate the City Resilience Index for the city of Reggio Calabria. Data from the initial dataset composed of the SDGs and BES indicators have been used. Each indicator has been assigned to the twelve drivers according to the four dimensions of the CRI using the Rapid Resilience Review tool.

From Fig. 6, it is possible to point out the city's resilience performance according to the main drivers of the City Resilience Index. Almost all the main categories present some criticalities. Specifically: (i) Health and Well-Being – Diverse livelihoods and employment; (ii) Economy and Society – Collective identity and community support; (iii) Infrastructures and Ecosystems – Effective Provision of critical services. The health and well-being category have a low-performance level in all the three main drivers. It suggests that the city should prioritize interventions to reduce unemployment and young participation – which is also one of the principal vulnerabilities detected. The economy and social dimension values suggest how collective identity and community support is the main driver to prioritize, specifically to whom it concerns inclusive social processes through services for vulnerable categories. The infrastructure and ecosystem category suggest that measures to reduce exposure and fragility are priorities to address.

Finally, the leadership and management category indicate that the integrated development planning driver should be boosted. This last dimension should be further investigated as the available indicators are not fully explanatory of the local integrated planning system. In the case under investigation, we have considered the available PON urban development strategy and the existence of official planning tools as a moderate example of integrated planning. Further inquiries should assess the coherence of all the planning tools available for the city of Reggio Calabria.

Table 10. Relational Matrix: vulnerabilities detected, resilience drivers, Pon Metro actions

Vulnerability (main)	***CRI vulnerability detected***	***PON - Metro Strategy***	
housing and urban quality	Collective identity and community support: *Active community engagement, strong social networks and social integration*	housing	Center for homeless people
			Recovery of the Ex Colonia (Catona headquarters for "After us" interventions)
			Recovery of "Ricoveri Riuniti" for social housing
			Recovery of public property for the SociaI Housing Agency
			Redevelopment and adaptation of affordable housing units
			Urban Regeneration of the Trabocchetto urban area
			Services and tools to address housing problems
		services housing	Network of Proximity services in the peripheral areas
			Beauty sites in degraded peripheral areas of the Municipality of Reggio Calabria and the small cities of the Metropolitan Area;
			Recovery of property in Arghillà for the creation of a proximity centre (community-based);
			Services Hub for families
			Redevelopment of Waterfront public spaces
			Redevelopment of confiscated property for minors who have left the criminal circuit
			Sport facilities energy retrofitting

(*continued*)

Table 10. (*continued*)

Vulnerability (main)	***CRI vulnerability detected***	***PON - Metro Strategy***	
			Under used and abandoned Urban Public Spaces maintance and improvement
			Redevelopment and maintanance of public spaces and urban green areas
			redevelopment and maintanance of public spaces and urban green areas
Health and Education		inclusion	Networks for the socio-working inclusion of Roma, Sinti and travelers
			Coordination street unit
			Services for homeless people
Employment and Income	Diverse livelihoods and employment: *Access to finance, ability to accrue savings, skills training, business support and social welfare*	work and entrepreneurship	Networks for the socio-working inclusion of Roma, Sinti and travelers
			Social entrepreneurship
			innovative services for the job placement of disadvantaged categories
			Support for citizenship of persons with disabilities and their families
			Recycle and reuse start-up center
			circular economy grants for small business
	Sustainable economy: *Sound management of city finances, diverse revenue streams, and the ability to attract business investment, allocate capital and build emergency funds*	energy	energy retrofitting of the public lighting system
			Energy retrofitting of the Municipality Directional Building

(*continued*)

Table 10. (*continued*)

Vulnerability (main)	***CRI vulnerability detected***	***PON - Metro Strategy***	
			Photofoltaic panels of the Municipality Directional Building
		mobility	Smart traffic and mobility control platform (CCM)
			Public transportation vehicles
			Protected pedestrian path and Waterfront-Pineta Zerbi cycle path
			Multi-storey car park and “Rausei” interchange
			TPL Waterfront protected preferential lanes
			City waterfront intermodal junction
			sustainable mobility measure to face the COVID emergency
		circularity	SMEs contributions for circular economy solutions
			Startup del centro del riuso
Water	Effective provision of critical services Active management and maintenance of ecosystems, diversity, redundant capacity, maintenance of essential services & contingency planning	Natural resources	Smart metering: conscious consumption and valorization of water resources
			Refurbishment of the electrical panels of the wells
			Sewage treatment
Waste		Waste collection	ecological waste collection plants
			Engineered bins

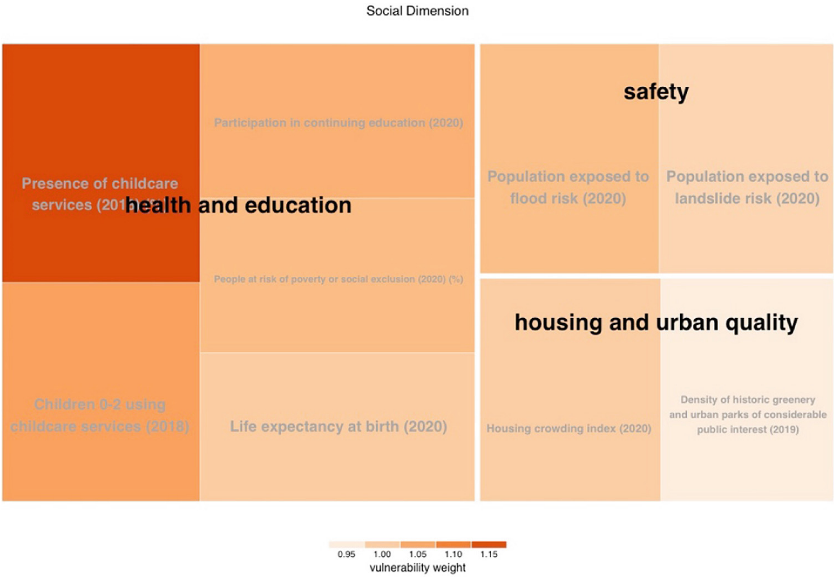


Fig. 3. Social Pillar indicators for the Metropolitan City of Reggio Calabria. Vulnerabilities by sub-themes and indicators.

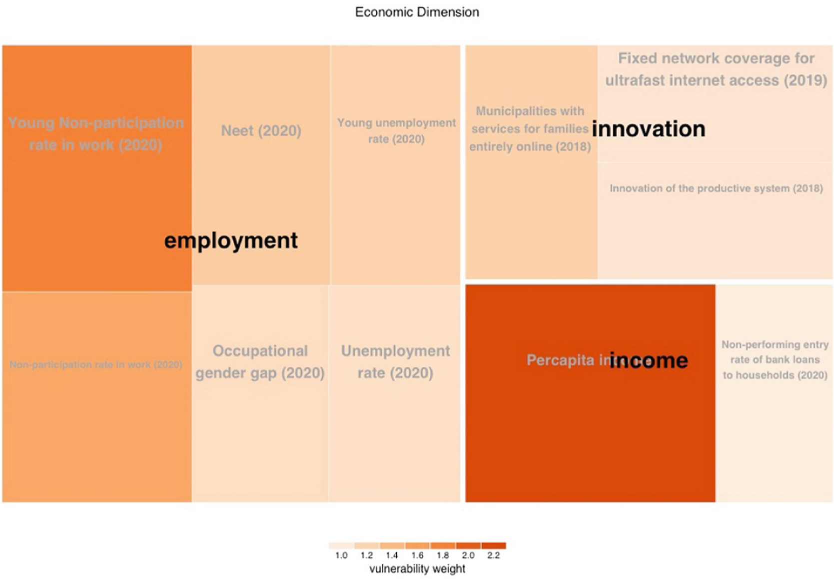


Fig. 4. Economic pillar indicators for the Metropolitan City of Reggio Calabria.

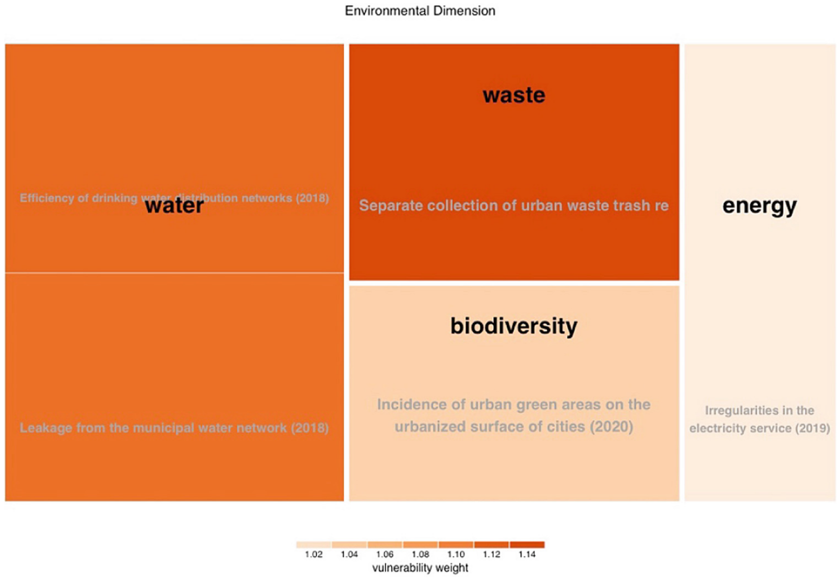
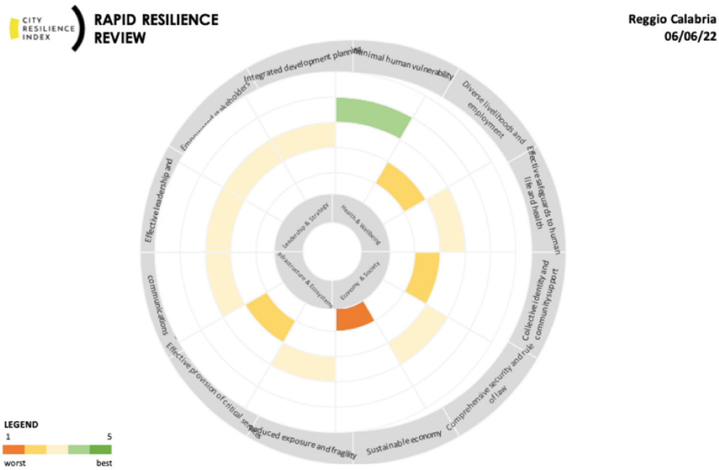


Fig. 5. Environmental dimension indicators for the Metropolitan City of Reggio Calabria.

5.3 Vulnerabilities, Resilience, and On-Going Urban Development Strategies

The vulnerabilities identified according to the sustainability dimensions point out the main context criticalities related to the city of Reggio Calabria. The City of Reggio Calabria has designed its green and digital transition towards resilience and sustainability. This strategy, funded by the National Resilience and Recovery Plan (PNRR), has been designed within the PON – Metro overall strategy. Table 10 shows the coherence of the actions in place with the context vulnerabilities detected for the city of Reggio Calabria and the resilience priorities emerged from the CRI Rapid Resilience Review Toolkit. However, starting from the vulnerabilities detected and the related resilience-based drivers, it is possible to notice how not all the vulnerabilities detected are adequately addressed by the city development strategy designed. While housing and urban quality seem to be oriented to address context vulnerabilities, employment and water vulnerabilities are poorly addressed.

Specifically, the main vulnerabilities addressed are the housing and urban quality subthemes, mobility, and energy. Few actions target employment and water vulnerabilities. The strategy was designed before 2014, and only recently, with the REACT-EU financial resources, it has been re-designed to foster urban resilience. Additionally, the PON METRO Programme has specific axes and objectives focusing on the digital transition of the public administration, mobility, and the increase of quality in the delivery of public services.



HEALTH AND WELL-BEING	
Minimal human vulnerability *The extent to which everyone's basic needs are met*	3,60
Diverse livelihoods and employment *Access to finance, ability to accrue savings, skills training, business support and social welfare*	2,00
Effective safeguards to human life and health *Integrated health facilities and services, and responsive emergency services*	3,25

INFRASTRUCTURE AND ECOSYSTEMS	
Reduced exposure and fragility *Understanding of the hazards and risks to which a city is exposed, informs the development of integrated strategies to physically protect the city*	3,00
Effective provision of critical services *Active management and maintenance of ecosystems, diversity, redundant capacity, maintenance of essential services & contingency planning*	2,60
Reliable mobility and communications *Diverse and affordable multi-modal transport systems and ICT networks & contingency planning*	3,00

ECONOMY AND SOCIETY	
Collective identity and community support *Active community engagement, strong social networks and social integration*	2,50
Comprehensive security and rule of law *Law enforcement, fair justice and prevention of crime and corruption*	3,00
Sustainable economy *Sound management of city finances, diverse revenue streams, and the ability to attract business investment, allocate capital and build emergency funds*	1,80

LEADERSHIP AND STRATEGY	
Effective leadership and management *Trusted individuals, multi-stakeholder consultation, evidence-based decision-making and disaster risk reduction activities*	2,80
Empowered stakeholders *Education for all, access to up-to-date information and knowledge to enable people and oranisations to take action*	2,67
Integrated development planning Presence of a vision, integrated development strategy, and regularly reviewed plans updated by cross-departmental groups	2,75

Fig. 6. Reggio Calabria Rapid Resilience Review Toolkit (CRI) based on the vulnerabilities selected [42].

6 Discussion: The Potential of the Integrated Approach to Address City's Vulnerabilities

The EU response to the recent pandemic has brought to the definition of the overall strategy for the recovery of the Union centered on the green, digital, and just transition, which is shaped in the NextGenEU instrument. Within the National Recovery and Resilience Plan, cities play a crucial role in implementing the transition towards resilience and sustainability. As the case presented in this contribution has shown, the main local vulnerabilities are not always adequately addressed. However, the policy frameworks and financial resources available call for implementing an integrated approach to facilitate such an ambitious transition.

In the case of the Metropolitan City of Reggio Calabria, two specific measures (but not limited to) allow the implementation of an integrated approach thanks to urban regeneration mechanisms: the PINQUA program [34] and the Integrated Urban Plans (PUI) [29]. The first focuses on urban regeneration projects in the city, the second on funding an overall set of interventions for the entire Metropolitan areas, including other municipalities. Reggio Calabria is benefiting from MEUR 45 to implement three urban regeneration projects funded by the PNRR within the national Programma Innovativo Nazionale Qualità dell' Abitare (PINQUA) [34], a specific national program to foster urban regeneration actions in distressed urban areas. Figure 7 shows the localization of the PON-Metro actions in place in the City of Reggio Calabria. The majority [34] are located in the southern part of its urban center. Figure 8 also shows the location of three urban regeneration projects funded by the Italian government within the One in the northern part of the city, where seven PON-Metro actions are localized and precisely one

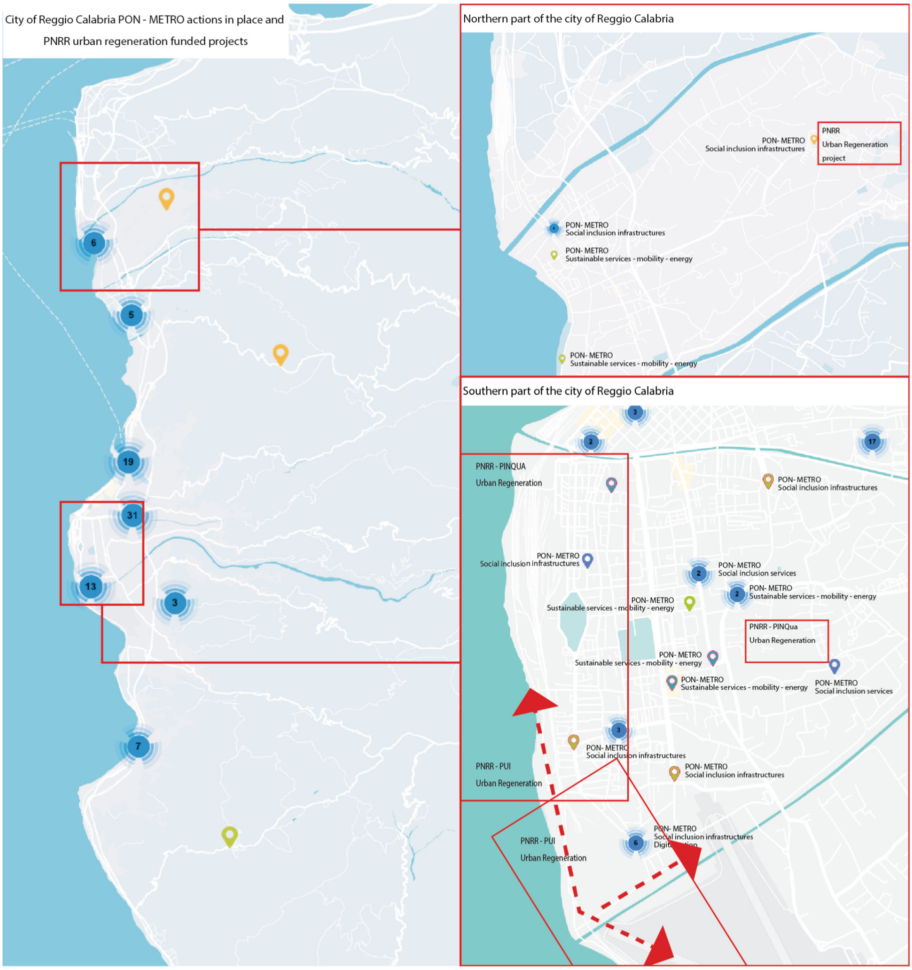


Fig. 7. Localization of Reggio Calabria PON METRO operations (available at http://www.ponmetro.it/home/ecosistema/viaggio-nei-cantieri-pon-metro/pon-metro-reggio-calabria/) - Italian Metropolitan Cities – PON Metro Programme [44], PINQUA, and PUI projects [29]. Authors' elaboration.

in the area of the PNRR project. Two are located in the southern part of the city center, where most of the PON Metro interventions are localized. Furthermore, the city also benefits from one of the interventions included in the PUI strategy, specifically a MEUR 20 urban regeneration project located in the south part of the city [29]. This intervention aims to reconnect the existing ecological corridors of the city with the urban and social context. It also addresses sustainable urban mobility, the energy efficiency of renewable sources, and urban public spaces empowerment. (Italian government, homeland minister). This area, characterized by environmental and urban decay, is crucial for the city as it connects the airport area to the urban center and revitalize the ecological corridors.

Despite the relevance of such interventions, a better integration with the existing urban planning tools could ensure the strategy's effectiveness. The granting procedures established at the national level are tightly scheduled and require huge efforts by the local public administration to draft adequate proposals. The risk is to formulate proposals that are not aligned with the current local vulnerabilities and with the objectives of urban planning tools, making ineffective the designed and funded interventions. Interestingly, following the Italian Partnership Agreement proposal on the next programming period, the PUI instrument could allow for a better territorial integration of the interventions at the metropolitan level as the Metropolitan City is the body in charge of the design implementation of the overall strategy (see Fig. 7 as an example of possible complementarity of strategies).

7 Conclusions

The paper aimed to explore how cities can formulate their recovery strategy towards resilience and transition in response to the pressing challenges they are called to face. The literature review showed how urban resilience is shaped by the complex interactions between socio-ecological and socio-technical systems [3]. Following the evolutionary resilience perspective, such interaction has implications for the urban planning dimension as it implies an effort to accommodate the process of change, adaptation, and transformation to stresses [21]. Therefore, designing and implementing effective urban development strategies to address local context vulnerabilities and boost local potential towards resilience and sustainability is central for the future of cities. The EU approach appears to support this perspective. The REACT-EU makes available unprecedented financial resources to facilitate the recovery and foster the green and digital transition of the union towards resilience and sustainability. Furthermore, the Italian PNRR shows how urban regeneration can connect many PNRR actions. In addition, the National Operative Program for Metropolitan Cities - selected to channel the financial resources from the REACT-EU for cities – can constitute the platform for implementing urban regeneration strategies. Therefore, urban regeneration appears strategic to address local vulnerabilities and leverage the untapped local potential toward sustainability.

Given this policy context, the study explored the case of the Metropolitan City of Reggio Calabria by assessing the alignment of its PON Metro strategy with the local context vulnerabilities. The case of Reggio Calabria was explored to three analytical layers. In the Italian Metropolitan cities' context, intermediate cities - such as Reggio Calabria - are experiencing a decrease in total population. The PNRR goes in this direction as one of its aims is to foster the territorial balance between northern and southern cities and urban and inner areas. The second analytical level allowed to detect context vulnerabilities by applying a multicriteria analytical approach (an adaptation of the weighted product model). Specifically, housing, and urban quality, health and education, employment, income, and water supply and distribution and waste are the vulnerabilities that should be prioritized. Second, the analysis of the city resilience performance level has allowed identifying the main drivers to follow for the city in addressing local vulnerabilities oriented to a resilience-based planning process. In this direction, the matching with the PON Metro strategy allowed us to explore the city's planned response to foster resilience and sustainability. Third, the on-desk analysis of the related official documents revealed how the actions included in the PON – METRO strategy (including the REACT-EU addition) implemented for the city address only partially the vulnerabilities detected according to three sustainability pillars. The reason is twofold. The nature of the PON-METRO strategy focuses on specific axes with specific overall objectives and actions, and the first version of the strategy was designed and implemented before the pandemic, with many of the designed measures not yet in place.

A further element to emphasize is the multilevel governance perspective and the integrated planning approach for deploying effective development strategies toward resilience and sustainability. For example, exploring possible interconnections of the PNRR with urban regeneration actions – such as the PINQUA or the PUI – can better address local vulnerabilities and leverage the potential for the green and digital transition towards resilience and sustainability through urban regeneration. In the case under investigation, it is possible to notice the linkages that urban regeneration mechanisms can activate in synergy with the PON Metro strategy.

The study's limitations match the potential further developments to improve this work. First, the datasets used– SDGs and BES – can be integrated with other quantitative and qualitative indicators according to the Cities Resilience Framework [41]. Second, stakeholders' interviews can provide helpful insights to detect urban vulnerabilities and the local potential to facilitate urban resilience and sustainability and better assess the city resilience index.

Finally, a specific element for further investigation lies in the role of traditional urban planning tools in managing the complexity of transition. Comprehensive and general urban planning instruments provides the framework for small, medium, and large municipalities to channel these investments more holistically and effectively. Such tools, where possible, should be updated based on a renovated analytical approach more oriented to the understanding of local context socio-economic and environmental transition dynamics. Moreover, given the financial resources available and the common strategic policy framework for EU Member States, such instruments can effectively facilitate the envisaged transition towards resilience and sustainability by placing cities at the core of such processes.

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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].

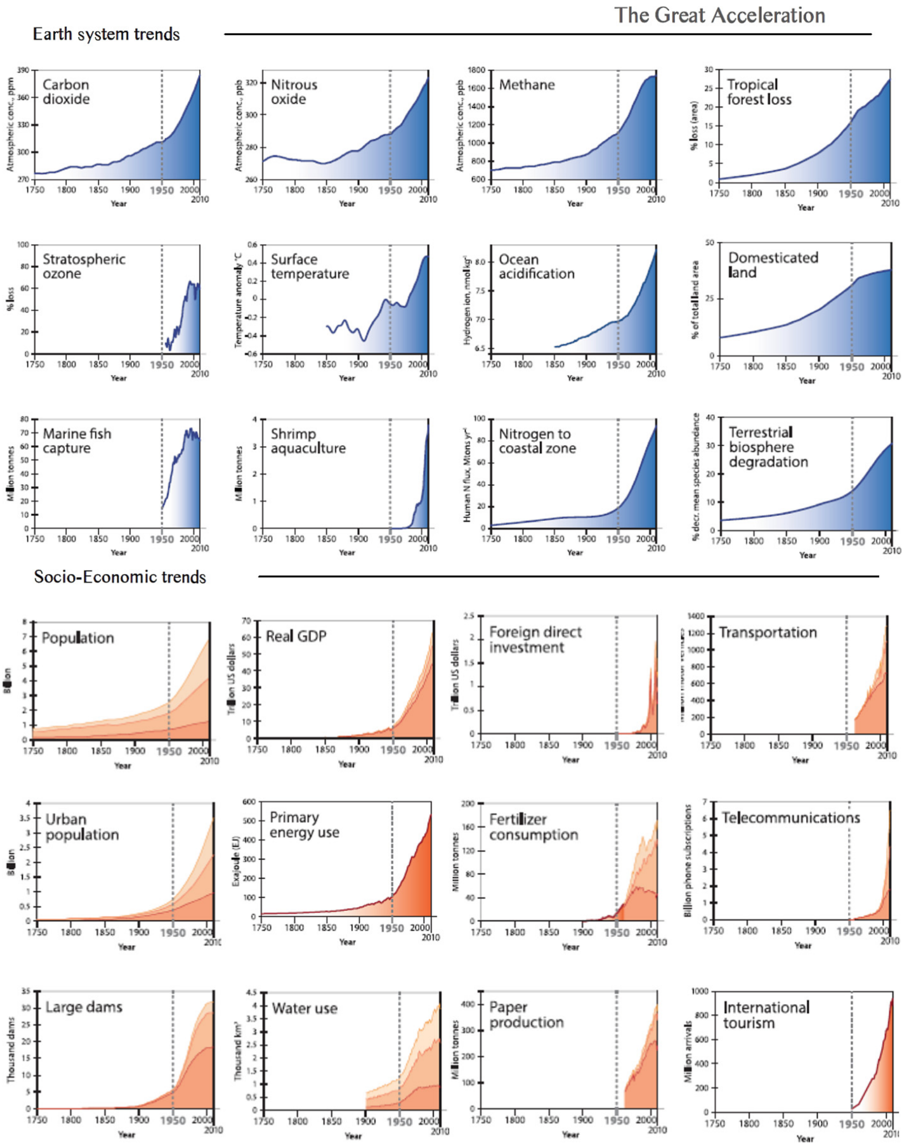

Fig. 1. The Great Acceleration: Trend over time (1750–2010) of Earth System parameters and Socio-Economic human activities [9]

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).

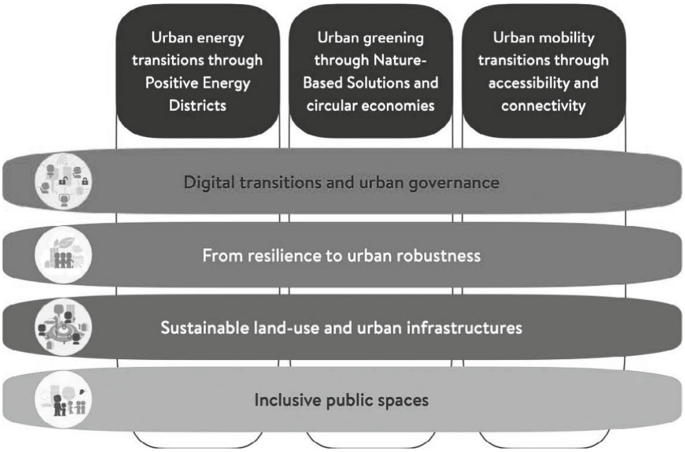

Fig. 2. The DUT's dilemma approach [38]

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).

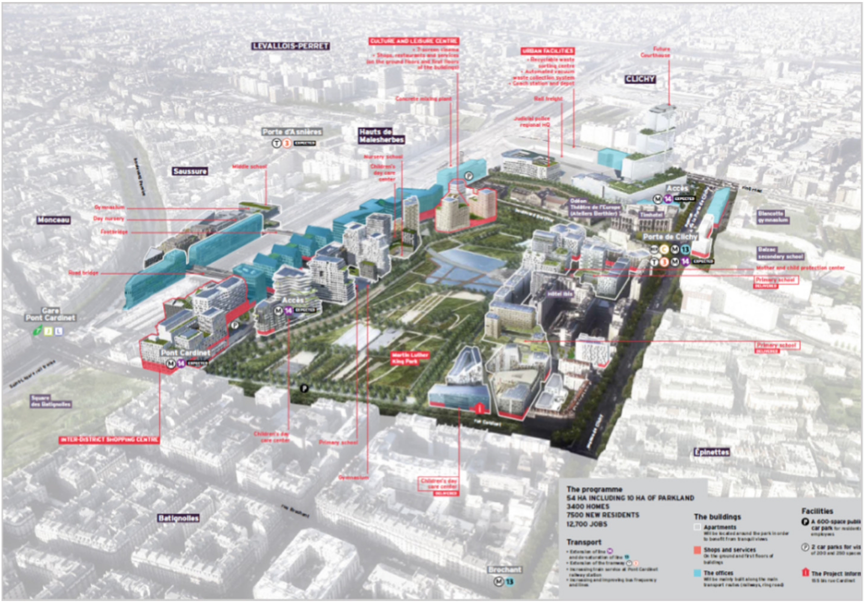

Fig. 3. The Clichy-Batignolles eco-district masterplan [41]

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 • Home weatherization • Home retrofits for energy efficiency (insulation) • Low energy new buildings • Renewable energy (solar panels) • Anaerobic digestion for local energy generation • Smart grid	• Mitigation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation • Mitigation
CURE – Circular Economy and Green Regeneration	
• Green Parks • Community gardens • Urban agriculture co-op and local farmers markets • Green walls and roofs • Green bus shelters • Rain gardens • Wastewater treatment • Building reuse	• Mitig./Adapt./ Social • Mitig./Adapt./ Social • Mitigation/Social • Mitigation/Adaptation • Mitig./Adapt./Social • Adaptation • Mitigation • 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 • Bus connections • Fronting tree lined sidewalks • Bike lanes • Wayfinding • Traffic calming through textured sidewalks • Parking • Rain barrels for storm water retention • Green Zones • Commercial spaces • Training and education • Mixed-use hub of innovation • Career training canters • Community spaces • Local produced art in within the public realm	• Mitigation/Social • Mitigation/Social • Mitigation/Adaptation • Mitigation • - • Mitigation • Adaptation • - • Mitigation/Adaptation • Social • Social • Social • Social • Social • 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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New Risk Assessments Due to Climate Change in Metropolitan Peripheral Areas. The Water Shortage Case in the Region IV of the State of México

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Abstract. A National Risk Assessment is a policy tool encouraged by the OECD since the 2010's decade to identify and analyse a range of events that can cause a shock in a country and to have adequate preparedness and response measures. As disaster risks are an always-changing phenomenon, especially since the climate change emergency has been acknowledged, it requires systematic monitoring and analysis to adapt the risk management policies to the changing situation. The paper adjusts the National Risk Assessment into a micro-regional scale to present the case of the water shortage emergency due to climate change in a peripherical urban area of Mexico City. In the paper, it is explained why it should be included as a Risk Assessment by local and regional authorities with the objective to create more resilient peripherical urban territories. Eventually, the research can serve as a base to create a National Risk Assessment for water shortage in metropolitan areas on a national scale. The paper presents the current situation of the water shortage in the case study, explains why it should be considered a risk, and analyses water shortage in urban areas within the Risk Assessment rationale, using the Region IV of the State of Mexico as the case study.

Keywords: disaster planning · risk assessment · water shortage

1 Introduction

Territories around the world are exposed to different kinds of risks that can transform into emergencies provoking an impact on society and economics [1, 2]. For this reason, different international organizations such as the OECD, European Union, and World Economic Forum present recommendations to prepare and respond in case of an emergency by identifying and evaluating risks that national governments can use and adapt according to their necessities. Among the different types of risks, environmental risks have gained relevance due to the climate change emergency [3, 4]. According to the World Economic Forum, climate change is striking harder and more rapidly than some experts on the topic expected, as consequence natural disasters are becoming more intense and more frequent [3, 5].

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Accordingly, in the Global Risks Perception Survey 2022 [6], environmental concerns dominate the top long-term risks by likelihood among the members of the World Economic Forum; also, three of the top five risks by impact are environmental [6]. In 2022 Climate change continues to be perceived as the gravest threat to humanity among the 12,000 leaders interviewed in 124 countries who ranked a list of 35 risks [6]. These leaders rate climate action failure as the risk with the potential to inflict the most damage on a global scale over the next decade. In this context, the water shortage contingency in the Region IV of the State of Mexico fits as an Environmental Risk of the Human-made environmental disasters type [3], because of the overexploitation and pollution of the local water sources, the lack of a proper federal water supply infrastructure, and poor prevention and response of the local authorities.

The Cutzamala system is one of the main providers of potable water for Mexico City Metro with approximately 26% of the water supply. In recent times, the loss of capacity of water collection of the basins that supply the dams that composes the system has put at great risk the supply of potable water in Mexico City Metro [7]. It has been reported that in 2021 the water levels of the Cutzamala system are at their lowest in the last 25 years [7]. This situation is associated with a drought of categories D2 and D3 (The United States Drought Monitor scale goes from D0 to D5 and considers D2 and D3 categories as severe and extreme drought [8]) derived from climate change in the supply basins for the system [7]. The local water bodies that can serve as an alternative to guarantee the water supply have reported high levels of contamination and exploitation [9, 10].

Mexico City Metro is one of the biggest cities in the world with more than 20 million inhabitants [11]. The peripheral areas of the city lack the same quality of services and infrastructure as the city's original centre causing the marginalization of the periphery's inhabitants [11]. One of the services that suffer from this situation, can be the water supply service. Like many peripheral areas of Mexico City Metro, the Region IV of the State of Mexico has suffered from water shortage in the last years [12]. Currently, the authorities in Mexico haven't acknowledged the Water Shortage in urban areas as a risk neither in the national nor local disaster management plans [13–15], which led to the necessity of a proper Risk Assessment in order to have adequate preparedness and response tools.

The research's main objective is to introduce water shortage in urban peripheral areas as a risk assessment using the Region IV of the State of Mexico as a case study. Other secondary objectives are to analyse and understand the water shortage contingency in the Region IV of the State of Mexico, adapt the National Risk Assessment indicators to the microregional peripherical context and the water shortage contingency, and present strategies to have better preparedness and response for the water shortage contingency. All the statements said before lead to the research question: How a simplified and adapted Risk Assessment can help Mexican authorities to address the water shortage risk in urban areas, with a special interest in the peripherical urban areas?

Territories are vulnerable to different kinds of risks, that eventually can become emergencies and cause a shock in a system. In that context, authorities develop Risk Assessments to prevent damages, have a proper response, and have a quick recovery process. Societies and territories adapt to the risks that they faced consequently becoming more resilient territories [16]. Risks are in constant change [2], and societies need to adapt to a constantly changing reality, that is why is recommended that authorities and organizations continue to search, update, and create Risk Assessments to identify new risks and have proper preparedness and response in case of emergency.

Water shortage in peripherical urban areas like in the case of Mexico City Metro has become a more common phenomenon in recent times, greatly affecting the quality of life of its inhabitants [17]. For that reason, it is proposed the water shortage in peripheral areas as a new Risk Assessment, using the Region IV of the State of Mexico as a case study. The study aims to use the case study as an example that can be adapted in different urban areas and become a National Risk Assessment that Mexico can use for its metropolitan areas. The innovation of this paper is to define a new risk assessment that is a direct consequence of climate change and man-made environmental damage. Another relevant aspect is to adapt the methodology of National Risk Assessments at a micro-regional level. Finally identifying new risk assessments is a useful practice to have more resilient territories that can adapt better to emergencies and their consequences.

The paper firstly presents a literature review of basic concepts and definitions to understand the research such as disaster planning, National Risk Assessments, and the water shortage crisis around the world. The next part is explained the chosen methodology and it is shown the basic structure of the paper. The third section of the paper presents the case study and explains why it is relevant for the study's purposes. Next, the research findings are presented. In the findings section, the field study results and the proposal of water shortage in peripherical urban areas as a Risk Assessment are shown. In the fourth part, a discussion about the results is presented. Finally, the conclusion argues for the importance of renewing and updating risk assessments to have more resilient territories.

2 Literature Review

2.1 National Risk Assessment

According to the United Nations Office for Disaster Risk Reduction (UNISDR) a disaster is defined as "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" [18]. In this paper, one of the main focuses is the evaluation and prevention of the breaking points, because a breaking point can be of natural, economic, or social matter [3]. In the case of an emergency, five main phases can be found: prevention, mitigation, preparedness, response, and recovery [19]. In the five phases, urban planners can intervene in the form of policies, methodologies, and other different instruments.

Since the first decade of the 2000's European and North American governments, began to analyse and report the possible hazards their national territory could face and result in major contingencies. The reasons each country creates these initiatives are different but can be categorized as follows [20]:

- The need for a systematic and organized approach for risk identification and the identification of weaknesses in the case of a contingency.

- The need for a comprehensive approach to preparedness that addresses the different types of risks according to a common set of criteria such as natural or man-made hazards and build consensus across different government levels concerning infrastructure and other investments in a territory.
- The need to better understand linkages between the different types of risks, and to understand how responses developed to treat the consequences of risk can in fact be useful to respond to different types of risks.

This led governments to create instruments to report possible risks, but without a unified criterion. In this context, international organizations presented recommendations to create a common policy tool. A National Risk Assessment is a policy tool encouraged by the OECD, the European Union and North American governments since the 2010's decade to identify and analyse a range of events that can cause a shock in a territory to have adequate preparedness and response tools [20]. This tool can be used in an urban or regional context to identify, prepare and respond to a possible contingence in a more specific territory.

The Risk Assessment is a part of the Risk Management Process, which involves the systematic application of policies, procedures, and practices for communicating and consulting, establishing the context, assessing, treating, monitoring, reviewing, recording, and reporting the risk [21]. The steps and stages to elaborate a National Risk Assessment according to ISO 31000 guidelines [22] and used in the European Union are the next: Risk Identification, Risk Analysis, and Risk Evaluation. The next table (see Table 1) presents the basic structure and steps to create a National Risk Assessment inside the Risk Management framework.

Table 1. Steps of the National Risk Assessment. (Source: ISO 3100)

Context	Risk Identification	Risk Analysis	Risk Evaluation	Risk treatment
Legal context Consider the scale of the available data Define 1. assets to protect 2. geographical scale 3. main hazards 4. potential impacts 5. time window 6. evaluation criteria 7. classification of impact and like hood levels 8. protocol to use expert opinion 9. evaluation criteria	1. Identify risk 2. Identify the risk drivers - hazard - exposure - vulnerability - capacities 3. Budling scenarios	Calculate the like hood and the relevant impacts Choosing an approach -Qualitative -Quantitative	1. Sharing the outputs of the risk analysis 2. Comparing and confronting risk to the evaluation criteria 3. Decide which risk to reduce	Describe the possible measures
	Risk Assessment			

It is important to mention that the Context and Risk Treatment phases even though are not formally part of the National Risk Assessment are key elements in their development of them. The Context phase serves to understand and prepare the National Risk Assessment, meanwhile, the Risk Treatment phase helps to apply the results of the National Risk Assessment.

In the North American case, The United States Environmental Protection Agency proposes a different methodology in the Risk Management Process for Human health risks and Ecological risks [23]. Since the paper treats the environmental and health risk associated with the water shortage in peripherical urban areas, it is adequate to refer to this risk assessment methodology.

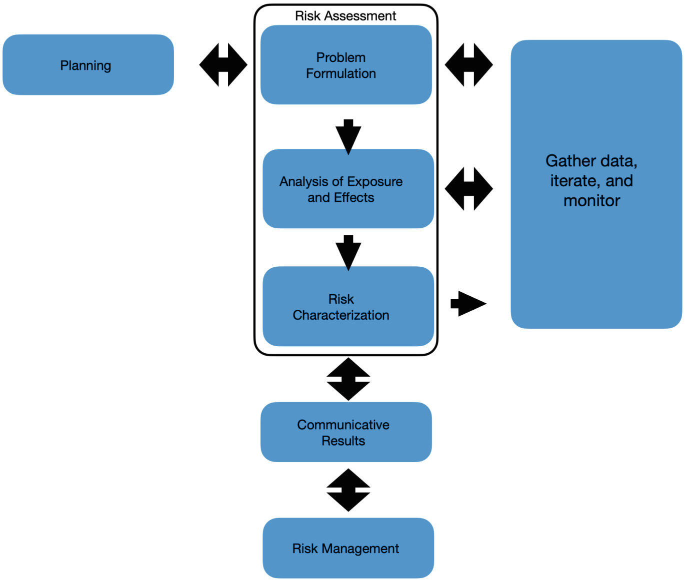

Fig. 1. Risk Management Process. Source: elaboration of the authors with data from the United States Environmental Protection Agency.

As seen in the diagram (see Fig. 1) the US EPA uses different names for each phase including the ones involving the Risk Assessment. Even though, many features and concepts and features are shared with the ISO 31000 guidelines, according to the authors the US EPA guidelines use a simpler approach specifically in the Risk Identification and Risk Characterization phases.

2.2 The Water Shortage Crisis

Access to potable water is recognized by the United Nations as a human right, supporting the fundamental nature of this natural resource in the life of every human being [24]. The lack of access to a sufficient, safe, and affordable water source has a devastating impact on the health and prosperity of a society and it has consequences for the realization of other human rights [24].

A useful tool to measure the shortage of water in a territory is the Level of Water Stress presented by the FAO (Food and Agriculture Organization) [25] and is used by national governments such as the Mexican for the case of study purposes. This indicator measures the quantity of available water that is used for human consumption. The indicator is divided into five categories, from no stress (below 25% of consumption), to critical (when the extraction is more than 100% of the available potable water, which means the water comes from other territories). The FAO has established 25% as the threshold of safe water stress, globally the water stress is below the threshold with 18% [25]. There are countries that surpass the threshold in a moderate way like Italy (30%), Mexico (33.3%), and the United States (28.16%). These countries need special policies to avoid the problematic escalates. But there are countries that surpass the threshold in a preoccupant way like Pakistan (118.2%), Saudi Arabia (992.8%), and the United Arab Emirates (1667.3%) [25].

The case of Mexico is interesting because although the water stress at a national level is moderate (33.2%) there are specific regions like the Valley of Mexico water region where Mexico City Metropolitan area is located, which have a critical water stress level (127.8%), where water is imported from other regions in order to supply water to more than 20 million inhabitants [26]. The water supply in Mexico City Metro problem increases due to polluted and over-exploited sources, and an inefficient water supply infrastructure, causing a shortage crisis in the city, mainly in the peripherical areas, like the case study region. This situation has become a constant in the last few years, making water shortage an authentic emergency in Mexico City Metro [27]. The importance of reviewing the water stress levels at a regional level rather than a national level gives valuable insight into the impact of big urban areas on natural resources such as water.

3 Methodology

Based on a documental investigation combined with a field study in the Region IV of the State of Mexico, the research was able to obtain an insight into the water shortage in the area, and why it should be considered a contingency that must have a proper risk assessment. With the data and experiences gathered during the research, it was possible to propose some strategies to increase the preparedness and response for this emergency. The investigation type for the project is the explorative type. Exploratory studies are used when the objective is to examine little-known research topics, which have not been addressed before, or there are still doubts [28]. This research type is useful when the bibliographic review reveals that there are only non-researched guides or ideas vaguely related to the study problem, or if the research project inquiries about topics and areas from a new perspective.

The paper was structured based on a systemic method [29], where the object is determining its elements, as well as the relationships that exist between them. Also, concepts of Strategic Planning were used, which is a very useful management tool that helps organizations, companies or governments make decisions, as well as the objectives that are intended for the future to obtain the biggest benefit in the projects that are developed [30]. The paper follows the next structure:

– Understand the water shortage crisis in urban areas as an emergency that needs a proper risk assessment by reviewing the literature on international organisms and the Mexican government.
– Analyse and understand the water shortage contingency in the case study region by a field study developed from late 2020 to mid-2021.
– Determine the variables required to evaluate and analyse the risk of water shortage in urban peripherical areas.
– Define a strategic plan draft that includes preparedness and response tools for the water shortage contingency in urban peripherical areas.

4 The Region IV of the State of Mexico. A Microregional Periphery

Urban areas are constantly growing around the world. The UN estimates that in 2050 68% of the world population will inhabit urban areas therefore metropolitan areas will be a more diffused phenomenon [31]. Metropolitan processes need to be studied and analysed to create instruments, policies, and methodologies that help to understand them and improve the administration of these big complex urban areas where cooperation between the different government levels will be essential. To develop a proper metropolitan risk assessment first is important to know and understand the territory and its social, cultural, and economic dynamics to evaluate the polycentric metropolitan urban systems.

Mexico City metropolitan area according to the United Nations is a Mega City with more than 20 million inhabitants and the 5th populated in the world in 2018 and is estimated that in 2030 will be the 8th most populated city in the world remaining as one of the biggest cities in the Latin America region [31]. In this context, according to Globalization and World Cities Research Network (GaWC), based on the theories of Peter Hall [32] and Saskia Sassen [33], Mexico City is considered an Alpha City which means that the city has a global influence [34]. Mexico City Metro involves three states and seventy-six municipalities [11] making the administration of the metropolitan area challenging because of the involvement of different government levels as municipal and state level that doesn't adjust to a changing metropolitan reality. This situation makes difficult the development of common urban and regional projects, like a common disaster planning strategy.

The Region IV of the State of Mexico was created after the State of Mexico Development Plan 2017–2023 [35]. It is a peripherical territory of Mexico City that includes three municipalities and a population of more than 1.5 million inhabitants. The Region IV is composed by the municipalities of Atizapán de Zaragoza, Nicolás Romero and Cuautitlán Izcalli (see Fig. 2). Inside the region are different realities that converge such as rural settlements, semi-urban areas, irregular urban areas, industrial polygons, and high-end residential areas, but as a functional region, they share common risks that are considered in the state civil protection such as flooding, fire, earthquakes, and landslides [13–15]. But as mentioned before there is a need to adapt to the new risks the territories are facing such as the climate change emergency and other social and economic emergencies. The research project aims to help to identify new risks and propose new risk assessments to give the different government levels tools to prepare and respond in case of a contingency.

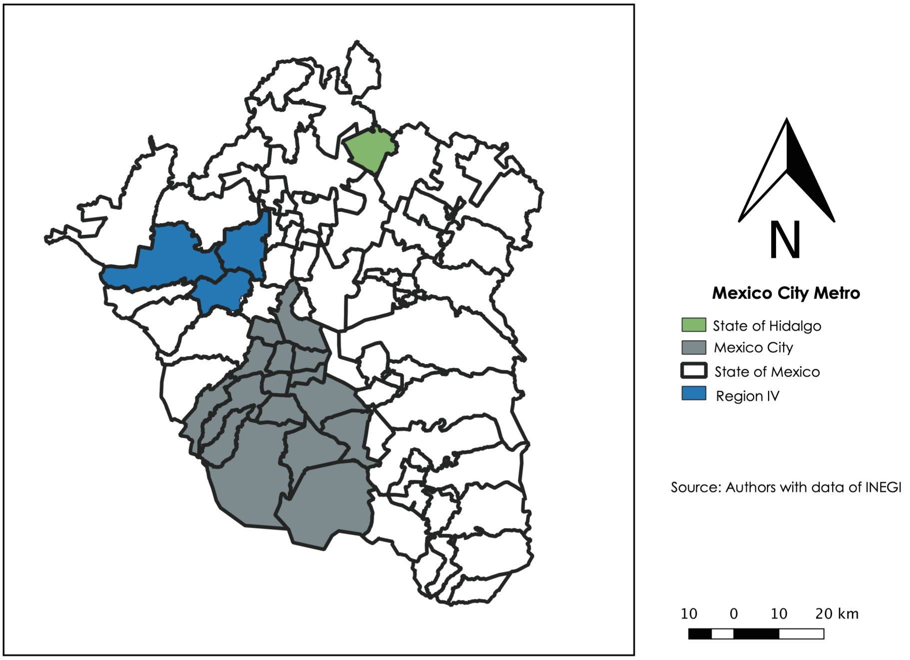

Fig. 2. Map of the Region IV of the State of Mexico in the Mexico City Metro context. Source: elaboration of the Authors with data of INEGI

5 Findings

5.1 The Water Shortage Contingency in the Region IV of the State of México

The water supply of Region IV mainly comes from the Cutzamala System which is also the main provider of water for the rest of the Mexico City Metro territory, which is part of the federal water system. Cutzamala system among other minor federal water networks represents more than 70% of the water supply for the Region IV of the State of Mexico [9], which makes the region highly dependable on federal water resources. Local water sources come from highly stressed wells or contaminated dams like the Madín dam in Atizapán de Zaragoza [36] and the Guadalupe dam in Cuautitlán Izcalli [10] which cannot fulfil the water needs of the local population. Regarding local water wells, it is reported great stress on the Metropolitan Water Mantle and the Cuautitlán-Pachuca Mantle which provides most of the water that supplies the region's wells [17, 37]. Worsening the situation, according to the federal government and the local water agencies due to poor maintenance in the Cutzamala system, there is an approximate loss of 40% of the water flow because of leaks [9].

A field study was carried out in the time-lapse between October 2020 and October 2021, where the water crisis was evaluated and analysed. During this time, it was possible to visualize the escalation of the contingency, from a manageable crisis to an emergency that greatly affected the normal development of activities of the population causing civic protests and a conflict with the local government. The study was carried out with visits to different districts of Region IV to obtain a general panorama of the situation, interviews with the inhabitants of the region (mainly in Atizapán de Zaragoza municipality), and informal interviews with the local public water agencies and private water supply agencies.

The next table as a result of the field study (see Table 2) it is presented the reported water supply cuts and reductions in the Region IV of the State of Mexico. The water shortage type is categorized into three levels: water supply with low pressure (1–3 L per min), water supply just in the morning (3–5 h) and water supply cut.

Table 2. Water shortage report for the Region IV of the State of Mexico. (Source: field study)

Date	Water supply shortage type	Duration
October 2020	Water supply with low pressure	Intermittent until the end of the study
November 28, 2020	Water supply with low pressure and Water supply just in the morning	February 2021
December 26, 2020	Water supply cut	4 days
March 16, 2021	Water supply with low pressure and Water supply just in the morning	Until the end 2021
March 25, 2021	Water supply cut	2 days
May 8, 2021	Water supply cut (Atizapán de Zaragoza)	2 days
June 11, 2021	Water supply cut	3 days
October 4, 2021	Water supply cut for 3 days each week (Atizapán de Zaragoza)	1 month

Table 2 indicates the contingency is real and constant, during the time frame of one year. This table gives an interesting insight of the dimension of the crisis in the region and why it should be acknowledged as a risk and therefore produce a Risk Assessment.

The water shortage contingency impacts differently depending on the water storage capacity of each household (see Table 3). The study identified three levels of water storage and what is the time each household can function without water supply. The criteria used come from the Mexican government that establishes that each person should be provided with 150 L–200 L per day [38]. Also considering that each household in Mexico on average has 4 persons [11].

Contamination and Drought of the Water Sources

Recent reports establish that the Cutzamala System is under great stress where the water levels are at their lower levels in the last 25 years which is associated with drought on D2

Table 3. Water storage report for the Region IV of the State of Mexico. (Source: field study)

Type	Water storage capacity	Days without water
Household with large cistern	6000 L–4000 L	200 L per day 7–5 days 150 ltrs 10–7 days
Household with small cistern	2000 L–3000 L	200 L per day 4–2.5 days 150 ltrs 5–3 days
Household without cistern	0 L–1000 L	200 L per day 1–0 days 150 L 2–0 days

and D3 intensity due to the climate change [7], another problem is the poor infrastructure that transports the water, it is estimated that about 40% of the water flow is lost due to leaks around the system [9]. This directly affects the water supply of Mexico City Metro, including the study area.

Other important source of water for the region is the Madín Dam, located in the south part of Atizapán de Zaragoza, this dam provides water to the municipalities of Atizapán de Zaragoza, Tlalnepantla de Baz, and Naucalpan de Juárez. In recent times it has been reported contamination and a significant reduction of the water reserves of the dam [36]. A study held by the National Polytechnic Institute (IPN) [36], has proven the contamination of the water that is directly affecting the life of the fish that live in the dam and the quality of the potable water that the inhabitants consume [39]. Another situation that affects the water supply in Region IV is overexploitation, recently it has been announced that part of the water of the dam will go to Mexico City's central municipalities, reducing the supply quantity for the local population.

Government Response to the Water Shortage Contingency
The government's response to the contingency can be divided into two parts. The first part is the response of the federal and state-level agencies like CONAGUA and the State of Mexico Water commission that held the labours of rehabilitation of the water supply network of the Cutzamala system to provide a regular potable water supply [7]. The second part of the response is the local authorities at the municipal level that provided a free service of water supply with trucks [40].

The field study reports that the government response in both mentioned parts was insufficient and inefficient according to the field study. The water cuts due to the labours of rehabilitation of the federal water network were more and longer than expected. When information was requested by the authors and the interviewed inhabitants about the duration of the cuts and rehabilitation of the water network the answer was vague and no specific dates were given, leaving the population of Region IV in uncertainty. The second part of the government response in charge of the municipal authorities was to provide potable water with a truck was insufficient. It was reported during the field study that the average response to a request of a water truck to fill the cistern of a house was between 4 and 7 days, an inefficient response to households with a small cistern or no cistern. This led some citizens turned to private water services that charged around 70 USD for each trip. The situation led to civil protests where citizens around the region blocked the streets in the months of July and October demanding a proper water supply [41].

Water Shortage as an Environmental Risk

The constant growth of Mexico City Metro and the densification of the peripheries have put under considerable water stress levels (127.8%) in the Valley of Mexico water region [26]. At the local level, the water sources are also under heavy stress which led to the prohibition to build new wells due to the low levels of the water mantles [9] like the Metropolitan Water Mantle and the Cuautitlán-Pachuca Mantle. The fast and unorganized urbanization has affected the absorption capacity of water mantles. The overexploitation of the basins that feed the Cutzamala system and the rain scarcity in the region due to climate change is affecting the natural process of water recuperation lowering the levels of the system. According to the National Commission of Water (CONAGUA) the rain levels of the hydric region of the Valley of Mexico had a drastic reduction from 581 mm in 2018 to 355 mm in 2020 [42]. Worsening the problem is the contamination of water bodies with littering and the discharge of sewage waters making it more difficult to obtain potable water from the local water bodies. The contamination of water bodies has led to the reduction of aquatic water life in Region IV. In the case of presa Madín it has been reported that high levels of aluminium in the water are affecting the life of aquatic wildlife [36, 39]. This situation has led to a reduction of the water supply for the inhabitants of Mexico City Metro, including Region IV. If the scarcity of natural water sources and the pollution of the water bodies continues, can provoke a risk in the natural equilibrium of the region and make the territory unhabitable because of the lack of potable water for a constantly increasing population. The next table presents a cause-effect of the environmental crisis derived from climate change regarding water shortage in Region IV.

Table 4. Logic-based cause-effect table of the environmental risk in Region IV. (Source: field study)

Cause	Effect
Overexploitation of Cutzamala system basins	Reduction of the potable water flow to the inhabitants of Region IV
Reduction of precipitation levels	Worst drought in the last 25 years
Pollution of local water sources	-Reduction of aquatic wildlife -Bigger costs for the purification of water
Overexploitation of local water mantles	Restriction for building new wells and reduction of levels of the current ones

The table (see Table 4) gives a basic insight into how the climate change emergency is affecting different aspects, that overall is creating a new contingency that was not considered before. The water shortage in urban peripherical areas like Region IV is a consequence of different environmental emergencies. To understand and eventually present a solution to the contingency is important to know the main drivers that provoked the water shortage in the form of a cause-effect table.

5.2 Water Shortage in Urban Areas as a Risk Assessment

Using as a base the guidelines provided by ISO 31000, the United States Environmental Protection Agency, OECD, World Economic Forum, and the Mexican Government, is presented the proposal of Water Shortage in urban areas as a Risk Assessment with the data collected in the time frame October 2020 to October 2021 for the case study area. The paper proposes five phases for a preliminary Risk Assessment in the context of a Risk Management Process using a qualitative approach, due to the limitation of the study for collecting reliable statical data.

Context

The context section introduces the problematic and presents basic aspects before starting the proper risk assessment. This section is important because establishes the scale of the study, the time frame, hazards, evaluation criteria, assets to protect and the expert opinion.

Table 5. Risk Assessment context. (Source: authors using as reference the guidelines of ISO 31000 and US EPA)

Scale	Region IV of the State of Mexico. Composed of three municipalities, with an approximate population of 1.5 million inhabitants and an extension of 432.64 km^2
Assets to protect	- Local water sources - Cutzamala system - Local economic activity - The population of the Region IV - The floating population of Region IV Aquatic wildlife
Hazards	- Overpopulation in the peripheries - Overexploitation of the local water mantles - Cutzamala system infrastructure in poor conditions - The drought affecting water sources Contamination of local water sources
Time Frame	Considering the contingency is currently happening. The temporal horizon for the risk assessment is the Immediate future (2 years)
Expert opinion	Create an expert committee that includes academics of urban planning, civil engineering, and environmental sciences
Evaluation criteria	- Days with constant water supply - Quality of the potable water - Quality of the water sources in the region - Days the regular commercial activity was affected due to water shortage

The context defines the basic features of the analysed contingency (see Table 5). First, the scale of the case study is defined, where the territorial extension and population are presented, in this way the decision-makers can know the scale of the study. In the second instance, the Assets to protect are identified, which means the elements that can be affected by the possible contingency. Next, the Hazards are listed, these are the current realities of the case study that can be a source of potential damage. The time frame is basic because actions need to be taken in a short period to avoid further damage since the contingency is currently affecting Region IV. The expert opinion section serves to identify the professionals that can provide knowledge to prevent and reduce the effects of the contingency. Finally establishing the basic evaluation criteria to measure the scale of the contingency is key to identify the signs of a possible contingency and act according to the situation.

Risk Identification

After the context section, the Risk Identification stage is the first proper step of the Risk Assessment. In this part, the main risks are identified and analysed to establish risk scenarios. Firstly, five main risks were identified, using a logic-based cause-effect diagram. The next figure (see Fig. 3) explains how the authors came to identify them.

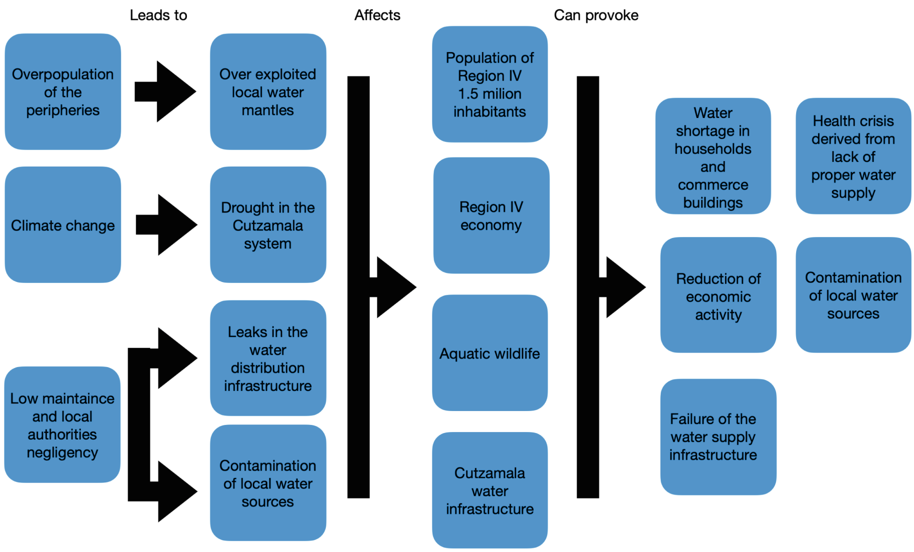

Fig. 3. Risk identification diagram. Source: elaboration of the authors.

Using as reference the World Economic Forum classification of risk types [3], the identified risks were categorized (see Table 6). This classification helps to understand the risks and how it affects the territory, society, and environment. Eventually, it will help to present specific solutions for each risk.

Table 6. Identified Risk types. (Source: authors)

Risks	Type
Water shortage in households and commerce buildings	Societal
Health crisis derived from lack of proper water supply	Societal
Reduction of economic activity	Economic
Failure of the water supply infrastructure	Technological
Contamination of local water sources	Environmental

Categorizing the risks for the study helps to understand how a contingency can affect multiple dimensions of the territory. Two of the risks are identified as societal because affect directly the inhabitants of the Region IV. An economic type of risk was identified because water shortage can eventually lead to a reduction in economic activity because many businesses rely on a constant water supply according to the field study. Even though one environmental risk was identified has a lot of weight in the study since is linked to the climate emergency. Finally, a technological risk linked to the quality of the water supply infrastructure was addressed, because if the water network does not function properly the population suffer from water shortage even if potable water is available in the basins.

The five main risks were evaluated using a qualitative approach where the impact and probability of the event were established (see Table 7). During the field study, several vulnerabilities were spotted from the water storage capacity of households to the capacity of public hospitals in case of a health emergency derived from lack of water. The vulnerabilities come from different aspects of the territory because the water shortage in Region IV has the capacity to affect multiple aspects of the Region IV urban system. It is important to mention the economic value of Region IV at the state level which represents around 9% of the State of Mexico's GDP [35]. These three municipalities although they are in the peripheric have an important value and a contingency like water shortage can have a bigger impact on the economy of Mexico City Metro and the State of Mexico. Finally, the induced risk gives an interesting result, where the risk of suffering from a reduction of potable water flow is rather constant than sporadic.

Building scenarios is a basic aspect when comes to building a Risk Assessment. Scenarios are widely used to better understand a contingency and plan future actions. A successful scenario tells the story of a defined event and its specific impacts. It helps decision-makers to visualize specific impacts that are based on currently accepted scientific knowledge [43].

Table 7. Risk Assessment identification. (Source: authors)

Dangerousness	- Water shortage in households and commerce buildings: Highly possible/Middle impact - Health crisis derived from lack of proper water supply: Possible/High impact - Reduction of economic activity: Less possible/Low impact - Failure of the water supply infrastructure: Less Possible/High impact - Contamination of local water sources: Possible/High impact
Vulnerability	- Water shortage in households and commerce buildings: There are houses with little capacity for water storage in case of contingency. Depending on the water storage capacity 10–0 days - Health crisis derived from lack of proper water supply: In the region currently are operating 10 public hospitals for 1.5 million people Reduction of economic activity: Gyms and restaurants rely on a constant water supply - Failure of the water supply infrastructure: Due to leaks in the system, it is estimated that 40% of the water flow is lost - Contamination of local water sources: It has been reported that the water in Madín Dam might be contaminated The Cutzamala system due to poor maintenance brings water with sediment Locals have reported the death of fishes at Madín Dam
Exposure	The Region IV has a population of approximate 1.5 million people. The region GDP is 7148.82 million USD that represents around 9% of the State of Mexico GDP
Induced risk	- 6.3% of probability that a water cut happens in a year - Around 70% of probability of water supply with low pressure in a year

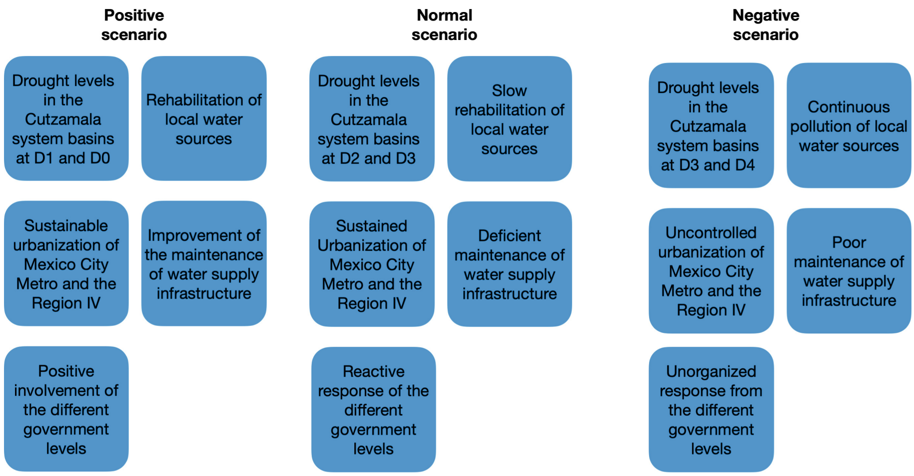

Fig. 4. Risk identification scenarios. Source: elaboration of the authors.

The figure above (see Fig. 4) shows a basic diagram of the proposed risk scenarios for the water shortage contingency. It is structured in three storylines: positive, normal and negative. In these scenarios are hypothesized the rhythm of urbanization, drought levels, government involvement, maintenance of the Cutzamala system and rehabilitation of local water sources. This helps decision-makers to have a context in which the water shortage contingency in Region IV can be developed.

Risk Analysis

After the field study and the documental investigation, considering the limitations of the study and the scale, it was decided for this research project to use a qualitative approach, where the risks were analysed based on observation, interviews, and documental investigation. To analyse the risks, it was used the 5 × 5 Risk Matrix [44], which is a useful tool to classify risks in a simpler way. Two dimensions were evaluated on the proposed risks: probability and impact. Giving values from 1 to 5 where 1 has the lowest impact and probability, while 5 has the highest impact and probability. The result of the evaluated dimensions gives the value of the risk, going from low risk to high risk. This first approach to the production of a Risk Assessment gives a basic insight into the impact of the water shortage contingency in the Region IV of the State of Mexico.

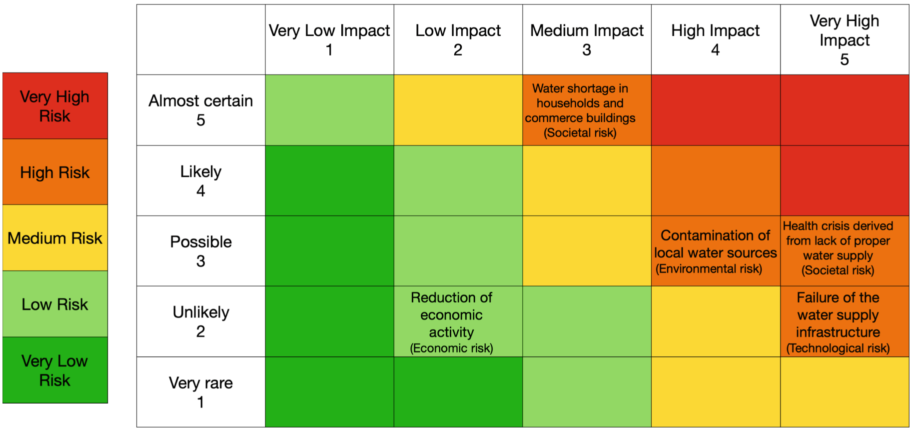

Fig. 5. 5 x 5 Risk Matrix for the water shortage contingency in urban areas. Source: elaboration of the Authors.

The matrix (see Fig. 5) gives an interesting insight into the dimension of the risks that Region IV of the State of Mexico is facing. Of the five risks that were identified in the study, four of them can be considered High Risk. This can be explained due to the constantly reported water cuts and the poor state of the water network. This confirms the necessity of elaborating a risk assessment for Region IV because the contingency is real and can cause a big impact in the region, that is why it is important to create tools, and public policies to afront the contingency. As seen on the matrix the environmental risk is one in the high-risk category, while the economic risk is categorized as low risk. These can help to guide the priorities of decision-makers to focus more on the environmental and societal related risks.

Risk Evaluation

After identifying the main risks derived from the water shortage crisis and the impact that can cause in the Region IV of the State of Mexico, the research project after the field study and a documental review proposes possible risk reducers.

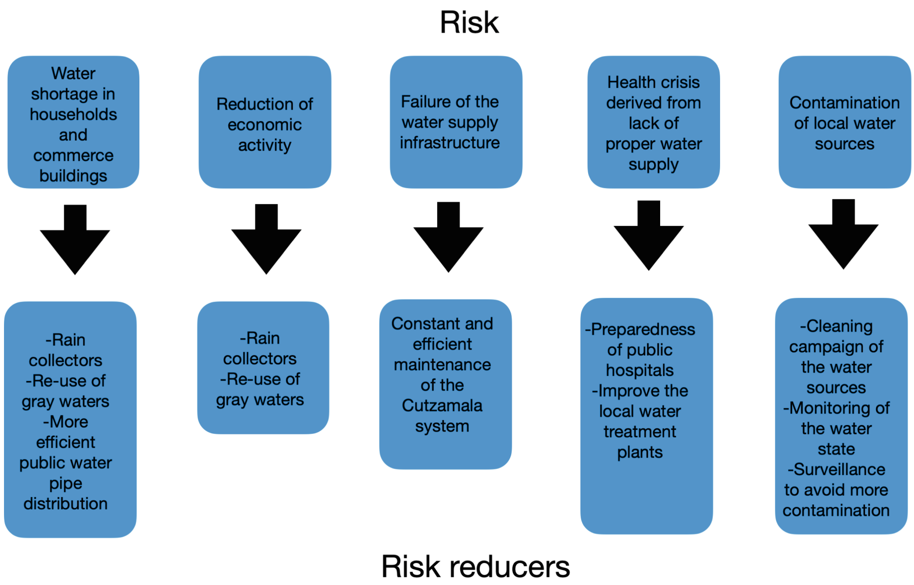

Fig. 6. Risk evaluation and reducers diagram. Source: elaboration of the authors

The risk reducers (see Fig. 6) were proposed based on the field study and observation of the Region IV reality. In the paper, most of the proposed risk reducers are based on sustainable practices, like the utilization of grey waters and the collection of rainwater, with the intention to increase the water storage capacity. Also is proposed the investment in improving the water treatment plants, and constant monitoring of the state of the potable water to avoid the supply of contaminated water. Is recommended that the federal government improve the maintenance protocol of the Cutzamala System to reduce the water cuts due to repairs of the water network. In the case of a health crisis, it is also mentioned the importance of preparedness for public hospitals in case of a health crisis derived from the consumption of contaminated water. Finally, a conscientization campaign regarding the importance of saving water and protect natural sources.

Evaluation Criteria

To measure the size of the contingency and how and when to activate the intervention protocols, it is important to establish a criterion to evaluate each of the proposed risks. In future research, the ranges to set the dimension of the water shortage contingency will be established.

The proposed evaluation criteria (see Table 8) use basic indicators due to the limitation of the study but can be further improved in future papers by establishing specific ranges to define the state of emergency. Firstly, it is advised to evaluate the days without constant water supply, to know if the storage capacity of water is surpassed in the households to intervene before reaching the shock point. In the second instance, it is

Table 8. Risk evaluation criteria (Source: authors)

Risks	Evaluation criteria
Water shortage in households and commerce buildings	Days without constant water supply
Health crisis derived from lack of proper water supply	Quality of the potable water
Reduction of economic activity	Days the regular commercial activity was affected due to water shortage
Failure of the water supply infrastructure	Percentage of water leak in the distribution network of the Cutzamala system
Contamination of local water sources	Quality of the water sources in the region

proposed to constantly measure the quality of the potable water that citizens consume to know if the levels of purity are adequate for human consumption. The next criteria are the days when businesses were affected by water shortage, this is to know the economic activity was reduced due to the water shortage contingency. To evaluate the state of the water distribution network the study considers it pertinent to measure the percentage of the water lost due to the leaks. The last criteria are the evaluate the water quality in the local water sources to prevent the loss of aquatic wildlife.

Risk Treatment

After the three phases that consist of a risk assessment, it is presented the final phase proposed in this research is the Risk Treatment using Strategic Planning criteria [30]. The research proposes the next recommendations.

As mentioned before this paper has the function of an introductory study on disaster planning for the water shortage contingency in urban peripherical areas, using as a case study the Region IV of the State of Mexico. The table above summarizes (see Table 9) the recommendations proposed by the authors after the field study and documental research. In the first instance, it is recommended to acknowledge the risk of water shortage and update the local and statal civil protection risk assessments. In the second instance is proposed the creation of a specific budget to deal with the contingency, raise awareness and participation of the citizens and the improvement of maintenance of the Cutzamala system. Next the creation of a permanent academic commission that watches over the water shortage crisis evolution and propose preparedness and response plans. Finally, is recommended sustainable techniques to preserve the local water sources and increase the water shortage capacity by recycling water.

6 Discussion

The results of the research describe and present the impact of water shortage in an urban peripherical area. This situation can continue and grow due to the constant urban expansion and the lack of preparedness for this new contingency due to climate change

Table 9. Risk treatment proposal (Source: authors)

Risk treatment proposals for the Region IV of the State of Mexico	Update the State of Mexico Risk Atlas and include water shortage as a risk assessment
	Update the local Risk Atlas at municipal level and include water shortage as a risk assessment with special emphasis on the local needs
	Improve the participation of the civil society in the distribution of the water resources
	Create a specific budget for water shortage at local and statal level
	Improve the maintenance of the Cutzamala system with preventive works and constant monitoring
	Create an academic commission that studies and evaluates the water shortage in its different dimension
	Propose a plan of action to clean the local water sources
	Encourage sustainable techniques in households and commercial buildings to save and recycle potable water

and man-made environmental damage. The situation of the Region IV of the State of Mexico is not unique and happens in many cities around the world that struggle to provide a proper water supply for their inhabitants [45].

The research presents a simplified form to create a risk assessment using a combination of different criteria from different organizations and governments in different countries. This can serve as a reverence for local authorities to develop their own risk assessments adapted to their own reality without the massive use of resources and data that implies a National Risk Assessment. In the findings section can be found the dimension of the water shortage contingency in Region IV and how it impacts different aspects of the region's proper function.

The paper presents the first approach to propose the water shortage in urban areas as a risk assessment that eventually can transform into a National Risk Assessment that can be used in the metropolitan areas around Mexico. The study uses a micro-regional scale because of the limited resources to gather data and do a field study. In Mexico, the data regarding disaster planning is limited at a local level [11] so it is important to present studies that can serve to encourage studies to promote resilient communities.

Due to the time frame of the field study and the lack of precise data at a local level the research project used a qualitative approach based on observation and interviews. It is expected that the qualitative approach can serve as a reference for further quantitative studies. The 5 × 5 Risk Matrix used in this project brings uses a basic 1 to 5 qualitative scale based on observations and interviews but can be improved by including more specific indicators and solid data. Regarding the evaluation criteria, it is important to mention that is required further research to establish concrete ranges. The final recommendations use basic criteria of strategic planning but need deeper research to turn into a full disaster planning strategic plan for the water shortage contingency in urban areas.

7 Conclusions

The climate change emergency is impacting harder than expected [3] for that reason, it is important constantly monitor, create, and update risk assessments. The water shortage in urban areas is a relatively recent phenomenon that hasn't been developed in deep. The research gives an introductory insight about the crisis and a simplified proposal of risk assessment due to the limitation of the study, but with further studies can become a National Risk Assessment useful for urban areas at a national level. The main five risks that were identified show the multi-dimensional condition of the contingency with risks of different categories. Also, the identified risks are not exclusively for the Region IV of the State of Mexico and can be present in other urban peripherical areas.

To build more resilient territories and communities it is important to have proper risk management tools and policies to respond and adapt easily and faster in the case of a contingency. As urban territories and populations are constantly growing urban emergencies is still an important topic in the disaster planning field of study. For that reason, the study gathers relevance and is pertinent in this time of transition to more sustainable and resilient territories.

A proper potable water supply is a human right that in Mexico City Metro is in danger because of the water shortage contingency that is currently happening in the city. The study explains the main drivers of the crisis, like poor maintenance of the current water infrastructures, the overpopulation of the urban areas, overexploitation of local water sources, poor preparedness and response of the local authorities and contamination of water sources. These drivers lead to five main risks that are water shortage in households and commerce buildings, health crisis derived from lack of proper water supply, reduction of economic activity, failure of the water supply infrastructure and contamination of local water sources. Identifying five basic risks serves as an important reference for further studies that want to continue the investigation on the topic. After identifying the risks, the next phase in this study was to identify the risk reducers that help to reduce the impact of the water shortage contingency. Finally, some basic measures were proposed. The construction of a simplified risk assessment according to the research can be a useful tool for local authorities that do not have the data or resources to conduct a full risk assessment.

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CLLD, Urban Agenda and Borderland. Governance and Innovation for the Sustainable Development of the Eurocity of Guadiana (Portugal-Spain)

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Abstract. Governance, innovation and spatial planning are recognised as dimensions of the territorial development process in the European Regional Policy. This paper explores the joint possibilities of Community-led Local Development (CLLD), as an approach that encourages the participation of local actors in sustainable urban development, and the EU Urban Agenda, as a strategic spatial planning instrument, applied in the cross-border area of the Eurocity of Guadiana. It draws on existing literature and the empirical development of the INTERREG EuroGuadiana 2020 project to define the objectives of the process and the key components of the territorial governance scheme. It shows that the urban governance formula for cross-border cities, based on the combination of European Grouping of Territorial Cooperation (EGTC), CLLD and Urban Agenda, represents an opportunity both to strengthen the organisational capacities of partnerships and to implement inclusive and participatory action plans. It is concluded that the Eurocity of Guadiana must overcome limiting factors such as community resistance to change, as well as the paradox of planning across borders and the demands of cross-border governance.

Keywords: Community-led local development (CLLD) · Urban Agenda · Eurocity of Guadiana

1 Introduction

Sustainable urban development is at the heart of EU regions and Cohesion Policy. Cities need to develop local responses to some of the most pressing social and environmental problems facing European communities. These responses follow the guidelines of the 2030 Agenda (especially SDG 11: sustainable cities and communities) [1, 2], the current EU Urban Agenda (Pact of Amsterdam, May 2016) [3] and Community-led Local Development (CLLD) [4, 5]. The latter initiative was first implemented in rural and coastal areas under Leader programme and Axis 4 of the European Fisheries Fund (EFF), and since 2014 it has also started to be applied at local level in terms of cross-border cooperation. In this respect, when Regional Policy introduced local development as a paradigm

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for territorial development, it enhanced its dimensions of governance, innovation and spatial planning [6, 7], achieving greater participation and better coordination between actions and decision-making [8, 9].

In the scenario of cities and urban areas to be described, the novelty consists of incorporating the EU Urban Agenda into the CLLD equation, as a new integrated and multisectoral territorial planning instrument linked to the action of partnerships as new management tools. The EU Urban Agenda was launched in May 2016 with the Pact of Amsterdam [10, 11], but it is not the first document of its kind at European level – the European Territorial Strategy (1999), the Leipzig Charter (2007), the European Territorial Agenda (2007, 2011) or Toledo Declaration (2010) could be mentioned. However, its implementation is different, as it introduces the 'partnership approach' as a new working method that specifies, unlike the rural development action groups, clear rules of participation, priority themes, working methods and expected results [12], which can ensure the creation of links between European policies and actors at different spatial and participatory scales, from the European to the local level.

First, the growing importance of cross-border governance in urban policy is evidence of its capacity to engage with a wide range of actors in different territories, including borders and small cities. In this sense, the Urban Agenda can also be understood as an example of the evolution towards 'soft' European spatial planning and urban development, and the creation of 'soft spaces' [13], as the EU continues to promote through the Interreg programme. Moreover, this makes the cities new actors in the European policy debate towards the green and digital transition to resilience and sustainability through an integrated urban development model, putting the Urban Agenda at the centre of strategies and action mechanisms. Changes and transitions can be seen, together with preservation, as central elements of the principle of sustainability through the management of specific, usually material resources in a combined ecological and economic approach. Sometimes social and cultural capitals are added to this approach, through specific political institutions or the concept of local identity. The latter is particularly relevant in places such as cross-border regions because it enables community commitment and social integration, and is therefore considered a key resource and factor for innovative and sustainable urban development [14].

The 'border condition', what makes borderlands unique, implies particular and valuable modes of observation and coordination and, in turn, a specific setting for cross-border governance, but without erasing the internal logic of previous governance on each side of the border. This means that the Urban Agenda and cross-border governance are intended to be a place of 'tension' and integration of urban, rural and coastal policies and activities. This tension contributes to the complexity of governance at the border, as a place of intense contact and interaction between groups of people, ecosystems, trade flows, etc. It is these dynamics that particularly define the Spanish-Portuguese border landscape in the *Bajo/Baixo Guadiana*, especially the clear separation of different modes of organisation, decision-making, resource management and governance mechanisms at the border (often distant, unfocused or poorly applied), challenged by local identities, territorial imbalances and changing materialities in economic, environmental and socio-cultural terms.

This situation encourages reflection on cross-border governance and its future challenges from the perspective of urban CLLD. Hence, this paper aims to assess the challenges of governance ‘on the move’, with reference to cross-border conditions and the possibilities of the Urban Agenda, through the case study of the European Grouping of Territorial Cooperation (EGTC) *Eurociudad del Guadiana*. In this sense, the Eurocity emerges as an innovative formula of applied geography, a laboratory of resource-based cross-border governance, which recombines and enables the management of the territory’s resources since cross-border local identity and appropriation. In a very short time, the Eurocity has been able to adapt the initial organizational scheme of the EGTC from a grouping restricted to the local authorities of three municipalities, to an enlarged multi-stakeholder partnership. From a spatial point of view, the challenge of this Eurocity is to unite a cross-border space that responds to both coastal and rural socio-territorial resources, while designed on the basis of urban logics. The analysis of problems (social and territorial imbalances), risks (adaptation to climate change, impact of the COVID-19 pandemic) and potentials (environment, tourism, circular economy, social innovation, cultural heritage) are common activities of strategic planning, as well as some of the critical success factors of the Eurocities on the Iberian Peninsula [15]. The cross-border Urban Agenda aims to be the appropriate scenario to consolidate a successful constructive project in a cross-border territory.

Specifically, the research questions are: (i) What are the key components of the cross-border urban CLLD framework? (ii) How have they been implemented in the Eurocity of Guadiana? (iii) Which developments does the Urban Agenda imply in the identified process of cross-border regionalization? Our hypothesis is that the application of the CLLD-Urban Agenda scheme is a formula for cross-border cooperation that enables the construction of new territories at the local and urban level. This approach provides an evolving, strategic, innovative and shared socio-territorial vision, an expression of the collective will to create new spaces, new scales of organisation and new horizons of action for sustainable urban development as a long-term goal.

This contribution is organised as follows: the next section provides a review of the academic literature and details the theoretical approach. This is followed by methodological considerations and a presentation of the study area. The empirical section presents the case study on the governance process within the *Bajo/Baixo Guadiana* cross-border cities. A critical discussion of the CLLD-Urban Agenda- cross-border governance scheme is included. Finally, some concluding remarks are offered.

2 Governance and Sustainable Local Development of Urban Areas: Borders, Eurocity and the Urban Agenda

Territorial and socio-spatial analysis of borders at the local level, and how they affect people’s daily lives, has been gaining significance. At the end of the 20th century, the partners in the European project designed a Europe without internal borders, unifying the market and eliminating fiscal and mobility obstacles. As early as 1974, Paul Claval pointed out that the transformation of the role and conceptual depth of European borders presaged a profound alteration in all territorial behaviour and organisation, asking whether “we are on the eve of a new geography of enclaves, of discontinuous zones and interpenetrating spaces" [16, p. 21]. European cities, including small and medium-sized ones, face the challenge of achieving prosperity and sustainability, meeting energy challenges and pursuing environmental quality. To this end, they must look beyond administrative borders and focus on functional regions, on their integration into a polycentric and balanced territorial development model in a broad sense, at cross-border level [17]. This confirms the definitive shift towards a spatial approach in European policy [18], the influence of relational space on debates and the emergence of new regional spaces that cross-cut the territorial map that prevailed throughout much of the twentieth century [19].

Cross-border regions, including so-called Eurocities, according to the EU and relevant literature, are characterised by homogeneous features and functional interdependencies, otherwise there would be no need for cross-border cooperation [20]. Some of these areas fit well with geographical units (urbanised areas or hydrological basins), but sometimes not. While some (such as cross-border urban regions) seem to exist prior to their institutionalisation, others may not until the actors planning to manage them have established their territorial boundaries [21]. This suggests that there is a nuclear link between cross-border cooperation and the cross-border region. Further, cross-border spaces, as new sites of action and intervention, are raising the question of how they should be governed [22].

Eurocities refer to cross-border territorial structures that derive from the Euroregions, but on an operational scale with a markedly local character. They are part of the process of Europeanisation and resignification of European borders, with a strong spatial planning component [13, 23]. As cross-border micro-regions, they have become the recent'leading roles' of Spanish-Portuguese cross-border cooperation, with the constitution of 7 projects based on very significant historical, cultural and socio-economic links [15, 24]. They have been agreed with the common denominator of focusing cross-border cooperation on the central population centres involved – irrespective of their size and entity. The principle is to share resources and synergies, in order to structure the proposed territory and organise it to promote local development processes based on endogenous resources and the attraction of investments related to the nearby regional, state and community scales. The Iberian Eurocities are part of the European impulse of the'Europeanisation Laboratories', in the new spatial concepts of spatial planning (soft spaces), in the creation of and access to real common services based on Eurocitizenship (as is already the case, for example, in Eurocity Chaves-Verín), or in innovation resource-based management and cross-border governance. Territorial structuring based on connectivity and accessibility and problem solving from strategic approaches of proximity, social cohesion based on identity and governance based on institutionalisation, in an evolutionary process of mutual learning, are the basis of activity of Eurocities [25].

European territorial cooperation has revealed a considerable mobilisation of the potential of the cities where it has been implemented [26]. Their regular integration into national, regional and local development strategies is associated with the convergence between functional regions and local development, where cities apply integrated multi-level governance approaches, involving local and regional authorities, strategic sectors and social groups [27]. The deployment of new strategic spatial planning documents (such as the EU Urban Agenda) also contributes to reaffirming borders as laboratories for European integration, and it rethinks the spatiality of spatial planning and territoriality to which the EU aspires, from the concepts of soft planning and soft spaces [28, 29]. The dimension of governance in terms of place-based policies means that the object is the territory, and that the objective is to regulate, govern and manage territorial dynamics by piloting a multiplicity of actors [6, 30]. It also implies that these 'soft' spaces, sometimes with 'fuzzy boundaries' are understood as units endowed with a certain degree of deliberate strategic capacity on the basis of certain political and organisational arrangements [28, 31]. This notion should take the form of local action groups representing the community, which can then take charge of preparing and implementing local development strategies, and defining geographical areas of intervention – in short, fostering the integration of the three key elements of CLLD: space, partnership and strategy [32]. This is the basis on which the applied CLLD cross-border urban framework is built.

In this context, the EU Urban Agenda emerges as a tool that breaks with the rigidities associated with formal scales and normative plans. In this respect, it improves the understanding of how EU spatial planning finds its way into national planning systems through cooperation and mutual learning [10, 12]. Governance thus becomes one of the main determinants of territorial development [33], with the capacity to mobilise endogenous potential in a new framework of social and political relations [34]. Its link with the territory can be explained insofar as it is built-in governance with two-way feedback.

The constructive project of cross-border territory (see Fig. 1) requires the implementation of an evolutionary process that encompasses the three dimensions of 'cross-borderisation': space (scales and articulation), actors (governance institutions) and cross-border representations (identities and discourses) [20, 22]. The project makes it possible to observe the interaction of these dimensions, which actively contribute to the processes of structuring, appropriation and institutionalisation existing in the cross-border region. The proposed scheme provides a strategic, innovative and shared socio-territorial vision, an expression of the collective will to build new scales of territorial organisation, create new projects and consolidate new institutions.

The theoretical approach provides an interpretative framework for Eurocities, with socio-institutional processes and territorial units built on governance. It derives from the new regional geography approach, which incorporates the debate on soft spaces [13, 19, 21]. The approach connects with the concept of the functional region, and with keywords such as networks, corridors, flows, relational spaces, etc. It also brings to the fore strategic planning and provides spatial planning with a powerful tool. Moreover, the approach combines Evolutionary Governance Theory (EGT) with the strategic framework of the CLLD-Urban Agenda. EGT understands governance as a continuous, changing and therefore evolutionary process of interaction between its constituent elements (actors, identities, institutions, knowledge, materialities and strategic interests) [35]. In spatio-temporal terms, the EGT approach suggests that territory and governance are co-dependent [36]. In turn, in local development, EGT recognises that the spatial configuration and its new forms of planning and governance could be defined in an intentionally open-ended way, in the sense that they can be modified and (re)designed to reflect different interests and challenges.

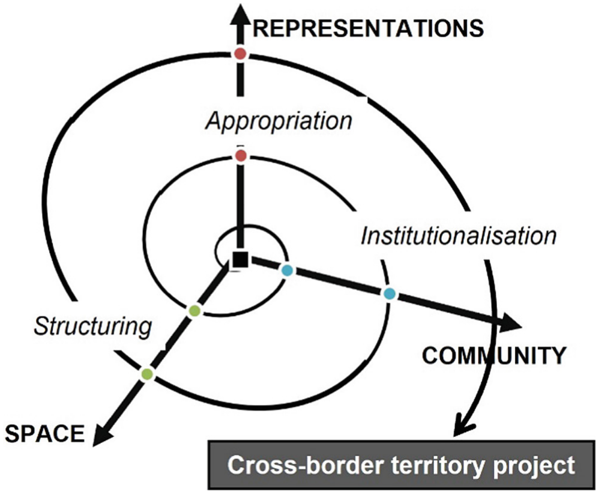

Fig. 1. Dimensions of 'cross-borderisation' over time. (Authors' own work).

3 Methodological Considerations and Area of Action

Two methods of data collection were adopted. Firstly, a detailed analysis of the documentation related to the framework of the 2030 Agenda, Urban Agenda and INTERREG VA programme (EU legal texts, operational programmes, strategic area plans, reports, projects and website information) was carried out. Secondly, semi-structured interviews and workshops were carried out with those responsible for the coordination of the EGTC, and with the beneficiaries of the EuroGuadiana 2020 project funds.

The methodological work was developed in three phases:

1. Analysis of the background to the implementation of the Eurocity of Guadiana, the selection of objectives and the establishment of the areas of intervention.
2. Analysis of the pre-planning phase carried out by the EGTC: to detect the obstacles to cooperation, to shape the inclusive partnership and to design the local development strategy.
3. Evaluation of the role of the Cross-Border Guadiana Observatory (OTG) within the EGTC's organisational scheme, as well as in its capacity for adaptation within the framework of local governance. In particular, an analysis of the adoption of the priority themes of the Urban Agenda, based on the participation in discussion groups within the framework of the territorial diagnosis debate.

To assess the cross-border construction process, the methodology followed was that developed by Perkmann (2007) in relation to the EUREGIO cross-border region [22].

In the Iberian border section of the *Bajo/Baixo Guadiana*, between the autonomous community of Andalusia and Portugal, cross-border spaces of variable geometry are overlapped. The Eurocity of Guadiana (see Fig. 2), established in 2013 and converted into EGTC in 2018, has coexisted since 2010 with the Euroregion Alentejo-Algarve-Andalusia (EUROAAA), after several generations of INTERREG cooperation projects.

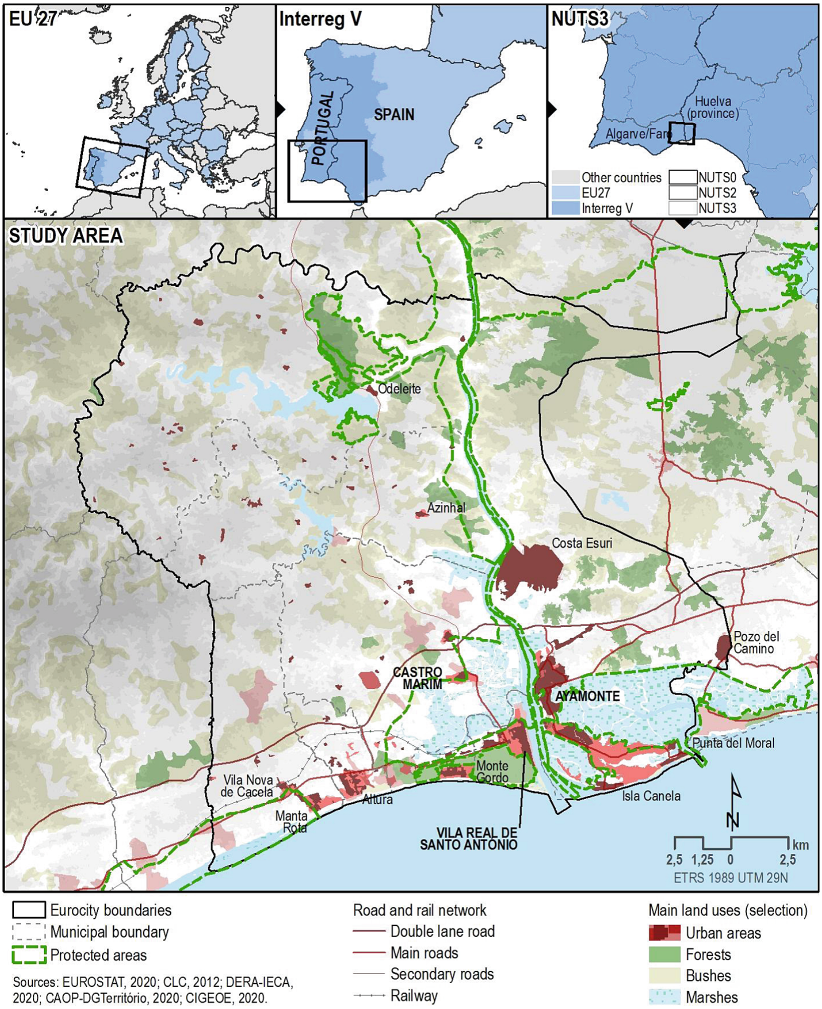

Fig. 2. Eurocity of Guadiana in its territorial context. (Authors' own work).

The Eurocity of Guadiana is made up of the municipalities of Ayamonte, Castro Marim and Vila Real de Santo António, totalling about 46,000 inhabitants in almost 505 km^2 (90 inhabitants/km^2), and including 26 linear kilometres of border. The three main urban centres, named after their municipalities, are home to more than 31,000 people, but there are other secondary centres with between 2 and 4,000 inhabitants each (Altura, Vila Nova de Cacela and Monte Gordo, all on the coast).

The main economic activities pertain to the service sector – urban commerce and coastal tourism – and to the primary sector – irrigated agriculture and a globalised agri-food system – together with marine aquaculture and the persistence of once flourishing small-scale fisheries and their associated canning industry [37]. Its spatial evolution as a functional corridor linking the urban centres received a definitive boost in 1991 with the international bridge over the Guadiana River. This remains the only land connection and has favoured the extension of the corridor across Andalusia and the Algarve to connect the cities of Huelva and Faro, and ultimately integrate it into the Seville-Lisbon axis. While the border appears unfocused in the immense territory of the EUROAAA (larger and more populated than mainland Portugal), the Eurocity of Guadiana is undoubtedly the cross-border entity with the greatest legitimacy among the border municipalities to carry out sustainable and participatory local development strategies [24]. At present, the Eurocity is preparing the documentation for the Urban Agenda within the framework of the INTERREG VA 'EuroGuadiana 2020' project, financed with an ERDF contribution of 805,496.25 € (1,073,995 € in total).

4 Cross-Border Local Area Development Scheme in the Eurocity of Guadiana

4.1 The Framework and Political Mobilisation

The Eurocity of Guadiana project has been built on very evident socio-territorial foundations, as a territorial unit aligned with urban approach, even for places that do not usually fit easily into urban policies (rural spaces or intermediate and small cities). Geographical factors, such as the Guadiana River and its essential role in the processes of territorial appropriation, alongside structuring, historical, cultural, and economic factors, as well as the landscape heritage, together represent solid constructive resources on which to build the Eurocity as a space capable of leading a CLLD strategy. To address its management, three fundamental framework components were necessary: (i) to organise a system of actors and a formal institution close to the needs of the cross-border space; (ii) to have a management tool, such as the cross-border Urban Agenda, inserted in the INTERREG EuroGuadiana 2020 project (2019), in which the Urban Agenda is inserted; and (iii) to delimit the spatial scope of the intervention, made up of the EGTC partner municipalities.

An initial territorial framework was established including the twin towns of Ayamonte (Spain) and Vila Real de Santo António (Portugal). Months later, also in 2013, the agreement incorporating the third municipality, Castro Marim (Portugal), which provided the purely rural component, was signed. Political mobilisation took place through the creation of a collective action of local authorities on both sides of the border of the Guadiana estuary. The initial interest was to create a cross-border cooperation structure that would harness the joint power of these authorities with the intention of attracting resources to the area. This met with the approval of the higher authorities (regional governments of Andalusia and Algarve – *Comissão de Coordenação e Desenvolvimento Regional*) and the EUROAAA. With the reinforcement of CLLD in the Regional Policy and the increasingly important role of local actors, the political partnership was mobilised to create (and try to maintain) a governance structure that would address the cross-border space as a new unit of intervention. For the time being, the actors-partners of the Eurocity are exclusively the local authorities, with little participation or interest from other collectives in the territory.

4.2 The Construction of Governance

Until its conversion into an EGTC, the activity of the *Eurociudad del Guadiana* focused on the tutelage of local initiatives in the cultural, sporting, and educational fields. The previous experience in INTERREG projects by the Eurocity partners, and the successful application of the ongoing project ‘Laboratory of Cross-Border Governance: EuroGuadiana 2020’, aligned with the general discourse of the Regional Policy, welcoming the bottom-up participatory process as a reference for action. The CLLD takes the form of an Urban Agenda, with the political commitment of the EGTC, and with the aim of building an inclusive and integrative governance process. It is the first Iberian cross-border local initiative of the Urban Agenda.

EuroGuadiana 2020 activities in the field of tourism and sustainable mobility are framed in the coordination space with the Urban Agenda. The constitution of the Cross-Border Guadiana Observatory (OTG) will mark the main milestone in the renewed governance of the Eurocity, playing a decisive role as network mediator, project animator and knowledge carrier. Both the local cross-border partnership and the higher-level network (EC, regional governments, and intermediate authorities) are highly interdependent, especially in terms of financial resources and organised projects. Thus, the governance aspect of the Eurocity, with the design of the Urban Agenda as a spatial planning document and its action plans, highlights the multi-level dimension of the strategy. The Eurocity of Guadiana meant constituting a ‘grassroots’ agency operating on a ‘grey’ governance and planning scale. This implies maintaining the relationship between ‘soft spaces’ and ‘hard spaces’, raised earlier as a planning paradox. This also allows us to reflect on its role in the reconfiguration of dominant territorial imaginaries, institutions, and the emergence of cross-border collective identities, in an attempt to move away from state-centred ‘metageographies’ [27, 28].

4.3 Strategic Unification in the Eurocity of Guadiana

The constitution of the system of actors based on thematic partnerships, the organisational foundation of the governance process, was created on the basis of participation in *ad hoc* workshops/focus groups and roundtables within the framework of discussion of the territorial diagnosis prior to the design of the local strategy. The questions of what problems affect us, what problems we can solve together and how to draw up the main strategic lines of the planning document provided the basis for proposing the priority themes of the Urban Agenda action plans (see Fig. 3). This participatory phase (territorial diagnosis and Urban Agenda guidelines) is the basis of the organisational mechanisms of the Cross-Border Guadiana Observatory (OTG), whose general mission is to favour the participatory process of analysis and continuous monitoring of the plans and projects that the Eurocity implements in the context of the Urban Agenda.

The strategic unification is inspired by a shared vision of development, based on a cross-border functional construction. The Eurocity of Guadiana EGTC was conceived of as a tool-object of intervention through development approaches already put to use in the Leader programme. The elaboration of the Urban Agenda is being recognised as a key factor for the stability of the EGTC. In a way, the Urban Agenda strategy reinforces not only the administrative level, but also the symbolic level, as a representation of a socially

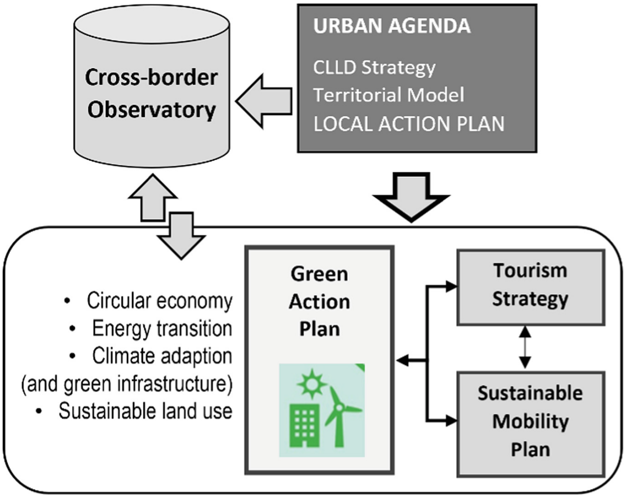

Fig. 3. Governance scheme of the Eurocity of Guadiana based on the Urban Agenda. (Authors' own work).

constructed space. Indeed, spaces are constructed by associating human meanings with real or imagined places [38].

Table 1. Evolutionary scheme of the Eurocity of Guadiana (2013–2021). (Authors' own work, based on Perkmann, 2007).

Stage	*Property*	*Feature*
1. Political mobilisation	Administrative	EGTC (2018)
2. Governance building	Stakeholder policy network	Cross-Border Observatory of Guadiana (OTG) (2021)
3. Strategic unification	Cross-border functional space	Urban Agenda: Actions Plans (2022-)

The Participatory Focus Group Process. Three participation workshops have been held up to now, convened through the OTG. Each of these focus groups was held in one of the main urban centres of the Eurocity (municipal capitals), addressing a total of 6 main themes (roundtables): culture and heritage (1), productive sectors (2), demographic challenge (3), environment (urban and territorial sustainability: green infrastructure, energy transition, climate adaptation and sustainable uses) (4), mobility in the Eurocity (5) and governance and shared services (6).

The procedure proposed was clearly propositional. Non-directed workshops (but guided and moderated by the technical team), based on the methodology established in the Strategic Design workshops of the former Helsinki Design Lab (HDL Studio Model), based on 'people, problem and place' [39], an approach with many points in common with community-based participation placemaking (Jane Jacobs, William H. Whyte), and even with the PPP Negotiation Model (problem, people and process) from the business world.

The sequence was as follows: first, all participants contributed their ideas for the diagnosis (challenges or key elements) at the thematic working tables, to be added to the debate. All these elements were subsequently prioritised, as each focus group participant was able to vote on which elements are considered to be the highest and which the lowest priorities. Secondly, specific proposals (projects, tasks) to address the problems identified were discussed, focusing the debate on realistic and feasible strategic solutions (Eurocity's framework of competence), and to take into account the complexity of the problem in a scenario of environmental, economic and social sustainability. Participants were also asked to express briefly what their expectations of the Eurocity are and what the Eurocity means for them (see Fig. 3). Finally, the third activity worked on two large maps to locate areas or spaces of opportunity/strengths or territorial vulnerabilities.

Preliminary Results (Advance). The results obtained are currently being processed, and the results of other participatory activities developed by the OTG (sustainable tourism strategy and sustainable mobility plan) are awaiting incorporation.

New Elements of the Diagnosis. The strategic plan pre-diagnosis has been clearly enriched with 79 new elements, while the hierarchy also gives us clear clues as to the issues that are key for the community.

Culture and heritage are already one of the key pillars of the EGTC's own activity (which has so far been focused especially on the development of cultural, sporting and recreational activities), but clearly, they also deserve special attention in civil society. Thus, identity and territory (natural, ethnological and historical-artistic heritage) has been the area where most ideas and new diagnostic elements have emerged, as well as the demand for new activities and events. The importance given to the Guadiana river as the backbone of the Eurocity was also highlighted in several round tables regardless of its central theme. Another element that stood out during this process was a "general lack of knowledge of the geographical structure of the Eurocity", and, also in relation to this, the need to improve communication, dissemination and communication of the activities already being carried out in the area, but also the need to create and/or strengthen networks and to establish alliances between different sectors, essential to create synergies.

Sustainable mobility is the area in which a greater number of new diagnostic elements were incorporated. This topic was present in almost all the working groups, pointing out its horizontal nature, but also because it is one of the aspects in which the Eurocity is clearly deficient (there is only a land connection limited to the traditional vehicle and scarce public transport offer). For example, in the roundtable on demographic challenge, three of the most voted elements deal with mobility. At the environmental roundtable, sustainable mobility together with the demand for urban greening were the main topics, followed by elements linked to the lack of control over environmentally damaging activities and several aspects linked to adaptation to climate change, many of them also linked with mobility and/or greening aspects.

In terms of governance and cooperation, the asymmetries between the administrations on either side, especially in the management of common or border areas (natural areas, river) were clearly identified as key elements, together with the need to strengthen multilevel strategies and fund-raising, and secondly, the need to incorporate the cross-border reality at all levels of planning and to increase citizen participation in decision-making processes.

Identity and Representations About the Eurocity. Without claiming that the identity and expectations of the Eurocity reflected by the participants in the focus groups are representative of the general feeling (the bias is evident from the mere fact that these are people who are participating in the process), the truth is that the ideas expressed offer interesting conclusions (see Fig. 4). The Eurocity is seen by citizens as a common project, but above all as an opportunity for the future with a marked identity accent strongly linked to their territory. Expectations are equally high, very focused on making the most of the territory's potential through cooperation, transparency (information, integration, cohesion) and citizen participation.

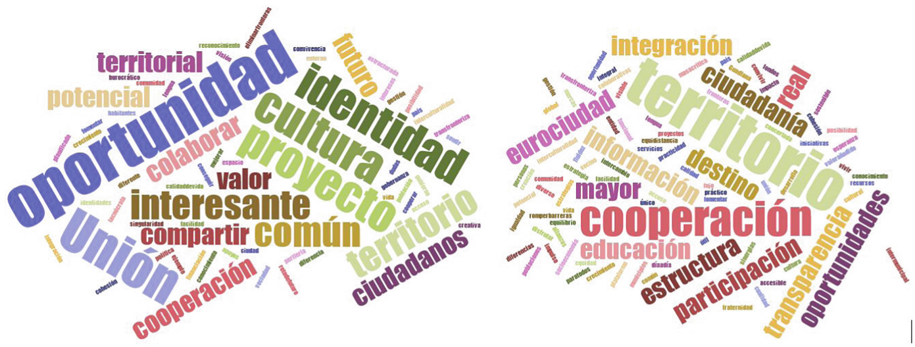

Fig. 4. Wordclouds generated from participants' answers on "What is the Eurocity for you" (left) and "What are your expectations of the Eurocity" (right). (Authors' own work).

Territorialising the Problem. The participants had also to point out on the Eurocity map those places and elements that they consider important or where there are impacts to be taken into account. However, the main conclusion obtained is the wide lack of knowledge that the population of the territory encompassed by the EGTC has (something that, on the other hand, was already pointed out in the participatory diagnosis.). Practically all the items and spaces indicated on the maps are limited to urban areas and their surroundings, and it is also clear that the residents of each town hardly indicate spaces outside the towns they live in (not only of the other two municipalities, but even of their own).

In any case, it remains to enrich these maps with the joint work of the technical drafting team of the Urban Agenda and the municipal technicians, with whom we hope to create a series of thematic'heat maps' with which to represent the entire territory.

Citizens' Proposals. A total of 49 proposals or projects that the Eurocity should undertake or promote were collected. Among the issues that stand out (see Fig. 5) are those linked to the improvement of governance and common management (especially in natural areas, cultural activities and transport). The second most repeated theme is mobility. It is very remarkable that half of the proposals in this field were not proposed in the focus group specifically dedicated to mobility in the Eurocity. For example, in the workshop on the demographic challenge, three of the four specific proposals revolve around this theme, as do three of the six proposals in the specific focus group on the environment. Also noteworthy were the numerous proposals relating to the enhancement of heritage and cultural activities, one of the fields that generated the greatest participation. Likewise, surprising was the large number of proposals linked to the need to improve communication and information, a theme that emerged also in practically all the working groups.

Other issues with special weight in the proposals are those linked to the productive system, education and training, protected natural spaces and the navigability of the Guadiana river, an element whose paradoxical role as a physical border, landscape resource and nexus of union and identity of the three municipalities of the Eurocity is highlighted.

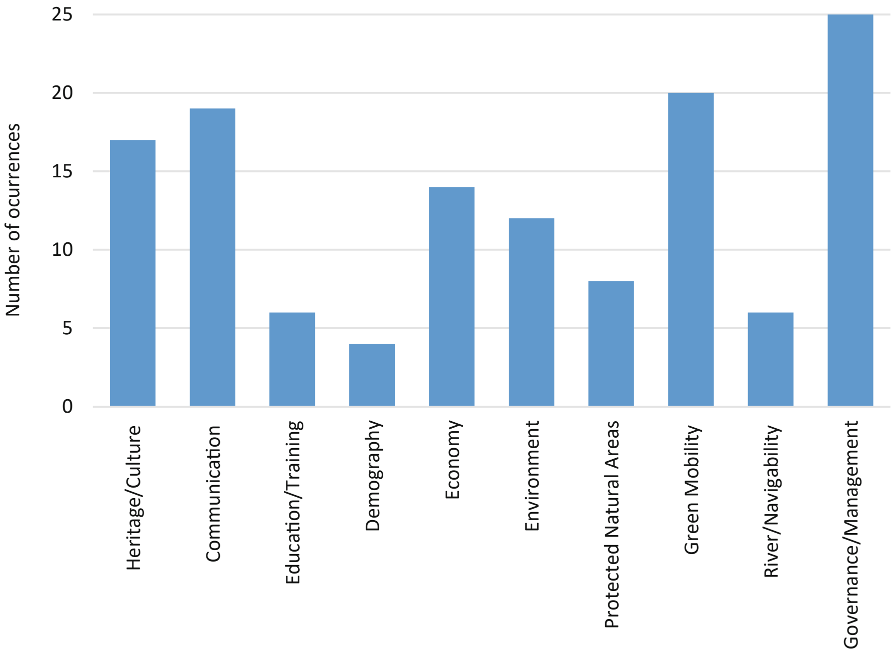

Fig. 5. Fields of action directly affected by the 49 proposals of workshop participants. (Authors' own work).

5 Discussion and Conclusion

An in-depth assessment of the strengths and weaknesses of the CLLD-Urban Agenda-Eurocity equation cannot yet be made. It is too early to calculate the added value in terms of governance at local level, to determine the effectiveness and durability of the partnerships planned in the Cross-Border Guadiana Observatory aimed at generating synergies between actors in the territory, or to measure the degree of complementarity with other local development initiatives coming from other local action groups (LAGs, FLAGs). Nevertheless, the current Eurocity of Guadiana is a projected entity in the organisational structuring phase that is making progress in local ‘cross-border thinking’, in the open dialogue on territorial development at the borders of Europe, and in its planning and governance strategies (see Table 1).

In this sense, the Eurocity is a radically evolving constructive project that translates the three dimensions of ‘cross-borderisation’ and its associated processes of structuring, appropriation and institutionalisation. Firstly, it does so on the basis of the spatial relations of the Eurocity of the Guadiana, as a new geographical object, delimited by local political agreement and EU support. The Eurocity is articulated in the (pre)existence of a cross-border ‘micro-network’ or of socio-economic mechanisms and processes and of certain horizons of action and change that translate the multiplicity of scales and the complexity of the interactions that take place in the *Bajo Guadiana.* Secondly, the shaping of the Eurocity may be mobilising cross-border identities and consolidating new representations, discourses and renewed imaginaries around which social support for the projects and the legitimacy to consolidate new agreements and institutions, such as the EGTC itself and the Cross-border Observatory, are being obtained. There is therefore the option of redefining the Eurocity and applying the CLLD management scheme of the Urban Agenda on the basis of a radical recombination of resources, materialities and identities, realised through services and products (territorial marketing, tourism, cultural agenda, mobility, etc.), and institutions (governance scheme on common competence agreements by the three local authorities of the Eurocity). Finally, the Eurocity is a territorial process that is intensifying cross-border interaction, the effects of which must be considered in terms of governance, the forms and formulae that it adopts and applies, and the changes and transitions that it promotes. The stages detected in such a short time reflect the will of the local authorities and the most active actors, but also demonstrate the co-dependence between territory and governance.

The Eurocity plans are proving that they can provide important lessons for the future in achieving a sustainable approach to territorial development. Our case study analysis has found that the implementation of the CLLD framework is serving to reinforce synergies between actors in the environmental management sectors with those in the productive sector (aquaculture-fisheries, tourism, trade), taking advantage of the heritage as a resource. In this way, the border provides cities and communities with an identity, as well as strengthening the economy. In summary, the focus groups raised the following key lines and issues in this regard:

- Adopt the resource of cross-border territorial identity through communication and information dissemination mechanisms about the Eurocity, or the continuation of purely participatory activities, based on extensive previous experience in the cultural, sporting and recreational fields.

- Reinforce or extend the connectivity and accessibility of the Eurocity territory to channel latent and potential flows and mobility, and structure the resources of the physical and human space with sustainable land uses and priority productive activities, such as tourism and trade, as well as other Nature-Based activities and solutions.

- To promote the strategic unification of the Eurocity through the implementation of the cross-border urban governance scheme (Cross-border Observatory and Urban Agenda), a strong spatial strategy and a joint and orderly planning between the 3 component municipalities. To boost action plans aimed at solving problems and challenges, it is necessary to develop thematic partnerships linked to tourism and cultural heritage, sustainable mobility and to ensure that changes in urban areas and in the territory of the Eurocity of Guadiana produce green, compact, resilient and energy efficient cities.

But this work also aims to highlight aspects to be improved and uncertainties to be resolved in the next ERDF programming period 2021–2027. These aspects are related to guaranteeing the role of the Eurocity as an agent of local development in the face of the interests of the political and economic powers. In this regard, the Eurocity of Guadiana must play a leading role in the design of its areas of intervention, in order to move from being project-based regions to functional and coherent areas, in which the local population becomes the promoter of participatory development processes. Naturally, it must face the challenge of the 'planning paradox', in which strategic planning, which must think in terms of open borders, must at the same time coexist with urban and territorial planning confined by regulatory frameworks and political units delimited by borders. The Eurocity of Guadiana should seek to draw attention to spatial planning, cooperation in horizontal and comprehensive strategies linked to the intrinsic values of the border, and the development of socio-territorial capital based on specific local skills, knowledge and resources that may not be easily replicable.

The main challenge for the Regional Policy on urban development is to create and maintain an integrated approach to the different dimensions of urban life (environmental, economic, social and cultural), promoting stakeholder participation and partnership, and ensuring that changes in urban areas (growth or regeneration) are environmentally friendly, improving the quality of life. The sustainable development of a cross-border region cannot be achieved without the promotion of critical factors in the organisational areas of the EGTC (actors, instruments and governance processes), or the cross-border representations (identities and discourses), such as the promotion of connectivity and achieving a city-city and urban-rural territorial balance, the design of a solid territorial strategy, the guarantee an offer of common services and facilities based on *Eurocitizenship*, the improvement of access to European funds, the promoting of public participation alongside Eurocity geomarketing.

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Monitoring Urban Planning Actions for Reducing Crime Risk Vulnerability

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Abstract. The topic of urban security has become highly relevant in the urban agendas of cities and metropolitan areas. One of the main requirements for well-functioning cities and their sustainability is that they have secure streets and public spaces as confirmed by the Sustainable Development Goals (SDGs) of the 2030 Agenda, in particular SDG 11 [1]. The proposed research addresses the issue through a quantitative model of crime risk mapping. More precisely, crime risk is linked to three risk factor-maps: crime hazard (H_c), crime vulnerability (V_c), crime exposure (E_c) and described through a spatially explicit *composite crime risk index*, IR_c [2, 3]. In this work the attention is focused on crime vulnerability risk factor and on the possibility to reduce its critical levels by defining and monitoring of specific urban planning actions, to be introduced in the municipal urban Plan.

Keywords: crime risk vulnerability · parametric model · urban planning

1 Introduction

The topic of urban security has become highly relevant in the urban agendas of cities and metropolitan areas. One of the main requirements for well-functioning cities and their sustainability is that they have secure streets and public spaces [4, 5] as confirmed by the *Sustainable Development Goals* (SDGs) of the 2030 Agenda, in particular SDG 11 – *Make cities and human settlements inclusive, safe, resilient and sustainable* and target 11.7 – *Access to safe and inclusive public space* [1].

Although security is recognised as a fundamental human right, it is a resource as essential as it is rare and, for this reason, must be pursued and protected. The daily occurrence of predatory crimes – assaults, thefts, robberies, muggings, pickpocketing and other violent acts – or episodes of incivility – environmental and social – leads to an increase in insecurity, both real and perceived by citizens, and fear of crime [6, 7]. Very often insecurity is associated with fear of those who are different. This situation leads to negatively labeling entire social groups and parts of city generating a closure to the outside world, either out of defense or spatial claim. Widespread fear becomes a real social problem with actual and measurable impacts on the city' s functioning and the economy of the whole urban structure.

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The achievement of security conditions can only be realized through good governance, planning and urban management, based on an integrated approach [8]. This is confirmed by the contents of the United Nations *Guidelines for the Prevention of Crime* [9] and as witnessed by some important International and European initiatives such as the now completed United Nations *Safer Cities Programme* [10], the *COST Action TU1203 – Crime Prevention through Urban Design & Planning* (CP-UDP), the European project *Cutting Crime Impact* (CCI), the establishment in 2019 of the *Security in public spaces* partnership of the Urban Agenda for the European Union [11].

«Since ancient times, the need for personal security has conditioned the way cities are built. Ditches have been dug, walls erected, in an attempt to physically separate the city with its citizens from the outside world, identified as a source of danger and threats to urban life. The difference from the past is that in the modern and postmodern city, danger is no longer outside. Security threats are inside the city» [12], p. 124]. This calls for a review of how this issue has been, and is being, addressed.

Both internationally and nationally, for a long time the problem of urban crime was addressed only through two approaches: *traditional* (law and order) and *social*. Since the second half of the last century, a third approach has been introduced: the *environmental approach.* This one is known internationally as *Crime Prevention Through Environmental Design* (CPTED) and is the field of action of urban planning on the issue. CPTED is a preventive practice whose attention is focused on the urban environment and on its potential to hinder illegal behavior and transmit confidence to population. This approach, initially only focused on the physical characteristics of spaces and safeguarding of the most vulnerable areas, has been enriched with new elements over time, opening up to the problem's social dimension as well. In fact, it's possible to identify three generations of this one [2]. Since its usefulness was formally recognized in 2001 in Sweden at the T*owards a knowledge-based strategy to prevent crime conference*, its basic principles have inspired the creation of standards and technical reports. These include the CEN/TR 14383-2: 2007 – *Part 2*, and the now international standard: ISO 22341:2021.

Unlike in the past, when these approaches were considered alternatives to each other, there is now recognition of the importance of integrating them in order to achieve concrete and lasting results. It is clear that the objective of making the city safer cannot be pursued exclusively through repressive or control actions or sporadic social interventions. The exclusive use of such actions, the overconfidence placed in them and the political exploitation of the problem only further increase the feeling of insecurity. The importance of urban security requires a change of perspective and more careful reflection, aimed at responding concretely to citizens' growing demand for security. This need is, today more than ever, indispensable, also in combination with the need for a rethinking of the traditional paradigms of urbanism, by virtue of adapting them to the needs of social distancing imposed by the recent, and still not overcome, Covid-19 pandemic [13]. The problem of urban crime is linked to the city' s physical and functional structure and its functioning. So, it is necessary to address the problem through an integrated approach in which socio-economic actions work together with physical and functional interventions in the built environment, in accordance with the environmental crime prevention strategies [2, 14–17].

The issue's complexity requires a systematic action on the territory which, from an urban planning point of view, should result in the introduction of explicit guidelines for crime risk prevention in the municipal urban Plan.

This article explores an ongoing research study in which the topic of urban security is addressed in terms of risk. More precisely, crime risk is linked to three risk factor-maps: crime hazard (H_c), crime vulnerability (V_c), crime exposure (E_c) and described through a spatially explicit *composite crime risk index*, IR_c [2, 3]. In this work the attention is focused on V_c and on the possibility to reduce its critical levels by defining and monitoring of specific urban planning actions to be introduced in the municipal urban Plan.

2 Materials and Methods

2.1 Disaster Risk

Disaster risk represents the likelihood that a given physical phenomenon will produce human or property loss or economic damage by investing with a given intensity, and in a given interval of time, a territory with a specific level of vulnerability. It is the product of three risk factors: hazard (H), vulnerability (V) and exposure (E). The risk fundamental equation is as follows:

$$R = H \times V \times E = H \times D \tag{1}$$

in which D represents the potential impact and is obtained as a product of V and E.

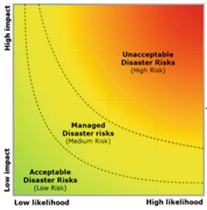
The risk analysis process and the results representation are linked to the analysis aim, the availability of data and the way in which uncertainties are managed. The European Commission recommends five types of analysis [18, 19]:

- qualitative,
- semi-quantitative,
- semi-quantitative based on composite indicators methodology,
- quantitative deterministic,
- quantitative probabilistic.

Among this, in the semi-quantitative approach based on composite indicators methodology the analysis results are represented by using risk matrices and risk maps. The risk matrices, in particular, allow to compare risks linked to different hazards with specific likelihood [19] and represent effective tools to define the risk acceptability (Fig. 1a). These are two-dimensional tables that combine event likelihood (H) and impact (D) and can be set up symmetrical or weighted (Fig. 1b) [18].

In health and social risk assessment, reference is made to five risk classes [20]: very low risk (R1), low risk (R2), moderate risk (R3), high risk (R4), very high risk (R5). These are constructed through the risk matrix and are linked to the five intensity levels that can be assigned to each variable on which the risk is dependent.

The assignment of the five risk classes to the analysis results exploits the matrix obtained from the combination of H and D. The intensity levels associated with the two factors are combined in the matrix cells according to the logical Boolean operator AND



(a)

Risk classes		Hazard Classes				
		H1	H2	H3	H4	H5
Impact classes	D1	11	12	13	14	15
	D2	21	22	23	24	25
	D3	31	32	33	34	35
	D4	41	42	43	44	45
	D5	51	52	53	54	55

(b)

Risk classes R1,R2,R3,R4,R5		Hazard Classes				
		H1	H2	H3	H4	H5
Impact classes	D1	R1	R2	R2	R3	R3
	D2	R2	R2	R3	R3	R3
	D3	R2	R3	R3	R4	R4
	D4	R3	R3	R4	R4	R5
	D5	R3	R4	R4	R5	R5

(c)

Fig. 1. RM method: a) Risk matrix template. Source: [19]; b, c) Matrix for risk-ranking in five classes (R1, R2, R3, R4, R5). Source: Authors' Elaboration.

and identify a specific intensity class of the phenomenon under study. For example, in the cell 11 are combined hazard map's intensity level 1 and impact map's intensity level 1. This combination is symbolically referred as 11 and correspond to R1 risk class (Fig. 1c). The method just described is identified in following as *RM (Risk Matrix) method*.

2.2 Spatial Analysis Techniques

2.2.1 Kernel Density Estimation

Kernel Density Estimation (KDE) is a spatial analysis technique which allows to estimate the intensity variation of a given phenomenon in the study area. It is part of Point Pattern Analysis. Starting from a point pattern, KDE associates a density value to each point p of space and then calculates the number of events contained within a given region of the space (kernel). The last is centered at the estimation point. The density at point L is measured by using the following expression [21, 22]:

$$\lambda(L) = \sum\nolimits_{i=1}^{n} \frac{1}{\tau^2} k\left(\frac{L - L_i}{\tau}\right) \tag{2}$$

in which:

- $\lambda(L)$ = estimated density at point L,
- L_i = generic event,
- $k(\ldots)$ = kernel which is defined by a probability density function [3, 21–23],
- τ = bandwidth.

The analysis result is influenced by the type of distribution, the bandwidth and the width of reference grid cell used to estimate the density values.

2.2.2 Space Syntax Analysis

Space Syntax Analysis (SSA) allows to measure accessibility of urban space by considering the spatial organization of cities as a factor affecting the pedestrian movement within it. The configurational approach considers the visual perspective connecting two points as the unit of measurement and a guide of movement within the urban grid. This one can be modeled in different ways based on the specific operational technique chosen: Linear Analysis (LA), which is divided into Axial Analysis [24], Angular Analysis and Angular Segment Analysis [25], Fragment Angular Analysis [26]; Visibility Graph Analysis (VGA), which can be normal or angular [27]; Mark Point Parameter Analysis (MaPPA) [28].

The Angular Segment Analysis (ASA) considers as basic element the *segments* obtained by splitting *axial lines* [24] at their intersection points. Starting from the *segment map*, this operational technique identifies the shortest route in a specific trip [25] by evaluating the sum of the rotation angles from the starter segment to any other within the system.

Among the configurational parameters, the most important is the integration index [29–31]. The last is specific for each segment and identifies the value of mean depth of this one in relation to all others in the segment map. It is associated with *to movement* [30]. A space is integrated if its depth is low, on the contrary it is segregated in correspondence of high depth values. The equation to evaluate the length-weighted mean angular depth of the segments ($C_{\Theta}{}^{1}$) is as follows [25]:

$$C_{\theta}^{l}(x) = \frac{\sum_{i=1}^{n} d(x, i) l(i)}{\sum_{i=1}^{n} l(i)}. \tag{3}$$

in which:

- C_{θ}^{l} = weighted mean angular depth,
- n = number of x segments in the graph,
- d_{Θ} = total angular depth,
- l = length of the x segment.

Another important configurational measure is the betweenness (or choice) index, which represents *through movement* [30]. It evaluates the potential of a given segment to be chosen as a route by or to all other segments during the travel within the urban grid. The high potential is associated to high values of the index. The equation to evaluate the weighted angular choice ($B_{\Theta}{}^{1}$) is as follows [25]:

$$B_{\theta}^{l}(x) = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma^{l}(i, x, j) \text{ such that } i \neq j \tag{4}$$

in which:

- B_{θ}^{1} = weighted angular choice,
- n = number of i, x, j segments in the graph,
- l = length of the x (i or j) segment.

Finally, connectivity identifies the number of segments directly accessible starting from the examined one. It represents the number of perspective openings of each segment to other convex spaces and its availability of movement to other segments [2].

3 Methodology

In the research mentioned above, crime risk is modelled according to the European Commission's recommendations on risk assessment and mapping and, more precisely, follows a semi-quantitative approach based on composite indices [18–20].

The IR_c index is structured according to the territorial risk paradigm and spatialized in a crime risk map [2, 3]. It combines the main aspects that contribute to the characterisation of risk scenarios through three risk factor-maps (H_c, V_c, E_c), described by appropriate spatial indicators (Fig. 2), as follow:

$$IR_c = H_c x V_c x E_c = H_c x D_c \tag{5}$$

in which D_c represents the crime impact obtained by combining the two factor-maps: V_c and E_c. The IR_c spatialization is performed by implementing density, proximity and spatial configuration analyses and through the use of appropriate map algebra operations. In detail the techniques and the operations used are respectively: KDE [22], Euclidean Distance (ED) function [32], LA [24], classification and overlay mapping between raster [33]. The crime risk map is structured in five risk classes: very low risk (R1), low risk (R2), moderate risk (R3), high risk (R4), very high risk (R5) [2, 3] which are assigned by using the RM method mentioned above (Sect. 2).

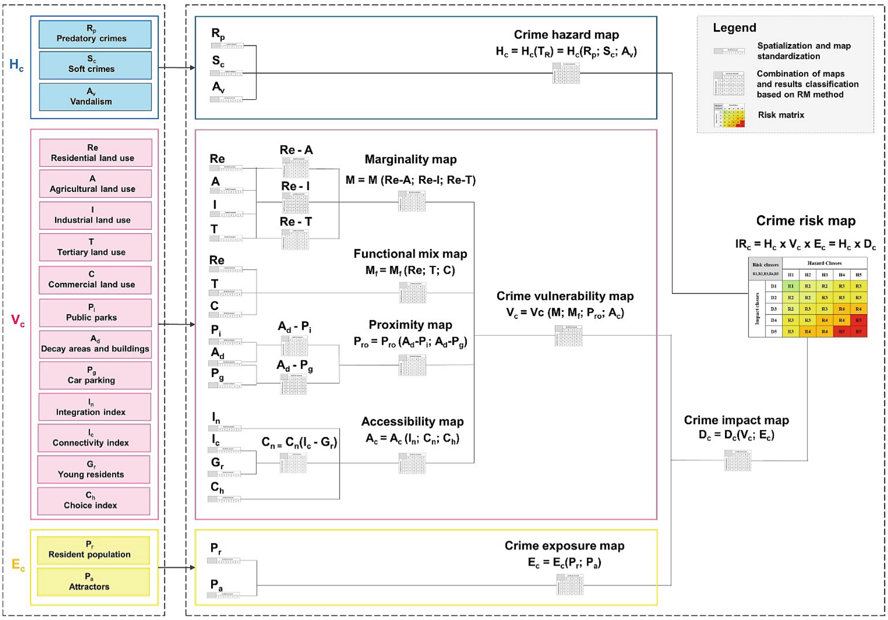


Fig. 2. Methodological scheme of crime risk map construction. Source: Authors' elaboration.

The approach used considers risk as a convolution of the three mentioned factor-maps and is based on the assumption that it can be reduced or eliminated when at least one of them is reduced or eliminated. Therefore, it is possible to examine each risk factor-map separately in order to outline the most suitable strategies to reduce its critical conditions and, consequently, reduce crime risk.

This study focuses in particular on V_c, in relation to which urban planning has full control. In the research, crime vulnerability is described as the ability of urban space – understood in terms of its physical and functional layout – to discourage or favour the occurrence of opportunity crimes. V_c is constructed as a combination of four spatial indicators: marginality (M), functional mix (M_f), proximity to decayed areas and buildings (P_{ro}) and accessibility (A_c), each of which is a function of specific parameters [2, 3]. Among these, M and P_{ro} were selected as baseline variables of V_c because the most marginal areas of city and the decay of areas and/or buildings are linked to a greater tendency to attract micro-criminality and incivility [14–16]. Therefore, both are considered directly proportional to vulnerability. M_f and A_c were selected as physical-functional characteristics through which it is possible to influence informal surveillance of spaces. In particular, the former is associated with more *eyes on the street* [5] as, if correctly calibrated, it can generate more vitality and continuous use of space. The second is a necessary condition, together with intervisibility and permeability, to ensure that spaces can be read and easily crossed by residents and non-residents alike [29–31]. For these reasons, both variables are considered inversely proportional to vulnerability.

V_c is structured in five classes: very low vulnerability (V1), low vulnerability (V2), medium vulnerability (V3), high vulnerability (V4), very high vulnerability (V5). The maximum values, which correspond to the highest concentrations of the four base maps (M, M_f, P_{ro}, A_c), identify the most vulnerable areas in relation to which appropriate intervention strategies should be planned.

3.1 Security Actions for the Municipal Urban Plan

The variables that contribute to determining crime risk conditions are numerous. Its critical levels may vary in space and time as a result of social, cultural and economic dynamics, but also as a consequence of urban planning actions. The criteria for planning, design and construction of cities can reduce crime risk or increase it, if not properly defined and assessed [14, 34]. In order to reduce it, urban security must be taken into account from the earliest stages of planning, by addressing its aspects in all urban planning tools, be they structural plans, operational plans, sectoral plans, urban regeneration programmes, major equipment projects, etc. The action, carried out following a multi-scalar approach, allows to simultaneously act on all aspects affecting the vulnerability conditions in order to ensure safer urban spaces.

According to this observation, the research proposes specific actions to be introduced in the municipal urban Plan to promote a systematic adaptation of spaces to security criteria [2, 3], acting both directly and indirectly on V_c (Table 1). These were defined as a result of a complex operation of systematisation and synthesis of data obtained from state of art reconstruction on the topic, carried out by analysing manuals, technical-scientific literature, twenty-five guidelines and twenty-five case studies relating to the application of environmental crime prevention principles. Therefore, starting from the elements of physical and functional organisation that showed the greatest relevance and recurrence, actions were defined for the Structural Plan (SP), the Operational Plan (OP) and the Urban Regulation (UR). Specifically, the security actions outlined for the SP are oriented to affect informal surveillance of urban space by acting on the city' vitality and on its time of use through suitable location choices of activities and land uses. The actions for the OP are aimed at strengthening the feeling of territoriality, i.e., the citizens' sense of belonging to the area in which they live [16, 17], and the possibility to exercise both informal and formal surveillance. They concern the structure of urban spaces, green areas, car parks, roads etc. In the UR it is intended to introduce actions mainly aimed at guaranteeing visual permeability from public and private spaces to public spaces and, therefore, informal control, and at enhancing the comfort of places by reducing their propensity to decay. This is possible through several measures including: the correct definition of semi-public spaces, routes, etc.; the type of urban green spaces and the criteria for its correct distribution; a correct lighting, transparency and appropriate fencing etc.

Among the actions outlined, those proposed for the SP mainly affect M and M_f. The actions outlined for the OP affect the variables M_f, P_{ro} and A_c. Some of the actions outlined for the UR directly influence M_f and A_c and indirectly P_{ro} (Table 1). For example, guaranteeing the continuity of urban structure, of road layout and cycle-pedestrian network and the correct location of commercial activities and services ensures equal accessibility conditions to spaces, infrastructures and services in all areas of the city, avoiding the creation of marginal zones or enclave situations, directly affecting M and also A_c. Again, actions oriented to place public spaces in densely populated areas, activities for continuous and night use in strategic points, commercial activities and public services also in the ground floors of residential buildings directly influence M_f, increasing and diversifying land uses to guarantee a continuous use of spaces. In this sense, it can be seen that some functions are more effective than others in ensuring vitality. The *activity generators*, i.e., schools, universities, hotels, public buildings, shops and commercial centres, which, wisely placed in the territory are able to increase the number of eyes on the street but also to attract other functions. In addition, by ensuring a clear distinction between public, semi-public, semi-private and private spaces, made possible through symbolic boundaries (by diversifying materials, paving, introducing flower boxes, benches, etc.) it is possible to indirectly influence P_{ro}. This action, in fact, is oriented to increase territoriality based on the principle that people tend to defend and take care only of what they consider to be their own. The care and maintenance of spaces reduces their degradation.

3.2 Crime Vulnerability Scenarios for Monitoring Urban Planning Actions

The changes in physical and functional organisation of urban spaces, as a result of urban planning choices, have impacts on V_c and therefore also on crime risk. Urban planning actions can reduce crime vulnerability but can also increase it, if not properly assessed, causing an increase in existing criticalities or triggering new ones.

In order to reduce V_c, it is necessary to start a systematic adaptation of spaces to security criteria, making urban planning choices aligned with the environmental crime prevention principles, applying specific urban planning actions and rules (Sect. 3.1) and monitoring their impact on the territory. In response to this need, the risk model outlined provides for the construction of crime vulnerability scenarios ($V_{c,i,}$ with i = 1, …, n) [2] (Fig. 3). The construction of these makes it possible to construct n crime impact scenarios ($D_{c,i,}$ with i = 1, …, n) and n crime risk scenarios ($IR_{c,i,}$ with i = 1, …, n) corresponding to them, according to the following expression:

$$IR_{c,i} = H_c x V_{c,i} x E_c = H_c x D_{c,i} \tag{6}$$

Table 1. Security actions and their influence on V_c. Source: Author's elaboration.

V_c base variables	Security actions	Plan	Impact*
M	Continuity of urban structure	SP	Direct
	Continuity of road and cycle-pedestrian network	SP	Direct
	Continuity of public transport system	SP	Direct
	Appropriate location of infrastructure to ensure accessibility, without creating physical barriers, enclaves and marginal spaces	SP	Direct
	Marginal area recovery and elimination of potential enclave situations	SP	Direct
	Location of commercial activities and public services so as not to create marginal areas	SP	Direct
M_f	Ensure functional mix (residential, commercial, recreational)	SP	Direct
	Mixed-use roads	SP	Indirect
	Location of public spaces (parks, recreation areas, children's playgrounds, etc.) in densely populated areas	SP	Direct
	Location of commercial activities and public services so as not to create marginal areas	OP	Indirect
	Urban regeneration aimed at introducing activities (ground floor of residential buildings) and public services at strategic points	OP	Direct
	Location of continuous and night-time activities at strategic points	OP	Direct
	Maximum length of inactive facades of 5m	UR	Direct
P_{ro}	Urban regeneration aimed at introducing activities (ground floor of residential buildings) and public services at strategic points	OP	Indirect
	Reorganisation of public spaces and oversized green areas. Possible splitting up of green areas and concession to residents for management	OP	Indirect
	Distinction of public, semi-public, semi-private, private spaces	OP	Indirect
	Distinction between public and private paths and areas through differences in material, finish, possible difference in level or symbolic indication	UR	Indirect
	Durable materials and urban furniture	UR	Indirect
	Use of anti-graffiti paints	UR	Indirect

(*continued*)

Table 1. (*continued*)

V_c base variables	Security actions	Plan	Impact*
A_c	Continuity of urban structure	SP	Indirect
	Continuity of the road and cycle-pedestrian network	SP	Direct
	Appropriate location of infrastructure to ensure accessibility, without creating physical barriers, enclaves and marginal spaces	SP	Direct
	Reorganisation of road network: design of roads to discourage high speeds	OP	Direct
	Reorganisation of cycle-pedestrian network: replacement of subways and raised bridges by paths at street level	OP	Direct
	Footpaths: minimum width sufficient to allow several people and disabled people to walk in both directions. Linear layout and smooth curves, avoid creating hidden spots	UR	Direct

Note: * Impact of security actions on M, M_f, P_{ro}, A_c and consequently on V_c

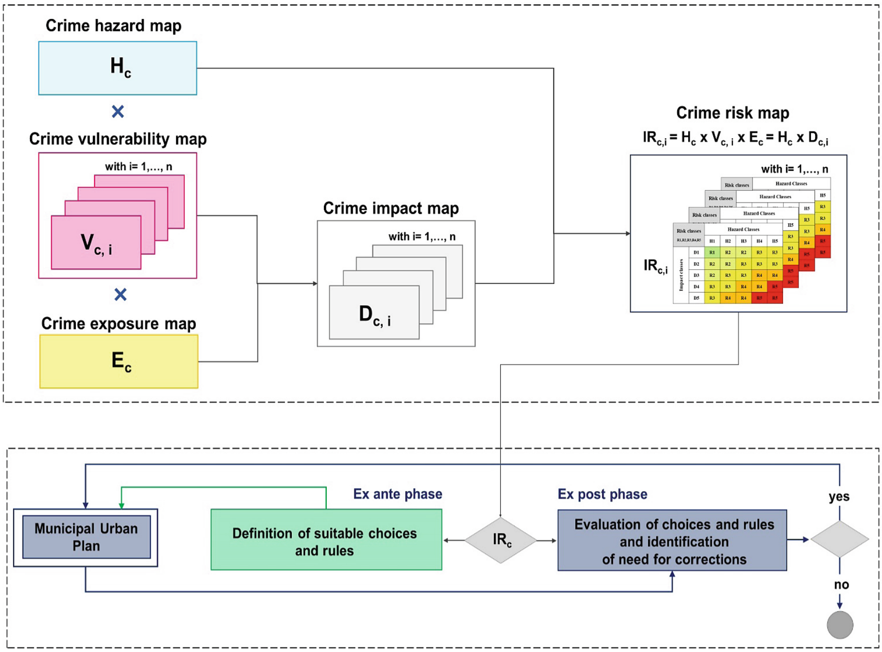


Fig. 3. Methodological scheme for constructing crime vulnerability and crime risk scenarios, and for integrating of the IR_c in urban planning tools. Source: Authors' elaboration.

These scenarios are important cognitive frameworks. If used in the ex ante and/or ex post phase of the municipal urban Plan formation, these ones allow to make informed choices, to outline an adequate framework of actions and rules, and to assess the need for corrections to them if the urban Plan is already in force. Through these scenarios it is possible, in fact, to highlight the criticalities in territory, to simulate the effect that urban planning choices may have on existing V_c levels (which may consist of a decrease or increase of these or in triggering new criticality); to monitor, over time, the results of environmental crime prevention strategies.

The model outlined allows to simulate, for example, the effect of actions on M_f such as refunctionalisation interventions; also, actions oriented to reduce M and P_{ro} such as regeneration and recovery of degraded situations by changing the input variables associated with the different land use categories and modifying the number and surface extent of degraded areas. Also, it is possible to simulate future scenarios showing changes in vulnerability conditions linked to the implementation of forecasts of the urban planning tool in force in order to identify the need for corrections.

4 Application of the Model

4.1 Case Study

The model was applied to the city of Milan, which was chosen for the availability of data on crimes, urban planning tools and elements of urban structure (Fig. 4).

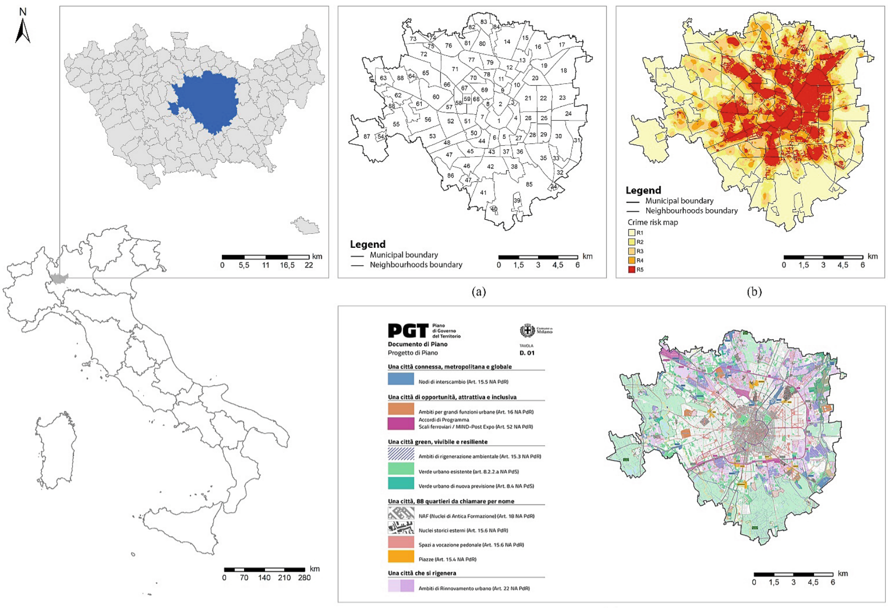


Fig. 4. Territorial context of the study area; a) Municipal territory divided into 88 neighbourhoods (NIL); b) Crime risk map [2], c) Zoning, PGT-Milano 2030. Source: Authors' elaboration.

The city, as of today, corresponds with the only statistically significant dataset that is available and can be used for research purposes in relation to the crimes under study. This was confirmed by the results of an investigation conducted on a selected sample of Italian cities, to whose Police Headquarters and Prefectures were sent a request for georeferenced data about crime occurred in their Municipality in a given time interval, and by subsequent research regarding the spread of crime mapping practices nationwide [2].

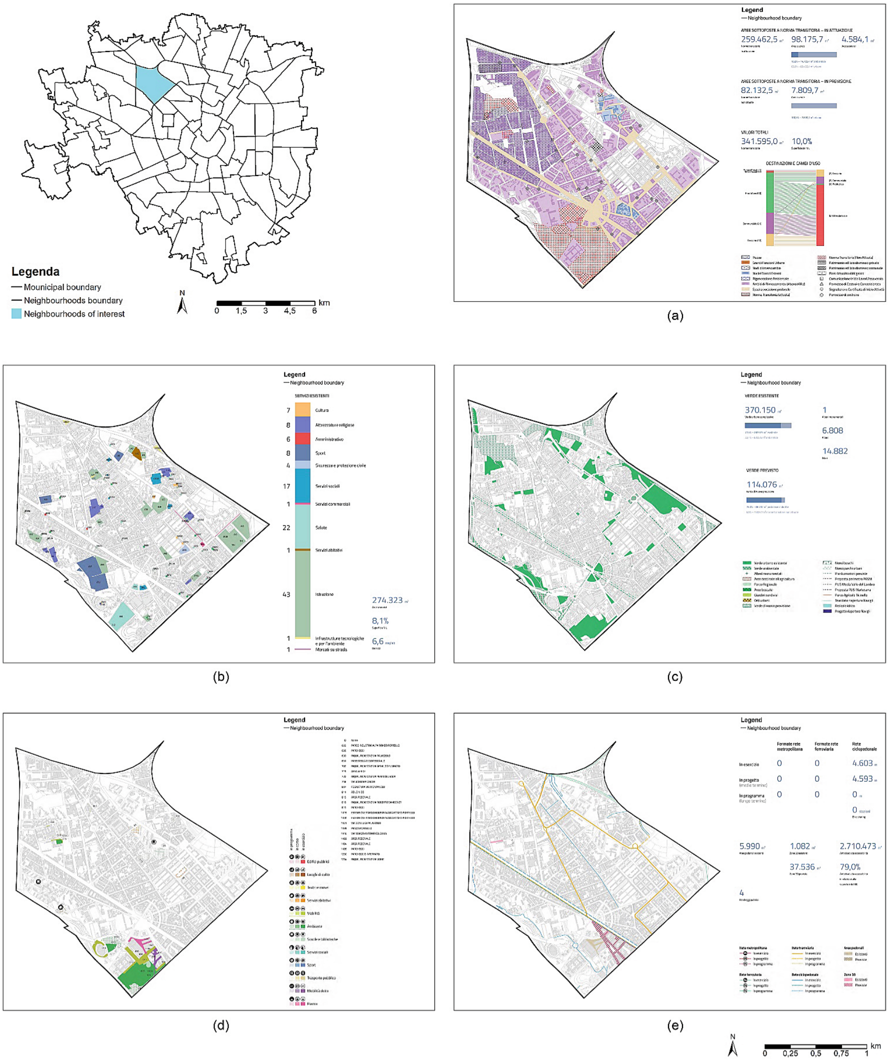


Fig. 5. Territorial context of the neighbourhood under study: a) areas planned for regeneration and transformation; b) existing services; c) the green and water system, d) public buildings and spaces; e) mobility and accessibility. Source: Authors' elaboration starting from PGT-Milano 2030 charts. Please refer to the following link for the plan charts used: https://www.pgt.comune.milano.it/pgt-previgente/pgt-milano2030-approvato-05022020/piano-dei-servizi-approvato-05022020/norme-catalogo-e-nil-05022020 (last accessed: 20/07/2022).

Starting from the crime risk map constructed for the city in a previous study [2, 3]. (Fig. 4b), the focus shifted from the urban to the detail scale. More precisely, the attention was focused on the *Villapizzone-Cagnola-Boldinasco* neighbourhood (Fig. 5). The latter is one of the 88 neighborhoods identified as *Nuclei di Identità Locale* (NIL) by the *Piano di Governo del Territorio* (PGT Milano-2030) which corresponds to the urban Plan of Milan [35]. The selected neighborhood is located in the northwest of the municipal territory, covers an area of 3.4 km^2, and is inhabited by 22.062 families with a population density of 12.178 inhab/km^2. The latter has a very high degree of urbanization, accounting for 92.6% of the total area. In detail, the prevailing land uses are divided as follows: 27.9% of the area coincides with built-up fabric, 24.1% with unbuilt-up fabric, 27.2% is for mobility and 21.4% is for green space. In PGT-Milan 2030 zoning (Fig. 5a), the neighborhood is characterized by the predominant presence of *Ambiti di Rinnovamento urbano* (ARU), which correspond to urban renewal areas, environmental regeneration areas, which are flanked by existing and newly planned urban green spaces. In addition, the presence of external historic cores and pedestrian-oriented spaces is found [35, 37].

The neighbourhood was selected for this study as it is characterized by high critical conditions in terms of crime risk and crime vulnerability (classes R3, R4, R5 and V3, V4, V5 respectively) and by a high concentration of urban renewal areas and areas of environmental regeneration, as mentioned above.

4.2 The Crime Risk Map (CRM) Model

The scenarios simulation is automated through the construction of a parametric model realised as a *Model Builder* through ArcGIS software [38, 39]: the *Crime Risk Map (CRM) model* [12]. The latter automates the procedure of crime risk map construction making it replicable in any context and in very few minutes. It is structured in four parts, the most complex of which is the one dedicated to V_c construction (Fig. 6). In fact, the last requires density analysis, proximity analysis, spatial configuration analysis and several steps of combination and assignment of criticality classes according to the RM method. The parametric model realised automates these operations through 9 functions and several parameters acting on 12 input variables.

4.3 Constructing Scenarios of Crime Vulnerability and Crime Risk

The application was carried out by simulating two reference scenarios using the CRM model [12]. *Scenario 0* describes the current state of the territory. In detail, for the neighborhood under study, $V_{c,0}$ (Fig. 7b) is characterized by critical levels (V3, V4 and V5) at the northern and central parts of the urban space. This circumstance is most influenced by conditions of unbalanced functional mix and the presence of decaying areas. Significant critical situations are also found in terms of crime risk. Indeed, as can be seen in $IR_{c,0}$ (Fig. 7d), over half of the neighborhood surface is affected by medium (R3), high (R4) and very high (R5) levels of risk.

Starting from this evidence, the urban fabric was examined in detail with the help of satellite maps and the Google Street View tool, in order to deepen factors behind the

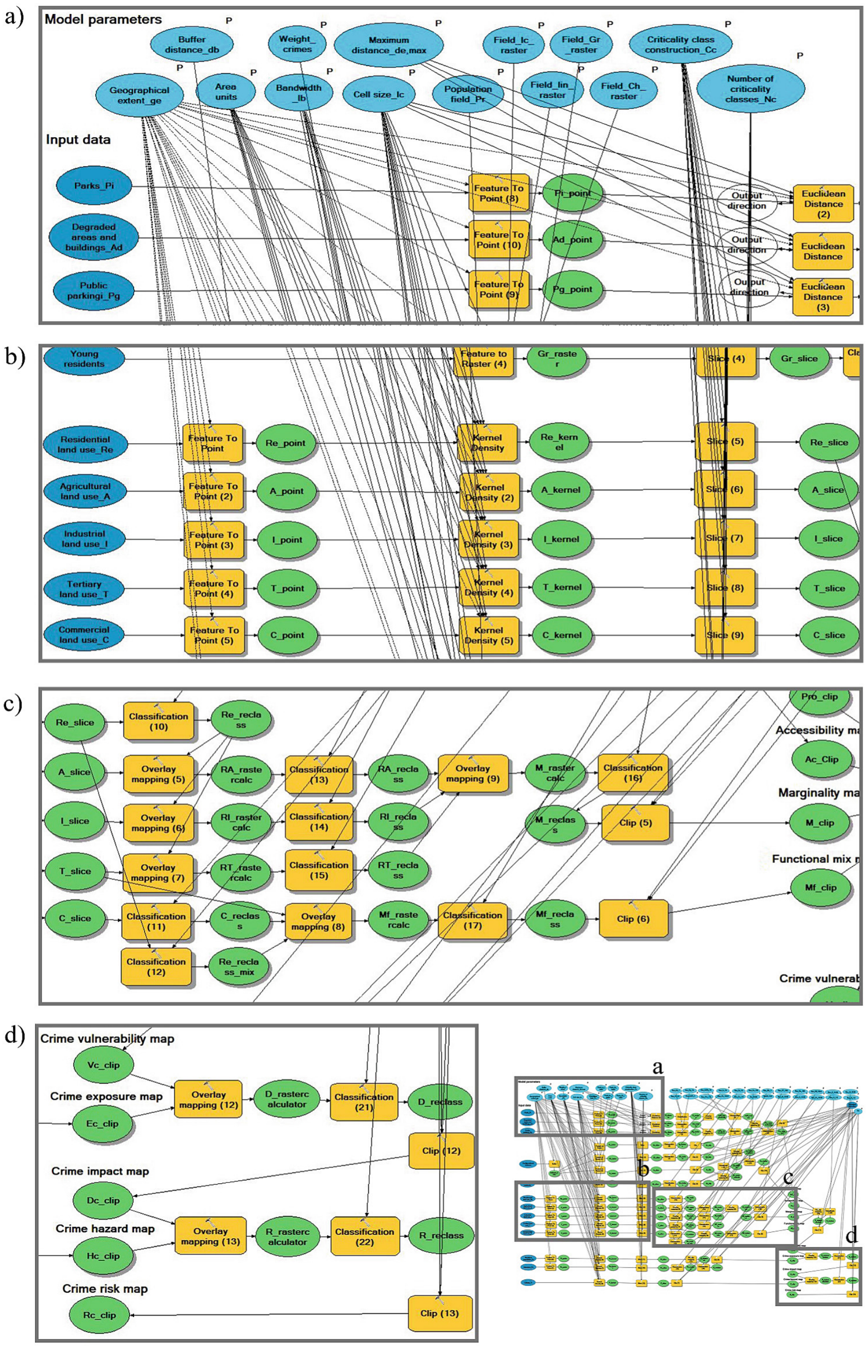


Fig. 6. Scheme of the Model builder constructed in GIS: excerpts. Source: Authors' elaboration.

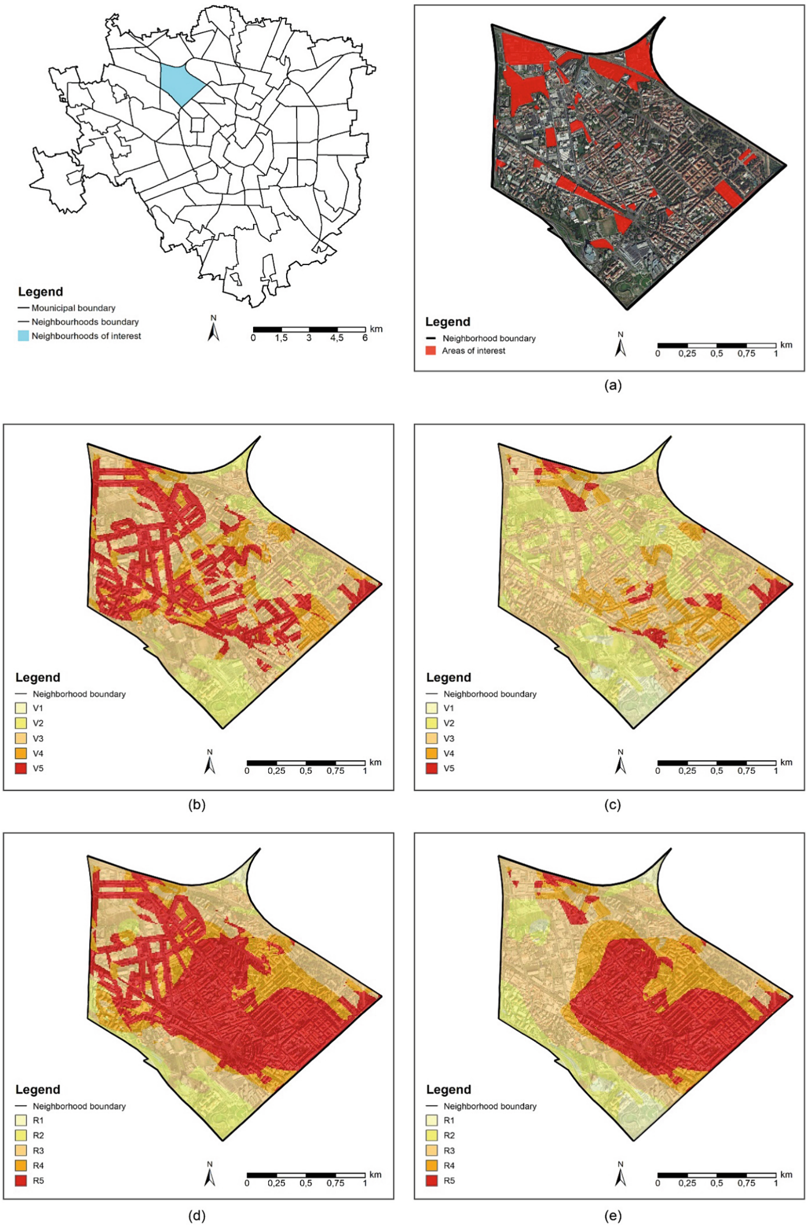


Fig. 7. Territorial context of the neighbourhood under study: a) areas of interest on satellite view; b) Crime vulnerability map – scenario 0 ($V_{c,0}$); c) Crime vulnerability map – scenario 1 ($V_{c,1}$); d) Crime risk map – scenario 0 ($IR_{c,0}$); e) Crime risk map – scenario 1($IR_{c,1}$); Source: Authors' elaboration.

neighborhood's high vulnerability and collect all the necessary elements to formulate a specific intervention proposal.

The study revealed the presence of entire blocks characterized by decay of building fronts, also marked by the presence of graffiti, especially in areas close to the railway infrastructure. The presence of the latter also serves as a physical barrier of separation from the rest of the neighborhood to the northeast. Even in this area, marked by the presence of railroad and industrial areas, a low quality of urban space was found, with the presence of elements of decay and graffiti. Such circumstances contribute to attracting petty crime and encouraging incivility and vandalism. In addition, the unbalanced functional mix is not supportive of informal control by citizens or city users [5, 31].

Based on the results of this step and in accordance with the PGT-Milan 2030 forecasts [35], a specific intervention proposal was formulated oriented toward reducing vulnerability levels by acting directly on M_f and indirectly on P_{ro} with reference to some selected areas (Fig. 7a). In detail, the proposed actions involve urban regeneration interventions aimed at the introduction of public activities and services in strategic locations and recovery of decaying conditions, preferring the use of durable materials and anti-graffiti paints (Table 1).

Therefore, a new scenario, identified as *scenario 1*, was constructed by simulating the change in crime vulnerability and crime risk conditions resulting from the implementation of the proposed interventions. As can be seen, $V_{c,1}$ (Fig. 7c) shows a significant reduction in criticality levels particularly in the northern zone where class V5 has almost completely disappeared. This decrease in vulnerability results in a decrease also in the crime risk classes. Indeed, $IR_{c,1}$ (Fig. 7e) shows significant improvement in the north side of the neighborhood.

5 Discussion and Conclusions

The model's application to the case study has shown the potential of the latter. The maps of scenario 0 ($V_{c,0}$ and $IR_{c,0}$) showed critical levels both of crime vulnerability (V3, V4, V5) and crime risk (R3, R4, R5) mainly concentrated in the central and nortwest areas of the neighborhood. As clarified earlier (Sect. 4), these criticality in term of vulnerability are mainly caused by the presence of widespread decay and an unbalanced functional mix.

The identification of these critical issues and the proposed intervention at the basis of the scenario 1 simulation ($V_{c,1}$ and $IR_{c,1}$) highlighted the potential of urban interventions in mitigating existing levels of crime vulnerability and crime risk and preventing new criticality.

In relation to the case study, such scenarios can be integrated into the municipal urban Plan at an ex post stage, as the PGT-Milano 2030 is now in force. Their integration makes it possible to assess the conformity of urban planning choices to security criteria and suggest possible corrections to them.

The comparison of the crime risk map constructed for Milan with the contents of the PGT-Milan 2030 highlighted a lack of attention of the latter in relation to security criteria, as shown in a previous study [2, 30]. In fact, some of the interventions allowed by the *Norme Tecniche di Attuazione* (NTA) which coincide with the urban Plan's normative regulations [36], are not aligned with environmental crime prevention criteria and could cause increased levels of crime vulnerability and crime risk, but also trigger new criticality. For example, in relation to the external historic cores [36, article 15] are planned regeneration interventions by allowing the realization of any urban function and the increase of private services, craft activities, neighbourhood shops and service activities. However, for areas already affected by critical conditions in relation to crime risk, especially if high (classes R4, R5) it is essential to ensure a suitable functional mix by balancing the amount of these services with other land uses, including residential [29]. With specific reference to the neighborhood under study the allowed interventions, if implemented without taking into account their impact on security, will result in an even greater imbalance in the distribution of functions that will potentially cause a worsening of vulnerability and risk from crime conditions (already currently critical). In addition, with reference to ARU, the NTA [36, article 22] allow for requalification of existing public spaces, affecting how they relate to private ones and promoting the creation of new local systems of collective spaces. However, such an incentive could negatively affect the levels of crime vulnerability and crime risk if the resulting interventions are located on the territory and designed without consideration of risk factors. In addition, the consultation of *Piano dei Servizi* (PS), which coincide with the Milan's Plan for infrastructures and public facilities [37] showed that many of the neighborhoods within the central core of Milan's consolidated fabric are affected by forecasts that, in the medium and long term, will lead to changes in accessibility conditions. Again, no consideration is given to the impact this factor has on vulnerability and risk from crime [29, 31].

According to the observations made, the forecasts contained in PGT-Milan 2030 should be modified taking into account their impact in terms of urban security, as well as the other needs they are aimed at responding to, either by indicating corrective factors or by providing a detailed urban regulation.

In order to better understand the potential of $V_{c,i}$ and $IR_{c,i,}$ scenarios (Sect. 3.2), consider, for example, the planning of public spaces and facilities for public use. These elements should ensure a balanced urban development. In Italy their planning is regulated as territorial facilities per inhabitant and no indication is given as to their location on the territory. However, this aspect is of fundamental importance from a security standpoint as such spaces and services if not carefully sized and located could transform into *attractors of crime* [15]. The model outlined, through the construction of scenarios ($V_{c,i}$ and $IR_{c,i}$) would allow for their calibration both in terms of size and location in relation to the territorial context under study and to its levels of crime vulnerability and crime risk.

In addition, $V_{c,i}$ and $IR_{c,i,}$ scenarios could be also complemented by the implementation of appropriate participatory techniques, through which to explore the subjective dimension of risk, and to outline the most suitable strategies to address not only actual risk but also perceived one [6, 7].

From the results obtained, further research developments are outlined that will be conducted by adopting a multi-scalar approach. These include an in-depth study, at-currently underway, geared toward introducing new variables into the E_c factor-map and simulating dynamic scenarios of crime exposure and crime risk by using geo-social media data [40]. Further in-depth study will be oriented toward exploring how different crimes patterns are distributed within various types of urban fabrics, focusing in particular on social housing neighborhoods. In addition, another study will deep the non-linear relationship between functional mix and crime rate and will be oriented to identify the optimal density value even in relation to urban fabrics other than the one currently examined.

In conclusion, it is observed how the issue of urban security is of great importance for urban policies. Preventing and mitigating crime risk and increasing levels of personal security is an important requirement for creating sustainable cities and communities, as other social, economic and environmental actions [41–43] and as the mitigation of other kinds of risk [44–46].

Very often, especially in Italy, the contribution of urban planning to urban security is overlooked and underestimated. On the contrary, the urban planning choices, if not correctly assessed, can affect crime vulnerability causing an increase in existing criticalities or triggering new ones. This increases crime risk conditions.

City security must be pursued systematically, adopting an integrated approach in which all possible actions or strategies work in synergy. For this purpose, it is essential to flank and integrate socio-economic interventions and traditionally adopted control actions with suitable environmental crime prevention strategies.

The work presented here is a small part of a wide-ranging research project exploring the issue of urban security and the possible contribution that urban planning can make to it. In doing so, the research adopts a constructivist approach [47]. The objective of the outlined risk model is not to solve the urban crime problem but to provide the decision-maker with a tool that help define the most suitable strategies to tackle it, in relation to the context's characteristics.

This article focuses in particular on V_c, proposing a set of specific actions to be introduced in the municipal urban Plan aimed at reducing its critical levels. The effectiveness of such actions is linked to knowledge of the specific context of interest and the impacts they may have in the short and long term. For this reason, the model outlined provides for the construction of specific scenarios ($V_{c,i}$ and $IR_{c,i}$) that are important cognitive frameworks to be considered in the ex ante and/or ex post phase of the urban Plan's formation, in order to evaluate the urban planning choices and outline a suitable framework of actions and rules for increasing the city's security.

In conclusion, the knowledge of the current vulnerability and risk conditions and of their variation caused by physical and functional changes of urban spaces, allows to orient the urban planning choices towards crime risk prevention for a better organization of the city according to security criteria.

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Economic Growth and Land Use Restraint

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Abstract. The injection of huge capital resulting from the European measures to cope with the pandemic (Next Generation EU) led to a revival of the economy which was then conditioned by the beginning of the war in Eastern Europe. The Italian situation promises considerable resources (PNRR) destined for the driving sectors of the production of goods and services. This will provoke the request for new settlement spaces for the rising companies and for the development of the existing ones. This need contrasts with the UN recommendations on the containment of land use (Sustainable Development Goals - SDGs - UN 2030), already supported by the European Commission (2012) in the guidelines for limiting, mitigating, and compensating for the waterproofing of the territory. Therefore, a gap is created between yearnings for economic growth and, on the other hand, urban and environmental sustainability, a dyscrasia which then finds a specific rebound in the regulatory-urbanistic condition of many municipalities whose areas of productive settlement must face up to nonrenewable expired expropriation constraints, despite the availability of lands included in the homogeneous areas intended for industrial settlement. If on the one hand this condition contains the transformation of new lands, on the other - in the presence of a strong demand for settlement - it entails the need to take a census of what is unused, to reacquire it to the public hand and to reintroduce it on the market at reasonable prices from a financial but also a social point of view. This study deals with this issue with reference to urban areas destined for industrial settlements, with reference to the definition of the problems of reacquisition, evaluation by reassignment and the discontinuity of the existing urban fabric due to the fragmented map made up of funds that become available again.

The study presented will be followed, in the forthcoming publication, by the examination of a case study of an industrial area of the Italian territory.

Keywords: Land consumption · Appraisal of industrial areas · Re-planning of production areas · sustainable land-use planning

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1 Introduction

The European Commission, the European Parliament and the UN have made their own recommendations for the enhancement of natural capital and the consequent reduction in net land use by 2050. Consumption is requested to align with demographic growth, a very binding condition for the Italian State given the constant decrease in recent years which leads to a strong action of recovery, requalification and revitalization of the existing to the detriment of any urban expansion initiative to new construction or to generic unjustified anthropization. Already in 2006, the Commission [1] laid the foundations for a strategic directive for soil protection [2] and supplemented the process with an impact assessment [3] analyzing the economic, social and environmental effects of different translating options of the strategy into law.The process came to a halt in 2010 due to the opposition of some Member States, it was relaunched in 2011 [4] by the Commission for the achievement of the net land take increase target of zero by 2050 and, in 2012, with a report [5] through which the Commission invited the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions to submit their point of view regarding the protection of continental soil and, at the same time, ensuring a sustainable use.

In 2015, the UN, in its Global Agenda, also declined the Sustainable Development Goals [6], highlighting a specific interest in the soil and requiring member countries to incorporate the following guidelines into short and medium-term programs:

- restrain land consumption within the limits of population growth;
- ensure the availability and access to safe and inclusive green spaces;
- pursue a *land degradation neutral* world to safeguard and develop ecosystem functions and services.

The containment of land use is also proposed by the UN among the objectives of the 2030 Agenda, SDG n. 11 ‘Sustainable cities and human settlements’; in particular the target 11.3 ‘improving inclusive and sustainable urbanization and the capacity for participatory, integrated and sustainable planning and management of human settlements in all countries’ includes among its indicators the’ Ratio between land consumption rate and of population growth’ [7].

However, the restraint of land use is opposed by lobbies which, for legitimate and non-legitimate purposes, support the greater efficiency (in terms of time and costs) of new buildings compared to redevelopment projects. Italy knows something about it, where land consumption grew by 1′045 square kilometers between 2006 and 2020 and the Nugnes draft law seems to have run aground in the quicksand of Parliament. In Italy every year, between 1990 and 2017, agriculture has lost from 17′000 to 35′000 hectares of arable land, and there have been unsuccessful attempts to legislate on the subject since 2012. The heart of the Nugnes proposal (draft law n. 164) connects urban regeneration with the containment of land consumption, so that the resources made available to the urban regeneration can only be exploited in the presence of initiatives with no impact on new territorial spaces.

The Senate, on the other hand, has already taken steps to separate the two issues by freeing from constraints the urban recovery actions that often conceal building projects from scratch. The problem concerns not only the destruction of valuable natural capital but also the encroachment of buildings in fragile areas due to hydrogeological conditions. The increase in consumption evolves hand in hand with the economic recovery and is particularly relaunched in the Northeast regions. This results in losses in value calculated to the extent of 1 billion euro per year in terms of lower carbon storage and lower agricultural production; and the same in reference to the decrease in ecosystem services that the soil can no longer guarantee (regulation of the hydrogeological cycle, improvement of air quality and reduction of erosion). Thus, the moments of economic recovery aggravate the criticality, especially when they are triggered by flows of financing to be spent in a short time and not compatible with eco-sustainable interventions based on the regeneration of the existing [8–11]. By virtue of the number and complexity of the technical and administrative constraints that the regeneration and the reuse must take into consideration. Specifically, this becomes more relevant when dealing with urban structures crystallized on outdated and not renewed for some time regulatory instruments. From this point of view, the theme of spaces for the establishment of production activities according to sector plans promoted by the Consortia of the industrial development Areas (Presidential Decree n. 218/78, Clause 50), framed in the various regional disciplines, is particularly felt. Many of these find themselves in the position whereby, preordained expropriation constraints lapsed, they can no longer proceed to acquire lands destined for business even in the presence of a growing demand for settlement by businesses.

Let's look at the problem in detail with reference to the question of the Campania Region.

2 Industrial Development Consortia

As is known, the Industrial Development Consortia were established with the law n. 634 of 29th of July 1954 for the refinancing of the *Cassa per il Mezzogiorno* (Italian public body created to finance industrial initiatives aimed at the economic development of the Southern Italy, in order to bridge the gap with the Northern Italy), 760 billion lire (today over 350 million euros) intended to promote the industrialization of the Southern Italy [12]. The provision provided that the Consortia would govern the industrial settlement through specific regulatory plans. With law n. 555 of 1959 and subsequent circulars, the criteria for identifying the areas to be industrialized were specified and, with the Circular of the Committee of Ministers for the Southern Italy n. 2356 of 9th of March 1961, the directives for the preparation of regulatory plans were issued. So that the plans for the various agglomerations were started. As can be guessed at a certain point the question of the survival of the constraints preordained for expropriation (of an original ten-year duration[1]) and their eventual renewal would have arisen. In some situations, this did not happen due to a jumble of administrative and political-social reasons, which is why it was necessary to identify alternative means to guarantee the territory the availability of areas to be used for productive investments. In this scenario, the reacquisition of

[1] In Campania Region extended several times.

unused properties opens important prospects in a moment of hoped-for revival of the industrial sector, given the contingent availability of public funding of European origin. Furthermore, the use of funds already integrated in the production circuit (even if to a different extent depending on whether it is free areas or already built) is also combined with the need imposed by the UN recommendations on the containment of use of the soil (Sustainable Development Goals - UN 2015), already supported by the European Commission (2012) in the guidelines for limiting, mitigating and compensating the waterproofing of the territory. Thus, in this case, a condition of necessity consistently prepared itself with the broadest expectations of environmental sustainability.

This work has been set up to guarantee the maximum reliability of the results in terms of the probatority of the referred mercantile sources to and the intelligibility of the mathematical calculations performed. In this sense, the original data will be made available to the reader and processed with basic computational procedures suitable for all. Precisely so that econometric modeling does not represent the easy pretext for subjectivation or for the questionability of the results. Since the study answers for the scope of the values at stake to stakeholders different each other for interests, skills and knowledge, it is designed and implemented with respect to the different skills in their possession, so that it can be immediately understood in the method adopted and in the implemented process, without claiming to be exhaustive also given the planning framework in strong evolution precisely in the period of elaboration of the study.

3 Urban-Economic Issue

To understand the scope of the issue, the Territorial Coordination Plan of the Industrial Development Areas in Campania Region can be used as a reference. The Plan was approved on February 14, 1992, and, by virtue of Presidential Decree 218/78, was effective for ten years until February 14, 2002. In particular, as highlighted by the Sentence of the State Council, Section IV n. 8710/19, the preordained constraint to expropriation decays, while the conforming uses of the urban planning regime survive. However, while the Plan was still effective, the regional law n. 168/98 extended its effectiveness by three years. Therefore, the deadline has been moved to the 14th of February 2005. Then the regional law n. 10/01 extended the life of Plan of one year to the 14th of February 2006. Finally, in 2007, when the Plan was no longer effective, the regional law n. 1/07 established that "is confirmed and extended the validity of the Industrial Development Areas' regulatory plans in force at the date of entry into force of the regional law 22 December 2004, n. 16 up to the enforceability of the TPCP (Territorial Provincial Coordination Plan) which, pursuant to article 18 of the aforementioned regional law, have the value and scope of the regulatory plan of the areas of industrial consortia referred to in regional law no. 16".

Therefore, the last provision has postponed the forfeiture of the Plan until the implementation of the TPCP to be done. In the specific case, the TPCP was approved on the 30th of December 2012 but - for the part relating to the reiteration of the expropriation constraints, it was stopped by the aforementioned Sentence. It follows that to date the expropriation restrictions have lapsed and therefore to proceed with the exercise of its functions, the Industrial Development Consortium must reacquire abandoned areas and assign them to subjects who request them. Leaving aside the issue of extension of compressive constraints on private property for a period of over fifteen years with no indemnity provisions (as instead envisaged by the Constitutional Court, Sentence n. 179/99), it should be highlighted how the situation leads to a natural alignment of the consortium activity (already interested in sustainability issues) towards the principles of reuse and re-functionalization of what has already been man-made.

4 The Ruling of the State Council

As mentioned, the highest Italian administrative justice body has sanctioned the impossibility of continuing to operate under an expropriation regime in the consortium agglomeration of the interested Municipality.

The claimant stated that the area he owned had already been affected by three previous expropriation procedures, the second of which had led to a dispute before the State Council for Campania, which with decision no. 429/2007, had cancelled the expropriation measures, "ascertaining the irreversible expiry of the Consortium Plan as of 14.2.2006". According to what the claimant presented before the regional administrative court, the company had however "stubbornly proposed a fourth assignment request (cadastral unit 443, approximately 4,500 square meters) for the establishment of the same activity", which was followed by the resolution of the Consortium no. 279/2017, which had approved a new authorization, subject to appeal. Against all the acts relating to the expropriation procedure previously highlighted, the complaints were deduced, which the first judge summarized as follows. With the first reason for burden, the measures challenged for excess of power for violation of the judgment formed between the parties, by virtue of the sentence of the Regional Administrative Court of Campania, detached section of Salerno, n. 429 of 2007.

With the second ground of appeal, it was pointed out that the preordained constraint on expropriation could not even derive from the approval of the TPCP of Salerno which "has no value of Regulatory Plan and, therefore, has not validly renewed or extended the expropriation constraints of the Industrial Development Consortium…. The TPCP of Salerno has not approved a new area Plan of Industrial Development Consortium".

According to the claimant, in fact, pursuant to art. 18 paragraph 9 of the regional law, n. 16 of 2004, "… The TPCP, to take on the value and scope of the Regulatory Plan of the Areas and Industrial Consortia, ex regional law n. 16/98, [must] be approved in agreement with the Industrial Development Consortia". In point 2.2 of the ground of appeal, moreover, it was pointed out that "Nor is it worth recalling, on the contrary, art. 8 co. 2 of thetechnical standard of the TPCP, in which it is generally prescribed that "pending the conclusion of the agreements", the TPCP operates a "dynamic reference to existing specialist plans".

This is because it is the regional legislature that requires the agreement as a means of concertation so that the TPCP can also take on a value in the industrial consortium area, failing which, if it were possible to obtain this effect through a unilateral planning imposition, the mechanism provided for by the regional law would be frustrated and, in substance, the latter would be violated, where "a norm of the technical standard (art.8) can never derogate from the binding provisions of the regional law n. 16/2004" (page 20 of the appeal).

According to the claimant, then, if it is believed that art. 8 can automatically extend the lapsed restrictions of the Industrial Development Consortium's Regulatory Plan, nevertheless this provision would be illegitimate:

- for violation of art. 18 paragraph 8, of the regional law n. 16/2004, because the agreements (with the Industrial Development Consortium and with the other competent bodies) must precede and not follow the approval of the TPCP;
- for violation of the law (articles 52 - 53 Presidential Decree no. 218/78 and article 8 paragraph 8, regional law, no. 19/2013), because the renewal of the expropriation constraints requires an adequate and justified re-evaluation of the territorial structure of the Industrial Development Consortium areas through a complete review of the specific public interest, otherwise violating the constitutional principles on property (Article n. 42 of the Constitution);
- for violation of the law (articles 2 and 8 regional law n.19/2013, art.7 regional law n.16/2004) and incompetence, because the province does not have the power to unilaterally regulate the Industrial Development Consortium agglomerates, renewing the expropriation bonds outside of an unfailing co-planning form with the Industrial Development Consortium (the agreements);
- for misuse and violation of the law, because the atypical renewal of the constraints pending the agreements had resulted in an elusive form of the typical and mandatory legal models, imposing constraints preordained for expropriation, which cannot be separated from the renewed evaluation urban planning needs;
- for further diversion, because through this elusive form the bonds, descending from the Industrial Development Consortium's Regulatory Plan (lapsed), prejudicing private property beyond any reasonable term;
- due to the absence of an adequate motivation.

With the third ground of appeal, it was also deduced that "The validity of the Industrial Development Consortium's Regulatory Plan, an indefectible prerequisite of the expropriation procedure, cannot even derive from the new consortium legislation variant (art.1.1 of the technical standards of the Industrial Development Consortium's Regulatory Plan) that the Consortium and the Province have recently approved (Presidential Decree of the Province n. 79/2017)". This variant (Article 1, paragraph 1) was certainly to be considered illegitimate because it was also ordered after the expropriation constraints expired (March 30, 2017) in contrast with the principle, of constitutional rank, according to which the time extension of efficacy necessarily presupposes that the constraint has not expired.

With the fourth, it was deduced that the reiteration of the constraint preordained for expropriation, implemented through the variant, was unmotivated and in any case approved without an adequate investigation that gave account of the motivation of the industrial interest over that of private property.

With the fifth ground of appeal, he complained of the illegitimacy of the acts that had extended the substantial constraint sine die, due to the “lack of a deadline in the provision of law or regulation of a deadline for the approval of the agreements”.

With the sixth reason, he complained, again, a defect in the procedure for the approval of the Industrial Development Consortium’s plan, which would have consisted in the failure to acquire the Strategic Environmental Evaluation or, in any case, in the failure to carry out the verification of eligibility.

With the seventh reason, specifically concerning the authorization of the consortium, the illegitimacy of the deed for the defects that concerned “upstream” the planning acts from which the preordained obligation to expropriation would derive was highlighted.

It was also deduced that the project presented by the claimant was not even compliant in terms of urban planning with the planning tool, which provides for the construction of a road in the area where the plant should be built.

Furthermore, the possibility of a different location of the structure, with less burden of private ownership, would not have been evaluated. Neither the deductions presented by the appellant had been adequately considered nor the technical and economic reliability of a subject who had not already given proof of reliability in the past been tested.

The Regional Administrative Court, in the resistance of the Industrial Development Consortium and of the opposing company, rejected the appeal and compensated the expenses.

The sentence was challenged, reproposing the questions rejected by the Regional Administrative Court, and, critically, the reasons articulated in the first instance.

Finally, the appeal was taken in decision at the public hearing on October 10, 2019.

With regard to the events of the planning in question, it is sufficient to refer to the exhaustive examination carried out by the Regional Administrative Court, which was previously reported.

It is only worth adding that the Constitutional Court has already had the opportunity to deal with the regulatory plans of the Industrial Development Consortia of the Campania Region, and with the legislative extensions of their effectiveness, implemented with regional laws (provision).

With reference to the time extensions established by article 10, paragraph 9, of the law of the Campania Region n. 16 (Structure of the Consortia for industrial development areas), and by article 77, paragraph 2, of the law of the Campania Region n. 10/2001 (Provisions of regional finance year 2001), the Constitutional Court (sentence n. 314 of July 20, 2017) resolved the question.

Thus, the State Council was able to resolve the dispute based on the following assumptions.

On a systematic level, it must be agreed with the claimant that the promotion of the agreement, if the TPCP also has the value of a sector plan, is by no means re-placed at the mere discretion of the province.

In this sense, within the framework of the aforementioned regulatory framework, art. 18, paragraph, 9, of the law n. 16 of 2004, which, in attributing to the approval of the TPCP, “value and scope of the master plan of the areas and industrial consortia referred to in the regional law of August 13, 1998, n. 16”, disposes expressly that “For the purposes of defining the relevant provisions of the TPCP, the province promotes [….] agreements with consortia for industrial development areas and with other subjects envisaged by regional law n. 16/1998”.

From this provision the definition of the agreements (or in any case the completion of the procedural scans provided for overcoming the dissent) is a constitutive element of the adoption phase of the Plan.

In the same sense, they lay down, on a procedural level, both the subsequent art. 20 (which provides for the calling of a service conference “at the start of the procedure for forming the proposal of the TPCP”), and Regulation no. 5/2011 which, even more clearly establishes “the agreement is promoted before the adoption of the plan referred to in paragraph 1 of article 3”.

Basically, the adoption of the TPCP - in the part in which it has the value of a Regulatory Plan for areas and for industrial consortia - is the result of a co-decision process, in which “consortia for industrial development areas must necessarily participate “together with” the other subjects provided for by regional law n. 16/1998”.

In this regard, the claimant’s findings appear to be shared even in the part in which he pointed out that, like law n. 16 of 1998, the subsequent regional law n. 19 of December 6, 2013, confirmed the competence of the consortia for industrial development areas to adopt the plan for the organization of the industrial areas.

This law too - mirroring the provisions of the regional law n. 16 of 2004 for the TPCP - has in fact established a co-decision procedure, the impulse of which belongs to the Province (see, in particular, art. 8, paragraph 2, according to which “The final adoption is preceded from the convocation of the conference of services by the territorially competent province, in which local authorities and institutionally competent bodies and subjects are invited to participate”).

As far as it may be necessary, it is also useful to remember that the “equalization” between the master plan of the areas and industrial development nuclei and the territorial coordination plan dates to art. 51, paragraph 8, of the Presidential Decree n. 218 of 1978, according to which “The approved plans produce the same legal effects as the territorial coordination plan referred to in law n. 1150”.

Therefore, the expiration of the ten-year term of effectiveness only leads to the termination of the effects of the declaration of public utility (as expressly provided for by art. 52, paragraph 1, of the same Presidential Decree n. 218 of 1978), while the industrial development areas’ plan is valid and effective with reference to urban destinations, in accordance with the provisions of art. 6 of the law n. 1150/1942 according to which the territorial coordination plan has an indefinite value (State Council, section IV, March 5, 2008, n. 930).

The sentence of the State Council must instead be confirmed in the part in which it declared inadmissible, due to lack of interest, the challenge of the variant to the Industrial Development Consortium’s Regulatory Plan approved in 2017 (resolution of the President of the Province n.79 of July 14, 2017).

In fact, the claimant's criticisms did not manage to undermine the findings of the first judge according to which, the variant in question "concerns aspects that do not concern the modification of planning in the Industrial Development Areas or, in any case, profiles that have some effect on the expropriation constraints and, therefore, on the disputed procedure".

From a different point of view, it must then be highlighted that in part here the sentence of first instance, despite having a content device - declaratory of inadmissibility - formally unfavorable for the claimant, constitutes a ruling, albeit in rite, substantially favorable to the same, because it ascertains and excludes that the aforementioned resolution of the President of the Province n. 79 of July 14, 2017 has, as far as it is of interest, some efficacy that is detrimental to its legal position and can therefore be applied and/or interpreted in the sense for these prejudicial. The reason for the appeal with which this part of the sentence is criticized, contesting a part of the first instance ruling sentence that substantially is in favor of the appellant, is therefore, in any case, inadmissible due to lack of interest in the appeal.

Ultimately, for what has just been argued, the appeal must be accepted in part and within the limits set out in the motivation.

As a result, the cancellation of the TPCP must be ordered - limited to the part in which it reiterated the expropriation constraints provided for by the Industrial Development Areas Plan of the Municipality - and of any consequent contested deed, and of the authorization issued by the Industrial Development Areas Consortium to the claimant.

5 The Process of Repurchasing the Areas

The operating method in the reacquisition and reassignment of land granted and never transformed or of settled and built properties, starts from the regulatory reconnaissance on the subject.

The state law n. 448 of 23.12.1998, in art. 63 establishes that:

a) have the right to repurchase the property of the areas sold for industrial or artisanal ventures in the event that the transferee does not build the plant within five years of the sale and to buy back the sold areas jointly to the industrial or handcrafted establishments built in the event that the industrial or handicraft activity has ceased for more than three years;
b) the consortia (in Fig. 1 the areas of industrial settlement belonging to the Industrial Development Consortium) must pay the transferee the discounted purchase price of the areas and, as regards the establishments, the value of the latter as determined by an expert appointed by the President of the competent Tribune for the territory, reduced by discounted public contributions received by the transferee for the construction of the establishment.

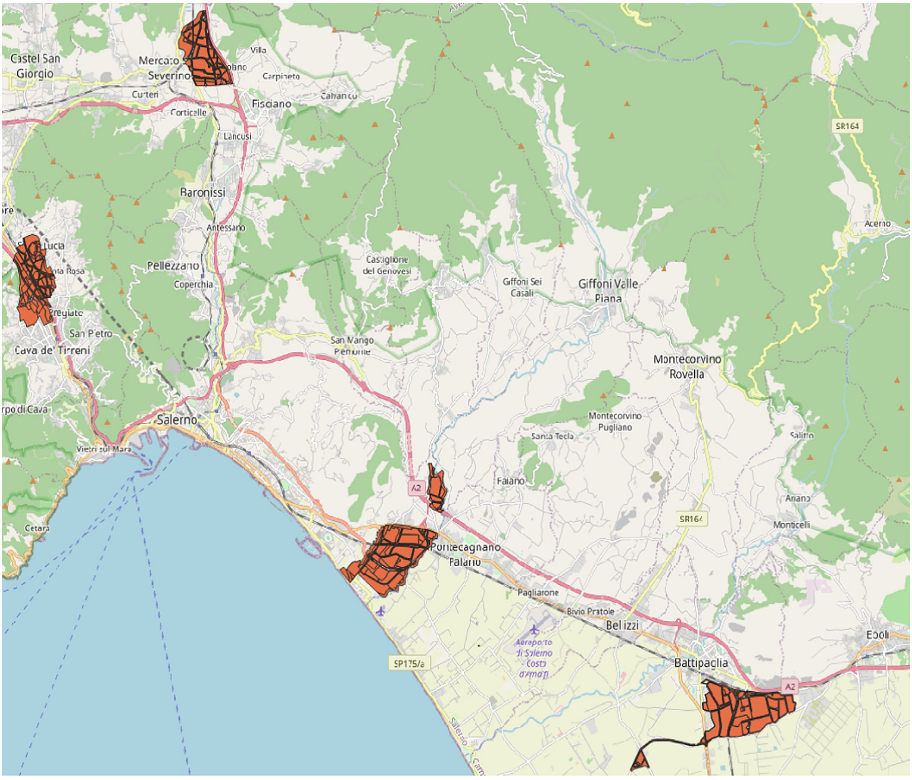

Fig. 1. The areas of industrial settlement belonging to the Industrial Development Consortium in the Campania Region.

Therefore, the question arises of the fair estimation of the repurchase value (also in consideration of the Campania law n. 19/13) in relation to the concept of actualization in its various meanings.

Furthermore, during the reassignment phase, the theme of the price at which the properties must be relocated on the market is emerging [13–19], creating a synallagmatic relationship between conditions and characteristics influencing the price of the first historical assignment and the status of the same variables at time of the current placement. In particular, with regard to the full and complete construction of the infrastructures essential to the settlement, to their state of functionality and maintenance, to the microeconomic and macroeconomic conditions that characterize the current business scenario.

Also remains open the question of settling spaces that will not plausibly respect a logic of strict rationality such as that of a virgin industrial settlement on which to flexibly project the needs of different companies according to the goods produced, the industrial processes implemented and the spaces who are necessary for the logistic specification [20–23]. With attention also to the infrastructures that will have been designed *illo tempore* with respect to all free settlements and not to the residual ones currently available and distributed in a patchworked way (think of the different needs of newly established industries compared to the most modern service distribution networks which could instead be unusable for old and persistent residents) [24].

5.1 The Price to be Paid to the Transferee

The delicate issue of the price to be paid to the transferee should also be highlighted[2]. Starting from paragraph n. 3[3], art. 63 of law n. 448/98 the jurisprudence clarifies that the criterion of discounting the original purchase price must be applied both to areas granted through consortium procedure and to those directly acquired by the entrepreneur on the free market (obviously areas on which he was authorized to realize a productive settlement). Furthermore, the repurchase must take place *in conditions of parity between what is received and what is to be returned*, without there being objective clarity on the formal or substantial scope[4] of the financial balance imposed by the law.

Reconnecting with the tenor of the regional law (implementing the state law), in which[5] the repurchase "without the price increase" is envisaged, it concludes according to two main guidelines (which also connotes questionability):

- The regional law, as the implementing law of the national provision, must respect its basic principles (discounting of the price);
- The principle of the price increase is a different concept from the discounting of the price;

So that the synallagmatic balance between the two sources would be achieved by aligning the regional law with the national one, with the sharing of monetary discounting (without which the Consortium would use a possible undue enrichment due to specific macroeconomic conditions) but with the exclusion of any alternative hypothesis of alignment of the historical price with those current at the time of the repurchase (principle not etymologically denied by the national law)[6].

5.2 How to Reassign the Areas

On the point of how to reassign the areas- of no direct relevance with the issue of this work - it should be highlighted the prevailing belief according to which *the power to*

[2] Many reflections refer to the in-depth study conducted by lawyer M. Monaco in a note to the Italian Federation of Industrial Entities Consortia of september 13, 2021.

[3] The Consortium is required to pay the transferee "the discounted purchase price of the areas and, as regards the establishments, the value of the latter as determined by an expert appointed by the president of the competent court for the area, minus the discounted public contributions received from the transferee for the construction of the plant".

[4] That is, if it is a question of exactly matching the historical price paid or discounting it due to inflation.

[5] Paragraph 1 of art. 10.

[6] So, the regional rule would even be precautionary with respect to the national one.

repurchase/reacquisition of abandoned areas must be exercised directly by the Consortium[7]*, but also considerate the possibility of regulating a procedure of repurchase intended to be initiated also at the request of the private individual concerned, in order, among other things, to have the financial coverage to carry out the repurchase.*

5.3 Evaluative Criteria for Appraisal the Reassignment Price

There are certain constraints to expressly mercantile interpretations:

- the reassignment price must take into account the principles of efficiency and economy that must govern the activity of any public administration;
- must be no less than the repurchase price[8];
- must take into account the charges and general expenses incurred by the Consortium for the reassignment procedures.

The object of attention must be the possibility of integrating the reallocation price with rates relating to the costs incurred for the infrastructural works on these areas, which have not already been fully amortized the calibration of the price with respect to the Consortium's Development Program. In fact, for free areas these costs are already included in concession fees and, in particular, in urbanization costs; for built areas, it would be a completion of the latter, already paid when the original building permit was issued. As well as any exogenous component (contribution to the consortium program) would discount the guidelines of the Constitutional Court on the matter.

6 The Hypothesized Model

As is known, the market value of building land depends on macroeconomic variables (fiscal policy, cost of money, reliability of the government system, foreign policy, etc.) and on local predictors (position, logistics, geomorphological data, accessibility, etc.). However, each mercantile segment (residential, commercial, productive, touristic, etc.) is affected by conditions also related to the characteristics of the specific land rent and the particular methods of exploitation of this.

In particular, the production areas sector [25] is certainly the least subject to building speculation traditionally devoted to the urban transformation of the funds into new buildings (industrial warehouses) to be placed on the construction market.

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[7] That is, the Consortium first repurchases and subsequently reassigns. Also, in order to guarantee equal and competitive conditions of participation to all economic subjects potentially interested in the reassignment.

[8] It goes without saying that this conditioning can prove to be contradictory from a purely estimative point of view, more so when compared with the mercantile criteria dictated by the law and by the Constitutional Court in the event of expropriation of industrial areas. In fact, the paradox could arise whereby two adjacent industrial areas, perfectly homogeneous, can be assigned for different prices due to the different procedure followed in the allocation to the requesting investor (law n. 448/98 or Presidential Decree n. 327/01). With the obvious risk of immediate jurisprudential arrests.

Indeed, the technological specificity that characterizes the production plants and, therefore, the related building containers means that construction activities are frequently conducted by the same economic operators who will then implement industrial production. It is not common that the production areas are built by real estate brokers who intend to place the already completed warehouses on the market.

Conversely, the implementation methods provide for the sale of the lots to the applicants, which are often ad hoc conformed to the executive expectations of the investors.

From this prospect it follows that in the construction of a lot for production use the builder is not interested in the profitability of the building operation, being instead projected towards the optimization of the industrial investment as a whole [26].

This paradigm can influence the specific real estate market by varying its cycle with respect to that of ordinary segments such as residential and commercial. The analyst must take this into account without in any way removing the basis of the price postulate [27] in the construction of the Judgment of Estimate.

The need to define an operational protocol identified by the following figure (Fig. 2) then emerges.

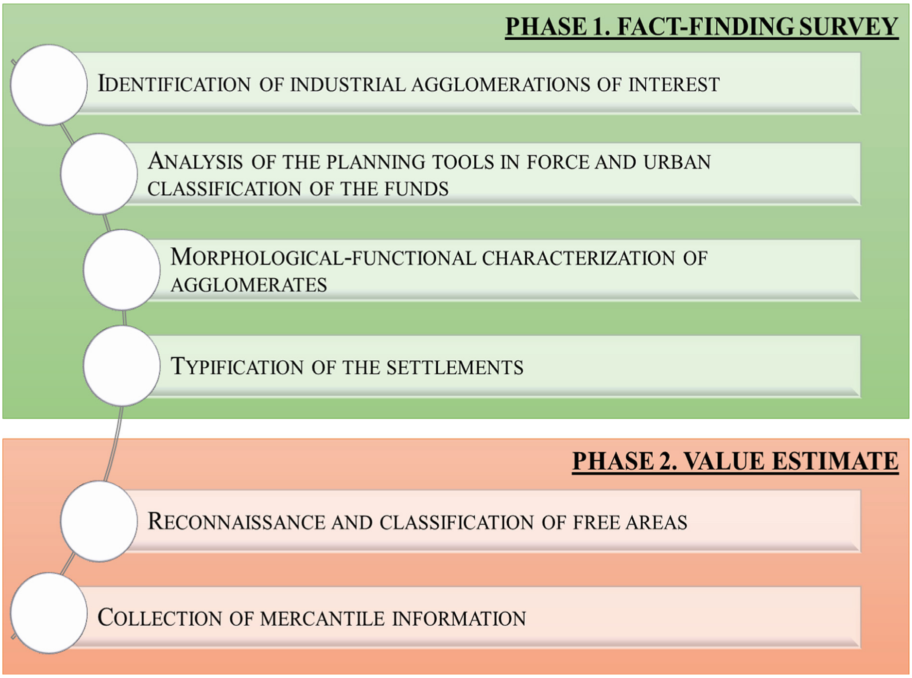

Fig. 2. The operational protocol identified by the study.

Therefore, in Phase 1 it is necessary to identify the different agglomerations that belong to the Consortium. In fact, in addition to the location characteristics, these can discount mercantile conditions depending on the affiliation to different urban reality.

Secondly, the urban connotation of the various agglomerations must be investigated; in fact, it should not be forgotten that within each agglomeration there are various intended uses allowed with repercussions on the settlement lots.

A morphological-functional characterization of the agglomerations must also be performed as the lots will be affected by the different conditions as orography, infrastructure in terms of equipment and obsolescence, accessibility, etc.

Finally, in the first phase, the typification of the settlements is of importance: number of companies, type of production, active and discontinued companies.

Phase 2 is then aimed at estimating the market values of the funds.

All the individual areas under investigation must be surveyed and classified in order to create homogeneous clusters for: morphology of the lot, accessibility, functional destination, characteristics of the companies located in the surrounding area, etc.

Finally, by setting up a price database (purchase agreement, expropriation decrees, voluntary transfers, final judgments, etc.) it will be possible to construct the price estimation function.

The functional form can be defined using linear and nonlinear multivariate regression analysis models, such as:

$$y_i = \beta_0 + \beta_1 x_{1i} + \ldots + \beta_p x_{pi} + \varepsilon$$

in respect of

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0$$

$$H_1 : \text{ any } \beta_j \neq 0,\ j = 1, \ldots, p$$

and of

$$H_0 : \beta_j = 0\, j = 1, \ldots, p$$

$$H_1 : \beta_j \neq 0.$$

7 One of the Agglomerations of Analysis and the Market for Soils

Among the four agglomerations under study (see Fig. 1), the one in a Municipality in the South of Campania Region is described below as an example. The nucleus extended for 450 hectares of total land area is divided into two sections.

The main compartment is located south of the residential area, the railway line separates the two different areas. It is also confined to the north by the state road and the motorway. It appears longitudinally marked by another railway connection. It is equipped with a road network characterized by different service levels and a waste treatment area (see Fig. 3) as well as purification (see Fig. 4).

Fig. 3. Waste treatment area entrance.

Fig. 4. Plants of the purification sector.

It also welcomes iperstructures for civil use (for example a higher education institution) within its perimeter. On the eastern side, the residential urban fabric alternates with the consortium area, specifically for commercial use. The current state of the road infrastructure is largely obsolete (see Fig. 5–6), except in the northern region (see Fig. 7) where there are modernized sections.

Mobility exchangers programmed and built with public funding remain inactive now (Fig. 8, terminal bus).

Fig. 5. Southern section of the sector.

Fig. 6. Eastern section of the sector.

Fig. 7. East area.

Fig. 8. Bus terminal conceived within a European funding program.

The second area of the agglomeration, much smaller in size, is located towards the South. Today it is established in limited percentages.

From a constraint point of view, the entire industrial area is not affected by landscape constraints and, with respect to the hydrogeological risk conditions, there are no areas classified with high and very high levels of danger and risk.

Over the years, the real estate market has followed the trend in Fig. 9.

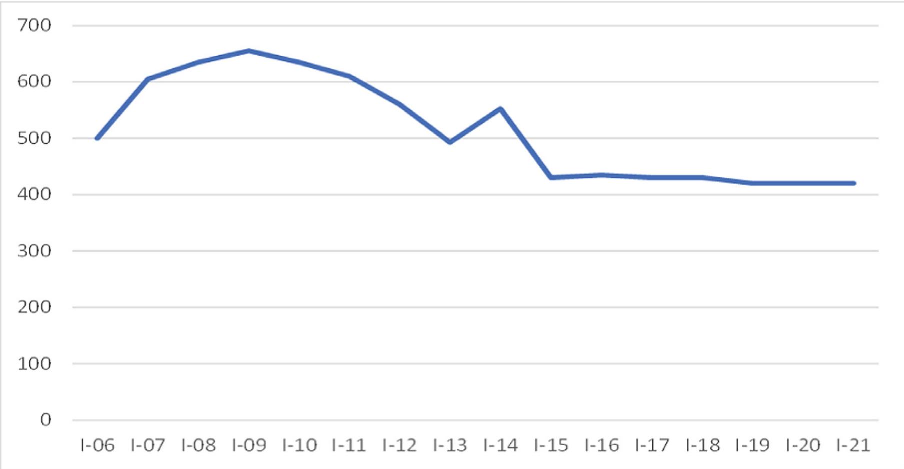

Fig. 9. Trend in unit prices of industrial buildings in the agglomeration under study. On the abscissa the semesters of the survey, on the ordinate in prices in euros per square meter (Source: Real Estate Market Observatory of the Revenue Agency).

These are the average market values for industrial buildings. Evidently, based on the correlation between building values and soil values, the diagram can also be used to reason on the trend of the land.

The maximum values are recorded between 2008 and 2009, with a subsequent decrease in prices. Today a substantial stabilization of the market is visible, on values lower than those of the last twenty years.

The data in the diagram may be useful for conducting time alignment operations on precise data arranged over the period considered.

8 Conclusions

The problem of the reuse of urbanized or built areas for the purpose of a sustainable exploitation of the soil that guarantees the possibility of settlement to the growing demand coming from the companies in a time of abundance of public financing for private investments, finds an important opportunity in the mechanism of repurchase and reassignment of industrial areas and of pertinent buildings abandoned by the original concessionaires.

The model for a correct and adequate relocation of these assets on the market must deal with appraisal profiles connected with the right value to be attributed to these assets in order to respect the social function of the Industrial Development Consortia appointed to this activity, but also with profiles of urban planning [28–32] correlated with infrastructural and morphological constraints that GIS systems concur to confront with perceptual and informative simplifications.

This study outlines an operational protocol useful for rationalizing the process, in order to arrive at recognizable, verifiable, and comparative solutions for strategic approaches, even potentially divergent ones.

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The Green and Digital Transition Between Urban and Rural: Approaches, Cases, and Experiences

Navigating the Green Transition During the Pandemic Equitably: A New Perspective on Technological Resilience Among Boston Neighborhoods Facing the Shock

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Abstract. Cities, public authorities, and private organizations respond to climate change with various green policies and strategies to enhance community resilience. However, these community-level transition processes are complex and require deliberate and collective planning. Under this context, the purpose of this study is to understand the energy actions taken at the local level, as well as to analyze the differences between the neighborhoods' green energy transitions in terms of their socio-economic aspects, using a big data perspective. The paper is addressing the following question: what was the role that the pandemic played in accelerating or slowing Boston's green investments, and to what extent do different racial and socioeconomic groups invest in green technologies during this period? The study aims to answer these research questions using the City of Boston as a case study to reveal different neighborhoods' paths in achieving the transformation of city ecosystems towards green neutrality. Next, the theoretical framework builds the linkages among the city's measures, climate actions proposed by the City of Boston, and their associated contexts and outcomes in shaping new policy and planning models for higher 'green' performance. Following the understanding of the actions, the neighborhoods' socio-economic and building permit data were assessed to understand whether economic disparities exacerbated during the pandemic have affected neighborhoods' performance in green transition. This method is applied in a comparative study of its 23 neighborhoods, using a dataset provided by Boston Area Research Initiative (BARI). Intriguingly, the paper's findings show that racial differences within the city have no significant impact on tech-related expenditures. There is a clear negative correlation between poverty rate and investment, which indicates the reverse relationship between these socio-economic factors. The study concludes that city authorities will need to address the challenges of each community achieving green transition with more targeted programs based on its needs.

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1 Introduction and Context

1.1 General Observations

The sustainable city discourse is becoming ubiquitous and highlights the need for a long-term strategic approach to create a regional context in which sustainable development is increasingly becoming the norm [1]. Wheeler identified sustainability "as requiring a holistic, long-term planning approach, as well as certain general policy directions such as compact urban form, reductions in automobile use, protection of ecosystems, and improved equity" [2]. By the end of the 20th century, "sustainable city" initiatives began to emerge in different parts of the world [2]. Then, the arrival of "resilience" as a new concept of urban policy and a buzzword has reformulated the imperatives of sustainability in the context of the environmental crisis [3, 4]. The current resilient sustainable discourse reflects that the city can and should be green but it needs significant innovations [5]. The discourse of sustainable and resilient cities showed that cities are the current major challenge facing sustainable development - this is mainly due to an ever-increasing population density and high energy consumption. But, at the moment, there is a shift from understanding cities as environmental problems towards cities being understood as the solution to environmental problems on a global scale [6]. Urban sustainability has guided the development in urban and metropolitan areas around the globe in lowering their carbon footprints and reducing greenhouse gas emissions by targeting resource and energy consumption in the construction, operation, and maintenance of the urban built environment [7]. However, the complex environment that characterizes cities, and especially metropolitans, makes the transition towards sustainability more challenging. The mounting climate pressures have compelled cities and planners to seek more green and innovative alternatives to steer cities and their inhabitants towards sustainable pathways [8].

The rapid growth of energy use has caused concerns regarding the supply, the collapse of energy resources, and the severe environmental impacts [9]. The global contributions from buildings towards energy consumption have steadily increased [10]. Around the world, buildings consume 38% of the world's resources, generate 40% of the waste in landfill sites, and emit 28% of the greenhouse gases produced on the planet [11]. Moreover, according to the US Green Building Council, buildings in the United States account for 36% of total energy, use 65% of electricity consumption, and almost 40% of global energy-related CO2 [https://www.usgbc.org/press/benefits-of-green-building]. For this, reducing energy use includes the goal of reducing the electricity needed while obtaining the same or nearly the same results from the building's systems. Improving the energy consumption in buildings is a prime objective to reduce human impacts on the environment at the national and international levels.

Despite all the big pronouncements and pledges of the city authorities to become greener, the pandemic has shown us a bitter reality; the world is still very dependent on fossil fuels [12]. Cities are far behind reaching their targets of achieving 100% use of clean energy. In this difficult equation, addressing the existing vulnerabilities, economic disparities, and race inequalities will be key for the cities to become leaders in creating a sustainable future for their residents. The current study works towards this direction, aiming to reveal a variety of inequities in how residents of different neighborhoods and racial and socioeconomic groups have been able to achieve a green transition before and during the pandemic. It uses the City of Boston dataset on building permits to test the hypothesis within the city's neighborhoods that vulnerable communities' socioeconomic context affects neighborhoods' capabilities to achieve green transition. In this line of reasoning, the research tries to conceptualize pillars of measures based on socioeconomic factors and neighborhood physical formation to understand which factors are most relevant to the pandemic shock absorption thus the resilience of the system.

In order to fully weigh the benefits of innovative neighborhoods as a way to achieve a green transition, we begin by identifying the city planning initiatives and discussing the city's climate actions. There are already citywide initiatives to finance energy efficiency in municipal buildings, for example, the Renew Boston Trust. Nevertheless, we seek to evaluate private buildings' implications for deep energy building retrofits, the installation of rooftop solar energy, and the procurement of zero-carbon electricity. The paper uses LEED's green building system assessment standards as a proxy for investigating tech-related permits. The following section provides a brief overview of Boston's climate action plans and policies. In the remaining part of the paper, 23 neighborhoods within the City of Boston will be evaluated on the basis of their characteristics and their adoption of green technology. We conclude by discussing the results of the study, to provide a sense of the extent to which Boston is considering the advancement of reducing the amount of CO2 emissions that is emitted from buildings.

1.2 Research Questions, Goals, and Hypothesis

During the last months, we have seen energy prices being dramatically surging as countries and households confront shortages of oil, gas, and coal. In this period, the neighborhoods of Boston need to look at some of the major factors behind the energy crunch, from the role of green policies to the historical housing discrimination affecting homeownership in the city. In this context, the discussion concerning urban informatics around the potential pitfalls of the field that could harbor its overall success in improving cities for the user. One of the biggest concerns is the lack of interconnectivity between studies in different cities of similar types. This seems like a big, missed opportunity as it could expose important relationships in the way cities function. Another, perhaps even larger challenge, is maintaining an even level of funding amongst cities for urban informatics, an issue which is not easily solved. Larger cities will have bigger budgets for this manner of project by default, meaning that cities without funding get left behind when it comes to the data analysis of the city. Although data mining and analysis in the urban environment has grown exponentially in recent decades, the organization and execution of how we interact with this data and use it for the public good are still in need of advancement.

This paper aims to lead the policymakers to pay more profound attention to the neighborhood level to enhance the community level and form a much more robust network to face shocks and stresses. Resilience strategies stem from the technological advancement of communities. Green technologies are knowledge-based assets; thus, local investments could lead the neighborhood to significant developments. Moreover, the current energy crisis has revealed the importance of creating self-sufficient communities that can long-term produce the energy they use. This type of open systems, which will allow the regeneration of the energy in buildings, will affect the sustainability of Boston's neighborhoods.

Through our research, we address the following questions: RQ1: what was the role that the pandemic played in accelerating or slowing Boston's green investments? RQ2: To what extent do different racial and socioeconomic groups invest in green technologies during this period? These questions address the ways the pandemic affected the neighborhoods' investments in green technologies as well as the ways that different racial and socioeconomic groups have been investing in green technologies before and during this recent healthcare crisis. We aim to approach our research as a critical point where we are collecting, analyzing, and visualizing big data which will allow us to understand neighborhoods' dynamics and constraints in green transition.

As urban problems continue to emerge, more data analysis is needed to support continued efforts. Cities are living laboratories and have certainly shifted because of the COVID-19 pandemic, so research should attempt to keep up with the latest changes. The recent unrest in cities and local governments necessitates research and expertise, especially since cities were almost breeding grounds for the pandemic. In order to understand cities, and reverse current inequalities, researchers must alter perspectives at the city level, such as health crises, and provide equal opportunities to all populations, which will certainly require more robust technologies, data, and instruments. We hypothesize that vulnerable communities' socioeconomic context affects neighborhoods' capabilities to achieve green transition.

In the end, if the green transition is reliant on public policy or government intervention, there will need to be a transfer of knowledge and associated advocacy to promote change at the neighborhood level. However, awareness of a problem does not necessarily bring a response that will follow suit, and though data can identify relationships, patterns, or problems, it does not always have the power to create change. Translating the findings of the current and similar studies into tangible policy will be the most ambitious goal and challenging aspect of our future work in big data analytics.

The paper sets out the study as follows:

Section 1 presents the topic of green transition and green neutrality as a way to enhance community resilience during the pandemic. It also introduces the two main research questions. The answer to these questions will provide support to city authorities to improve the current programs and policies they propose to enhance green neutrality at the local, neighborhood scale. Section 2 provides an overview of other studies, previous research attempts and measurement tools in the discourse of big data analytics and urban informatics to identify city areas with better performance in carbon neutrality. Section 3 introduces the socio-economic context of the City of Boston, which is used as a case study and provides significant considerations regarding previous strategies and climate actions in support of its green neutrality. It also analyzes significant constraints for Boston's neighborhoods to achieve high performance towards that goal and attempts at exploring correlations between 'green' neighborhood performance and socio-economic context.

Section 4 contains a big data-driven analysis of city investments in building permits related to green transition, which was used as the main method to provide insights into how different neighborhoods are incorporating green technologies. Section 5 contains the findings with a summary of the range of factors that affect neighborhoods' performance, while Sect. 6 provides conclusions and recommendations for further study.

2 Literature Review

2.1 Building a Framework for Measuring Green Transition Based on Other Case Studies and Toolkits

Buildings contribute to 38% of carbon emissions which highlights the need for green buildings [11]. Therefore, over the past two decades, the green building movement started to emerge and new councils for green building were established. The US Green Building Council defined a green building as they "are designed, constructed, and operated to boost environmental, economic, health, and productivity performance over that of conventional building." [13]. As a result, green buildings have become a promising pathway for the nation's sustainable development. New assessment systems developed around the world. For example, the US Green Building Council (USGBC) developed its green building rating system, which is Leadership in Energy & Environmental Design (LEED). Similarly, the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, and the Green Star in Australia. Among those, the US was one of the most developed areas in green building projects [14]. For instance, Austin, Texas, is best known for its efforts in green building [15]. It won an award at the first UN conference on sustainable development in Rio de Janeiro in 1992. Subsequently, local residential green building movements rapidly emerged in many American cities such as Denver, Colorado; Kitsap County, Washington; Clark County, Washington; the Baltimore Suburban Builders Association; and the EarthCraft Houses Program in Atlanta. Besides USGBC, the US has a wide range of green building local organizations that took part in the green building movement. For example, the National Association of Homebuilders issued guidance on how to create a green building program in the local area [16]. Additionally, local and state governments have been highly involved and promoting green building. In 1998, Boulder, Colorado stood up and passed an ordinance requiring specific measures with respect to green building. Moreover, Pennsylvania, for example, made significant efforts to promote green building. It established the Governor's Green Government Council (GGGC) in part to address the implementation of green building principles in the state. The country even made it feasible for everyone and all organizations to be up to date regarding everything related to green buildings in the US through the Environmental Building News - a monthly newsletter published by BuildingGreen.

However, investments in green buildings have been very limited. For example, only US$148 billion of the total US$5.6 trillion investment in buildings are allocated to green buildings [11]. Moreover, Debrah et al. revealed the gap in green finance in green buildings in the research area [17]. They pointed out that although the US is dominant in the green investments debate [18], it has very limited academic research on this topic. Their review of the research area worldwide on green investments in buildings shows that "GF-in-GBs [Green Finance in Green Buildings] research has been around for about only a decade now, although both the green finance and green building research fields in general were born in the 1970s". This underpins the crucial need for more studies on green building investments.

For this, this study examines the econometrics capturing patterns of a US city's performance in supporting green building projects. We assess Boston's neighborhood growth and 'green' investment through the volume and profile of building permits. We focus on the spreading supply of GHG-free electricity in the City of Boston. We evaluate the number of investments that go to green transition, assess the number of buildings' tech-related projects such as rooftop solar energy in different neighborhoods and assess the potential of the city's neighborhoods in adopting low- and zero-GHG fuels to reduce emissions and adapt other green technologies. Our central argument is that innovation is one of the main drivers to post-carbon transition at the neighborhood level. Innovation is at the heart of the transition to a cleaner global environment. However, "it is still insufficient to address the environmental challenges facing the planet today" [19]. There are some barriers that could limit the green transition such as a lack of public acceptance of new technologies, financial barriers, and innovation capacities [19], and there is evidence to suggest that the pace of green innovation has slowed in recent years. This suggests that major barriers remain and need to be lifted to accelerate the transition.

2.2 Technological Resilience as a Factor of Neighborhoods Green Transition Before and During the Pandemic

Technological resilience is a factor of regional resilience that relies on the capacity of a city or region to capture technological changes over time. Balland et al., proposed four pillars to identify this concept in a regional realm [20]. Although our research deals with similar attributes, we aim to extend this understanding to a local level, where communities have their own evolutionary paths to fulfill transition goals requirements, and local units have their own structural identities based on path dependency. In other words, we are translating the effort of technological resilience conceptualization in regional economic geography into a tangible measurable analysis to generate local maps and models. According to the mentioned reference, looking at two semitrances aspects: first, evolutionary development path: could be addressed in a way to reveal the crisis effect on the evolution of a city utilizing the neighborhoods as cells of the system. The shock due to the pandemic, stated earlier, changed the course of the investment pattern, and emerged a new ornament that creates a local definition of evolutionary development. In this research, we rely on these attributes benefiting from a before/during shock classification.

Second, Path dependency: as explained by scholars there is a strong relationship in the legacy of the history of local units and the current status of the resources. In this research, we brought the structural properties of the neighborhood into the investigation in a way to address the racial configuration and physical characteristics of the neighborhood. Nevertheless, there is a tendency in the literature claiming path dependency is an issue for looking at the emerging characteristics of the local units.

In this research, we are looking at the mentioned identities under the lens of big data to examine historically claimed status about racial disparities and physical configuration.

3 The Case Study of Boston

3.1 Assessing Boston as a Case Study Towards a Net Zero Carbon, Equitable and Resilient Built Environment

Boston is an East Coast city with 23 neighborhoods (Fig. 1). Boston is experiencing increasing sea levels and a range of climatic issues, including flooding, storm surge, and extreme temperatures. Historically, Boston expanded by landfill projects which created new neighborhoods and almost doubled the city's area. Thus, the City of Boston now deals with a vulnerable position on reclaimed land. If sea levels continue to rise in the Boston area, the Climate Ready Boston initiative predicts that by 2070, upward of 90,000 residents in the city will be at severe risk, with billions of dollars of infrastructure, property, and business loss [21, 22]. Future sea level rise and temperature change depend on how much the world is able to cut carbon emissions. Nevertheless, water is not the only risk, extreme temperatures and heat waves put Boston under threats for public health, especially for vulnerable communities. Sasaki analyzed that by 2070s, the annual losses from flooding could cost up to $1.4 billion, and the exposure to flooding could

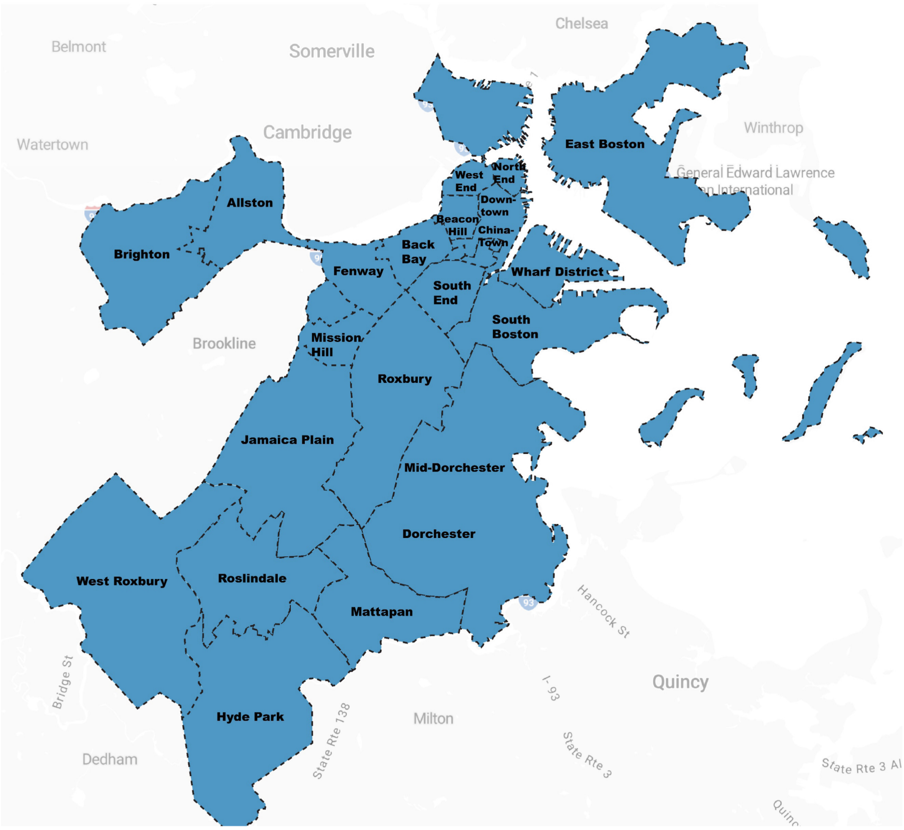

Fig. 1. Boston's Neighborhoods

include 14% of Boston's population (88,000 people), 10% of the city's K-12 schools, 32 MBTA stations, 240 essential public facilities (law enforcement stations, fire stations, and EMS), and sections of many evacuation routes [23]. On the other hand, extreme heat will increase mortality rates [23].

3.2 Previous Strategies and Climate Plans in Boston to Understand Green Transition

Boston's journey toward resilience planning and climate action has been comprehensive since the start of the twenty-first century [24]. In 2000, Boston joined the Cities for Climate Protection Campaign of ICLEI—Local Governments for Sustainability. Through this campaign, Boston pledged to step up for increasing energy efficiency and reducing greenhouse gas emissions. Moreover, Mayor Menino decided to develop and implement a local action plan to fight against greenhouse gas and air pollution emissions. Five years later, Boston adopted the U.S. Mayor Climate Protection Agreement and joined the target of reducing carbon emissions to below 1990 levels [25]. In 2007, the city of Boston released its first citywide climate action plan. Boston's former mayor, Thomas Menino, issued an executive order in 2007 on climate change that set an ambitious goal for the city to reduce its GHG emissions by 80% by 2050. In 2008, Massachusetts enacted a law that required "the Department of Environmental Protection to establish targets for GHG emissions reductions below 1990 levels between 10–25% by 2020 and 80% by 2050" [26]. Since then, the city has adopted long-term climate goals such as waste reduction, transportation and mobility, mitigation, and adaptation. The City of Boston started to integrate the community in the action plans and thus in March 2009, Mayor Thomas M. Menino formed the Boston Climate Action Leadership Committee and Community Advisory Committee. The aim of the committee is to propose recommendations to the Mayor and set the goals and objectives that Boston should follow in order to confront the risks of climate change. Hence, over a year, community leaders came together to develop recommendations on buildings, transportation, and adaptation. In 2010, the committee proposed Sparking Boston's Climate Revolution report [27]. This report was fruitful and rich of recommendations to tackle climate change.

Along with Mayor Menino aiming to bring all levels of community together, the Green Ribbon Commission was launched [28]. The commission was a way to engage the city's business and civic leaders for the same goal. It aims at designing and implementing the City's climate adaptation and mitigation strategy. In 2011, Boston set carbon reduction goals of 25% by 2020 and 80% by 2050 below 2005 levels. Later, Mayor Martin J. Walsh announced that Boston joins the C40 Cities Climate Leadership Group (C40). In 2015, the City of Boston joined the Carbon Neutral Cities Alliance (CNCA) with cities from all over the world. Each city has committed to save the planet and mitigate global warming. A year later, the Mayor launched Climate Ready Boston [29]. It is "an initiative to plan for how the city will continue to thrive while adapting to long-term climate change. It has three main components: climate project consensus (completed by the Boston Research Advisory Group), vulnerability assessment, and resilience initiatives". In 2017, Mayor Walsh announced Boston's goal of carbon neutrality by 2050—an ambitious yet necessary commitment to meet the urgency of the climate challenge [30]. In Imagine Boston 2030, the city's long-term strategic plan, also sets an interim carbon reduction goal of 50% by 2030. Carbon neutrality goal means that Boston is fulfilling the commitment to the Paris Climate Agreement and leading efforts to keep global warming under 1.5 degrees Celsius. By 2017, the City of Boston reduced emissions from municipal buildings and fleets by more than 40% below 2005 levels. Based on the progress Boston expects to make in energy efficiency and renewable energy, this Plan increases the reduction goal for municipal operations from 50% to 60% by 2030.

Boston's most recent climate action plan, released in 2019, sets the stage for Boston's transition to carbon neutrality and describes the roadmap for the next five years [31]. The 2019 Climate Action Plan (CAP) focuses on strategies to accelerate emissions reductions from three work areas: buildings, transportation, and energy supply. We focus in our study on Boston's buildings as buildings account for over 70% of greenhouse gas emissions in Boston [32]. Boston's two main targets for building are adopting a zero net carbon standard for new constructions by 2030 and retrofitting and electrifying at least 80% of exciting buildings over the next 30 years. Adopting a zero net carbon standard by 2030 would cut 17% of cumulative emissions from new construction to 2050; adoption by 2023 would cut another 17% [31]. According to the city, reaching carbon neutrality is possible if effective legislation is enacted and implemented in a timely manner. On the other hand, four out of five existing buildings in Boston will need deep energy retrofitting and moving to fossil-fuel-free heating and hot water systems in order to reach carbon neutrality by 2050. Existing building energy retrofitting can lead to reducing the city emissions by up to 40%. The City of Boston requires residential buildings that are 20,000 ft2 or larger (excluding parking) or have 15 or more units to reduce their building emissions and to begin reporting their energy use in 2022. By doing this, owners and tenants would become more aware of their energy use and costs, and greenhouse gas emissions. They would be able to compare them to similar size buildings and give opportunities to reduce the energy consumption. The City of Boston suggested that deep energy retrofits should happen by 1) Upgrading mechanical systems, lighting systems, and appliances; 2) Insulating walls, roofs, crawlspaces, and foundations; 3) Upgrading HVAC and plumbing; 4) Replacing windows; 5) Air sealing; 6) Installing renewable energy systems where possible.

Moreover, the city suggested converting fossil fuel systems to electric equivalents. With deep energy retrofits and electrification, existing buildings can become carbon neutral. There are existing state incentives, such as Mass Save, that help residents upgrade their energy efficiency and it offers a wide range of services, and incentives. In addition to Mass Save, there are over 14 units that were implemented by E+ Green Building Program launched by the City of Boston in order to regenerate multi-unit residential buildings and bring energy and environmentally positive homes to Boston's neighborhoods. To reach carbon neutrality, the city will need to implement deep energy retrofits and electrification by 2050. Businesses, residents, and the city should invest more in solar panels on building rooftops and other green technologies to have more energy-efficient buildings. In the end, communities will benefit environmentally, socially, and economically, since these investments will also spur innovation and job creation.

In the next section, there is a data analysis of the city's investments in technological projects that will help the city and each neighborhood to make a successful transition to being a green city. Throughout the section, we get a glimpse of how different neighborhoods are adopting green technologies.

Boston's Demographics

Boston was ranked 19th in terms of segregation in 2019. By 2020, the city's dissimilarity index between black and white residents is 68.8, which implies that more than 68.8% of whites would have to move to a different neighborhood so that blacks and whites are equally distributed across all neighborhoods. As compared to 2010, this was an increase from the 60% index of dissimilarity [33].

There are several articles discussing Home Owners Loan Corporation (HOLC) "redlining" maps (Fig. 2) and how in the long run it still affects the trajectories of urban neighborhoods and more specifically the structure of segregation and economic inequality [34, 35]. Areas that were labeled hazardous or "redlined" by lending institutions, were denied access to capital investments, which could improve the housing and economic opportunity of residents. In spite of the fact that redlining occurred throughout the country, racial segregation in Boston was particularly egregious. In addition to

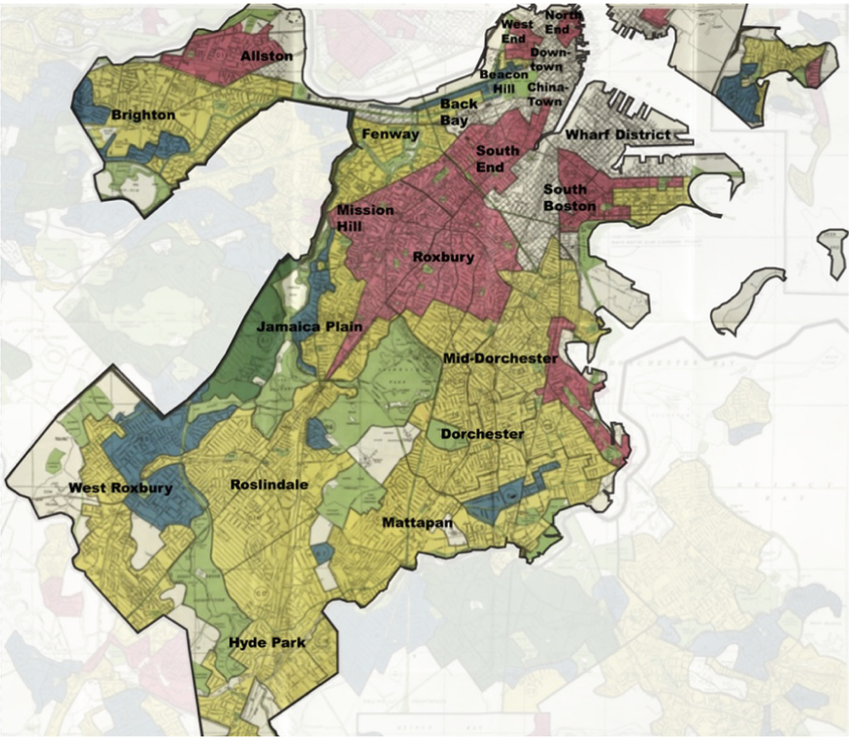

Fig. 2. Boston's Redlining Map. Source [33].

redlining, the federal government funded 25 public housing projects in the Boston area, all of which were racially segregated by race [33].

It is likely that the long history of racial disparities in the US has affected the neighborhood's ability to make the transition towards a green economy, which we are exploring in this study.

4 Scope, Methods and Data Collection

The study uses big data analysis as a crucial method to detect patterns and correlations related to neighborhood inequalities in green transition. Furthermore, it explores new opportunities that can be derived from such analyses. The research methodology is structured to assess the prioritization of each neighborhood's investment before and during COVID-19 pandemic shock in the City of Boston and to find out the most relevant variables for this prioritization. We tested our hypothesis on vulnerable and prospered neighborhoods' behavior against acute shocks. The methodology of this research relies on exploring a significant number of observations in the City of Boston to see if COVID-19 pandemic changed the investment priorities among the city's 23 neighborhoods. This could shed light on the inclusiveness issue in transition during shocks. Thus, to answer the research questions stated earlier, we used the Boston Permits dataset published by Boston Area Research Initiative (BARI) to capture neighborhoods' tendency to invest in technological-related projects prior to and during the pandemic shock. When this study was conducted, the data was only available up until March of 2021. Due to this and in order to create two equal subsets of observations, we selected the period 23rd March 2019–2020 as the pre-pandemic and the period 24th March 2020–2021 as the pandemic period.

The following step was to transform the dataset from addresses and ZIP codes to the 23 neighborhoods defined by the City of Boston for easier interpretation. The dataset contained 435k observations for all recorded permits which were filtered and then summed to the neighborhood level. As the permits were related to different aspects of buildings, we ran a text analysis algorithm using solar energy and LEEDs' certificate-related keywords (Table 1) to find tech-related projects in order to be aligned with our questions regarding green transition.

Table 1. Keywords used for supporting the dataset based on LEED measurements.

solar	Voltage	low emitting
Energy	Recycle	Thermal comfort
Tech	waste management	innovation
panel	Environmental	refrigerant
renewable	green power	cooling tower

This step revealed a total of 299 building permits aimed at decreasing energy consumption by using technology. Among the keywords listed in the energy section of the

LEED, we identified a corpus of 15 keywords that are repeated several times and identified as important to the research question and topic of this paper (Table 1). We analyzed the green transition across Boston's neighborhoods before and after COVID-19 pandemic based on these keywords. Then we used the IQR technique and removed outliers due to the high data variance within a neighborhood.

After sorting the observations, and creating two time periods, we conducted three parts of analysis based on this data. The first part started by creating a frequency table to compare the number of all permit requests for each period to the number of permits for tech-related projects. To compare these numbers, we compute the proportion of each category (all permits issued and technology-related permits) for each period (Eqs. 1&2). Then, in order to determine the trend of permits issuance, we calculated the change rate of each category (Eq. 3). If the results show a positive sign that indicates that technological projects were less impacted by the shock than the other categories, while the negative sign describes that in these areas technologically related projects were heavily affected by the shock.

$$A = \frac{\sum X_A}{\sum (X_A - a)} \tag{1}$$

$$T = \frac{\sum X_T}{\sum (X_T - a)} \tag{2}$$

$$M = A - T \tag{3}$$

where

A is the change rate in the number of all issued permits

T is the change rate in all tech-related permits

X_A is the number of all issued permits

a is the change in pre- and during-pandemic

X_T is the number of all tech-related permits

M Proposed technological resilience measure

After the first part of the analysis was completed, the next step was to quantify the investment per neighborhood in both periods and compare the two to find a specific flow. As a way of making a fair comparison between neighborhoods, we calculated a fixed amount of USD (100 dollars) per house.

The third part was to measure and determine which possible variables influence the investment in these periods. We explored a mathematical model to work on the context-based indicators to find an appropriate regression line. After combining socioeconomic factors of Boston neighborhoods retrieved from Census.gov & Analyze Boston platform (the City of Boston's open data hub to find facts, figures, and maps related to lives within the city), we decided to elaborate on three pillars. Social factors include age, race, and educational degree. The next pillar is dedicated to exploring the economics of people, such as median income, and poverty rate. The last pillar of the data set investigates the physical properties such as the ratio of vacant houses, poverty rate per neighborhood, and race proportion. After that, we ran a multivariate regression (MVR) in which we had a dependent variable of 100 USD invested in tech-related per house in each neighborhood and the variables mentioned earlier as independent variables. After running the model, residual analyses and ANOVA explain the model fitness and quality of selected variables.

5 Research Findings and Discussion

Based on the analysis of the patterns of permits issued by the city of Boston over the past decade, it appears that the number of permits issued by the city in 2020 has shown a dramatic decline (see Fig. 3). Subsequently, the technology-related domain has also been impacted, but the rate of this change has been quite slow. This 2019–2020 period can be compared to the Covid-19 pandemic. A major objective of this study is to identify the trend distribution and the possible factors that impact this distribution at the neighborhood level, and then to draw a different line between the general permit rate and the technology-related ones to determine if there are specific factors that influence these two patterns differently.

The first finding shows that the number of the total permissions for the period of one year before and the number for the one-year period during the pandemic differ by 46%. In this dataset, there are 50k records for 2019–2020 and 27k for 2020–2021. The second finding reinforces the first by estimating a similar proportion; in the first period, 8116 tech-related projects were recorded, while in the second period, 4679 were found. Table 2 illustrates a comparison of the change rate among Boston neighborhoods in the two periods. On average, the number of projects set up dropped by almost half. Its standard deviation is 0.09, which indicates that all neighborhoods had a declining trend. However, we could later determine what was driving that in each neighborhood. The range is vast, from 23% for the downtown neighborhood to 62% for Chinatown and the financial district. When we examine the frequency of the technological project, we observe a higher variance that could translate to a gap between areas of Boston, and we introduce this as the first step in technological resilience explorative research. The average change in technological projects is 41% less than the prior year, which is lower than the drop rate in the total projects. The standard deviation was 0.2 and the range is from 0.01 in Hyde Park to 0.94 in South End, showing a 0 to almost 100% spectrum. We then proposed a technological resilience measure (See Table 2 & Fig. 4) by subtracting the change rate of technological projects frequency from drop rates in all issued permits frequency.

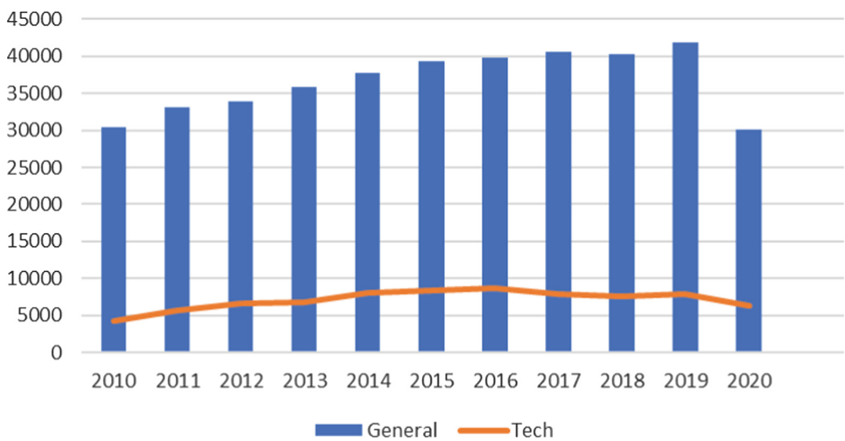

Fig. 3. Number of permits issued by the City of Boston from 2010 to 2020.

Table 2. Boston's Neighborhoods and tech-related building permits change pre and during the pandemic.

		Number of all projects			Number of Tech-related projects			
	Neighbourhood	**Pre-pandemic**	**During Pandemic**	**Change rate**	**Pre-pandemic**	**During pandemic**	**Change Rate**	**Proposed Technological Resiliency Measure**
1	Allston	836	477	0.43	118	91	0.23	0.2
2	Back Bay	3354	1486	0.56	798	321	0.6	-0.04
3	Beacon Hill	976	409	0.58	210	88	0.58	0
4	Brighton	1776	1039	0.41	262	152	0.42	-0.01
5	Charlestown	1522	753	0.51	151	76	0.5	0.01
6	Chinatown	1114	418	0.62	228	91	0.6	0.02
7	Dorchester	5446	3301	0.39	761	528	0.31	0.08
8	Downtown	844	647	0.23	214	167	0.22	0.01
9	East Boston	2416	1341	0.44	390	209	0.46	-0.02
10	Fenway_Kenmore	3117	1580	0.49	812	383	0.53	-0.04
11	Hyde Park	1636	1157	0.29	269	249	0.07	0.22
12	Jamaica Plain	2404	1196	0.5	317	157	0.5	0
13	Mattapan	1416	912	0.36	244	223	0.09	0.27
14	Mid_dorchester	1144	635	0.44	171	113	0.34	0.1
15	Mission Hill	528	300	0.43	102	50	0.51	-0.08
16	North End	398	203	0.49	59	25	0.58	-0.09
17	Roslindale	1946	1069	0.45	242	125	0.48	-0.03
18	Roxbury	3258	1971	0.4	470	307	0.35	0.05
19	South Boston	3752	2065	0.45	652	386	0.41	0.04
20	South End	67	35	0.48	18	1	0.94	-0.46
21	West End	1815	771	0.58	481	218	0.55	0.03
22	West Roxbury	1854	1147	0.38	177	143	0.19	0.19
23	Wharf District	1527	561	0.63	390	148	0.62	0.01

Interestingly, we can observe a polarization of values with negative and positive values. There was a more significant trend in technology-related projects than in the rest of categories. The frequency of 12 neighborhood tech projects did not decrease as significantly as the rest of neighborhoods. The resilience measure we proposed showed negative values in 8 neighborhoods (Fig. 5), but they are relatively minor when compared with the negative rate in South End, which is −0.46. Beacon Hill, Jamaica Plain, and the

Wharf District, however showed no signs of any deterioration or improvement during the pandemic.

Having said that, South End, North End, Mission Hill, Fenway-Kenmore, Back Bay, Roslindale, East Boston, and Brighton hold a negative value, sorted in ascending order. As mentioned before, since the decrease rate in tech-related projects is higher than other categories, this indicates that technological domains were more valuable during the shock. Alternatively, we have a list of neighborhoods, including Mattapan, Hyde Park, Allston, West Roxbury, Dorchester, mid-Dorchester, Roxbury, South Boston, China Town, Downtown, and Charlestown showing a positive value. This group of neighborhoods was more resilient to the pandemic shock in a way that minimized the stagnation that would have affected their technological behavior.

Fig. 4. Technological Resilience Measure.

After describing the first layer of this analysis, we created the measure of the amount of investment per house unit based on the number of occupied houses. As discussed earlier in the methodology, a 100 USD per house unit was selected. Table 3 indicates the rate of investment evolution on tech-related projects before and during the pandemic.

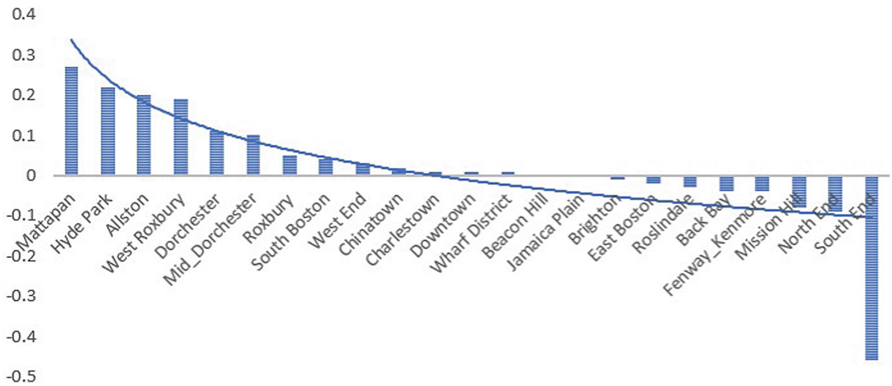

Fig. 5. Technological Resilience Measure

Results show two neighborhoods with higher investments, Mattapan, and Allston, 8 and 4% increase, respectively. In the other 21 neighborhoods, however, the situation is different (see Fig. 6). As a result of the pandemic, the budget was reduced by 3 to 100% through different neighborhoods compared to the pre-pandemic year. West Roxbury, Mid-Dorchester, and Hyde Park showed around roughly 5% reduction of investment. South End, Wharf District, and Chinatown show the lowest expenses compared to the rest of the neighborhoods with 100, 68, and 62% decline, respectively.

Before the pandemic, we see that Wharf District, Chinatown, West End, Fenway Kenmore, and Back Bay were the neighborhoods with the highest investment, while during the pandemic, few changes in this order are observed. West End becomes the neighborhood with the highest number of green tech investments, followed by Wharf District, Fenway Kenmore, Chinatown, and Back Bay. However, the declines in preferences for investment in technology projects has varied among different groups of neighbourhoods and it could be interpreted due to context-specific factors that we will be explaining in the following paragraphs.

First, we retrieved the City of Boston maps based on some socio-economic factors and aligned them to our work (Figs. 7, 8, 9, 10, 11 and 12) to see any spatial concentration and to try to see if these factors could be the reasons behind our results. Surprisingly, Fig. 9 shows how the highest "vacant unit ratio" neighborhoods are concentrated in the Boston center area. Figure 8 shows the poverty rate and that Fenway, Kenmore, Mission Hills, Roxbury, and Dorchester are the highest in Boston. Then, we focused on a number of variables that could have an impact on the neighbourhoods' investments. The variables that are included in the analysis are vacant units' ratio, white people's ratio, median age, master's degree ratio, graduation ratio per capita, income, poverty rate, population, and the number of families.

All in all, running an iterative multivariate regression helps interpret Table 3, which describes why investment criteria vary among neighborhoods. Table 4 is a merged index that shows how the model works by comparing the so-called "100 USD per House" expenditure on tech-related projects.

Table 3. Investments in tech-related projects in Boston's neighborhoods and their change rate.

	Neighbourhood	Pre-pandemic 100 USD per House	During-pandemic 100 USD per House	Change rate
1	Allston	0.95	0.99	0.04
2	Back Bay	8.69	5.28	-0.39
3	Beacon Hill	5.24	2.59	-0.51
4	Brighton	1.02	0.85	-0.17
5	Charlestown	1.25	0.64	-0.49
6	Chinatown	14.34	5.4	-0.62
7	Dorchester	1.58	1.48	-0.06
8	Downtown	6.37	3.74	-0.41
9	East Boston	2.06	1.13	-0.45
10	Fenway_Kenmore	11.81	5.59	-0.53
11	Hyde Park	2.4	2.27	-0.05
12	Jamaica Plain	1.35	0.92	-0.32
13	Mattapan	2.55	2.76	0.08
14	Mid_dorchester	1.11	1.07	-0.04
15	Mission Hill	1.87	0.83	-0.56
16	North End	0.67	0.27	-0.6
17	Roslindale	2.07	0.92	-0.56
18	Roxbury	1.8	1.49	-0.17
19	South Boston	5.83	3.54	-0.39
20	South End	0.14	0	-1
21	West End	13.24	9.23	-0.3
22	West Roxbury	1.15	1.12	-0.03
23	Wharf District	24.92	7.85	-0.68

In the pre-pandemic period, the multivariate regression (MVR) model held an 82% R-squared which we can interpret as a relatively significant number of observations explained by this model. Considering that the significance F in the pre-pandemic period is 0.001, we are able to consider the model relevant to the proposed hypothesis. In this way, we are able to establish a meaningful relationship between the technological expenditure and the three pillars of indicators. The most significant coefficient is for the "vacant unit ratio" which is 81.755, which explains how neighborhoods with a larger ratio of isolated buildings have the propensity to invest in tech-related projects. There is a negative 27,150 correlation between poverty rate and investment, which indicates the reverse relationship between these socio-economic factors. While the number of families and median age have relevant P-values, the coefficients are relatively small. The model for pre-pandemic period is as follows:

$$
\begin{aligned}
Y = {} & 81.755(\mathit{vacant\ units\ ratio}) + 0.6613(\mathit{median\ age}) \\
& - 27.65(\mathit{poverty\ rate}) - 0.003(\mathit{no.\ of\ families})
\end{aligned}
$$

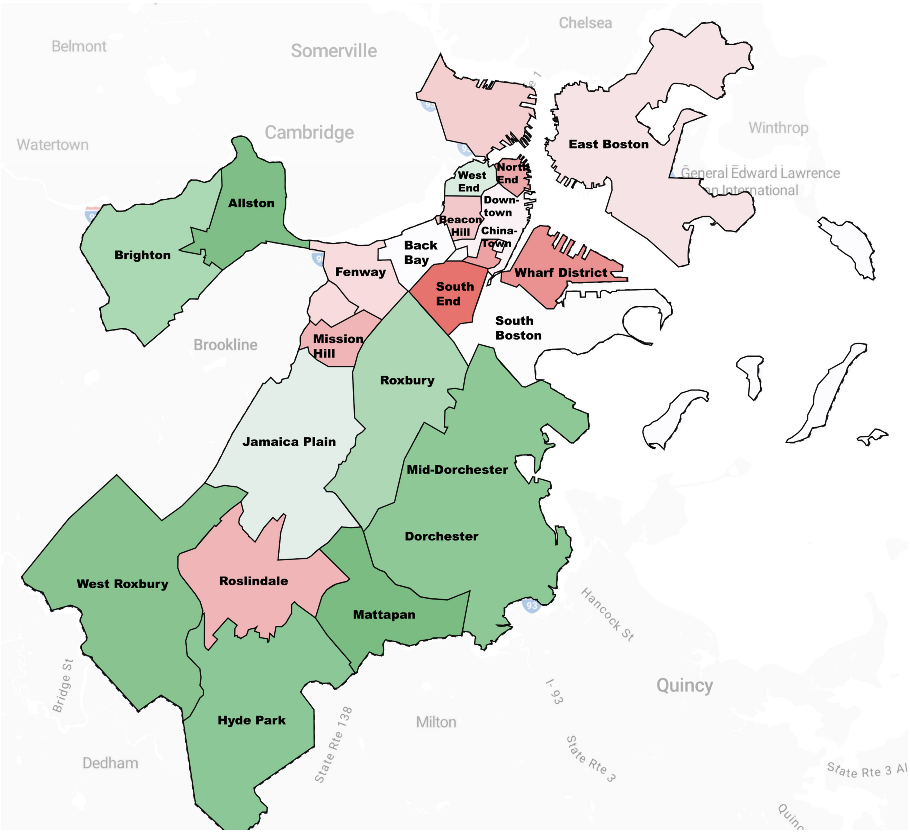

Fig. 6. Boston's Neighborhoods and Change Rate in Green Tech related investment

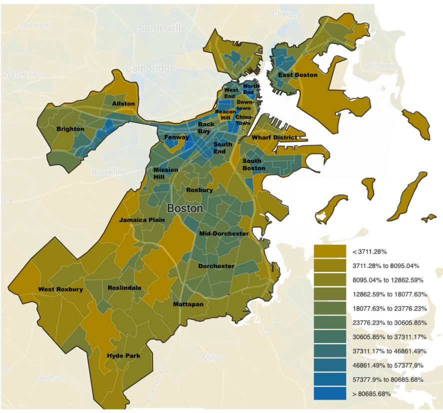

Fig. 7. Population Density

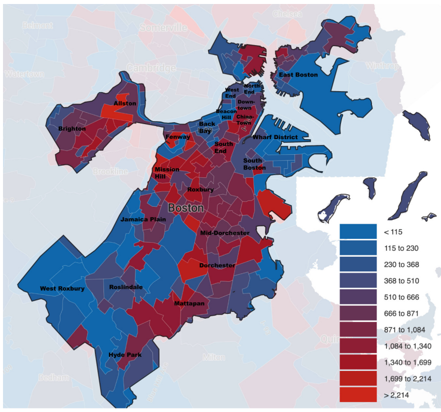

Fig. 8. Population in Poverty

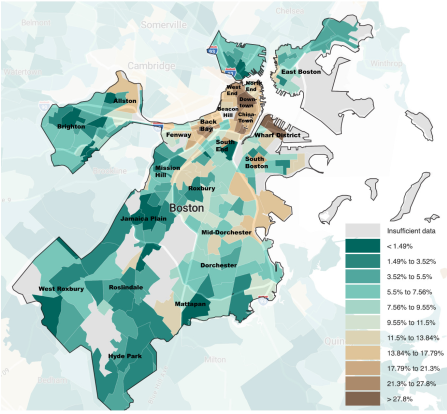

Fig. 9. Vacant Units

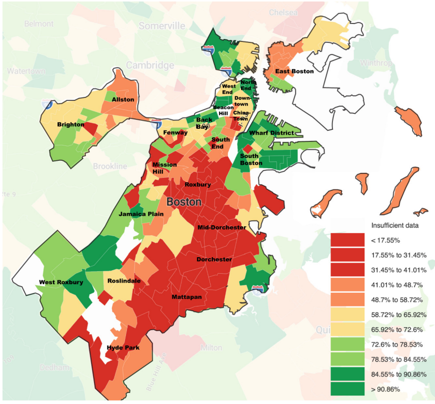

Fig. 10. White population

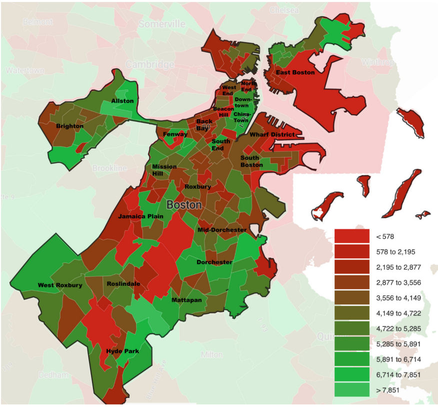

Fig. 11. Number of Families

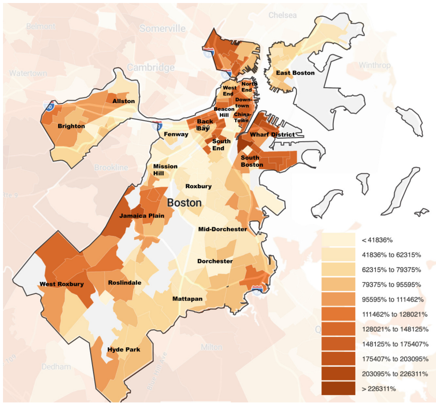

Fig. 12. Median Household Income

Next, we explore the post-pandemic period. We see that the R-squared and significance F are 67% and 0.033, respectively. On the one hand, we could observe the same model and relatively slight discrepancies in p-valves, but the coefficients are formed differently. It is essential to shedding light on the proportion of coefficient formations in pre-pandemic and post-pandemic periods. For example, the falloff is more significant in the “Poverty rate” from -27.65 to -6.52. Decreasing the share of the poverty-related recession could pave the way for new research on neighborhood clustering topics for understanding community-level programs that rendered this amount of resiliency. The model for during-pandemic period is as follows:

$$Y = 32.13(vacant\ units\ ratio) + 0.377(median\ age) \\ - 6.526(poverty\ rate) - 0.001(no.\ of\ families)$$

In the last step, we look at the variables of MVR under the lens of transmutation in investment between pre-pandemic and post-pandemic to find out the most influencing

Table 4. Regression Coefficients and P-values

	Pre-pandemic		**During-pandemic**		**Change**	
R Square	0.826146821		0.679134786		0.763318434	
Significance F	0.001086511		0.033345573		0.006418594	
	Coefficients	*P-value*	*Coefficients*	*P-value*	*Coefficients*	*P-value*
Vacant Units Ratio	81.7552	0.0016*	32.1304	0.0157*	43.7726	0.0135*
White Ratio	−7.8836	0.1864	−4.0397	0.2241	−6.3106	0.1570
Median age	0.6613	0.0445*	0.3774	0.0398*	0.1683	0.0407*
Master's degree ratio	−3.2727	0.5350	0.5240	0.8582	0.8115	0.8242
Graduate ratio	−12.6381	0.2671	−1.6336	0.7931	−11.3157	0.1963
Per capita Income	0.000003	0.9593	−0.000005	0.8903	0.000027	0.5980
Poverty rate	−27.6500	0.0490*	−6.5263	0.0466*	−17.5702	0.0406*
Population	0.0006	0.0088*	0.0002	0.0458*	0.0003	0.0401*
Number of Family	−0.0031	0.0046*	−0.0012	0.0319	−0.0016	0.0352**

variable in this before-after regression. At first glance, the same variables are considered significant but looking more in detail, we observed a more significant opposing footprint of poverty rate compared to post-pandemic analysis. Furthermore, we find out the "vacant unit ratio" is the most significant factor here, followed by the same pattern of median age & poverty rate. The change model is as follows:

$$Y = 43.772(vacant\ units\ ratio) + 0.168(median\ age) \\ - 17.57(poverty\ rate) - 0.001(no.\ of\ families)$$

While all neighbourhoods across Boston have dealt with navigating the challenges of the healthcare crisis, we clearly see that there are inequities in how different neighbourhoods were able to achieve their green transition vision. Our model suggests that city authorities will need to address the challenges of low-income communities achieving green transition with more targeted programs.

6 Conclusion

First, we observed clustering phenomena by neighborhood's tendency on tech-related project continuation trend versus the permission of the general project requests among 23 Bostonian neighborhoods. This finding could reveal the disparity among districts in the same city regarding green transition. We tested this finding in the spatial context to perform an illustration of technological resilience mapping for policymakers.

Second, for neighborhood groups, we suggested a measure of "100 USD per unit of housing" spent on tech-related projects. In this way, we captured neighborhoods' size, population, and housing density patterns to find a uniform measure in comparing them. After drawing districts' behavior diagrams and their pre/post-pandemic observations, we noticed a pattern of transition among them; this leads us to conduct a model for this phenomenon. Finally, to allocate scalable weight to each independent factor, we ran an MVR model and discussed the findings above. Suggesting a model despite results guides us to characterize groups of variables; these suggested pillars of ingredients offer a perspective to qualitative research plans for conducting surveys within the suggested neighborhoods to enhance the pillars. We believe there is more room for investigating community-level priorities and opportunities due to the diversity of Boston. Exercising shock heat maps, known as resilience mapping, is a novel perspective in urban studies investigating the flexibility of communities facing acute turbulence.

Third, the final maps are created to call for more attention on structurally weak neighborhoods by policymakers and the communities to think again. The acute shock of the Pandemic enhanced the transition in structural change level. This phenomenon addresses the socioeconomic disparity at the local level. As a team of researchers, we believe the so-called post-carbon transition could be implemented locally. While this micro-scale is obliged to follow global programming structures, the ability to reveal inclusive shifts is a nexus between actors and places. Finally, we suggest spatial network analysis approach for the next steps of this research question on technological resilience assessment by benefiting from a relatively long panel data analysis of neighborhood behavior [36]. In this paper, we suggested an MVR Model test and demonstrated the hypothesis on the lack of inclusiveness of transition based on the spatial disparity between Bostonian neighborhoods. In this way, there were limitations on expanding the pillars to more flexible measures at the neighborhood level, which one can suggest as a novel perspective in big data for urban research.

7 Limitations of the Study

Surprisingly, looking at the model and pillars of the suggested variable, we could conclude that race, despite of long history of being addressed as a discrimination factor, has no significant effect on this transition model. However, one could claim "poverty rate" and "white race ratio" have a collateral relationship; we could not find any in this paper. Racial disparity is known as a risk factor in most American resilience plans. However, in the technological resilience domain, this could be addressed differently due to the reasonably uniform access to federal and local government funds on tech-related projects in the housing field. Although the highest R-squared is below 85%, this range's consistency allows us to generalize these findings as a call to map the city based on more research-based factors. Enduring a most significant variable pattern with expenditure (specifically on tech-related) layers on a dashboard could lead the policymakers to design an appropriate real-time and place-based plan for communities to prioritize actions.

Even if the differences in green technology investment didn't translate to ethnic and racial differences in our model. We understand that looking only on the white population ratio is a starting point for our study. In a future study, it would worth it focusing more on different ethnicities and races to explore how these can explain the neighbourhoods' tendency to invest in tech-related projects and ability to deal with green transition.

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Data Availability. Https://dataverse.harvard.edu.

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Renewable Energy Communities: Enabling Technologies and Regenerative Models for the Green and Digital Transition in the Inner Areas

Investigation Through Case Studies for the Experimentation of Living Lab in the Grecanica Area

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Abstract. This contribution addresses issues of research in Architectural Technology conducted with the laboratory ABITAlab of dArTe-Unirc, with reference to the design of devices for regenerative models based on the tool of "Renewable Energy Communities" in territories subject to marginalization and depopulation phenomena, such as the inner areas of Grecanica Area in Reggio Calabria. The aim is to envisage a transformative path of sustainable development, which can implement "mechanisms of just and equitable transition" at the local level, placing itself within the lines of support and public investment for climate neutrality, such as the Next Generation EU and the National Plan for Recovery and Resilience in Italy. We investigate the key issues of advanced sustainable project, for the design of devices and integrated innovative tools based on solar technologies (PV) for the production, storage and distribution and sharing of energy by communities settled in the inner areas (*prosumers*), helping to obtain economic and environmental benefits, towards the "climate neutrality". The model of Energy Communities, using processes of Advanced Regenerative Design, which increase the performance of the system, thanks to the integration of hybrid "zero impact" technologies, become the tool through which to trigger processes of regeneration and new quality of space and life in the inner territories, where there is a greater presence of natural resources (air, water, sun, biomass, etc.) to be used as renewable sources for energy production, but also the possibility to monitor and more easily account for the impacts of a settlement model based on "carbon free" energy production chains, with the reference community settled.

Keywords: Energy Communities · Enabling Technologies · Inner Areas

1 Introduction

The trend towards a paradigm shift in energy production, management and consumption, triggered by the gradual transition from the use of fossil sources to the prevalence of renewable resources, is the domain within which to achieve the decarbonization

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goals of the European energy system defined in the Clean Energy Package adopted in 2019 [1]. In deed, the European Union's energy policy promotes an integrated approach to environmental, climate and energy safety in order to solve also social needs [2]. Moreover, in Italy, as in all industrialized countries, buildings are assigned about 40% of total energy consumption and almost 50% of Co2 emissions. It is noteworthy that even if recent commitments rule out the worst-case emissions scenario (a global temperature rise of more than 3 °C), the transition to a net-zero GHG energy system will be costly. The problem of pollution is solved not only by limiting energy consumption and thus by using smaller amounts of energy, but also by using "clean" energy sources and, finally, by increasing the efficiency of energy transformation, that is, by using thermal and electrical energy production systems with as little loss as possible. In this sense, the solar energy produced by photovoiltaic plants (PV) is advantageous since it is currently the cheapest source of electricity. Certainly, other important advantages are related to the wide availability of energy sources and the return on investments for electricity, thanks to the payback period and the environmental friendliness (zero impact) [3]. In addition to environmental issues, the challenge also concerns the phenomenon of energy poverty, "a situation in which a household is unable to pay for the primary energy services (heating, cooling, lighting, moving, and power) needed to ensure a dignant standard of living, due to a combination of low income, high energy expenditure, and low energy efficiency in their homes" [4]. This phenomenon affects mostly the inner areas communities, which live in conditions of marginalization, caused by the lack of access to primary services (health, education, mobility) and energy sources [5]. As stated by Gaman et al. [2], in order to trigger a sustainable transformative pathways and implement "fair and equitable transition mechanisms" at the local level, it is necessary to develop an integrated sustainable development strategy, which includes the capability to adopt approaches that encourage cooperation and partnerships between the public bodies, private sector and civil society in experiences, capable to transfer knowledge and sustainable models "innovation driven" and to be accelerated by large-scale investments from sustainable policies.

In this context, the paper investigates the issue of Renewable Energy Communities (RECs) as a tool capable of responding to the environmental issues of clean and affordable energy production and the scarcity of primary services due the lack of energy provision in marginal territories, through the adoption of a method related to advanced type design for impact control and the experimentation of the Living Lab (LL) model as a demonstrator capable of implementing, managing and validating a REC. The paper is structured as follow:

– the Sect. 2 illustrates the key issues about the policies for the "green transition" and the renewable energy communities, followed by a sectoral overview at case studies of REC implemented in rural areas at the european and national levels;
– the Sect. 3 investigates the methodological approach and aspects with which architecture technology can contribute to achieve the goals of reducing impacts for climate neutrality, acting through processes and strategies of mitigation and adaptation and activating "advanced sustainable projects" for energy self-production;

– the Sect. 4 describes the preliminary findings for the experimentation of Living Lab (LL), illustrating the LL approach in european projects and key issues for the application on the Grecanica Area of Reggio Calabria;
– the Sect. 5 critically discusses the five innovative aspects for favourable conditions for an experimentation of REC in the Grecanica Area;
– in conclusion, the possibility to activate LL processes and future steps of research are discussed.

2 Key Topics of the Reference Scenario

2.1 Policies for the Green Transition

In order to accelerate the "green and digital" transition in the regions of the member countries and the achievement of the global goals for climate neutrality and sustainable development of the UN Agenda 2030, Europe has launched an "Energy Transition Strategy" to guide the transformation of the global energy sector from fossil to zero carbon by 2050 and a 55% reduction in greenhouse gas emissions by 2030 [6]. In this direction the Next Generation EU (NGEU) program operates, which has made available substantial financial resources through the Recovery and Resilience Facility (RRF), the tool through which the European Union intends to achieve the green and ecological transition of society and the environment. In July 2021, the italian Government has finally approved the National Recovery and Resilience Plan (NRRP), the package of reforms and investments launched in order to access the resources of the NGEU, which is divided into 16 components, grouped into 6 missions, including the "M2. Green Revolution and Ecological Transition" [7]. In particular, the NRRP reserves large shares to actions aimed at "Increasing the share of energy produced from Renewable Energy Sources (RES) in the system" and has identified investment lines dedicated to innovative tools and technologies for these purposes, such as the "Promotion of renewables for energy communities and self-consumption" (M2C2 – "Renewable energy, hydrogen, network and sustainable mobility"). In addition to these lines of intervention, it is also worth considering the facilities that will be available to the regions with measures of the Cohesion Policy in response to the effects of the crisis and contributing to a "green, digital and resilient economic recovery" [8]. Moreover, the areas referable to the Ecological Transition are also traceable in other trajectories, measures and actions, such as: the National Research Plan 21–27, Trajectory 5.5.2: "Climate Change, Mitigation and Adaptation", Articulation 4/8/9 [9]; the Specialization Smart National Strategy (SSNS), Regional Specialization Area "Energy" with the national priority development trajectory 5.5.4 "Intelligent and sustainable industry, energy and environment - Evolutionary and adaptive production systems for customized production - Technologies for smart grid, renewable sources and distributed generation" [10]; the 2030 Agenda with Goal 7 "Ensure access for all to affordable, reliable, sustainable and modern energy systems" and Goal 11 "Make cities and human settlements inclusive, safe, durable and sustainable" [11] and, at the local level, the National Strategy for Sustainable Development, Area "Planet", strategic choice "Ensure sustainable management of natural resources" [12]; the Regional Operational Program-ROP Calabria 21–27, Specific Objective 2 "Greener

Europe and free of carbon emissions" and the S3 Calabria Region, for the trajectory "Energy and Climate - Energy Communities and technologies for smart grids and renewable sources" [13].

These references are the framework of intervention policies to support the implementation of new models of production, storage and exchange of energy from renewable sources, which employ innovative technologies and advanced devices and promote forms of decentralization and self-consumption through the so-called Renewable Energy Community (REC).

2.2 The Renewable Energy Communities

The path of regulatory adaptation in the field of renewable energy communities ended last December 15, 2021 with the Legislative Decree that definitively transposes the Renewable Energy Directive - RED II (2018/2001) and Internal Market in Electricity-IEM (2019/944) directives. This process, which began with the "Milleproroghe Decree" of February 2020, will allow the large-scale promotion of the implementation of energy communities in order to achieve the minimum target of 32% green energy as early as 2030. In distinguishing "Renewable Energy Communities" from "Renewable Energy Self-Consumers", the RED II Directive defines the former as legal entities made up of groups of individuals, local entities, companies, located in the vicinity of plants producing energy from renewable sources that on a voluntary basis come together to produce and consume clean electricity, according to the principles of self-consumption and energy self-sufficiency [14]. The purpose of REC is in fact to aggregate and account for the energy demand of a defined local community, capable of having technologies and devices for energy production from renewable sources.

The users are configured then no longer as mere "consumers", but also as "producers" of energy ("presuming" model: producing + consuming), able to cope with the issues of "energy poverty" and to operate in a participatory and collaborative way to design systems for the satisfaction of their energy demand of residential type and the management of collective structures/manufactures with social purposes. The Article 2(16) of the Renewasbles Directive defines a REC as a "legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; (b) the shareolders or members of which are natural persons, SMEs or local authorities, including municipalities; (c) the primary purpose of which is to provide environmental, economic or social community benefits of its shareolders or members or for the local areas where it operates, rather than financial profits". RECs are entitled to produce, consume, store and sell renewable energy, including through renewable power purchase agreements, to share renewable energy within the community, and to access to all suitable markets [15] (Table 1). In addition, the Legislative Decree defines the increase in the power limit of plants eligible for incentive mechanisms (from 200 kW to 1 MW) and removes that of the creation of energy communities by users under the same secondary cabin.

Table 1. Comparition of energy "production/consuming" models. Source: elaboration by G. Mangano

Model	Production	Market	Transmission	Distribution	Consumer
Traditional	Few large plants	Centralised, mostly national	Based on large power lines and pipelines	Top to Bottom	Passive, only paying
Renewable Energy Communities	Many small power produces	Decentralized, ignoring boundaries	Including small-scale transmission and regional supply compensation	Both direction (sharing in the place)	Active, Partecipating in the system

The principles on which an Energy Community is based are that of "decentralization and localization of energy production", where "the concept of self-consumption refers to the possibility of consuming on site the electricity produced by a local generation plant to meet their energy needs" [16]. In particular, the RECs organization, governance and purpose can be summarized in multiple aspetcs: generation from Renewable Energy Sources; Electrical Energy (connected to RES supply); RES supply; RES aggregation; RES sharing; RES self-consumption; E-mobility connected to RES of RECs.

Moreover, it is worthwhile to clarify the substantial difference between Citizen Energy Communities (CECs) and Renewable Energy Communities (RECs). The former's scope is currently limited to electricity sector and is technologically neutral, while RECs are able to engage in the collective management of all energy sectors (production, consumption and selling of renewable energy, renewable gas, etc.), but limited to renewable energy technologies and the shareholders or members in RECs must be located in the proximity of the renewable energy projects that are owned and developed by the REC [17]. Both contribute to energy poverty reduction, especially in marginal or less-favored areas, and resilience to climate impacts. In fact, the production of energy at the point closest to end use and the possibility of storing and redistributing it are instrumental to the development of smart grids, that are more adaptable to the needs of the electricity system, peaks in demand, and the peculiarities of each energy source.

Therefore, it is interesting to define RECs as the result of an integration of four dimensions, which make their activation possible: a "legal" dimension, in that they are a subject defined by specific regulations; a "social" dimension, in that they constitute a new model of local governance and sharing of resources on the ground; a "political" dimension, in that it is a tool to achieve the climate goals mentioned above (New Green Deal, Ecological Transition Plan, Agenda2030, etc.); last but most decisive aspect in future developments, a "technological" dimension, as RECs take advantage of the latest storage technologies, Smart Home and Energy Box for example, for energy efficiency aspects. In fact, to support an energy community, there are many technologies that facilitate consumption monitoring and help community users save and consume energy more efficiently. These include technologies for the management and storage of energy from renewable sources, small local generation plants used by energy communities can predevelop electrochemical storage using batteries, as lithium-ion batteries commonly do. The advantages of using such technologies are the greater utilization and better management of energy produced from renewable sources: the battery allows the excess energy produced to be stored and delivered when production is lower (e.g., at night) and reduces power peaks and imbalances due to the randomness of renewable sources, making it easier to feed into the grid electricity of energy not consumed. Smart devices for optimizing flows and energy management include the Energy Box, a device that communicates with sensors installed in the home and transmits collected data to a cloud platform that analyzes it and provides the user with suggestions for optimizing consumption. Thanks to these sensors, the user can also be informed and manage the devices in his or her home remotely via app or pc (ICT technologies) [18].

The advantages that derive from the adoption of a model of energy community are certainly, on the one hand, environmental and economic (CO2 savings in energy production and incentives for prosumers), on the other hand, indirect with positive effects on the productive and economic system of the community, especially for those territories, such as inner areas, which have depopulation trends, lack of services related to energy poverty and a heritage to be regenerated. In these contexts it is possible to experiment with projects with "high rate of innovation", cohesion and promotion of knowledge, consistent with the mechanisms of "just transition", in which users are not only end users, but actively collaborate to save energy and create a circular model and collaborative economy (co-design approach), which is based on the adoption of key enabling technologies (KETs) and advanced design processes of regenerative type [19].

Although the EU legislation on RECs is of recent conception, already in the last two decades have spread in Europe some successful practices of "prosumer" communities in rural/local context, able to achieve high levels of energy self-sufficiency.

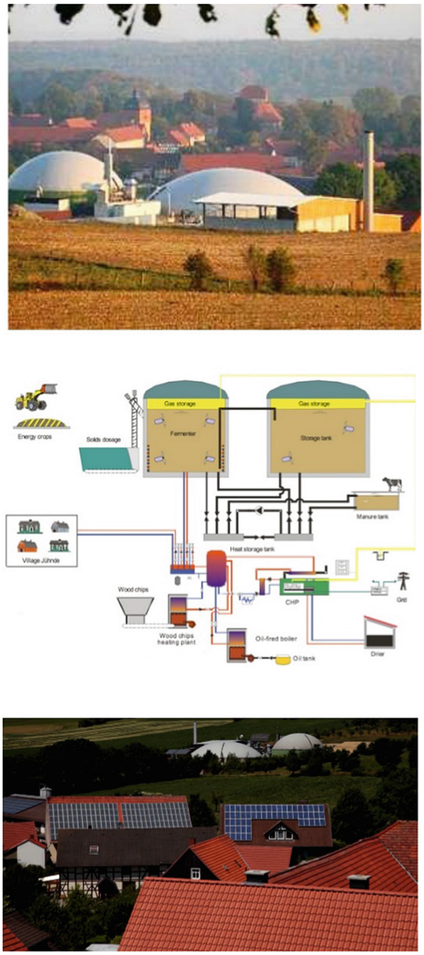
2.3 Renewable Energy Communities in Inner Areas: A Study Cases Overview

As mentioned above, although Renewable Energy Communities are instruments regulated by recent European legislation, experiments have been conducted in recent years that have become successful experiences in the field of "green" energy production with only renewable sources. In Italy, according to the last Electricity Market Report by the Politecnico of Milano [20], there could be about 20.000 REC by 2025, serving more than 1,000,000 users households and 300,00 non-domestic (public buildings – schools, municipalities, libraries…). Currently, there are 46 active RECs in Italy and it is important to notice that the 75% is located in the inner areas. Below are three national case studies located in inner territories. Since rural areas can give a substantial contribute to the goals related to climate neutrality [21] and energy transition [22], it is useful to investigate selected case studies of energy communities in rural/inner areas, at the European and national levels, summarized into "info-boxes" (Figs. 1, 2, 3 and 4):

- CS1 – Bioenergy Village of Jühnde (Ger)
- CS2 – REC Cooperative of Melpignano (Ita)
- CS3 – REC "Energy City Hall", Magliano Alpi (Ita)

– CS4 – REC "Berchidda Energy 4.0" (Ita)

Case Study 1 (CS-1). Bioenergy Village of Jühnde [23]



Location:	Jühnde (Niedersachsen, Germany)
Year:	2006
Population:	989 inhabitants (up to date 31-12-2019)
Management model:	Energy community of citizens' cooperative (shareholders) with the University of Göttingen
Technology used:	biogas plant for combined heat and power production (cogeneration) from liquid manure and whole plant silage of different crops and photovoltaic plant
Energy Production:	- 700 kW cogeneration - energy for building heating= 6,500 Mwh/year - electricity= 5000 MWh/year
Energy demand coverage:	- 70% of the energy needed to heat 145 buildings - twice of electricity demand
Impacts:	- Switch from a consumption model based on fossil fuels to one based on the production with biomass - 75% of the inhabitants are members of the energy community - Quality of life of local community increased

Fig. 1. The Bioenergy plant and PV on building roofs. **Source:** IEA Bioenergy Task 37, www.100-percent.org/juehnde-germany/

As illustrated in these few study cases, the creation of RECs in inner areas, territories suffering from depopulation and aging of the population, reduces energy poverty and creates or enables new services to the population. In continuing what has been argued by Kitchen and Marsden [26] and Von Bock und Polach et al. [27], the inner areas are an optimal settings in which is favourable the promotion of models based on renewable

Case Study 2 (CS-2). REC Cooperative of Melpignano

Location: Melpignano (Lecce, Italy)
Year: 2021
Population: 2135 inhabitants (up to date 31-05-2021)
Management model: Energy Community including Cooperative (Municipality with Legacoop) with the role of installing, managing, maintaining the pv systems and selling surplus energy
Technology used: photovoltaic panels on roofs of private and public building (tot. 33 solar plants, 29 owned by cooperative)
Energy Production: - 179.67 kW of photovoltaic systems (159.93 kW owned by the Cooperative)
Energy demand coverage: Total satisfaction of electrical energy needs of REC households
Impacts: - 400,000 euros of investment - Renovation of private buildings roofs - Renovation of public buildings roof

Fig. 2. Melpignano municipality and PV installed on buildings. **Source:** www.comunirinnovabili.it/cooperativa-di-comunita-di-melpignano/

energy technologies, especially by adopting the decentralized and community based form of Energy Communities. The creation of "island" plants in rural areas not served by the electricity grid and the adaptation of existing plants according to the new energy model, also increases the resilience of territories to the impacts resulting from climate change and enables the experimentation of advanced technology in the field of production, consumption, monitoring and distribution of electricity generated from renewable sources, such as rooftop photovoltaic systems, community battery storage, residential heat pumps, electric vehicles, smart platform for energy management. These technologies can be considered either individually or integrated, hybridizing the "presuming model of buildings/structures/places in which they are considered.

Case Study 3 (CS-3). REC "Energy City Hall" [24]

Location: Magliano Alpi (Cuneo, Italy)

Year: 2020

Population: 2166 inhabitants (up to date 31-12-2020)

Management model: Energy Community made up of Municipality of Magliano Alpi, the Public Library, the gym, the school and n.4 residents

Technology used:
- 20Kwp photovoltaic plant on the roofs of the Town Hall
- Connection PODs for energy sharing
- Electric Vehicles (EV) recharging stations
- IoT platform for real time energy management and monitoring (Energy4Com support)

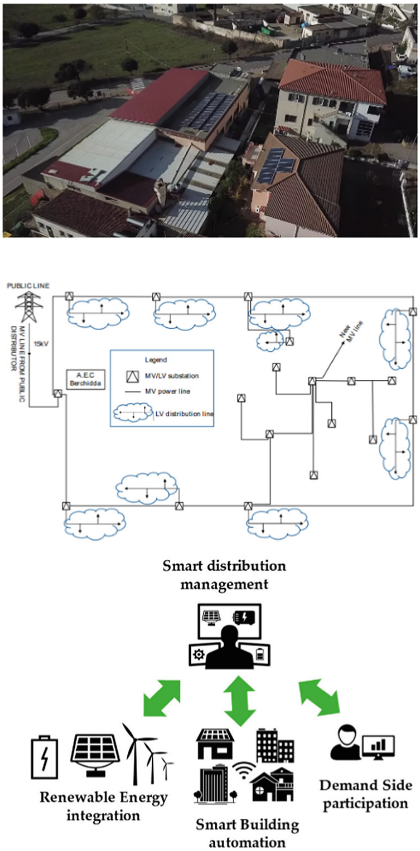
Energy Production:
- 24 MWh by photovoltaic system

Energy demand coverage: 7 households of which three municipal 3 households and 1 small handicraft enterprise

Impacts:
- Building retrofit
- Processes of local development
- Local short supply chains with a strong cognitive and technological value
- Free services for residents (EV charge, energy sharing)

Fig. 3. PV plant and energy monitoring platform. **Source:** https://cermaglianoalpi.it

Case Study 4 (CS-4). REC "Berchidda 4.0" [25]



Location: Berchidda (Sassari, Italy)

Year: 2019

Population: 2688 inhabitants (up to date 31-08-2020)

Management model: Energy Community made up citizens, Sardegna Region, Department of Engineering and Electronic University of Cagliari

Technology used:
- 200 photovoltaic plants with >1500 kWp of power
- Storage systems with a capacity of 50 kW/50kWh
- Smart Home Systems (smart box) for energy monitoring

Energy Production:
- solar energy production of about 3 GWh/year

Energy demand coverage: Local self-consumption >50%

Impacts:
- Activation of 30 pilot projects on existing pv systems for self-consumption promotion and community engagement
- 620,000 € savings (-50% public cost of energy) and 30% energy bill reduction

Fig. 4. PV panels for REC on roofs and Smart distribution manage-ment of the local energy community resources. **Source:** web search

3 The Methodological Approach: Advanced Impact Design for the Renewable Energy Communities

The enabling technologies to support the model of energy communities are part of the family of "smart" devices, aimed at production, storage, distribution and monitoring for energy efficiency and savings (such as Smart home and energy box). These technologies are configured as integrated devices to different living systems (private and public), structures and open spaces and infrastructures, becoming technological components of the "architecture in transition", whose morphology and life cycle are the result of processes of "Advanced Design" with a strong "regenerative" character from the point of view of the energy-environmental profile of high performance. As stated by C.Nava in fact, "the enabling technologies become the service devices to such "performance, they themselves adapt to the contexts in which they are called to govern the process/design to produce quality in the use, operation, configurations of urban systems and built architecture" [27]. Since climate change has become a central theme in global sustainability policies, architectural technology has begun the transition from the themes of "sustainable design" to those of "regenerative design driven by innovation", in which the objectives of the ecological transition re-establish the relationship between design and resources (water, air, sun, materials, but also data). It is no longer sufficient to apply "restorative" design processes, which meet performance requirements in terms of energy and only reduce the environmental impacts of the building, but it is necessary to respond in an "advanced" and "regenerative" way, pursuing not the reduction of impacts, but the production of a positive impact on the environment. The shift from a "degenerative" to a "regenerative" model is to move from a model of reduced consumption to a model of "positive" production (Fig. 5).

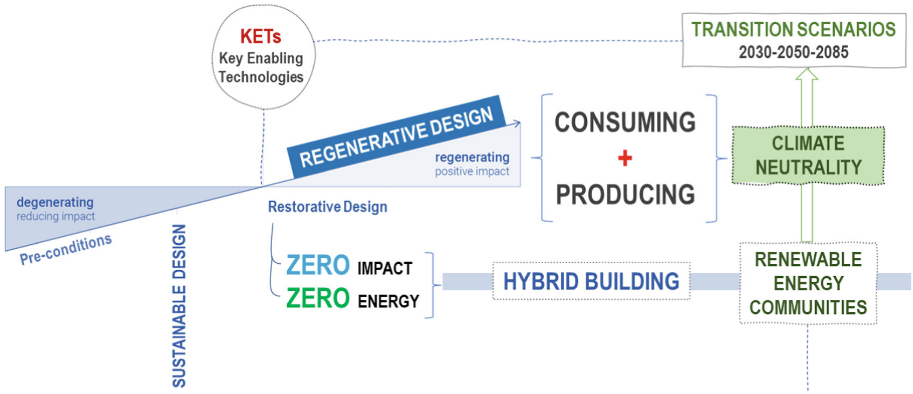


Fig. 5. Relationship between design, presuming, technologies and REC towards climate neutrality in transition scenario. Source: elaboration by G. Mangano on C. Nava's note (Design Culture Technology Course – dArTe, 09-11-2021)

In this sense, "Impact is the way but also the gauge by which the effects of transformations in the built environment and on all social and economic scenarios are measured [and] in their assessment, impacts are not assumed as the limits of the project but rather correspond to the very resources of innovation, for each resilient transformation" (impact design).

Ecological transition and digital transition then become the caliber for the application of processes based on the availability of resources and enabling devices capable of leveraging the regenerative capacity of the same. This is a logic of distribution of "circular" type networks, based on processes of production, storage and sharing of resources and energy (smart grids, systems based on PV technologies, batteries of the latest generation, etc.), where the role of the user becomes central, no longer the final recipient but the protagonist of an iterative process of "empathy, definition, design, prototyping and testing" that can generate a positive impact on natural and human ecosystems [29].

The devices, buildings, structures will therefore have the ability not only to consume resources, but also to produce and redistribute energy. Therefore, it means developing new integrated devices by innovating existing technologies, so that these can represent not only a new hybrid model of energy production, but can also allow to act, through a project of technological and environmental type, on a new quality of open and private spaces, that make the city become a functional phenomenon expression of the relationship between its components, able to define advanced and performing spatial systems, which become "regenerative" for those territories where there is low quality of services and spaces, energy poverty and lack of networks.

The issues of "energy efficiency", "renewable energy" and "combined heat and power" (Fig. 6), become the actions addressed by advanced design processes and enabling technologies, with the aim of pursuing mitigation actions capable of acting on the causes rather than the effects of climate change.

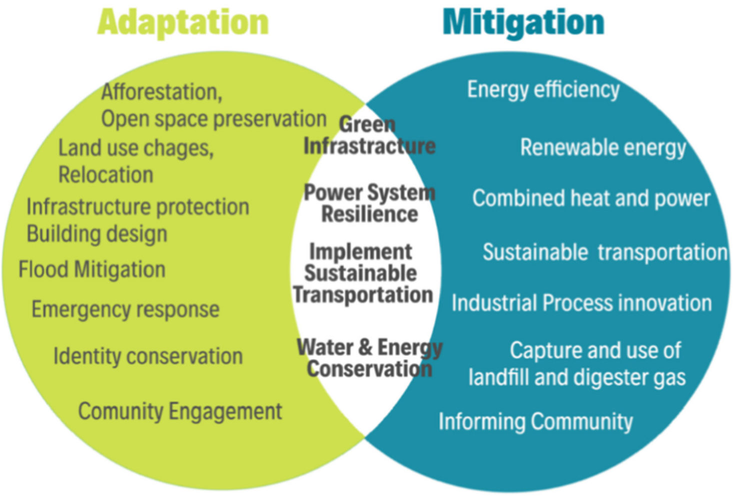


Fig. 6. Actions for Adaptation and Mitigation investigated for energy issues. Source: Climate Technology Centre & Network figure, www.ctc-n.org

The level of innovation triggered for the benefit of users/citizens, continues Nava, concerns the "control of the physical components city/building […], in which the existing context can produce regenerative systems […], implementing policies of circular economy, metabolism, densification, compensation, resilience, recycling, through processes of scenario 2020/30/50, for assets in energy transition (user-producer, renewable, smart grid, etc.), but also the design and process of environmental factors city-building, in which the themes of energy and hybrid systems innovate the very configuration of the project at urban and building scale. The aim is to realize climate neutral buildings/environments, that efficiently produces and consumes energy while providing high comfort and being "CO2 neutral" by passive and active systems for energy supply. The Advanced Regenerative Design, when integrating levels of monitoring and evaluation of impacts at the local level takes into account the indicators and targets of sustainable development at different scales (*micro, meso, macro*) and indicators for the accounting of resources. It is a design that provides different time scenarios in order to work on the concept of "adaptation" and "mitigation" of climate phenomena, focalized on a "performance-based approach", that "deepens the relationships that the experimental design undertakes with the physical environment, focusing the study on aspects that relate to performance attributes, referring to quantifiable parameters that can influence both the quality of the environment, when they intervene on the performance aspects of the building, and the measurement and visualization of impacts" [30].

The role of open knowledge, capacity building and co-design processes are therefore fundamental in models that include aspects of monitoring with the involvement of key players and end users together (designers, policy makers, citizens, etc.) and that identify the physical "limit" of the community of reference.

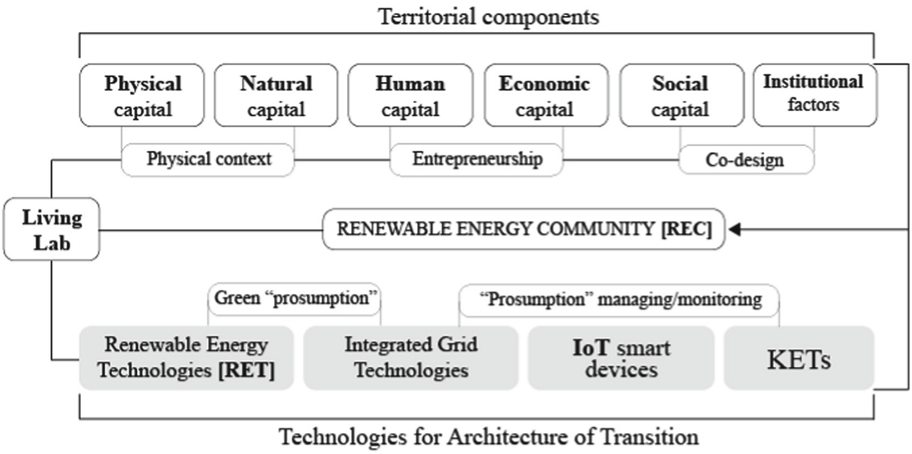


Fig. 7. Territorial components and technologies for transition as factor to trigger LL processes with REC. Source: elaboration by G.Mangano

These aspects become key levers for the development of Renewable Energy Communities with a regenerative character for the context in which they are realized, allowing also to make this model more advanced, by integrating transdisciplinary and interscalar research, knowledge, technologies and methodologies (building/neighborhood or village, citizen/community, inner areas/urban areas) (Fig. 7).

Indeed, examples of energy-efficient buildings from this point of view are many, and consumption reductions of up to 50% are easily achievable goals through applications of technological innovation. Not to mention positive energy buildings, that is, those that produce more energy than they consume. Enclosures will be made of "smart" materials, with automatic activation of control systems and management of microclimatic parameters. Each building will be interconnected to a network with which it will exchange, reversibly, energy [31].

4 Preliminary Findings for Living Lab Experimentation in Grecanica Area

The above topics are part of the research-project starting in January 2022, entitled "Advanced Impact Design and Enabling Technologies for the design and activation of "energy communities" with models, devices and prototypes for "self-production" and "assessment of impacts" from "climate change in the Mediterranean area" [32]. The objective of the research is to conceive, design and implement a device with advanced design approach, which exploits the potential of assisted and digital design and provides a phase of prototyping, verification and testing for control and technical choices, the level of efficiency, technical feasibility (and economic), at a scale of system/component of study. The prototype of this structure/system/infrastructure can be realized at a scale of 1:1 and be placed in the space under study within the area and the community identified with a path of study and scouting (territorial laboratories and co-design). It will integrate the technological devices for the station/building aimed at the production of solar energy and the devices for energy control and monitoring (consumption and impact accounting). The integrated solar and pv technologies will therefore allow to achieve adequate levels of satisfaction of energy demand, new quality of space in the areas in which it fits and new quality of life, helping to produce clean energy at "zero emissions". The research, conducted by the Center ABITAlab of the Department of Architecture and Territory will aim to implement an experiment in the territories and communities of the inner areas of the Grecanica Area of the Metropolitan City of Reggio Calabria, on the "Living Lab" model, involving local authorities, businesses, community representatives, associations and laboratories of the experimental area identified.

The Living Lab aims to be a "demonstrator" with the goal of facilitating the transfer of scientific innovations into applications through the provision of facilities and expertise qualified largely within applied research pathways. As argued by Teixeira A.J.S. et al. [33], "the Living Lab is not just a repository of technologies. It is essentially an interactive environment in order to facilitate the research, development, integration, validation and evaluation of multimodal, adaptability and user monitoring technologies, new modes of interaction and new services supported". It means searching for new research paradigms, which intends to increase the understanding of problem statemens; explore and evaluate new ideas and concepts; confront the new ideas and concepts with users' value model; triggering iterative processes for experimentation; more accurate results in reliable producats and services; scale-up concepts and contribution to bring scientific results and innovation to the citizens (Fig. 8).

The "Living Lab" approach is that of "user-centered research" and ecosystems of Open Innovation, which involve public and private entities in multi-actor partnerships (co-design) and territorial impact. In this sense, important Living Lab pilot cases for the design, implementation and management of energy communities can be found, for example, in the "Smart Energy Living Lab" project, developed by Enerbrain with the Energy Center of the Polytechnic University of Turin [34] which aims to develop a digital platform for the optimized management of multiple energy communities, understood as constituent elements of a functional Smart District for the implementation of territorial policies aimed at carbon neutrality with solutions aimed at increasing the energy efficiency of buildings, decreasing the needs of users and increasing the use of

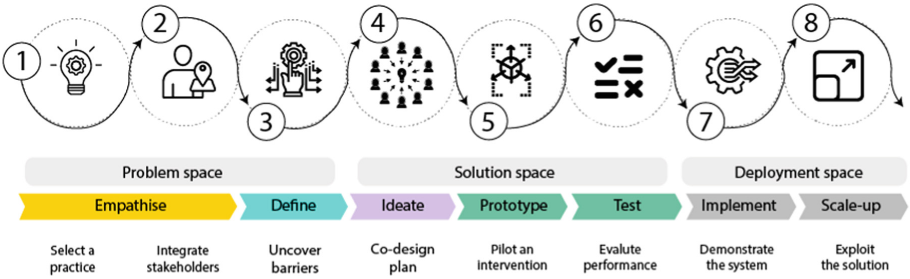


Fig. 8. Living Lab integrated approach. Source: G. Mangano's elaboration on Mastelic, 2019

self-generated energy from renewable plants. At the European level, it is interesting to point out the project "LEC-Civic energy future: sustainable Local Energy Communities" (Interreg-IPA CBC EU-Axis "Environment and Energy"), led by Montenegro, Italy and Albania, whose objective is contribute to improving energy efficiency and renewable energy usage through the development of a "local community of active energy consumers", which cooperates with municipalities, by promoting local actions inspired by switching to "energy presuming" model. Within the framework of Smart Specialization Strategy (S3) of Portugal, it is worth mentioning the "Culatra 2030 - Sustainable Energy Community" initiative, a living lab for the sustainable energy transition, a real-life laboratory for green transition, aimed at the transformation of all structures on the island into energy self-sufficient systems, through new technologies implemented. The community "produces energy exclusively from renewable sources, use electric mobility, decarbonise its fishing industry and acquire sustainable habits and living practices" [35]. Based on the framework described above, the pilot experiences illustrated and the methodological approach adopted in the ABITAlab research, it is possibile to integrate these research experimental trajectories for the Grecanica Area with the National and Regional Strategy of Inner Areas and the Framework Programme Agreement already ongoing. The experimentation will be conducted in order to trigger advanced regenerative processes and the opportunity to contribute to the objectives for climate neutrality to 2050, starting from those territories that constitutes about 80% of the territory of the Calabria region and are inhabited by over 60% of the population of Calabria. In particular, the "Grecanica" Area is the second pilot area for the implementation of the National Strategy of Inner Areas in Calabria (after Reventino-Savuto).

The Grecanica Area includes a wide territory in the eastern part of Metropolitan City of Reggio Calabria and includes eleven municipalities in the Project Area, with four additional municipalities added for the Strategy Area. The area surveyed is inhabited by 18,821 people out of the total 551,380 in the Metropolitan City of Reggio Calabria. In the last forty years have suffered the loss of over 40% of the resident population and marginalization phenomena (Fig. 9).

These factors have caused the almost total abandonment of entire inner centers, affected by both events of hydrogeological instability that led to the construction of a new town far from the places of "historical foundation" (see the case of Roghudi), and the lack of adequate connections with the metropolitan area of Reggio Calabria and coastal centers, where they are provided the essential services of health and education.

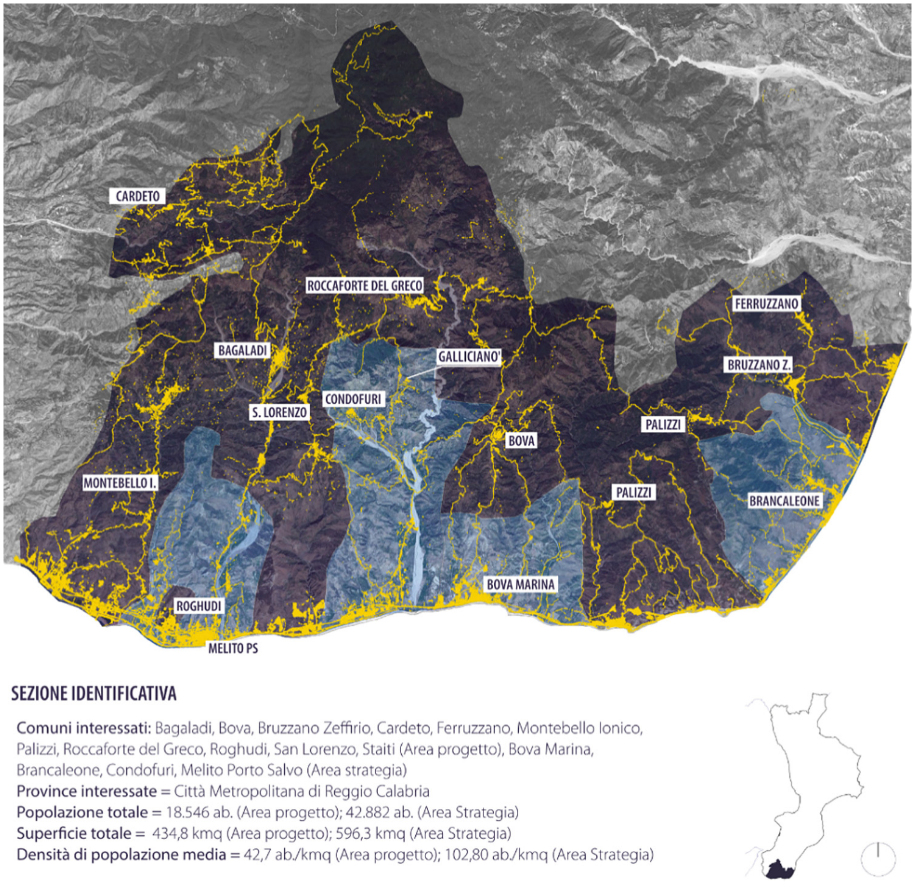


Fig. 9. Grecanica Area Identifying map. In light blue: the municipalities inside the Strategy Area. In purple: the municipalities in the Project Area. Source: Data processing for G. Mangano's phd thesis, 2019

In response to these conditions, the "Grecanica" Area Strategy has focused on the adjustment of rural infrastructure to ensure access to resources (water, electricity) by farms in areas not yet served by adequate networks. The Area Strategy includes, in fact, lines of action dedicated to the experimentation of "new models and tools for the production and use of energy produced from renewable sources" [36]. At this point of the research, on the basis of the identifying scenario for the Pilot Area "Grecanica" [37], a preliminary survey is carried out for the candidacy of three "inner" settlements that possess favorable characteristics for the activation of an energy community, from the point of view of location, solar radiation and performance potential of installable PV systems.

This analysis is carried out by means of the open access tool made by the Join Research Center of the European Union "PhotoVoltaic GIS" (PVGIS) [38], which returns the calculation for the power generation potential for different photovoltaic technologies and configurations and solar radiation and temperature, as monthly averages or daily profiles in complete time series (annual, monthly, daily), calibrated by the European Solar Test Installation (ESTI) photovoiltaic calibration laboratory and accredited by ISO17025.

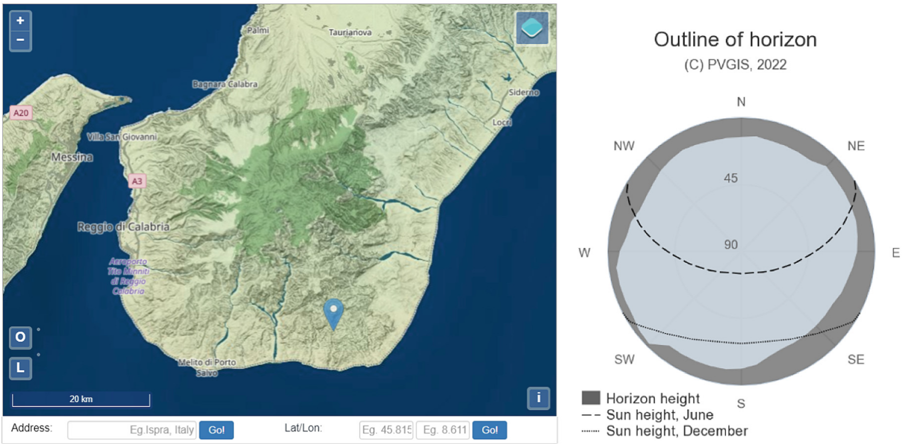


Fig. 10. Outline of horizon, localized in Palizzi (RC). Source: PVGIS (2022)

Simulations were performed on the municipalities of Cardeto, Condofuri, and Palizzi, using the PVGIS-SARAH2 database, crystalline silicon PV technology, with installed PV [kWp] = 1, system power loss (average) of 14% and fix-angle 35°.

The results show that among the three candidate municipalities for the experimentation of a REC (Table 2), from the point of view of the performance of grid-connected PV, Palizzi has an annual PV energy production potential of 1631.26 kWh and flat irradiation of 1979.47 kWh/m^2, with higher values than Cardeto (1424.95 kWh–1839.72 kWh/m^2) and Condofuri (1516.9 kWh–1952.61 kWh/m^2), due to its location and exposure more favourable to the performance of photovoltaic panels (Figs. 10, 11 and 12). In addition, the municipality of Palizzi, located in climate band C, is the one of the three municipalities that has the lowest number of degree-days. Therefore, already in this preliminary investigation phase, it is possible to state that, from an environmental point of view, it possesses conditions that make heating less necessary. In energy terms, this translates into lower energy requirements, an important factor in the dimensioning of renewable energy production systems.

Table 2 is also useful to give a comparison between the data related to demographic size of the municipalities and the presence or absence of policies and investments (past and ongoing) on renewable energy sources. Palizzi municipality is divided into two settlements: one coastal, with higher presence of services (roads, schools, commercial) and one inner (at 680 m. of altitude), with the presence of historical architectural heritage (16th century), in process of depopulating.

These preliminary findings at this stage of research make the municipality of Palizzi as favourable territory and community for triggering a LL process for the creation and the management of a REC.

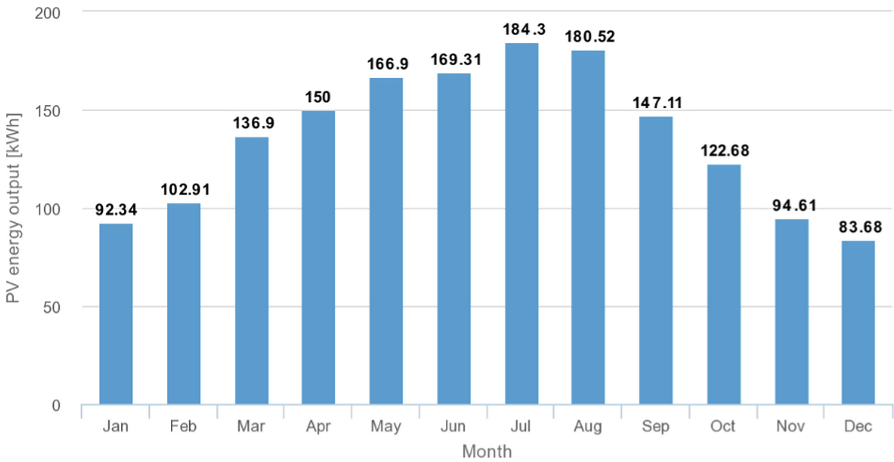


Fig. 11. Monthly energy output from fix-angle PV system in Palizzi. Source: PVGIS (2022)

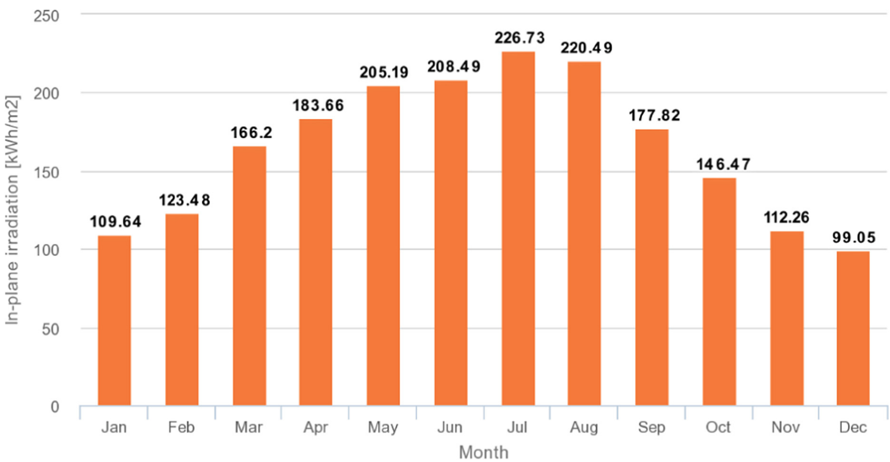


Fig. 12. Monthly in-plane irradiation for fixed angle in Palizzi. Source: PVGIS (2022)

5 Discussion of Innovative Aspects for the Experimentation in the Inner Areas

The recognition of the value of ecosystem services in Ecological Transition policies has once again highlighted the importance of energy production through renewable sources. The experimentation of development models of Energy Communities in Inner Areas opens to processes of territorial, technological and social innovation in the direction of smart communities (SDG 11 of Agenda 2030), equipped with technologies for smart grid and the exploitation of renewable sources (SDG 7). Therefore, it is possible to identify some specific factors that make it advantageous to start the model of energy communities

Table 2. Comparison of three inner according to population, REC and RES ongoing or past investments, climatic zone and yearly energy output and irradiation in the three inner areas candidate for REC. Source: elaboration by G. Mangano

	CARDETO	CONDOFURI	PALIZZI
Population (n. inhabitants)	1,591	4,656	2,017
Ongoing REC or green policies (Yes/ No)	No	No	No
Past investments on RES	Yes (ROP 2007–2013 – Axes I/II)	No	No
Climatic Zone	D	C	C
Degree-days	2,033	1,323	**1,205**
Monthly energy output from fix-angle PV (kWh)	1424.95	1516.9	**1631.26**
Monthly in-plane irradiation for fixed angle (kWh/m^2)	1839.72	1952.61	**1979.47**

in inner areas in order to make these territories self-sufficient from the energy point of view and trigger processes of sustainable development:

1. *Climatic and environmental factors*. The inner areas and their villages have a favorable location in terms of availability of resources, exposure, natural capital to be used in sustainable energy production chains;
2. *Defined settlement pattern*. In inner areas it is easier to identify the scale of intervention not only from a demographic point of view (villages and settlements of less than 5000 inhabitants), but also from the point of view of accounting for the energy needs of the community of reference;
3. *Absence or low efficiency of primary services*. Inner areas are identified by their dependence on urban centers for the provision of essential services (health, education, mobility) and energy supply. Breaking this dependence would allow communities to reach levels of self-production and self-sufficiency, such as to trigger new development processes and thus combat the phenomenon of energy poverty. In particular, energy poverty is a central issue in regions such as Southern Italy, where almost 1/5 of households live in energy poverty [39];
4. *Scalability of interventions*. In inner areas it is possible to act with projects at different scales (object/manufactured, structure/building, network/landscape), thanks to the great availability of territorial capital and architectural heritage to regenerate;
5. *Public policy investments*. As discussed in more detail in Sect. 2, community planning in the period 2021–2027, thanks also to the role of the National Strategy for Inner Areas, which is being implemented throughout Italy, will invest large amounts of money in the development of energy communities and smart grid technologies with renewable sources in municipalities identified as Inner Areas and the energy efficiency of the existing housing stock.

6 Conclusions and Future Steps

The reduction of the dependency between the location of resources and the places of production reverses the role and the relationship between cities, urban areas and marginal and inner areas: there are contexts which possess an underutilized environmental heritage and capital of natural resources, capable to be enhanced by using innovative technologies for energy production and energy saving, in order to increase both the "margins" of self-sufficiency of socio-productive systems from the energy market, and to trigger local development processes through the grafting of new energy and economic supply chains, through the involvement of new professional experts in the field of energy and smart grid and in land management (emerging co-communities) and local communities [40]. On the basis of these considerations, which coincide with the state of the art study phase, the next steps of the research will concern the planning of the activities preliminary to the start-up of the Living Lab phase in the internal municipality of the Grecanica Area for the experimentation of a Renewable Energy Community. The LL, as an open innovation environment that brings together public subjects, enterprises, universities, research centres and citizens' associations), will be structured as an "enabling" place for experimentation and co-creation with stakeholders to

– a REC management (production and consumption) model;
– a protocol for the monitoring and management of functional aspects (services) related to RES technologies;
– a validation system, enabling its application in a pilot community, with the possibility of scale-up within the same municipality or co-territory.

To this aim, scouting activities with the administrators and communities of the candidate municipalities for the experimentation of the LL REC and the involvement, from the initial phases, of market players with experience in the KETs and green technologies sector will prove propaedeutic.

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- "New Metropolitan Perspective International Symposium 5th edition (NMP2022)", Reggio Calabria 25-27/05/2022, title of presentation "Renewable Energy Communities: enabling technologies and regenerative models for the green and digital transition in the inner areas of the Grecanica Area" at the session FS-04 CITIES AS RESILIENCE "MACHINES": DRIVING THE URBAN TRANSITION (Chair: prof. C.Bevilacqua, Arch. P.Pizzimenti).

- the theoretical and experimental discussion of TREnD (Transition with Resilience for Evolutionary Development) research project, which has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 823952;

- the research granted to arch. Giuseppe Mangano, with PON "Research and Innovation" 2014–2020, Axis IV "Education and Research for Recovery" - Action IV.4 – "Doctorates and research contracts on innovation themes" and Action IV.6 – "Research contracts on Green themes" aimed at supporting fixed-term research contracts of type A), referred to in Law No. 240 of December 30, 2010, Art. 24, paragraph, Mediterranea University of Reggio Calabria - Department of Architecture and Territory. For further information, visit www.abitalab.unirc.it.

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A Methodology Toward a Just, Digital and Ecological Transition for Resilient and Sustainable Scenarios

Innovations in Urban Water Management

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Abstract. Climate change-related extreme events, like droughts and heavy precipitations, are increasingly leading to water-related problems, such as flooding, water scarcity, and disease spreading. Furthermore, it appears insufficiently effective working on the adaptation to some conditions, by merely reducing their impacts on the built environment. The current scenario rather suggests the necessity to produce positive impacts. In this paper, a methodology using the Advanced Resilient Design (ARD) approach is proposed. The ARD is a Regenerative Design that works on resilient scenarios to manage water resources and pieces of information, as a starting point to tackle climate change effects such as floodings and drought. The ARD applies to circular development models, focusing on "enabling water technologies". In the first part of the paper, some literature will be discussed, from climate change scenario and water involvement to the necessity of organizing built environment spaces as "urban districts in transition". Also, the need to reach resilience through sustainability and the critical role of water management for innovative and inclusive transitions are discussed. Then, three paradigms are presented: liminal scale, urban water districts, and Nature-Based Solutions (NBS). These paradigms are considered critical to understanding the following presentation of a methodology based on the Advanced Resilient Design. Afterward, some research on the criticality of water management in the post-Covid19 is presented as examples for a first validation of the proposed methodology. Finally, the innovative aspects of the methodology, bottlenecks, and further research from the methodology application are discussed.

Keywords: Methodology · Digital-Ecological Transition · Water Management

1 Introduction

In the climate change scenario, it is widely discussed how extreme events are increasing the demand for urban resilience. At the same time, recent studies demonstrate that the construction of a resilient condition for climate-related events in the built environment needs profound modifications in the economic as well as the social sector [1, 2].

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With regard to the second sector, social aspects, the scientific community is also widely demonstrating that an effective climate resilient transition regards the construction of social conditions of understanding of the ongoing transformations, in the forms of knowledge transfer as well as capacity building for the direct contribution of the communities to the built ecosystem functioning [3].

In this paper the discussion on a sustainable and just climate-resilient transition related to water technologies is addressed focusing on the relations between [a] natural emergency and social aspects, [b] natural emergency and technological opportunities, [c] technological opportunities and social aspects.

[a] As regarding the first relation, with regard to water, climate change and anthropic activities are negatively affecting different forms of the hydric resource, thus leading to social issues, related to: water scarcity [4], due to always longer and more severe drought periods; low-quality water services [5], as a consequence of resource insufficiency or bad quality, water excess during flooding events [6] for which, as for droughts, foresights indicate high levels of increase [7]; health issues [8], connected to water deployment and sanitation.

[b] Also, currently, about 70% of global water is used by agriculture, 20% by industry and 10% by domestic [9]. Following a more diffuse research on energy implications on a structured transition [10], an increasing interest in innovations in water technologies [11, 12], in the Food-Energy-Water Nexus [13], and in Nature-based Solutions [14] is retrievable. Furthermore, to solve the presented social issues related to water distress, the design of the urban water management within the built environment in transition can, at the same time, highly contribute to the transformation needed.

[c] However, some of the most recent studies on social-ecological design related to the deployment of physical and digital technologies, suggest that working on the adaptation to some conditions, by merely reducing their impacts on the built environment, is no more sufficiently effective [15]. In fact, the current scenario rather suggests the need to produce positive impacts on the three relationships taken as reference in this paper. Furthermore, despite the multiple literature available, a validated methodology for the specific potential contribution of water technologies in the process of a just climate resilient transition needs to be further investigated.

The paper presents the discussion as follows: Introduction; Literature review; Experimental context; Experimentation; Methodology; Results; Discussion; Conclusions.

In the first part of the paper, some literature will be discussed, starting from a wider point of view regarding the design approaches and then focusing on the latest contributions on water management for climate change resilient and inclusive transition. Then, three paradigms are presented: liminal scale, Urban Water Districts, and Nature-Based Solutions (NBS). These paradigms are considered critical to understanding the following presentation of the methodology based on the Advanced Design with the resilient approach. Afterward, the experimentation is presented, discussing the construction of the methodology through the integration of two different approaches. Then, some research on the criticality of water management in the post-Covid19 is presented as examples for a first validation of the proposed methodology for the just, climate resilient and inclusive transition, within the digital and ecological transitions. Finally, the results are pointed out, the innovative aspects of the methodology, bottlenecks, and further research are discussed, and conclusions are presented.

2 Literature

In the latest years the scientific community has discussed in a transdisciplinary way about climate resilience in the built environment, social transitions and sustainable development. Following the aim of the presented study, the contribution to the frontier research starts by innovating some theoretical and practical paradigms for their valid application within the methodology for the integrated climate resilient and inclusive transition scenarios. The proposed innovation takes some theoretical and practical references that are considered fulfilling the need for integration of the three architectural relations (natural emergency/technological opportunities/social aspects), thus working within the frontier research. To the building of the methodology, the climate scenarios and foresights of the IPCC [7] are taken as reference for the natural/social issue. In addition, the definition of advanced design for the digital and ecological transition is assumed as proposed by Celi [16]. Especially, with reference to the Advanced Sustainable Design for resilient scenarios, Nava's contribution is taken as reference [17]. Furthermore, the process of the socio-ecological design by Graves et al. [18] is considered for the implementation of the methodology through the latest studies on integration of social and ecological design. Finally, the study on the contribution of digital technologies for the regenerative design is considered important for the definition of environmental and social positive impacts [19].

As regarding climate change-related water issues, to which contemporary cities have to respond to address digital and ecological transitions, most recent models and simulations show an increasing scarcity of water around the Mediterranean, parts of Europe, Central and South America, and Southern Africa, but also an increase in the intensity of extreme precipitation events [21, 22]. In 2020, the Alliance for Global Water Adaptation (AGWA), published a report on water issues related to climate change, explaining how, since "access to a reliable water supply is critical to nearly all sectors working to combat climate change, water is a fundamental, cross-sectoral component of all national climate planning and implementation" [22]. Furthermore, according to the World Economic Forum (WEF) ranking of the top global risks, infectious diseases, climate action failure, and biodiversity loss are within the top 4 global risks in terms of impacts in 2021, and they all derive from climate change effects of availability and bad water quality [23].

In the next paragraphs, the literature aims to organize the latest innovations in the contribution of water management and related methodologies for a climate resilient (Sect. 2.1) and inclusive (Sect. 2.2) transitions within the digital and ecological transition.

2.1 Latest Contributions on Water Management for Climate Change Resilient Scenarios

The study intends to find the contribution of water management in the resilience of an urban district in case of floodings and droughts, as climate change-related events. In this context, the contemporary scientific community is widely discussing the need for a paradigm shift, being reinforced by the necessity of a digital and ecological transition [24]. Some authors suggest a paradigm of sustainability and integrated water resources management (SWRM and IWRM) [25], towards an innovation-driven transition. To date, IWRM and the nexus are the most investigated approaches to manage water resources in built environments [27, 28].

However, recent research is establishing the basis for a regenerative just and sustainable ecological and digital transition, through the development of some experimental technologies that apply innovative stormwater management on a neighborhood level and combine NBSs with social benefits. Moradikian, S., Emami-Skardi, M. J., and Kerachian, R., for example, suggest a multi-agent model for water and reclaimed wastewater allocation in urban areas through the application of a modified ADOPT algorithm [28]. In some cases, innovative LID on SWMM model is proposed [29].

Also, since water is globally recognized as a resource at risk of scarcity, different water-related environmental footprint assessments have already been generated, with multiple appliance sectors. Specifically, are considered for reference the ISO 14046, according to which "the water footprint assessment refers to the total freshwater volume consumed and polluted directly or indirectly across a product's end-to-end supply chain [...]" [30] and the Water Footprint Assessment Manual on the scientific definition of water footprint and evaluation of consequences of existing production models, connecting, once again, water technological innovations to resilience and sustainability [31]. These findings may be helpful in the definition of a methodology that aims at including communities in the understanding of water urban metabolism.

2.2 Latest Contributions on Water Management for a Just Transition

As for a just and inclusive transition, beyond the undisputed importance of a resource such as water in the contexts of human and non-human living, several authors have recently emphasized the key character of water in the governance of urban issues related to social, environmental, and health crises, including the livability of spaces [32], adaptation and mitigation of effects of climate change [33] and pandemics [34].

Furthermore, considering climate change effects in terms of excess water during a cloudburst, a push of design effort for architectural technology, beyond the concept of the sponge city is needed. In fact, while the research and applications on the practices of the sponge city are widely investigated in the literature of the sector and contemporary design cases [35], the contribution of these technological design systems to the inclusivity of the transition and to a just transition are still not clear.

Finally, although the emerging urban issues mark a more abrupt and uncertain pace of change, requiring both social and technological transformations [36], to date, the scientific literature still refers to the "urban districts" mainly regarding energy transitions (Net-Zero Energy Districts - NZED, nearly Zero Energy Districts - nZED, Positive

Energy Districts - PED, Low Energy Districts - LED, etc.) [37]. On the other hand, Vail Castro [38] has proposed an optimization of nature-based solutions by combining social equity, hydro-environmental performance, and economic costs through a novel gini coefficient. These last advances, specifically, contribute to the investigation of methods for the calculation of qualitative water management systems contribution to the social aspects. Another contribution valid to the building of a methodology is the IUCN self-assessment tool, still in construction and verification, which includes the social benefits in nature-based solutions [39].

Two Case Studies. The two cases that are proposed below are related to water technologies for water purification from Covid19 concentration for sustainable, resilient and just transitions.

Hart and Halden Study. In 2020, Hart and Halden [40], employed computational analysis and modeling "to examine the feasibility, economy, opportunities, and challenges of some active coronavirus infections locally and globally using wastewater-based epidemiology (WBE)", as it was done for polio and hepatitis. According to the authors, temperature effects to obtain robustly, informative data are critical for effective use of WBE; while, regarding the process, the system can alert emergency response teams to the presence of infected individuals in towns, cities, and specific drainage areas, assessing the importance of advanced resilient urban solutions that enable agile water management for epidemic risks due to climate change.

Bogler et al. Study. In the same year, Bogler et al. [34] published a study that gave information on the survival and dissemination of enveloped viruses in general, in particular during wastewater collection, treatment, and reuse, thus contributing to the construction design criteria of the methodology for Advanced Resilient Design through water management. The study reports that the size of the population connected to the sewer system has a direct impact on the concentration of SARS-CoVs in wastewater and thus the potential for dissemination. This aspect suggests the importance of the development of urban districts, with reduced dimensions for easy monitoring. Furthermore, and more importantly, they found that "survival time of SARS-CoVs in wastewater is sufficiently long for infective viruses to reach WWTPs and […] natural water bodies used for recreation such as ponds, rivers, and lakes via leakage or combined sewer overflows during storm events" and that "SARS-CoVs may be disseminated to aquatic ecosystems during an outbreak due to leaking sewers or insufficient removal following wastewater treatment".

Preliminary Findings. The proposed technological case studies widely contribute to the technological field, while lacking climate scenarios, adaptive co-management, capacity building, knowledge transfer and embedded knowledge. However, their contribution on social aspects through water management can be related to the definition of long term just transition, through the monitoring of water-related health issues.

2.3 Lacks and Gaps

The reviewed literature presents some lacks in different terms, that can be summerized as follows:

- the contribution of the discussed technological design systems to the inclusivity of the transition and to a just transition are still not clear.
- to date, the scientific literature still refers to the "urban districts" mainly regarding energy transitions. As a consequence, a better focus on the water resource or the Food-Water-Energy Nexus, may be useful to investigate the transition possibilities more systemically.
- The only assessment methods available are still in construction and verification, like the IUCN for social benefits associated to the nature-based solutions. The construction of a specific methodology that integrates different approach may be useful to assess the constructed transition scenarios.

However, all the contributions are still strictly related to the technologies and not on social involvement or just transition and the literature lacks methodologies for the involvement of communities in process of ecological and digital transition strictly related to the water management, as tools of knowledge transfer and capacity building. As a consequence, the experimental application of a valid methodology finalized to the just, ecological and digital transition through resilience and sustainability is still required.

3 Experimental Context

The experimental context is related to the use of innovative water management in the frontier research to address a climate resilient and inclusive sustainability. To this purpose, a methodology is constructed, based on the Advanced Resilient Design approach. The three principal paradigms related to the Advanced Resilient Design Process are identified as: Liminal scale (1), Urban Water districts (2), and Nature-Based Solutions (3).

(1) The liminal scale contributes to a change of perspectives in the design concepts. It is not considered as the juxtaposition of two different scales (e.g., neighbourhood and building), but rather it implies consideration of the contribution of one urban "organism" (e.g., the building) to the proper functioning of the metabolism of another "organism" (e.g., the square in proximity, the neighbourhood). Through the application of "Enabling Technologies" of the type of water technologies, this way of designing contributes to the implementation of the impacts needed, by building technological and human capacities for social and digital innovations and resilient transitions, with direct impacts on cultural and environmental components.

(2) As already discussed, districts in transition are widely studied. However, to date, energy districts are much more investigated than water districts. In the resilient and agile sense, integrating water districts would mean triggering a 'transition' from unfavourable conditions, resulting from the effects of global warming on atmospheric factors and resource scarcity to a new metabolic balance of resources and quality of life. The principle can be traced to the integration of climate change resilience issues

with questions related to the sustainability of urban living patterns. This principle describes urban districts in resilient transition with a circular character and responds to the need to drastically reduce reliance on primary sources, through self-production of the resources needed to ensure the dynamic balance of their urban metabolic flows, in the event of extreme events. As a consequence, it appears reasonable to talk about “Positive Water Districts” (i.e., all the districts involving a completely circular use of the hydric resource) (Fig. 1).

CASE 1_Terneuzen District
Place: Terneuzen
Environmental performance: wastewater stock for filtration and industrial reuse
Issue: Eccessive amount of industrial water use
Other specificity: Treated wastewater reused in DOW industrial production
Area of application: urban district, industry

Fig. 1. **a.** A picture of Terneuzen houses and in the background the industrial area. **b.** The water purification system. Source: rietland.com

(3) Nature-Based Solutions are design interventions in the adoption of a nature-based approach and the actualisation of resilience through sustainability. The nature-based approach reduces the use of grey solutions while exploiting or mimicking nature workings and capacities (infiltration, evapotranspiration, CO_2 stocking, cooling, etc.). These properties become criteria for the resilient and sustainable transition urban projects for both environmental aspects (de-impermeabilization, more water in the aquifer, better quality of surface water, regulated urban metabolism) and social aspects (more natural spaces, better quality of living, better quality of services, more inclusive resource management). Furthermore, adopting Nature-Based Solutions, thus reactivating natural functioning, water enabling technologies can contribute to the implementation of quality of life, guaranteeing cultural and social transition through the innovation of systems. For example, by integrating technologies for purification and digital monitoring it is possible to reach better quality of water in the aquifer, to reduce the risk of infectious diseases due to water quality and exposure

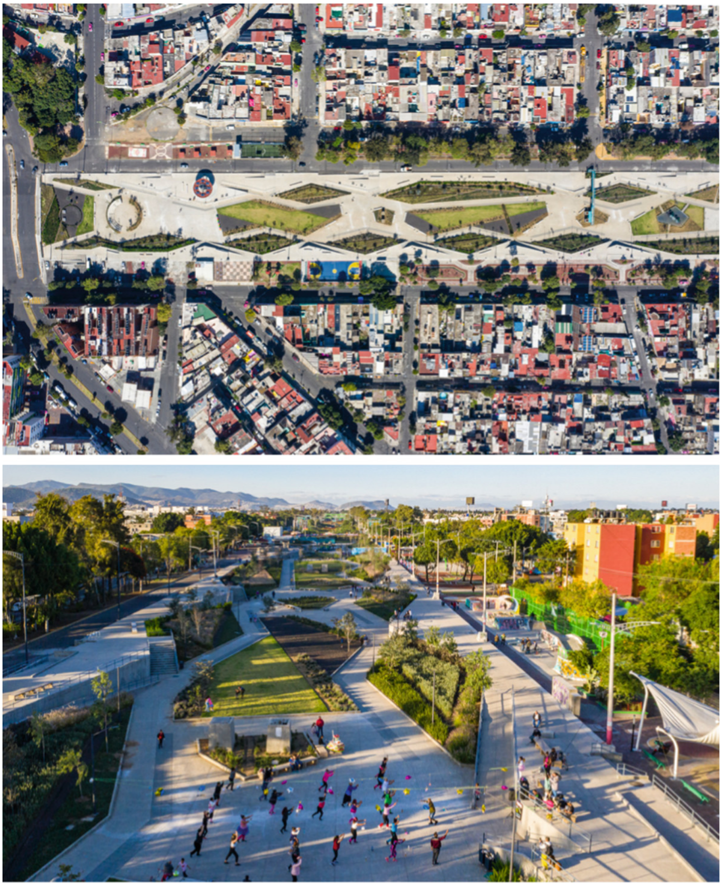


Fig. 2. a/b. Linear Grand Canal Park, in Mexico, as an example of application of Nature Based Solutions. Source: archdaily.com

to sewer water, and to better monitor health conditions through sewer digital analysis (Fig. 2a/b).

CASE 2_Linear Grand Canal Park, Mexico
Place: Mexico City
Dimension: 70,000 mq
Environmental performance: + 16% in relative humidity; −5% in temperature + 100% permeability recovered
Issue: Heat Islands effect
Other specificity: recovery of capital's historic Grand Canal Structure
Area of application: Urban, highly dense, old canal structures.

4 Methodology

The subject of the experimental study concerns the elaboration and validation of a methodology useful to address the digital and ecological transition in the built environment, relating on climate resilience and inclusivity. To this aim, the proposed methodology integrates the resilient approach of the Advanced Sustainable Design and the social-ecological design process as defined by Graves et al. [18].

Advanced Sustainable Design mainly contributes to the construction of sustainable ecological and digital transition scenarios. In fact, sustainable design is defined as advanced because it uses data, design and digital devices. Data are used in the construction of transition scenarios, sustainable technology design serves the technical definition of spaces and architecture for ecological transition, mainly the resource management, and digital devices are used in the processing of data and information for a just digital transition. Specifically, the resilient approach provides the principles for the construction of ecological and digital transition for resilient scenarios [17]. Furthermore, Advanced Design already indirectly works on the social aspects of the transition with regard to the use of digital devices and work application in knowledge transfer and capacity building [41].

However, a specific contribution is still needed to ensure the construction of just and inclusive transition scenarios.

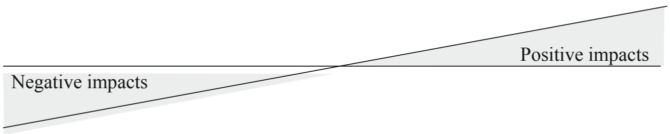
4.1 Construction of the Integrated Methodology

In order to effectively construct the methodology for the application to transition of reference, it is possible to generate a matrix in which the Advanced Resilient Design (ARD) components (Data, Design and Devices) are explicated with regards to the Regenerative Design (RD) approach and the contribution of each component to the just, ecological and digital transition through sustainability and resilience.

Table 1 shows the matrix that, for water related climate-resilient transitions uses "Data" retrievable in the latest scientific documents regarding climate change, including data, 2050–2085 climate scenarios, reports and specific platforms of climate services (i.e., IPCC scenarios, CMCC data, WEF reports and Copernicus platform). As for the "Design" component, following the regenerative Design approach (i.e., moving from the degenerative approach for negative impacts reduction to the regenerative one for positive impacts), the matrix includes Nature based Solutions (NBSs), Integrated Water Resource Management (IWRM), Stormwater Management Models (SWMM) and the assessment tools available from RES and IUCN. Finally, the "Devices" component implies parametric environmental analysis, water quality sensors, other monitoring devices and open platforms. The latter are considered especially useful for the dissemination of pieces of information and the construction of an open knowledge for the community.

Respectively, the contribution of the three components on the transition of reference are: Climate-resilient and just transition for the "Data" component; climate-resilient and just transition for the "Design" component; just and digital transition for the "Devices" component.

Table 1. The linkages between Advanced Resilient Design, the Regenerative Design and the just, ecological and digital transition for water-related resilient and sustainable scenarios. The image shows as ARD water-related components of the RD type can contribute to the transition of reference. Elaboration: A. Leuzzo, 2022.

Advanced Resilient Design	**[Data] Data management**	**[Design] Resource management**	**[Devices] Digital intervention**
	IPCC scenarios CMCC data WEF reports	NBSs IWRM SWMM RES+IUCN assessment tools	Parametric analysis Water quality sensors Monitoring devices Open platforms
Possible contributions on transition	Climate-resilient/ Just	Ecological/ Climate-resilient/ Just	Just/digital
Regenerative Design			

Furthermore, Fig. 3 shows the social-ecological design process, as described by Graves et al., which is taken into account. A predesign process of needs and goals assessment is established, then a phase of implementation through capacity building and monitoring, a phase of context identification and local engagement and a new phase of evaluation of needs and goals follow. Finally, the design phase integrates system design with capacity analysis within the timeline, before verifying the whole process.

As part of the Advanced Resilient Design Process, there is a predesign phase of circular reasoning, which places future design actions within the framework of hyper-sustainable regenerative design. The process is also based on the idea that Regenerative Design provides the operational methodology to reason on performative-analytical and proof-of-concept criteria. That is, the analysis capabilities of the project, refer to the character of design, which is technical, but also capable of analyzing social and ecological systems. Similarly, process proofing relates to ecological transition and effective governance of resources.

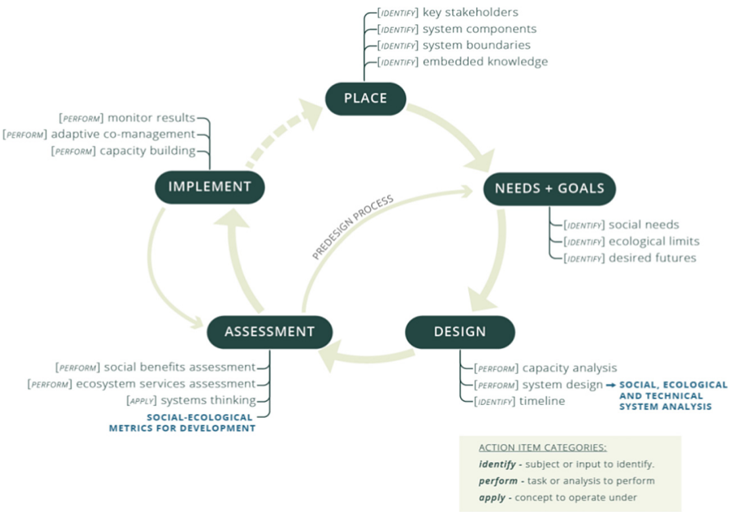


Fig. 3. The social-ecological design process, as described by Graves et al. [18], is taken into account for the application of the advanced resilient design approach, as advanced regenerative design.

As a consequence, based on what has been discussed, it is possible to state that the social-ecological design provides an operational process useful for the construction of the required methodology, through the implementation of Advanced Resilient Design approach. By integrating the Advanced Resilient Design approach with the social-ecological process it is possible to build the following methodology flow (Fig. 4):

4.2 Surrogate Strategies of Methodology Applications for Transition Scenarios

In the application of the proposed methodology, Advanced Resilient Design approach components (data, design, devices) can be distributed in different orders in the methodological flow. These different configurations represent, in fact, surrogate strategies which enable the methodology to be valid for different transition scenarios. This paper indicates three different scenarios of application of the methodology:

1. Database (principal issue individuated) → Data findings → Resource management → Digital intervention

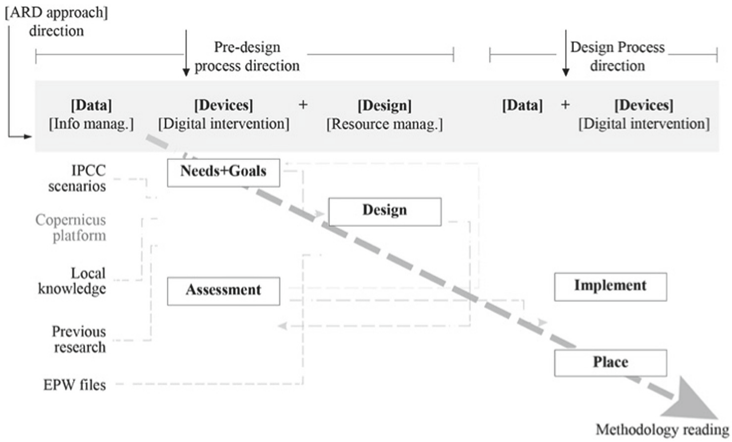


Fig. 4. Schematic flow of the proposed methodology based on ARD approach and SE process. All the phases of the methodology are chronologically retrievable from the upper left part to the bottom right part of the flow. Elaboration: A. Leuzzo, 2022.

2. Database (principal issue individuated) → Data findings → Digital intervention (analysis for local data implementation, in case of local data lacks) → resource management → data + digital intervention (knowledge transfer and capacity building to the community)
3. Database (principal issue individuated) → Resource management → Data findings.

In the next section, in order to validate the proposed methodology, the experimentation will apply the methodology to all the surrogate strategies, for 3 different scenarios.

5 Experimentation: Application and Validation of the Proposed Methodology

In this section, the proposed methodology is applied to n.3 case studies in order to prove its validity for different transition scenario, with specific reference to climate change-related water management.

The validation of the methodology is organised on the application to:

- n.1 innovative water management system (Michigan, USA)
- n.1 research project (Southern periphery of Reggio Calabria, ITA)
- n.1 urban district (Terneuzen, NL).

5.1 Application on Biochar-Based Water Filtration System on Mobility Infrastructure [Virus Reduction]

Place: Coon Rapids, Michigan, USA
Year: 2021–2023
Issue: Grey wastewater filtration (BIESF Biochar- and Ironed-Enhanced Sand Filters)
Application framework: Infrastructure, urban, open spaces available
Experimental context: research project
Other specificity: Innovative water filtration system applied (Fig. 5).

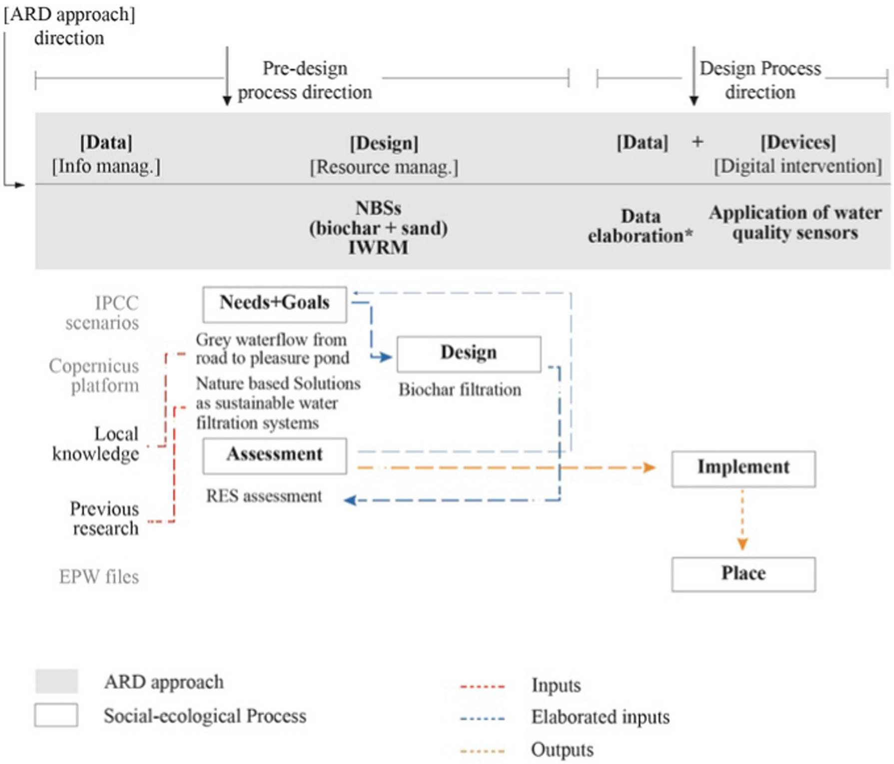


Fig. 5. Surrogate strategy n.1. Scenario: Ecological and Digital transition for mobility infrastructures scenario with the scope of reducing virus concentration from wastewater before its reuse in recreational ponds. Elaboration: A. Leuzzo, 2022

The first study case is provided by Matthiesen E., and Megow, E. [42]. They studied how biochar can be useful to reduce virus concentration [E. Coli, Total Phosphorus, Ortho Phosphorus, TSS] on grey wastewater coming from a car road. The principal issue was the confluence of wastewater directly inside a pleasure pond (Fig. 6).

Preliminary Findings. The preliminary results from 2021 of the two applications show that BIESF systems are more efficient than IESF systems, above all regarding E. Coli,

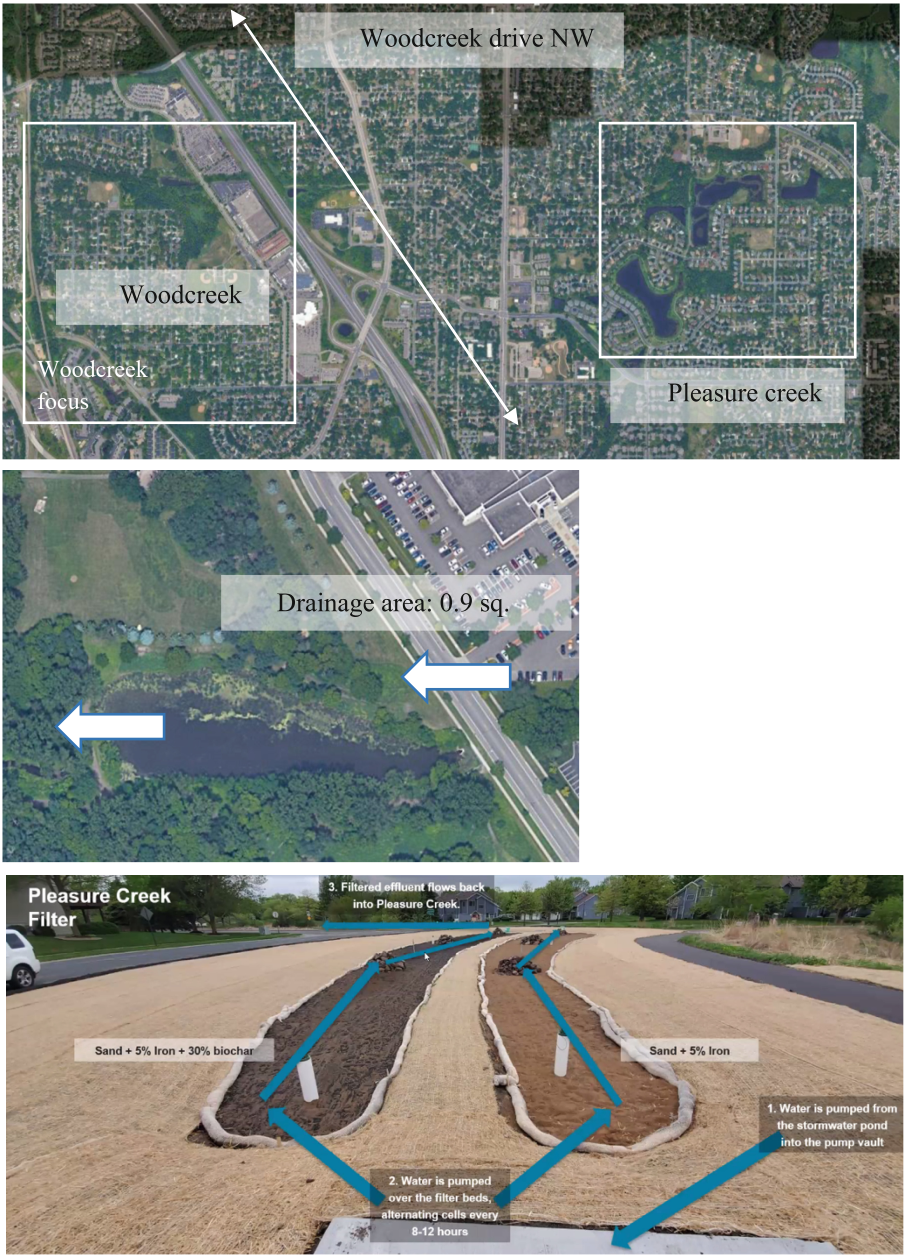


Fig. 6. In the first picture, the Woodcreek drive NW running between the woodcreek and the pleasure creek. In the second picture, a focus on the Woodcreek drainage area used is offered. The third picture shows exactly how the double filter (IESF and BIESF) are applied to the pleasure creek drainage area. The last picture is retrieved from Matthiesen E., and Megow presentation at SER webinar, 22.06.2022.

from 69% to 72%. TP is consistently removed by both filters. OP is still insignificantly present.

5.2 Application on Nature-Based Solutions for Urban Periphery

Location: Southern Periphery of Reggio Calabria
Year: 2020
Issue: Floodings after brief cloudbursts and UHI (high soil covering rate)
Application framework: Urban areas, high density
Experimental context: research project (Fig. 7)

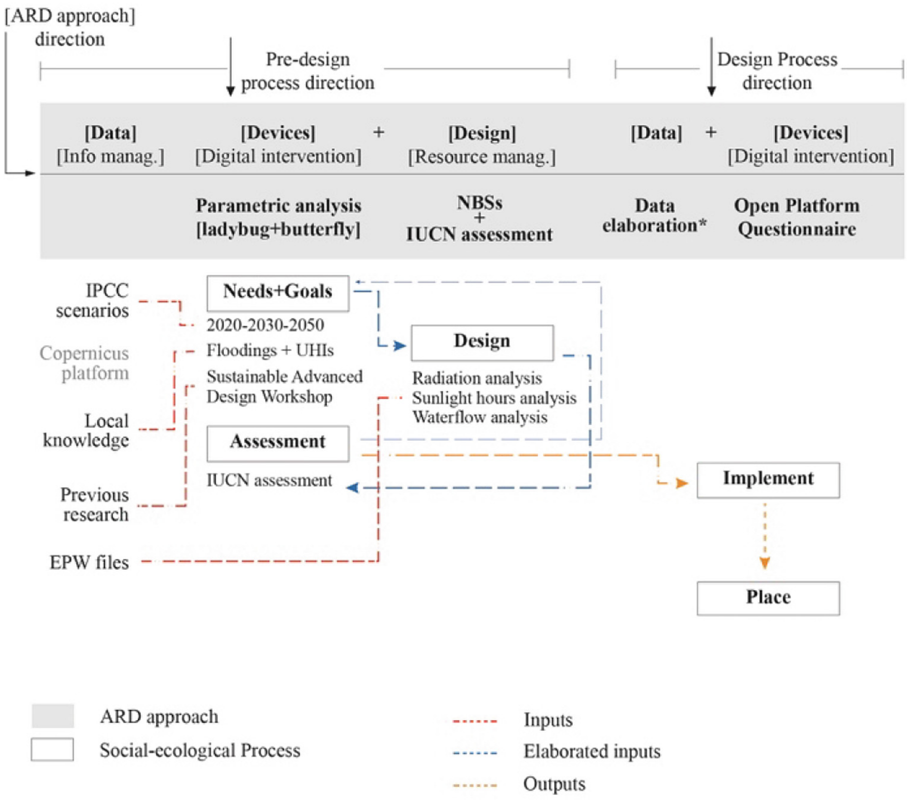


Fig. 7. Surrogate strategy n.2. Scenario: Ecological and Digital transition in urban periphery Elaboration: A. Leuzzo, 2022

The presented case study is retrieved within the works elaborated during the Sustainable Advanced Design II (SAD II) workshop as part of the activities within the Sustainable Innovation Design course, coordinated by Prof. C. Nava. The second edition of the workshop contributes to the activities of the KnowledgevsClimateChange project [3]. The aim of the workshop was the transfer of knowledge on the topics of climate change, transition and urban sustainability, with reference to the Southern Periphery of

Reggio Calabria. In fact, the periphery suffers of floodings during brief cloudburst due to high impermeabilization and Urban Heat Island effects due to diffuse materials with very low levels of albedo.

For the methodology application: parametric analyses have been applied for the calculation of solar radiation, sunlight hours and waterflow to the ground (Fig. 8). Then, Nature Based Solutions have been applied, in some specific areas with implementation of areas of previous research (Fig. 9a/b). Finally, the IUCN assessment tools has been used to evaluate the level of correspondence of the project environmental and social performances to the NBS criteria for IUCN (Fig. 10).

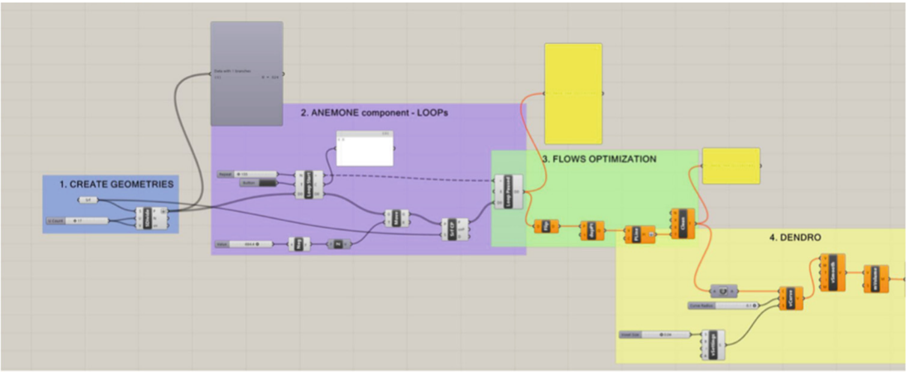


Fig. 8. Waterflow workflow on grasshopper. The analysis has been carried out using Butterfly tool, among the Ladybug tools for Grasshopper. Source: A. Leuzzo, 2022.

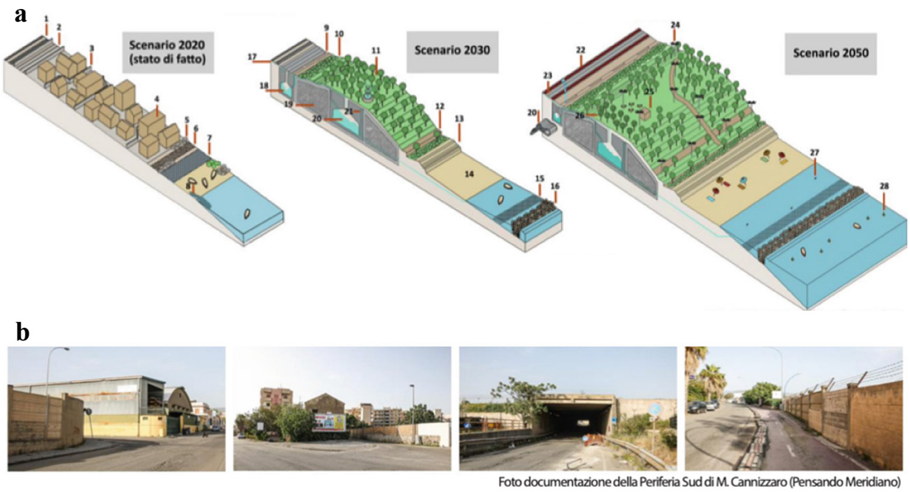
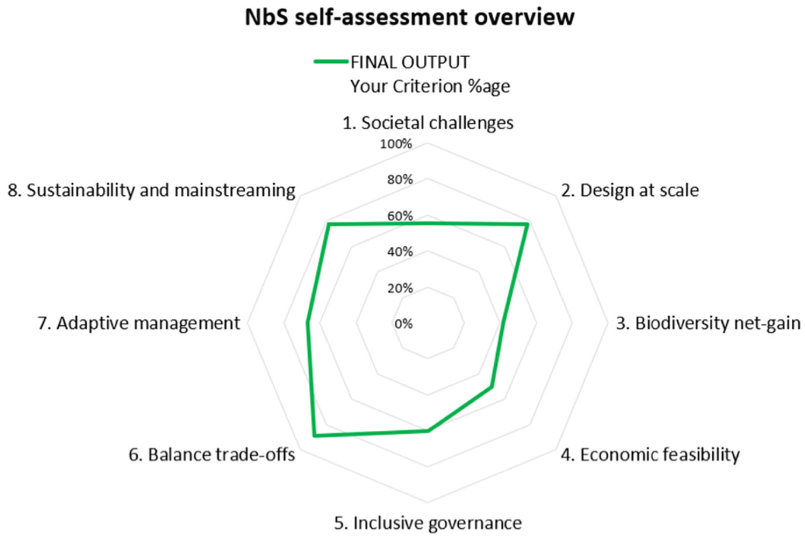


Fig. 9. **a.** Nature based Solution for the area of the railway district in the southern suburbs of Reggio Calabria (students: M. Colosimo and V. Forestieri). **b.** Pictures from the project for the recovery of the Annunziata torrent area and the industrial area in the southern suburbs (students: G. Matranga and S. Vitale).



Criterion	Your Criterion Score	Maximum Criterion Score	Normalised criterion	FINAL OUTPUT Your Criterion %age
1. Societal challenges	5	9	0.56	56%
2. Design at scale	7	9	0.78	78%
3. Biodiversity net-gain	5	12	0.42	42%
4. Economic feasibility	6	12	0.50	50%
5. Inclusive governance	9	15	0.60	60%
6. Balance trade-offs	8	9	0.89	89%
7. Adaptive management	6	9	0.67	67%
8. Sustainability and mainstreaming	7	9	0.78	78%
Total Percentage match				65%
Is this in adherance with the IUCN Global Standard for NbS?			In adherance	

Fig. 10. The IUCN assessment tool applied to the case study to assess the quality of the Nature-based Solutions adopted. Elaboration: A. Leuzzo, 2022.

Preliminary Findings. +9,5 sustainable mobility, +80% soil permeability; +10 recycle and reuse of waste; +75% greening. Furthermore, the IUCN assessment tool indicates that high levels of "sustainability and mainstreaming", of "design at scale", "adaptive management" and "balance trade-offs" are satisfied. The assessment tool based on the NBSs criteria considers "high level" the value between 80 and 100% of criteria satisfaction (Fig. 10).

5.3 Application on Urban Water District for Industrial Water Recycle

Location: Dow Industrial Area – Terneuzen (NL)
Year: 2014–2021
Issue: Floodings after brief cloudbursts and UHI (high soil covering rate)
Application framework: Industrial plants, urban water districts, stormwater recovery
Experimental context: research project/industrial area and urban water districts

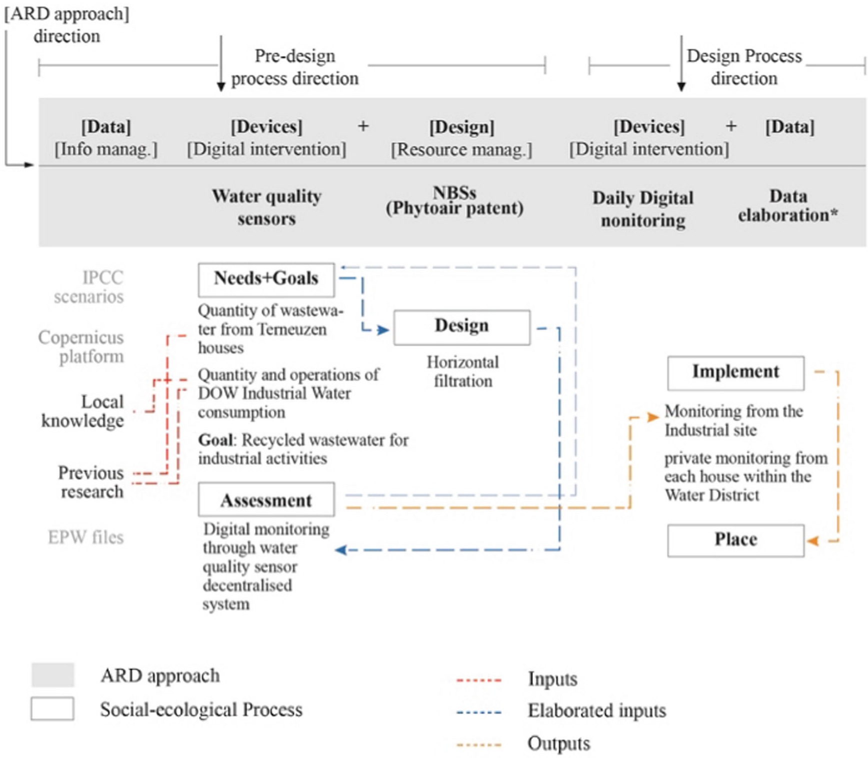


Fig. 11. Surrogate strategy n.3. Scenario: Ecological and Digital transition in urban water districts and industrial areas. Elaboration: A. Leuzzo, 2022

The Dow Industries, thanks to the co-operation of the Waterschap Scheldestromen (Scheldt Water Office) located in Terneuzen, can use the wastewater of the Terneuzen community (2.5 million m3 per year) purified by the treatment plant. Before this wastewater can be used for Dow's cooling towers, however, it has to be desalinated, via membrane filtration, at Evides; however, as the treated wastewater is not clean enough at this stage, frequent rinsing of the membranes is required for high-energy, water-embedded treatment; hence, the use of experimentation for natural pre-treatment. In short, green technologies serve to reduce and facilitate the use of grey technologies, because through biodegradation and absorption by plants in the marsh, components of the cooling water, which would otherwise disrupt the functioning of desalination membranes used later, are eliminated (Figs. 11, 12 and 13).

For example, between September and November 2020, four samples of the 'Phytoair' filters were examined for the Brabantse Delta Water Board, two in Rucphen and two in Zundert, noting that the system used, the same as that developed for Water Nexus, produces an effluent of much higher quality than the influent; the results report the complete removal of suspended dust and organic materials, a nitrogen removal rate of between 75% and 89%, and a phosphorous reduction rate of between 83% and 90%.

Fig. 12. The Dow Industrial are and the Municipality of Terneuzen. Elaboration: A. Leuzzo, from bing.maps.com, 2022.

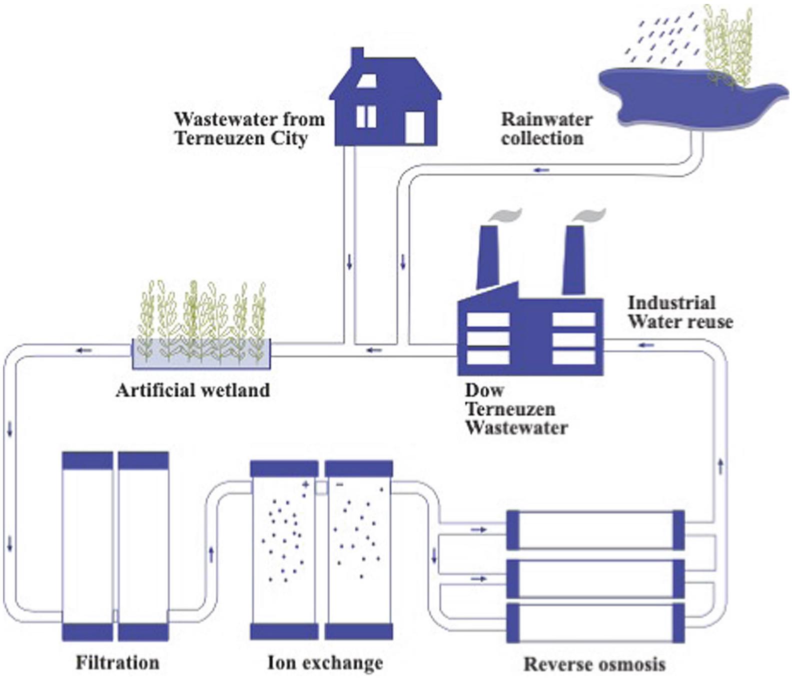


Fig. 13. The process of wastewater filtering from the Terneuzen houses. Rainwater collection and Dow Terneuzen Wastewater to the artificial wetland for the primary filtration and then to the standard filtration to industrial water reuse. Graphic re-elaboration: A. Leuzzo from Rietland.com

Preliminary Findings. From the illustrated experimentation it is possible to retrieve some preliminar findings on pollutants reduction: suspended solids - 92/94%; BOD - 100%, COD - 97/98%; Nkj - 99%; TN - 82/89%; NH4+ - 100%.

6 Results

The obtained results show that:

- BIESF systems are more efficient than IESF systems, above all regarding E. Coli virus. The methodology as constructed is well functioning with the first case study. Although, due to the highly technological character of the first experimentation, was not possible to completely specify the information regarding the social-ecological phases of the implementation and the placement. The Advanced Resilient Design approach through the use of digital devices contributes on the just transition from a health point of view.
- Through the application of the methodology to the second experimentation impacts on the construction of climate-resilient spaces and on knowledge transfer have been registered. Also, the IUCN assessment method is confirmed as valid assessment method inside the proposed methodology, because of its comprehension of technological, social and economic aspects. Il also helps the direct understanding of possible improvements to the project.
- From the illustrated experimentation it is possible to retrieve some preliminar findings on pollutants reduction: suspended solids – 92/94%; BOD – 100%, COD - 97/98%; Nkj 99%; TN 82/89%; NH4+ 100%.

Furthermore, in Table 2, reporting the linkages between the Advanced Resilient Design and the Regenerative Design with positive social and environmental impacts, it is possible to understand how an integration of the above analysed experimentations with the complete components of the ARD (Data + Design + Devices), the just ecological and digital transition through sustainability and resilience is satisfied.

Namely, the Advanced Resilient Design uses data to work on the technological and social-ecological design, in order to produce positive environmental impacts and social impacts; some of the contemplated technological solutions are innovative techniques for water filtering to enable water recovery and enhance stormwater stock and natural-decentralised treatments. From this point of view, methodology contributes to the development of the sustainable and resilient aspects of the transition of reference. Also, following the ARD organisation, digital devices are used to elaborate new data to be elaborated in pieces of information that can be accessible to all via open platforms. Consequently, the application of the devices ARD component focuses on the construction of the factors needed for a digital transition that can be considered just and inclusive, since the retrieved pieces of information can produce positive social and environmental impacts.

Table 2. The Advanced Resilient Design (ARD) components (Data, Design and Devices) with regards to the Regenerative Design (RD) approach and the contribution of each component to the just, ecological and digital transition through sustainability and resilience. Elaboration: A. Leuzzo, 2022

ARD	**[Data]** to work on technological **[Design]**	Use of digital **[Devices]**	To elaborate **[Data]** to be accessible for all
Transition of reference	Focus on sustainable resilient transition	Focus on digital transition	Focus on just and inclusive transition
RD	Producing positive environmental impacts	Producing positive social/environmental impacts	
		S-E PROCESS	

7 Discussion

Basing on the methodology proposed, on the application presented, and on the results obtained, it is possible to discuss that:

- The integration of the Advanced Resilient Approach and the social-ecologial design process enables the construction of the methodology, guaranteeing wide range impacts as required in order to realize the just, digital and ecological transition for resilient and sustainable scenarios.
- Despite the good results obtained from the application of IUCN assessment tool on the second experimentation, and because of the complexity and transdisciplinarity of the impacts that the methodology tends to involve, a specific assessment method would probably entail indicators for the measurement of quality of life and social and cultural innovation, such as SDGs indicators, CAM parameters, beyond the IUCN Global Standards for Nature-based solutions.
- As regarding innovative aspects, the combination of green and digital innovations with social and cultural aspects for a resilient and sustainable transition is considered the innovative aspect of the Advanced Resilient Design for the Innovations in water management. In fact, integrating the new paradigms for the proposed methodology with the examples for a first validation, it is possible to affirm that green (NBS) and digital innovations (SWRM, IWRM, WBE) for the Advanced Resilient Design in water management contribute to social and cultural innovation, in terms of implementation of quality of life and empowerment of local knowledge, that are critical for a just and equal transition. In fact, this condition relates to the concept of "citizens in transition" [50], by activating "prosumer strategies", based on the capacity of the community to produce besides consuming a certain resource, thus contributing to local resilience and sustainability. As a consequence, the development of a

"prosumer strategy" could replicate inclusiveness and equity in the autonomous production within sharing economy, leading to potential forms of local competitive sustainability and agile water resource management [51] to accelerate the digital and ecological transition for resilient and sustainable scenarios.

8 Conclusions

The proposed methodology generates from recent but solid research on resilient design, in the application of sustainable circular models, that require the managing of resources and information, through green and digital innovations. The regenerative design positively responds to the insufficiency of degenerating impacts designs, while proposing social, economic, and environmental positive impacts. Furthermore, the Advanced Resilient Design methodology first validation still needs more integrative validations, but the adherence of paradigms and technological considerations with the most recent and advanced research on water and wastewater management proves that the theoretical apparatus is coherent with the contemporary scenario and suggest that promising results can be reached in further applications of the methodology towards resilient scenarios in response to climate change.

Acknowledgements. This text is part of the scientific activities carried out by ABITAlab, as a contribution to the theoretical and experimental discussion of the TREnD (Transition with Resilience for Evolutionary Development) research project, which has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 823952.

In the presented paper, the themes and the progress discussed are based on the activities conducted within the doctoral research: "Advanced Design Process and enabling technologies for the resilient transformation of urban districts in transition: designing for climate change. From the experience of Dutch water cities, the exportability of an operational methodology for the southern suburbs in Reggio Calabria". The PhD study of reference was carried out by Ph.D. Arch. Alessia Leuzzo, under the supervision of Prof. Arch. Consuelo Nava.

Results presented in terms of state of the art, methodologies, and experimental progress reflect the experiments conducted within ABITAlab dArTe UNIRC (www.abitalab-unirc.com) and during the study conducted abroad at the Technological University of Eindhoven.

A presentation of this paper took place at the New Metropolitan Perspective international symposium on 05.26.2022, to the session FS-TR04 CITIES AS RESILIENCE "MACHINES": DRIVING THE URBAN TRANSITION.

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The Contribution of the Green Responsive Model to the Ecological and Digital Transition in the Built Environment

The Proto-Typological Experimentation for the UpCycling Design of the "Liminal Space"

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Abstract. The proposal represents a framework for the digital transition of the construction sector and architecture without depletion, towards a resilient system for the management of the circularity of resources and the optimization of performance in the building organism by intervening on the liminal space, controlling its impacts. The research on the themes of Advanced Sustainable Design, in which the approaches to circular design and UpCycling are placed, interprets the mission of the necessary ecological and digital transition, in the construction sector and for the architecture of buildings and spaces with zero impact, reforming design processes and using computational simulation and prototyping strategies. The experimental topics addressed in doctoral research experiences and competitive projects within ABITAlab, investigate the relationship between hypersustainability and enabling technologies, between advanced design and transition scenarios, providing a contribution to frontier research in which theoretical paradigms and experimental results are innovated and transferred to the sector of transformation of the built environment at the building and urban scale. The contribution reports some theoretical and experimental activities in progress. To summarize the topics that will be found within the paper, they can be listed: Introduction; Literature review; Experimental context; Green Responsive Model; Methodology; Green Responsive System approach; Results; Conclusions

Keywords: Ecological and Digital Transition · UpCycling Design · Liminal Space

1 Introduction

The thematic areas of research investigating issues related to the ecological and digital transition transfer to the area of KETs, in terms of innovation and sustainability, the opportunity to experiment with new approaches and models. In this discussion, the investigation applied to the topic of 'green responsive systems' [1] measures the ability to address the complexity of global issues related to 'transformation and construction

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impacts' and how these can be optimized from an ecological perspective through the use of methods and tools defined in the Advanced Circular Design approach.

The aim is to develop and refine the previous scientific positions in relation to references to design activism that have underpinned past attitudes and actions, and to find alternative declinations of the Circular Economy paradigms [2] by investigating the design of sustainable materials, components, and construction systems for architecture.

Engage in an interdisciplinary approach to the radical innovation of meaning [4] through the measurement of the degree of hypersustainability and the use of enabling technologies (digital and process).

This research implements the experiences related to the study of the potential that technological systems for the integration of elements of a biological nature [5], and/or from recycling sources have in the UpCycling project, in their ability to innovate, in form, and process, materials derived from waste or refuse processes.

In the following proposal, a framework has been proposed for the digital transformation of the built environment and the architecture of the transition towards a resilient system for the management of the circularity of resources and the optimization of performance in the building organism by intervening in the frontier space, controlling its impacts.

The issue of 'Liminal Space Design' becomes a central node in the development of responsive technological systems integrated with physical and digital devices since the qualities to which the system aspires do not only concern the optimization of adiabatic operation at the building scale, but the new definition of 'liminal space' incorporates in the design the processes of optimizing the energy and environmental balance of the physical and climatic context in which it is inserted. The levels of applied experimentation, through regenerative digital design, intend to overcome the limits of the predictive approach tool itself and go as far as coupling concepts capable of realizing the 'jumping scale,' interfacing data-information-resources in configured and 'site-specific' design scenarios.

In the context formulation, the Liminal Space is defined as a driver to achieve carbon neutrality and a positive impact on the mitigation of the climate change effects.

The definition of the Green Responsive Model became the central node to identify the main topic to address the experimental settings to achieve the principal aims presented in the paper.

The literature review proposes a critical reading based on the evolution of the design for sustainability and presents state of the art to identify tools and practices in the design experiences for the digital and ecological transition in the architectural practice.

The methodological approach based on a Parametric Workflow process to design responsive technological systems is presented to explain how the integration of the physical aspects in the operational phase with the digital simulations of the climatic conditions based on the IPCC Climatic Scenarios is directly related to the increasing of Global Surface temperature with the CO2 emissions.

To be clear on the extent of the impact on CO2 emissions that various building materials produce, it is necessary to take into account the indicator known as the global warming potential of a product (GWP). GWP is a standardized way to measure the greenhouse gas emissions associated with a product from the extraction of the material of which it is composed, up to disposal or recycling at the end of its life, and is expressed in CO2eq / m2 and/or Kg [6].

The experimental themes addressed in the research doctorate experiences and in the competitive projects within ABITAlab, and in the experiences made in the NYIT laboratory that investigates the relationship between hypersustainability and enabling technologies [7], between advanced design and transition scenarios.

By enhancing the Green Responsive Model qualities through the dissertation wants clearly link the optimization of the adiabatic functioning of the building with the succession of the processes for optimizing the energy balance of the environmental system.

The results show how the system is affected by the precedent topics and gives the mid-term results, that allow the experimental setting to validate, at least, the readiness level of the processes.

To summarize the topics that will be found within the paper, they can be listed:

Introduction; Literature review; Experimental context; Green Responsive Model; Methodology; Green Responsive System approach; Results; Conclusions.

2 Literature Review

The last few decades have witnessed a scientific revolution in the field of architecture [8] that has led to a profound understanding of the relationship “between form and sustainability” that the natural systems can assume when they are placed in urban contexts.

By the assumption of state of the art, the intention is to provide a contribution to frontier research in which paradigms theoretical and experimental results are innovated and transferred to operate the transition scenario in the building industry both on a building and urban scale.

In this sense, the innovation proposed is not only based on the superimposed use of plug-ins for life cycle analysis and plug-ins for the optimization of environmental context factors.

The level of innovation is measured by the use of overlapping plug-ins to delimit the quality of the output data, referring to both the L.C.A. to the environmental context.

The contribution reports some theoretical and experimental activities in progress in which this condition indeed represents the fundamental contribution to the evolution of the principles related to environmental sustainability in architecture and the innovation of its design and construction processes.

In the study of these principles, the theoretical precepts on the evolution of design for sustainability are assumed as proposed in the definitions by Ceschin [9] and in the study of life cycle performance systems and physical-environmental performance proposed on the themes of regenerative design [10].

Since there are few references regarding the transfer of the principles of the circular economy into transferable numerical parameters in an Algorithm Aided Design system [11], the proposed research has moved towards the areas for the assessment of sustainability (L.C.A.) [12].

The study also wants to organize the responsive systems for vertical greening as a green technology [13] and their inter-organizational relationships through sustainable management of the value chain of UpCycling materials.

All the published and updated literature in question is taken on this subject, from Badrulzaman [15] with his evaluation of the impact of the vertical vegetation system on the cooling effect on skyscrapers and surroundings in 2011, in Afrin in the possible integration of plant plants in tall buildings 2009 [16], which provided to characterize two main types of vertical greening system such as modular truss/support systems and support/cable and rope systems.

The literature review tries to incorporate all the technological devices and formal configuration systems that are capable of offering an increased performance as CO2 storage units, both minimizing the impacts on the life cycle and through systems capture and disposal of CO2 emissions rate (par.2.1).

The technological aspects want to underline the importance of the and the possibility of studying plug-ins, workflow, and methodologies not to answers to urban heat island (UHI) issues but as strategies for mitigating the effects of climatic aspects on the built environment (Par. 2.2) [14].

2.1 Enabling Technologies for the Ecological Transition in the B.E.

The contribution of digital and physical technologies for the mitigation and adaptation of the atmospheric phenomena of global warming needs a deep and advanced reading based on a sustainable design strategy that is able to contribute to the ecological and digital transition of the construction sector.

The literature review wants, in the experimental architectural field, to review all the design practices and the most advanced technologies able to reduce CO2 emissions.

Several examples of technological exaptation [17] in the UpCycling design practice can be found in the studies based on technologies for the "permanent sequestration" of CO2. Among these, one of the most relevant examples of UpCycling recorded in the world panorama is the CO2 mineralization technology [18] patented by the San Francisco company Blue Planet, which allows capturing and permanently sequestering CO2 from any source of emissions.

The process, in this case, involves an exact capture system, which in fact can use CO2 extracted from any source, in any concentration, and transform it into aggregates for construction.

Although each ton of the aggregate produced allows for the permanent disposal of 440 kg of CO2, preventing it from escaping or accumulating in the atmosphere, any necessary supply of CO2 can be considered one of the limits of this experiment.

In fact, the mechanical extraction of the latter would not be at the same level as the patented system. It would not be sufficient to cover the amount necessary to mitigate emissions on a global scale significantly.

The study in question invites us to reflect on the possible applications to mean in the relationship between nature and the built environment (Fig. 2). Complementary answers in this sense must indeed absorb the results obtained in the experiments concerning new consumption models [19], which contemplate considerations of differences in the design evaluations.

The aim is to have a point of view based on the experimental field. Several tools have been studied and sequenced in a reiterative process to achieve the complexity required by the transition mechanism to reach the resiliency aspects by design.

2.2 Parametric Approach for the Digital Transitions in the B.E.

The study retraced the advancement proposed by the "Regenerative Digital Design" approach, his proposal of a radical change of perspective, which defines the fundamental principles of regenerative Design, focuses on new digital “tools” and their applications to support the design phase.

The focus is on those models that support an interdisciplinary performance assessment, with the aim of showing the state of the art of the computational optimization techniques (Parametric Design) that helps to achieve regenerative, open, implementable, combinable design objectives in its “simulation” states as “predictive” digital prototyping experiences.

State of the art presents essentially three different processes to reach an interdisciplinary relationship with the environmental performance by parametric Design and operational phase optimization.

The first is the algorithm-aided Design to identify the characters for the so-called co-optation of components; the second is the performance-driven design approach for generating the performance model; The synthesis finds its natural evolution in applications to an advanced circular design, designed as a regenerative algorithm to be used for the UpCycling of innovative materials, components and construction systems for architecture.

The second is the parametric algorithmic design approach (Grasshopper) is performed in several approaches to extend the geometric capabilities of the software. In particular, the relevance of the system can be found in the ability to manage and interface in formal way materials, components, and systems able to interfacing both with environmental aspects with the optimization of the components in terms of performance capabilities.

The last parametric model is then defined by the basis for the UpCycling Design in the Green Responsive model within the advanced circular design process, determining the taxonomy of the components and coding their language, thus allowing to reach an evolutionary approach with computational methodologies and tools.

In the realization of the prototypes, therefore, we try to experiment and visualize the factors that optimize the climatic adaptation of the components, the circularity of resources, and biodiversity in the built environment [20].

The operational step involves the use of plug-ins that interact in the parametric space of Grasshopper. Specifically, the LadyBug + HoneyBee tools report on the performance status of the experimentation object, describe the endogenous aspects related to the composition and functioning of the component/system (HoneyBee), and analyze the environmental aspects related to the scenario in which the experimentation is conducted and allows you to perform accurate simulations on performance scenarios (Ladybug). [21].

The synthesis of performance-based design approaches assisted in a parametric environment naturally flows into a regenerative process of responsive optimization of building components and systems, which actually achieves advanced circular Design.

The proposed approach aims to demonstrate that a sufficient comparison can be provided for the optimization of the parts in an advanced circular perspective already in the early design phase, adding to the performative tools, the parametric evaluation tools of the impacts.

This type of study is done by comparing the operation of the Grasshopper Cardinal L.C.A. and Bombyx 2.0 plug-ins.

By accessing international opensource databases, an L.C.A. of a simplified type and the impacts on the entire life cycle of the buildings are quantified, visualized, and optimized in an algorithmic sequence, having an objective comparison of the values in terms of CO2eq / Kg, determining the optimization on the GWP.

2.3 Lack and Gaps

The increase of the Performance-Based Design Optimization Processes presents still few deficiencies in terms of lack of validation.

The experiences that emerge from the reading of the case studies become necessary to recognize all the capabilities of the process enabling technologies, which innovate the UpCycling project, but it's also useful to highlight the gaps and the lacks in the general sector.

The investigation and practice of the technological functions that influence the performance in the design phase, for the most part, concern the aspects related to the realization with the use of simulation and digital manufacturing techniques, which operate evolutionary management in the use phase (Responsive Consumption) and optimize the disposal of reusable building components (Advanced Disassembling).

The approach based on performance deepens the relationships that the experimental project undertakes with the physical environment, focusing the study on the aspects concerning the performance attributes, referred to quantifiable parameters that can influence both the quality of the environment when they intervene in the aspect's performance of the building, both on the measurement and visualization of the impacts [22].

For any further applications, we had to consider the increasing trend in using Grasshopper components instead of using single common simulation software for any kind of computational analysis in the design field.

The intention of this paper in the optical to fast the digital and ecological transition is to overcome the difficulties and fill the gap related to the lack of inclusivity of simulation tools in hybrid systems with an integrated system.

3 Experimental Context

"Liminal space" in hybrid buildings, according to the literature review, accounts for over 40% of heat loss in winter and overheating in summer [23], in addition to the embodied energy that is involved due to its presence within the building organism as a predominant mass element (Fig. 1).

The Liminal space in its morphological aspects increased in its performance by the G.R. model helps the reclaiming process by extending the lifespan of building facades and reducing maintenance costs in the long term.

The analysis of the concepts proposed for the definition of the Green Responsive Model wants to contribute to the advancement of the technology applications and digital simulations in the integration of processes for Zero Carbon construction processes and elaborating environmental sustainability in the built environment through the definition of several processes to achieve the climate neutrality targets [24].

The protocol that is perfectly suited to the transitions model is based on the performance adaptation of the carbon sequestration technologies and on the mitigation of the factors that contribute to reducing the climate change effects by optimizing the adaptability of the UpCycling project in the project.

It is also highlighted how the integration with biological systems contributes to the protection from environmental damage such as extreme heat radiation and high rainfall [26], hence the need for a systemic approach in liminal space, according to the Green Responsive Model principles.

The systemic responsivity to this type of phenomenon highlights the concepts of transformative resilience through technologies of adaptation to phenomena that increasingly appear as the directly tangible effects of climate change due to rising temperatures [25].

The validation of the UpCycling project with a Green Responsive System approach is qualified in the Advanced Circular Design environment by performing and evaluating in the parametric environment the workflow as a tool to enhance the importance of the digital transition in the construction sector to improve the sustainability aspects.

According to the aims, the proliferation of biological nature in the urban environment became an additional aspect to contribute to the conservation and increase of biodiversity in the urban environment [26].

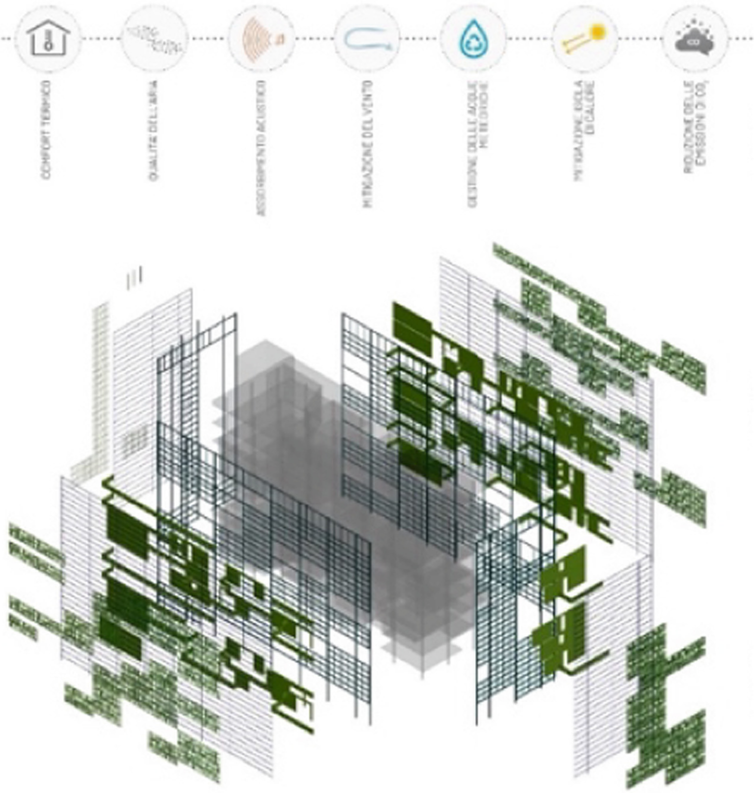

Fig. 1. Green Responsive Envelope (source: Thesis Research R.Raso, ABITAlab, 2020)

4 Green Responsive Model

The subject of the experimentation concerns the integrated design [27] and the hybrid prototyping [28] of the components for the construction of modules and systems for the vertical greening to enhance the ecological transition in the built environment through digital practices and optimization processes.

The approach called "Green Responsive Model," within an Advanced Circular Design process, re-interprets the set of possible solutions for the ecological optimization of the advanced and circular project through a technological system to create vertical and horizontal closures of casing and components integrated into the urban space, with a strong responsive character and capable of offering high ecological performance.

The idea stems from the need for a holistic approach to design for the prototyping of the "liminal space" industrial component, which can trigger, in its characterizing processes, mechanisms capable of improving the relationships resulting from the contact between the building and the exterior, in its third environment and for which the envelope border takes on a "liminal" function.

The "green" nomenclature, of which the approach to prototype experimentation has, intends to include in the field of experimentation all those systems of a biological nature that allow the creation of materials, components, and systems for bio-ecological architecture with a high energy profile and with an environmental load close to zero.

This system, capable of contributing to the climate neutrality of hybrid buildings, for example, thanks to the functional co-optation [29] of its components, increases their configuration capabilities as a CO2 store and as a mitigator of climate-changing gas emissions into the environment and optimizes the life cycle [14], assuming an open configuration depending on the context/environment system in which it is inserted.

The evolution of the proposal of a multi-objective optimization framework is realized in the integration of LCA and Energy Optimization Analysis [13] to the trade-off between embodied and operation energy and with the plus given by the approach of using Urban Mining resource supplying and the renewable energy generation systems to decrease the building operational phase consumption.

Technologies and projects that operate in UpCycling on resources deriving from scraps or waste for the creation of innovative frontier components to increase their ecological value [30], intervening in the development of its performance attributes and using the advantages of computational design tools.

In this sense, design approaches based on increasing ecological performance have been examined, understood as the ability to store C02, and have studied the life cycle stages of the building from the cradle to the grave.

The proposed framework on a case sample was studied to measure the versatility of the upcycled systems to balance the embodied energy and operation energy.

The innovation at this stage is to add an UpCycling factor to optimize and balance the embodied energy and energy of the exploitation period through the control of material procurement processes and process innovation in which the returning of increased ecological performance lightens the environmental load to achieve low energy buildings using parametric modeling and genetic algorithm.

5 Methodology

The research on the themes of Advanced Sustainable Design, in which the approaches to circular design and UpCycling are placed, interprets the mission of the necessary ecological and digital transition in the construction sector and for the architecture of zero-impact buildings and spaces, reforming design processes and the use of computational simulations and prototyping strategies.

The methodology chosen for the creation of the model provides for the definition of a dedicated and original framework for the implementation of production models linked to the circular economy.

The relationships of those aspects, when they work together in the built environment, want to translate into advanced construction systems with a strong ecological character.

For characterizing this methodology, there are the two research trajectories that connect the issues related to UpCycling, indicating the fields of environmental issues related to the optimization of the "liminal space" and the search for "formal configurations" in the field of design. [10].

The basic foundations at the small scale are approached regarding the evolution of design on an architectural project without depletion involved in the design practice the radical innovation on circular design in the scientific field,

In the large-scale conditions, the contextual operating environment, taking into account the scenario that represents the application domain and its optimization in the parametric environment.

Within the field defined by the experimental environment, a design cycle iterates its alternative solutions between the processes related to the performance and construction activity of the artifacts and their subsequent evaluation and optimization, focusing on the aspects defined in the development of the framework on the advanced circular design (Fig. 2).

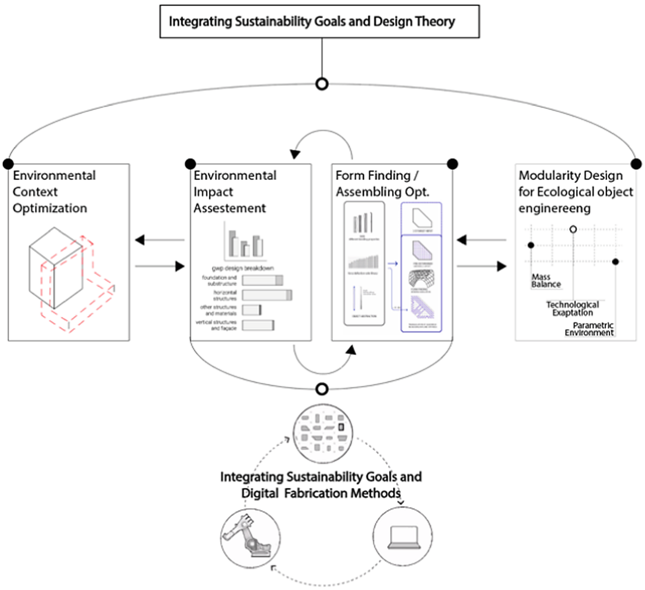

Fig. 2. Diagram scheme for ISG*DT – Integrating Sustainability Goals and Design Theory (source: D. Lucanto, NYIT, 2021)

The drafting of the methodological proposes a synoptic framework for the digital transition of the construction sector to achieve the circularity by design in the construction sector.

The structure of the methodological approach enhances the systemic resiliency by including in the same workflow the management of the circularity of resources and the optimization of performance in the building organism by intervening on the liminal space, controlling it the impacts.

6 Green Responsive System

“Every organism in nature avoids excesses, avoids overbuilding, and obtains maximum efficiency with the minimum amount of matter and energy.” [31].

Nature finds a use for everything, adapts it to local conditions, and uses the sun and other natural sources of energy, but above all, it uses only the energy and resources that are needed. Assuming this behavior is part of the systemic approach exemplified by the Green Responsive Model.

In this particular and urgent scenario, every type of transformation is activated to increase the quality of life of living and therefore, the regenerative processes, which concern architecture and the city, must look at the adaptability of each action in its processes, from design to “zero impact” creations. In the contribution illustrated below, we focus on the ability of circular design to activate virtuous processes of control and management of these transformations.

The current experience of the Circular Advanced Design project applied to the frontier environmental system is presented with prototype experimentation called “Green Responsive System (G.R.S.).”

The capacity that the prototype/model is called to optimize concerns the performance measured on the reference environmental unit, considering the relationships between the environment and the building organism, innovating the component through the use of new materials in UpCycling. From construction.

The “green” meaning, which is given the name of the prototype being tested, intends to broaden the field of experimentation towards all those systems of a biological nature that allow the creation of materials, components, and systems for bio-ecological architecture with a high profile environment and with an environmental load close to zero, which thanks to the functional co-optation of its components increases its configuration capabilities, as CO2 storage and as a mitigator of climate-altering gas emissions into the environment.

The theme of the Liminal Space, as an example of a transition mechanism in the building sector, it’s studied as the space of relationship and mediation between the indoor spaces and their border space by extending to the context and its components.

The theme of the Liminal Space goes beyond the concept of building envelope since it does not consider, in the study of technological unity, the only element of internal/external separation, but designs with other profiles all the technical elements of an adiabatic nature that offer a dynamic response system, positively influencing the performance related to the environmental and regenerative requirements of the entire building and its internal and external environmental units.

First of all, two types of prototypes were identified in terms of embodied energy and the qualities for the integration of biological materials and greening.

The two prototypes (Fig. 3) were created and studied during the exchange period abroad in the NYIT advanced manufacturing laboratories.

This sample was selected with a focus on the conventional construction system in the Innovation market to investigate the potential of this kind of process to increase the efficiency and conversion of conventional buildings to positive energy buildings to put into practice the digital and ecological transition in the building practice.

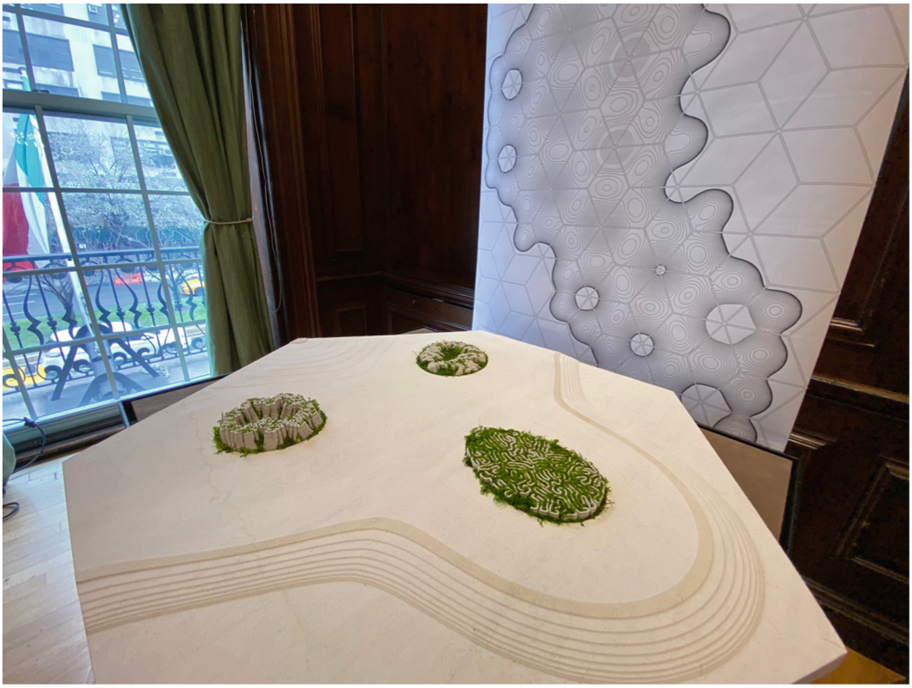

Fig. 3. Images of the UpCycling exhibition held from March 31st to April 30th at the Italian Cultural Institute in New York (Curated by A. Melis, C. Pongratz, M. Perbellini, NYIT, 2022)

The model of an architectural structure and its associated experimentation demonstrate how it is possible, through a new approach, to "produce an architectural structure of any size, shape, or height, whose visible or exposed surfaces can present a permanent growing vegetation cover." [32].

Research into architecture has demonstrated that natural systems and structures are efficient in terms of material use, lightness, rigidity, and stability, so it is no surprise that designers can learn much from them regarding efficiency and sustainability [18].

6.1 Environmental Optimization for UpCycling Process

Cities today, as well as the structures, materials, and design of their areas, display a lack of integration with biological and nature-based systems, which is certainly harmful to the climatic characteristics of these areas. [33].

Temperature, relative humidity, and wind speed are used as boundary nodes to optimize the model.

Solar radiation and climatic characteristics were obtained through simulations on Grasshopper using the LadyBug Legacy Plug-in. Solar radiation is emitted onto surfaces depending on their orientation, inclination, and shading pattern.

Through the HoneyBee plug-in [34], where the same facade geometries were inserted, the adiabatic operation was calculated based on the physical configuration of the system and the exposure level of the studied part. The air velocities in the vicinity of the canyon were calculated with the CFD code EDDY 3D. [35].

In order to determine the optimal parameters in the Grasshopper environment, first, the geometric and the performative variables were identified.

The geometric variables include external shape, composition, and configurations that determine the capability to integrate a biological system in its evolutionary phase.

The performative one was included as a consequence of the geometric shape and as a result given by the materials used.

In the experimentation, all those characteristics are considered to favor the growth of spontaneous bio-vegetative species that interpret the principles of exacting resilience in integration with advanced technological systems.

Then, the geometrical type was constructed as optimization parameters (Fig. 4). Next, by identifying the parametric variables, including embodied energy, the possible integration of renewable energy, and embodied environmental cost of each parameter, these data were entered into the grasshopper environment and were added to the attributes of each variable.

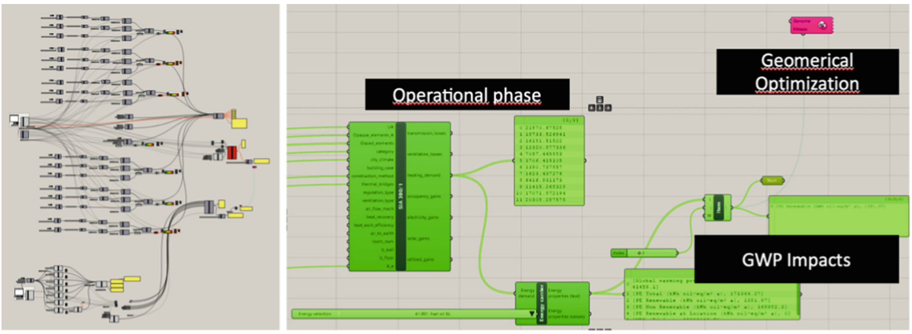

Fig. 4. Parametric Workflow to integrate the Operational phase impact with the GWP impacts (source: LCA Experimentation in D. Lucanto PhD Thesis, ABITAlab, 2022)

The illustrated application measures the growth capacity on different types of surfaces, exploiting the various levels of humidity and PH levels controlled in the computational phase for their growth and diversification.

Climatic file According to the case study was located in New York City and was extracted in epw format and attached to the model. The energy calculation time setting was set to one year and multiplied by 60 according to the 60-year lifespan intended for the building.

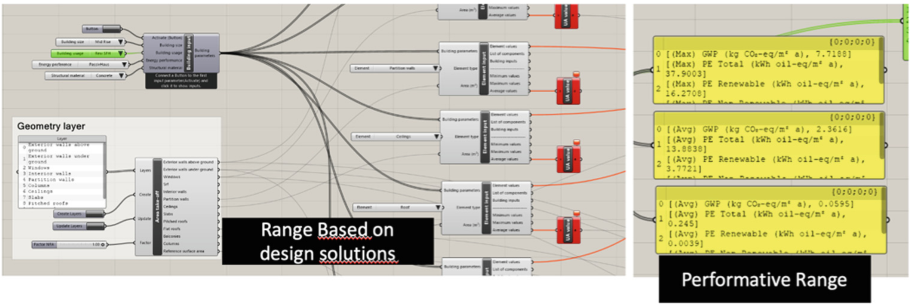

Fig. 5. Parametric Workflow to identify the Range of the proposed design solutions to assest the performative range (source: LCA Experimentation in D. Lucanto PhD Thesis, ABITAlab, 2022)

In the following, according to Fig. 5, an algorithm was written in the Grasshopper environment that divided the energy output of the LCA engine [36] into two modes. In the first case, where the scene is the use of Advanced 3D Printing (Fig. 6), the geometry generated by the parametric succession of the design is deducted from the overall complexity in the parametric environment, and simultaneously the embodied energy generated by the optimization is added to the embodied energy of the building (Fig. 7).

The second scene is the use of the municipal grid system to power the building, in which case the results go directly to the output. At this point, the cost of each of these scenes is calculated by multiplying the energy consumed by the price per unit of energy (Fig. 5).

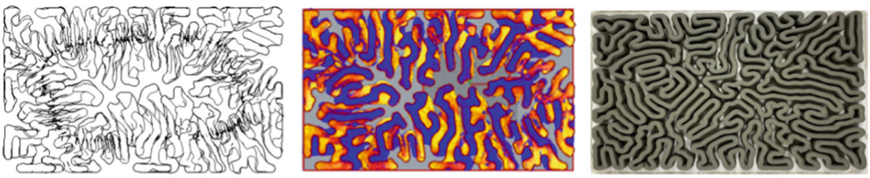

Fig. 6. Parametric prototyping steps of the first prototype considering the computational design 3d printing optimization, and the environmental optimization (source: Prototyping Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

The experimentation conducted configures the contact surfaces for the proliferation of devices capable of accommodating natural systems for the storage of CO2 through computational systems (Fig. 6).

The component innovated in this phase allows for to study of the integration in advanced systems of algae, bacteria, and photosynthetic organisms and photo reagents that feed on carbon dioxide fumes and their capacity once inserted in complex systems of oxygen and nutrient release for growing biomass (Fig. 7) (Figs. 8 and 9).

Fig. 7. First Prototyping evolutionary based at his greening stage (source: Prototyping Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

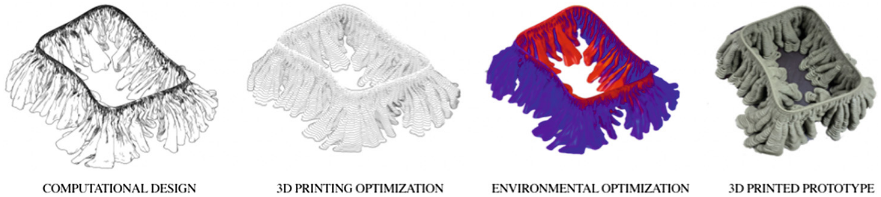

Fig. 8. Parametric prototyping steps of the second prototype considering the computational design 3d printing optimization, and the environmental optimization (source: Prototyping Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

Fig. 9. Second Prototyping evolutionary based at his greening stage (source: Prototyping Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

7 Results

In the optimization process, an optimal first workflow was obtained from the Green Responsive Model in the parametric environment.

Due to a large number of different plug-ins in all the functions at this stage, it is necessary to analyze the Green Responsive System sensitivity to obtain an optimal solution considering the life cycle assessment and the consumption of energy in its operational phase.

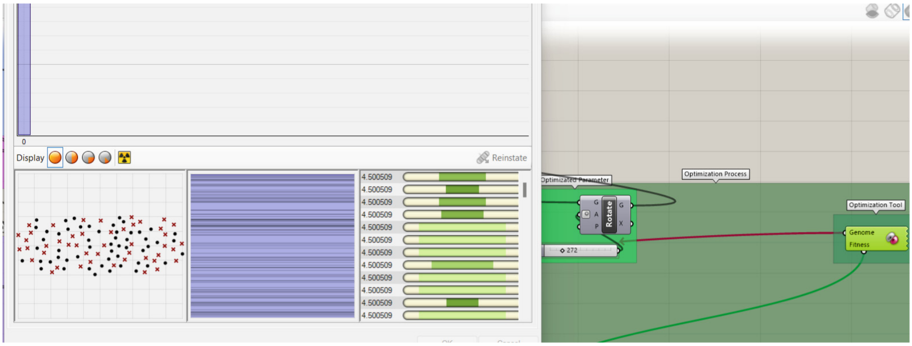

Fig. 10. Taxonomy of the proposed technological solutions (source: Parametric Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

As shown in Fig. 10, the marked line represents the combining of different ranges of lifecycle-based parameters, indicating that all the solutions can be optimized in a reiterative way that uses the parametric geometric modeling system, and as they get closer to the optimal combining of components, the variety of solutions becomes more intense, reflecting an increase of complexity in the design solutions.

This type of solution shows further room for improvement because the optimization of the orientation and the adaptation to different surrounding environmental conditions can improve the renewable energy consumption over the material life cycle.

The areas shown with the fine lines are the solutions that use only a few parameters of optimization, and they do not fall within the optimal solutions for the purposes of the study.

Therefore, based on Green Responsive Model optimization, the two prototypes shown in the previous paragraphs are located in the range of optimal solutions.

The range refers to the priority responses to the use in the life cycle of the advanced materials and gives priority to reaching less embodied energy in the material life cycle.

In the conclusive graph shown in Fig. 11, the most optimal point is selected in each of the attempts that have been sought in the iterative process of parametric design.

This diagram shows that the use of more plug-ins used in the life cycle of materials can be considered an advantage but can still mean more energy consumption in the whole life cycle of the building than normal.

Therefore, it is necessary to consider the effect of the database available in the life cycle of materials in both prototypes in comparison with the energy consumption of the entire life cycle of the building.

This suggests that it is important to consider the energy of the entire building life cycle in order to determine the effect of each of the objective functions on the other and to achieve the optimal answer.

Next, to select the optimal solution, a Green Responsive Solution was selected from each of the parametric optimization processes, and they were next separated according to ISO14040 to focus the processes with the highest energy expenditure on the life cycle energy consumption.

The results of the comparison of the two prototypes shown in Fig. 11 illustrate that the Green Responsive Model can effectively act as a useful tool for the digital and ecological transition in the construction industry because it is capable of reducing energy losses and CO2 emissions by 30%.

Furthermore, integration with biological systems contributes to the passive functioning of cities.

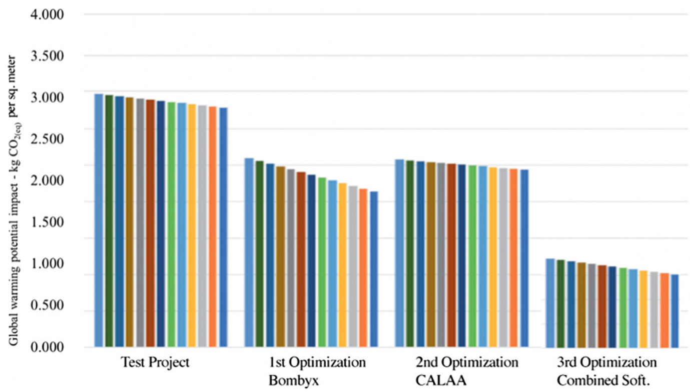

Fig. 11. Graphs of the results of the comparative analysis on the life cycle of the optimized components (source: Parametric Results Experimentation in D. Lucanto PhD Thesis, ABITAlab, NYIT, 2022)

8 Discussions

The resulting double positive effect enhances the optimized life cycle performance achieved in the parallel computational optimization of the selected plug-ins (Cardinal LCA and Bombyx 2.0).

The dissertation aims to provide a practical framework for evaluating embodied and operational energy trade-offs based on the integration of Environmental Analysis and Life Cycle.

Combining these factors and the multi-objective optimization process can allow the selection of optimal solutions, considering the wide range of factors that affect energy efficiency and life cycle cost for designers and planners in the early design phase to improve the decision-making.

Based on the studies proposed, the methodology, and the data obtained, it can be summarized that:

- A computational optimization process can achieve optimal solutions for reducing energy loss, cost, and adverse environmental effects through an integrated approach to building life cycle thinking. By incorporating the approach of building life cycle thinking, taking into account various shaping factors affecting energy and life cycle costs, and adequately planning the early design phase and the life cycle of the building, optimal solutions can be implemented.
- The study demonstrates how it is critical to consider the building shapes and materials used in the construction process in order to integrate a biological integration into the built environment in terms of sustainability and resource efficiency.
- It was demonstrated in the results that by using the proposed framework and reducing the time for the optimization process, the proposed platform could provide a platform in which renewable energy can be considered in the optimization process.

9 Conclusions

The authors retrace the salient points of the positions presented in the paper, in conclusion, taking into account the relationships between state of the art, a methodological comparison, and a description of the results obtained through proto-typological experimentation.

According to the interpretation of the succession of contributing thoughts to the knowledge process referenced to the systemic resilience in the field of design for the ecological and digital transition in the built environment, there are still several open paths to explore:

Each type of experimentation on the issues of ecological and digital transition requires a strong experimental character.

- The design experimentation carried out in the field of architecture is based on the radical innovation of digital tools and processes that make it possible to achieve a high level of operation based on the ecological performance of the system.
- The recent constitution of the reference literature and the strong interdisciplinary character allows to decline the experimentation towards a new cognitive level of the reference discipline.
- The experimental character of the pre-presented prototypes represents a borderline case that underlines the openness to new developments of the outputs obtained. The output data in this sense are therefore strongly influenced by the tools used, hence their performance value is underlined strictly referred to the context of the experiment where they are measured.

Acknowledgements. This text is part of the scientific activities carried out by lab, as a contribution to the theoretical and experimental discussion of TREnD (Transition with Resilience for Evolutionary Development) research project, which has received funding from the European

Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 823952.

In the paper, the themes and the progress discussed are based on the activities conducted by Ph.D. student Domenico Lucanto, under the supervision of Prof. Arch. Consuelo Nava within the doctoral research: Circular Processes and Enabling Technologies for the UpCycling of innovative frontier systems. Advanced Circular Design for the Green Responsive System prototype.

Results presented in terms of state of the art, methodologies, and experimental progress reflect the experiments conducted within ABITAlab dArTe UNIRC (www.abitalab-unirc.com) and during the study abroad conducted at the manufacturing laboratories of New York Institute of Technology's architecture department.

A presentation of this paper took place at the New Metropolitan Perspective international symposium on 05.26.2022, to the session FS-TR04 CITIES AS RESILIENCE "MACHINES": DRIVING THE URBAN TRANSITION.

Also noteworthy is that the results of the Life Cycle Assessment were published and presented at the TS41 session of the New Metropolitan Perspective international symposium: SUSTAINABLE BUILDINGS AND LOW-CARBON TECHNOLOGIES FOR SUSTAINABLE CITIES AND COMMUNITIES with a contribution entitled: Advanced Circular Design, a Life Cycle Approach. Methods and Tools for an Eco-Innovative Life Cycle Approach for Buildings Energy and Resource Optimization.

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Data Driven Smart Cities and Data Spaces

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Abstract. *Smart Cities* are places where traditional networks and services are made more efficient through digital solutions, benefiting residents and businesses. Moving to digital solutions basically means applying a technological process that transforms various aspects of social or individual life into data that are subsequently transformed into information endowed with new forms of value, including economic value. In addition to economic value, in the digital age, access to data makes it possible to have transparent and open government, build trust, fight corruption, address inequality, and create more resilient democracies. This chapter describes how, for these purposes, data management and sharing are changing with the adoption of *Data Spaces*, a new approach that moves away from data integration to data coexistence.

Keywords: Smart City · IoT · Data Spaces

1 Introduction

Smart City term has many different definitions, evolved in the years with evolving of technologies and lifestyle. One of first definition is dated 2007. In [1] the authors describe *Smart City* as a city with the following six characteristics:

– Smart Economy (Competitiveness)
– Smart People (Social and Human Capital)
– Smart Governance (Participation)
– Smart Mobility (Transport and ICT)
– Smart Environment (Natural resources)
– Smart Living (Quality of life)

These features are described in detail in Fig. 1 below.

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Nowadays, *Smart City* refers mainly to smart environments integrated into city life, that is, cities in which objects such as sensors, devices, appliances, and integrated systems provide services, producing and manipulating complex data, thus focusing more on the aspect of Information Technology (IT) serving inhabitants to improve their lives and make urban development more sustainable.

Therefore, *Smart Cities* are places where traditional networks and services are made more efficient through digital solutions that benefit residents and businesses, as stated by the European Commission. In addition, a *Smart City* must also have a more interactive and responsive city government that keeps citizens informed and involves them in decision-making processes.

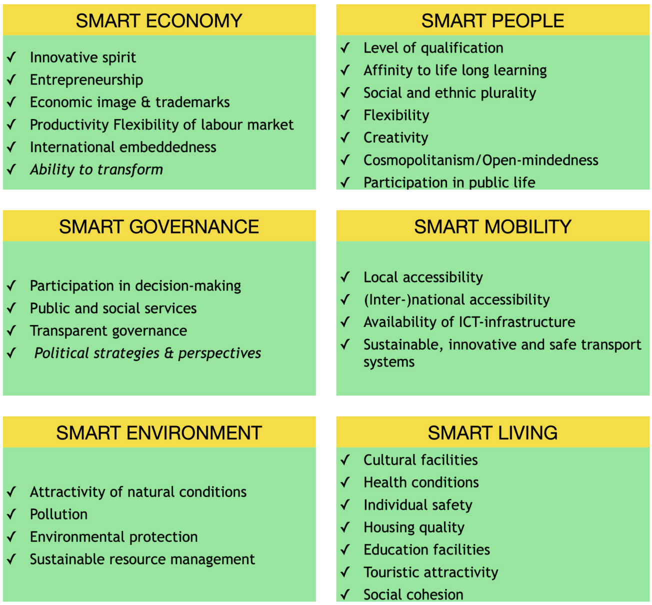

Fig. 1. Characteristics and factors of a Smart City according [1]

The United Nations 2030 Agenda [2] set out an action plan to achieve participatory, integrated, and sustainable territory planning and management in Goal 11 of the agenda.

It is expected by citizens the participation in city administration and its sustainable development, taking an active interest in the governance and management of the city.

The inclusion of citizens in decision processes, to shape public policies and services is also strongly agreed by all that countries partners of the Open Government Partnership (OGP) initiative [3]. OGP claims that a transparent and open government can build trust, fight corruption, tackle inequality, and create more resilient democracies [4, 5].

To promote a culture of transparency in public administration, OGP pursues Open Data policies.

Open Data must be available under a license or regulatory provision that allows its use by anyone, including commercial purposes, in a disaggregated format, accessible through digital technologies, provided with relevant metadata, and made available free through digital technologies.

The European Commission (EC) also states that "Data-Driven innovation is a key enabler of growth and jobs in Europe."

How do *Smart Cities* play an important role in *Data-Driven* innovation?

As will be explained in Sect. 5, *Smart Cities* are an inexhaustible source of data that delineate and shape the well-being of their inhabitants. These data are produced by both public and, more importantly, private entities. Since the United Nations estimates that today 57% of the world population lives in urban areas and that this percentage will reach 68.4% in 2050 [6], then the data produced by *Smart Cities* is very significant for the sustainable development of human welfare.

The fact that Open Data, produced mainly by government organizations for the common good, is only a part of the available Big Data, raises the need for its coexistence with data produced by the private sector. As a result, the European Community has established guidelines for *European Data Spaces* to encourage the sharing of private sector data in the European data economy. This new paradigm has thus forced a new evolution of the data management system.

2 An Overview on the Data Management Evolution.

Since 1980, a *Data Warehouse* has been an extensive collection of business data helping the decisions of an organization. It belongs to a single organization and usually contains private and sensitive data to not share with others. Data sources of data warehouses are mainly from internal applications such as marketing, sales, finance, customer-facing apps, and a few external partner systems.

In data warehouses, the data are periodically fetched from their sources, processed, and stored ready for the decision support systems. The only data available with this solution are those autonomy chosen by single departments, losing a holistic vision of the organization.

In 2010, the term Data Lake was born. It is a centralized storage for raw, unstructured, semi-structured, and structured data, taken from multiple sources, mostly external to the organization. The data are simply stored in one owned place from where all departments could Extract, Transform, and Load (ETL) for their purposes. The processes are distributed among departments that can extract the information relevant for them without excluding the information relevant for the others.

The following Fig. 2 summarizes the relevant evolution of data paths, where (Dep_1 … Dep_n) are internal departments and ($Ds_1 \ldots Ds_n$) are generic external data sources. In Fig. 1(a), enterprises were almost isolated, except for some partnerships among them. The data processing was centralized for cost optimization due to the high processing resource and storage costs. In Fig. 1(b), the enterprises take data from various heterogeneous sources as raw data, store them in centralized storage resources, and distribute the data processing among the internal consumers (departments.) In this way, each department can process the data according to its interests.

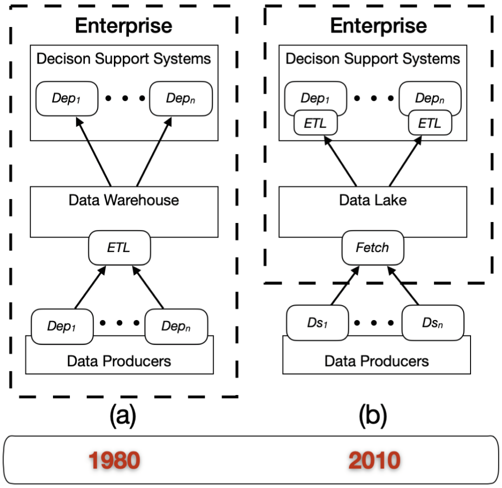

Fig. 2. From Warehouse to Data Lake

Undoubtedly, scenarios have changed today. Sharing data is a win-win situation. Data provides information that enables better decisions. Those who have data can offer it for free if it benefits them or sells it for a profit.

3 Data Sharing in the EU: Data Governance

The EC aims to create a single market for data, where data from public bodies, businesses, and citizens can be used safely and fairly for the common good.

This initiative will develop common European *Data Spaces* rules guidelines. The goals are to better use public data for the common good, support voluntary data sharing by individuals, and create structures to enable critical organizations to share data.

Data Spaces should be places where it is possible to find the sources of relevant data. They are not thought to be central storage of data but a central repository from where to connect to the data sources, which are widely distributed.

This paradigm shift stems from an awareness of two factors. First, with the large amount of heterogeneous data sources, it is no longer thinkable to an integration that allows for a unique structuring of all the data. Second, the sheer volume of data, produced continuously, does not allow for centralized storage, which in many cases would be a duplication of data.

In addition, the different mix of sources that each consumer uses to extract information is an important competitive factor that allows each stakeholder to prepare its own secret recipe.

Therefore, *Data Spaces* are end points from which to obtain valuable, secure and validated data, and end points to securely offer the data possessed.

In addition, data owners can determine and keep track of the permitted access and use of the data provided and any compensation charged.

Figure 3 depicts the *Data Spaces* stakeholders as prosumers, i.e., *Producers* and *Consumers* at the same time.

In a *Data Space, Producers* open the access to not personal data, specifying license, and all the conditions of use and access.

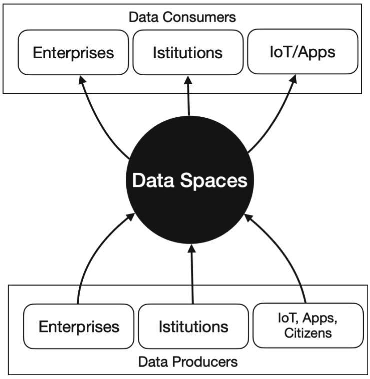

Fig. 3. Data Spaces

Although data produced by public funds must be Open Data, according to the EC, with the *Data Spaces* approach, private companies also have the opportunity to profit from the investment made in data collection and processing and at the same time support the *Data-Driven* innovation.

Whenever a company shares data provided by its processes or services, needs to trust that it can control the limit of use of those data and that the licenses associated with those data are respected. Thus, the EC Data Governance Act [7] try to address these concerns, making the *Data Spaces* paradigm feasible by strengthening data-sharing mechanisms across the European Union (EU) and creating a robust framework to generate digital trust.

Furthermore, the "Guidance on sharing private sector data in the European data economy" [8] document provides a toolbox for data producers, data consumers, or data prosumers, guiding on the legal, business, and technical aspects of data sharing that can be used in practice when considering and preparing for data transfers between companies or to the private.

4 Data Sharing in the EU: Technical Aspects

Guidelines to make data interactions in business-to-business and business-to-government from a legal and technical point of view are defined in [8, 9].

In [10], a factsheet of the [9], authors highlight how the Data processing will move from a centralized architecture from the year 2018 to a distributed architecture in the year 2025. This change estimation is depicted in the following Fig. 4.

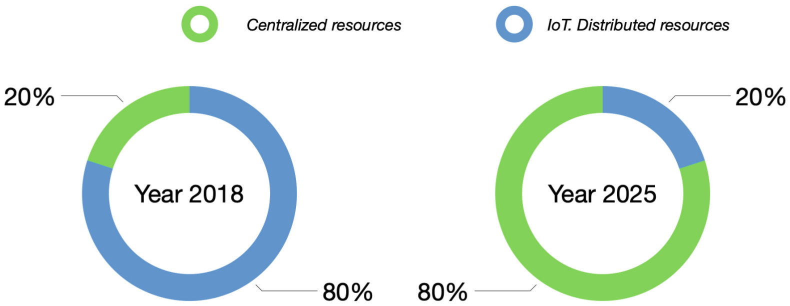

Fig. 4. Data processing chances

Indeed, *Data Spaces* will be almost marketplaces where stakeholders will interact and exchange data in a safe and controlled way, and the data processing and storing will be executed by data producers and data consumers.

5 Smart and Intelligent Cities

Smart City refers mainly to smart environments, as seen in previous introduction. Smart environments imply smart objects connected to the internet, i.e., the Internet of Things (IoT).

The Cisco Annual Internet Report [11], estimates that by 2023 there will be 29.3 billion networked devices. These devices will directly or indirectly produce an unprecedented amount of precious data, most of it in continuous streams. Thinking about integrating this data with conventional structured data is not feasible in the traditional way and especially in a centralized way. The IoT infrastructure should be seen as a system of systems (SOS) where the information must be extracted by coexisting heterogenous systems producing data.

In [12] a data ecosystem is depicted as a socio-technical system for extracting value from data with the support of interacting organizations and individuals. *Data Spaces* should be exactly such an ecosystem.

Although smart and intelligent are almost synonymous in natural languages, in technical language they express significant differences.

Intelligent systems (IS) are systems that use artificial intelligence (AI) technologies and are a complement to the smart environment. Most often, intelligent environments govern smart environments, thus joining the SOS and becoming a new type of stakeholder in the data ecosystem.

This complexity entails two important requirements that this chapter seeks to emphasize.

Broaden the audience of participants in *Data Spaces* as much as possible and create data access solutions that are both human and machine readable.

6 Conclusions

6.1 Broaden the Audience

In [13] it is observed that in enterprises 50–80% of the costs of data projects are related to data integration and preparation activities. These costs are high and are not sustainable by small enterprises or individuals. If we want a broad sustainability effort that enables small stakeholders to engage and leverage the value available in the data, this must change. The solutions glimpsed involve the adoption of new data management systems other than the traditional Data Base Management System (DBMS). In fact, the words *Data Base* itself no longer fits the situation described.

Pay-as-you-go data management is the most promising approach in *Data Space* implementation [14–16]. Instead, of the classic one-time integration of datasets, which causes a significant initial cost, the pay-as-you-go paradigm supports an incremental approach to data management and the principle that the data publisher is responsible for paying the costs of joining the dataspace. That is, the publisher is responsible for finding a solution that makes its data accessible. In addition, the data are managed using a tiered approach, where an increase in the level of active data management results in a corresponding increase in associated costs [13].

Another concern for effective and broad participation in the *Data Spaces* is the constraint on data validity. This constraint primarily affects data producers. Data cleaning and validation is a very expensive task, especially for large amounts of data produced in real time. Although it has traditionally been said that good data are only reliable data, in the current evolution of Big Data, even this taboo needs to be reconsidered. Many sources are not validatable, especially when made available voluntarily by citizens eager to contribute to the sustainable development of their territory. But precluding the participation of these individuals would go against the principles of the United Nations' Big Data for Sustainable Development (BDSD) [17].

Thus, the invitation is to consider what Pat Helland of Microsoft expressed in 2011: "If you have too much data, then 'Good Enough' is good enough." In [16] he argues that it is possible to switch from an absolutely accurate approach to a more "lossy" response when the amount of data is huge. This principle could allow the involvement of a significant amount of data from unvalidated sources, particularly networked sensors, or smartphone applications, but with some concerns.

A first concern is that when the data are incorrect, the information will not be accurate, and the decisions made may not be correct. Another concern is that the data could be maliciously wrong to steer to decisions that do more for personal interests than for the community.

The proposal is to equip the datasets with a reputation metric, which can be continuously reevaluated by nonarbitrary mechanisms in the head of the community. In this way unreliable datasets will tend to disappear because they will have dubious reputations and those with more reliable reputations will emerge. In any case, consumers of the data will be informed in advance of the reliability of the data and will be able to decide, according to their own goals, the right cost to pay to get the information they need. In addition, as is already the case, private companies could perform the task of data cleaning and validation, as a service, by taking data from the *Data Space* and providing the results in the same.

One example of this strategy is the Kaggle website [18]. It offers a huge repository of data published by the community. It allows users to publish and find datasets but gives each dataset a usability rating. This rating is a single number calculated for each dataset that rates them on several factors such as level of documentation, availability of related public content as references, the type of file, and coverage of key metadata.

While there are many data profiling tools that assess data quality, [19] and [20] are just an example, they could need to be set up by experts in the field. Thus, any solution should consider tools for volunteer collaboration and engagement, incentivizing their participation and making it as easy as possible for them to assess data quality as well.

Data quality is often defined in terms of measuring specific dimensions, including completeness, validity, uniqueness, timeliness, consistency, and accuracy.

Many data profiling tools combine the results of the various data quality dimensions into an aggregate data quality score. This approach could provide a simple metric that assigns an initial level of confidence to the data element.

A similar score should be given to the producers of the data themselves so that the reputation of the sources is also valued. Such a score would encourage data producers to strive to produce better data and gain, if not financially, at least in reputation.

Their score would, go up when their data has a good rating over a long period and go down when their data has a persistent bad rating. To this should be added the reviews of the users who have used the data, which will affect the overall score of the data producer.

In the latter case, since the reviews are subject to ’fake reviews,’ ’deceptive reviews,’ ’deceptive opinion spam,’ ’review spam,’ or ’review fraud,’ i.e., practices aimed at artificially altering the real reviews result, one of several mitigation methods would be established. In [21] the authors give an example of a solution for such an issue.

Thus, the data consumers should opt for adequate data cleaning and validation processing depending on the rate of the data source and the context of use. Of course, private, and validated data would have a high rating but could be costly and have a restrictive license. Open Data would have a high rating and be free with a permissive license but not cover all the stakes.

Low-rated data could need a cleaning and validation process but could be free, have a permissive license, and cover many domains. All of them should be available from *Data Spaces*.

6.2 Humans and Machine Accessibility

As mentioned before, the data provider should take care of make their data accessible.

In terms of Open Data, current examples are the Spatial Data Infrastructure (SDI). In [22] SDI is defined as “a framework of spatial data, metadata, users, and tools that are interactively connected in order to use spatial data in an efficient and flexible way”. As an example, the INSPIRE Directive, [23], aims to create a European Union SDI for the purpose of environmental policies or activities that may have an impact on the environment. This European SDI should enable the sharing of environmental spatial information among governmental organizations and facilitates public access to spatial information throughout Europe. Unfortunately, in practice, derived national platforms are not easily used by non-experts because of the methods and technologies adopted.

One of the reasons that most impact the usability of such solutions is the use of separate catalogs in which the metadata necessary to know the structure and content of datasets are described. Such catalogs are not searchable via Web search engines, and the user must first be familiar with their repositories, which is unsuitable for users who are not domain experts. The catalogs then provide instructions on how and where to access the actual datasets, which are often found on other repositories. Once the user has located the dataset of interest, he or she can download it as a file. In the best cases, the data are also offered through traditional Web services with which specially programmed applications can interface.

Instead, the proposal is that *Data Spaces* should be designed so that even non-expert users in the field can find and use the data, just as they do with other documents available on the Internet, while applications can discover the data sets and use them mostly on their own.

An example can be found on the Internet by turning to private companies that offer data via Web Application Programming Interface (API). A Web API allows external applications to access datasets by common web protocols and technologies. Furthermore, the access is controlled, according to the license assigned, and in an authenticated manner so that the identity of the user is known.

Most importantly, the API documentation is embedded in the API itself, is human- and machine-readable, and can be searched by standard Web search engines. This means that people can search for data sources using common search engines, read the documentation, and learn about metadata, data structure, and retrieval methods. Any application that decides to use the API can do the same automatically.

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Rural and Creativity HUB for the Vulture Regional Park: Making Community, Starting with the Construction of a Participatory LAB

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Abstract. The Vulture Regional Park is a unique territory for its geomorphologic and vegetation characteristics but also because of its strategic position between Basilicata, Campania and Puglia which preserves the signs of different ages, territorialization and deterritorialization that have affected it over the centuries. This territory represents a great scientific challenge for our Center that has proposed an innovative technical-operational methodology based on the territorialist approach [1] and on interpretation planning [2]. This tool allows one to recognise the relationships between the nodes of the identity of places, the development of society and the modification of the behaviors of consumption of resources. Our goal is to make the Vulture Regional Park a model of study and experimentation of a Rural and Creativity Living Lab, through a "place-based and people-oriented" approach. We strongly believe that the value and potential of the territory's resources must be considered as a driver for sustainable development and quality of life in an evolving society. It is necessary to highlight the importance of a broad knowledge of the resources that must be respected and defended.

Keywords: Natural Park · Living Lab · Partecipation · Community · Cutlural Heritage · Engagement

1 Introduction

The current EU rural development policy is based on a history of activities that recognise the fundamental role and the benefits that innovation and creativity offer to citizens in rural areas, as well as to the wider users of the European countryside. In particular, fostering innovation, cooperation, knowledge exchange, as well as strengthening the links between agriculture, food production, forestry with research and innovation is the first of the 18 specific focus area defined by the European agricultural fund for rural development [3]. Almost 100 billion euros have been budgeted by the EAFRD between 2021 and 2027 to help address the challenges related to rural development. EU countries implement EAFRD funding through rural development programmes. These programs are co-financed by national budgets and may be prepared on either a national or regional basis. While the European Commission approves and monitors them, decisions regarding the selection of projects and the granting of payments are handled by

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national and regional managing authorities. It is therefore fundamental to reach a cultural European identity which ensures equal opportunities among citizens from different countries, social contexts, and backgrounds.

The strengthening of the European cultural identity is therefore not only a rhetorical necessity; it is a primary political objective which has been included in the the Community Strategic Guidelines for Rural Development [4]. For instance, president Von der Leyen, in setting out the objectives of the Recovery and Resilience facility, has identified as its primary mission the "economic, social and territorial cohesion", even before "green" and "digital" [5]. The twin green and digital transition is clearly a central topic for the European Commission to better shape the future of our countries in the long-term. While these two simultaneous transitions, can reinforce each other in many areas, they are not automatically aligned. Clearly, if we aim at enhancing the developing of rural and green areas, we need to make sure to have under control and limit the environmental footprint of digital technologies. But this is not enough. The role of cultural and territorial resources, and of the Cultural Industry as such, must come into force as a social, political and economic leverage. An effective means to amplify those "marginal" voices. Digitalization has a huge (positive and negative) impact on the society and on human's life. Hence everybody has the moral and ethical right to be a part of the digital transition and transformation processes, also and foremost in rural areas. This is in line with the "participatory design" approach [6, 7].

Social innovation practices involve a deep understanding of the new emerging needs of society and individuals and are based on multiple dimensions of sustainability: economic, social, cultural and environmental. This kind of innovation also goes beyond the obsolete concepts of innovation linked exclusively to the technological component, such as that of the Smart city [8]. Social innovation, which is born from citizens, probably represents the best way to achieve local community regeneration and citizen participation in urban dynamics, with then results in social and cultural as well as economic advances [9]. Technology must be considered only as a tool to pursue social innovation, acting as the conduit between territorial capital and territorial innovation. The role that technology acquires in this context can be also extended to urban heritage management processes, where it accompanies the transition to restore continuity to the process of landscape change, supporting the local community in the re-appropriation of a critical knowledge linked to the specificities of the place they inhabit.

The main objective of social innovation is to have a positive social impact on a community of reference, with the ultimate goal of improving the quality of life of individuals. For this reason, it is necessary that social innovation becomes the main driver of territorial development, replacing the classic economic engines that have driven the sector until now.

Furthermore, innovation is considered a particularly important factor in promoting sustainable development systems that foster a balance between economic growth and the protection of "public goods" such as biodiversity and other environmental resources. Finally, creative thinking is also an essential tool for rural development practitioners and policy makers, engaged in addressing key issues such as competitiveness, quality of life, diversification and territorial cohesion.

One of the most successful examples of creative innovative thinking, involving the society of rural areas, are Living Labs (LLs): open innovation environments in real-life settings, in which user-driven innovation is fully integrated within the co-creation process of new services, products and societal infrastructures [10]. This also allows the creation of collaborative nets at local, transregional and inter-social levels [11].

The living labs have been proposed as an inclusive and sustainable approach involving various stakeholders, focusing on individuals in their role as citizens, inhabitants, end-users etc., are engaged throughout the digital and green transition process in their real-life setting [12]. Accordingly, LLs can be seen as an approach for facilitating innovation processes, as they allow one to simultaneously focus on individuals, technologies, tasks and structures, and the interactions between different stakeholders [13] To date, much attention has been paid to urban areas as the context of LL activities, the so-called Urban LL [14, 15], e.g., the initial list of key components of the traditional LLs were further revised and modified for the context of Urban LL.

In this essay we will present the case of study of the Vulture Park as a practical application of the LL model, presented in Sect. 2, highlighting the current plan to develop 4 different rural creativity hubs within the biggest natural park in the rural area of the Region Basilicata (Sect. 3).

The park is a unique territory for its geomorphologic and vegetation characteristics (as there is a volcano that visually characterises the panoramic and landscape profile and two lakes that make the fauna unique), but also because of its strategic position between Basilicata, Campania and Puglia [16]. Indeed, thanks to this special geographical position, the park has gained a special path in the history of southern Italy and preserves today the signs and evidence of different ages, according to the phases of territorialization and deterritorialization that have affected it over the centuries [17].

The protection and implementation of ecological networks, takes on a multi-scalar role for the enhancement of connection systems and ecological, landscape and environmental continuity: from the interregional level (joining the European ecological networks), to the local scale, through ecological corridors able to create connections between the fragmented portions of the park and the surrounding natural territory [18]. This theme is fundamental in the park's planning to create itineraries of protection and enhancement through several specific strands: blue ways, green ways, etc. [19].

Moreover, the Volture Park is not only unique from the point of view of geomorphology and history, but also allows us to experience the concept of participation and community, starting from the social, cultural and human stratification.

In fact, if the foundation of cultural heritage is the "generation" of territory and landscapes, the witnessed restitution of what it has given and how it has influenced the identity of those who live it, is the "re-generation".

The participation of the community is particularly necessary in the case of revitalization, also from the point of view of tourism, where various decisions are made that will have effects, more or less strong and more or less reversible, on the local population. The value and potential of the territory's resources must be considered as a driver for sustainable development and quality of life in an evolving society. It is necessary to highlight the importance of a broad knowledge of the resources that must be respected and defended [20].

It is also essential to rethink the assets of the territory, especially in regions of profound social transformation, as a path that must belong, with full awareness, to the community in which it is located. This represents one of the opportunities for the development of the territorial economy, and an important occasion to test good government practices that require the ability to link the different forces that insist on a territory [21].

For these reasons, each territory, and above all the Vulture Park, can be considered as an ideal and privileged "planning site" to carry on in-depth research on the cultural identity of a society with a diversification of history, religion, art, food and wine, etc. In other words, a "return to the territory" is desirable, or rather an "ecological conversion of socio-territorial models", built from the bottom up through the reconstruction of cognitive, cultural, and productive relationships between active citizenship and territorial heritage, and of solidarity-based and non-hierarchical relationships between inhabitants, producers and local societies.

2 Methodology: The Living Lab Model

The Living Lab (LL) model was defined, for the first time, in 2003 by the **MIT Media Lab,** an interdisciplinary research lab that encourages the unconventional mixing and matching of seemingly disparate research areas [12].

Since then, in the last years, LLs have become a powerful instrument to effectively involve the user at all stages of the research, development and innovation process, thereby contributing to European competitiveness and growth [13].

They are today strong instruments that support cities and regions in their transition towards a resilient and sustainable future based on open and inclusive innovation. LLs represent a key element in empowering citizens to co-create their cities and regions while enhancing their ecosystems through emerging technologies. As protagonists of open innovation environments, Living Labs involve all stakeholders to tackle real-life problems and co-create concrete, long-term impacts which can be scaled-up. Living Labs can support their cities and regions in becoming Green and Digital and they can have a real impact in society by supporting decision and policy-making towards sustainability and zero pollution.

Additionally, Living Labs allow to reach a bottom-up policy coherence that starts from the needs and aspirations of local and regional stakeholders. Therefore, Living Labs can be considered as transversal tools to strength the synergy between EU support policies in the area of research and innovation while placing regions and cities as leading actors in Europe's innovation strategies.

The most innovative aspect of the LL model resides in the fact that they allow for an active and proactive participation of the community that has the great opportunity to shape the future of the territory in which they live. In fact, with the LL model, citizens and communities have the possibility to express their needs through working groups and activities, users are able to generate innovation in the places where they live and hence generate and regenerate them [22]. They are not only testers of a final product, but they act as project managers at the same level as the other LL partners (universities and research centres, private and public sectors, see Fig. 1) and have the possibility to participate and organise innovation initiatives such as masters, summer schools or bar camps [23].

In the specific case of Rural LLs, as the one proposed here, these concepts are applied in particular to inland and rural communities and realities. Moreover, with respect to urban LLs, Rural LLs do not consider LLs as an environment or a context only. The Rural LL is a general approach that is meant to facilitate the processes of digital transformation in the "green"context of rural areas, where the identified key components and stakeholders will be a part of the overall innovation process, such as piloting and experimentation. Hence, in Rural LLs, smaller activities (e.g., hubs, see Sect. 3.1) will follow the LL approach and become an "instantiation" of LLs.

The innovation based on the concept of active participation is a crucial factor to promote the sustainable development that in turns favours the balance between economic and social growth. Therefore, LLs are a strategic opportunity to switch from a PPP formula (public and private partnership) to a 4xP one (people, public and private partnership) [24], where open innovation, generation and re-generation are driven directly by the users [25]. In conclusion the LL model eliminates the distinction and separation between producers and consumers but activates an equal cooperation mechanism. It creates the theoretical and methodological infrastructure necessary to join together collaboration pacts and patrimonial communities [26], which are shortly described in Sect. 2.1 [27].

LLs can be of precious help in the digital and green transition too. In particular, in Rural LLs, digitalization means much more than merely digitalizing a business a city or an industry. Digitalization becomes an important tool for inclusion and access to broad societal services. Digital innovation is the key component that integrates both digital innovations that will be co-created by various stakeholders and rural residents, as well as the digital infrastructures such as hardware, software, data (open or closed data), networks (e.g., 4G, 5G, fiber, Wi-Fi), smart cameras, sensors in smart agriculture, and wearables.

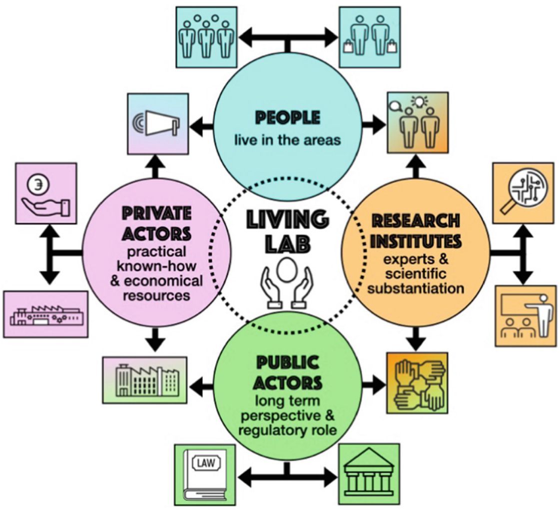

Fig. 1. The Living Lab Model and its main actors.

2.1 Examples of Rural Living Lab in Europe

The innovation potential of rural areas and parks plays an important role in the European Commission's plan to develop a long-term vision for inland and rural areas. Nevertheless, and despite the many successful applications of Living Labs in the European landscape (see e.g. the European Network of Living Labs, ENoLL, 2006, which, with more than 480 members, is the largest international no-profit association of benchmarked Living Labs), there are still too few EU-funded projects within the Horizon 2020 programme that have dedicated capacity and expertise to address the problems of rural and green areas, with the aim of improving their potential and analysing the opportunities they offer in contributing to Europe's future [28].

In this section, some international projects are introduced and briefly described as examples of the importance of the concept of Rural Living Labs and how they can contribute to enhance the potential of inland territories and rural areas. It should be noted that the pilot programme proposed in this essay, together with the examples given below, is among the very first to bring the 'placed-based and people-oriented' Living Lab methodology into a Park, also focusing on the digital transition. Digital transformation has received increasing attention in recent years. Despite this, most of the current studies focus on digital transformation in more advanced societies, particularly urban areas, and the concept has not been investigated enough within rural contexts.

1. The Social Innovation in Marginalised Rural Areas Project (SIMRA). The main objective of the SIMRA Project is to study, through numerous case studies, the notion of social innovation and innovative governance in the agricultural and forestry sectors, to then be able to promote these sectors in rural areas in the Mediterranean regions of Europe and beyond [29]. Specifically, the Project partners (also including 4 Italian entities) analysed 24 regions and 7 innovation actions, divided into 8 work packages, in order to provide concrete solutions to address the challenges of marginalised rural areas. The covered topics included forest management, social agriculture, local development, energy, child and health care and social networking. The final product produced by SIMRA is a systematic collection of empirical evidence of the drivers, processes, outcomes and impacts of social innovations in Europe, North Africa and the French Caribbean. The main strength of this Project is the systematic work carried out on a statistical sample of case studies that allowed the construction of a solid theoretical and operational framework.

2. Heritage for Rural Regeneration (RURITAGE) [30] is a research project that establishes a new paradigm of heritage-led rural regeneration, capable of transforming rural areas into practical examples and laboratories of sustainable development, through the valorization of their potential. Ruritage has identified 6 Systemic Innovation Areas (pilgrimages; sustainable local food production; migration; art and festivals; resilience; integrated landscape management) that, integrated with transversal themes, show the potential of heritage as a powerful engine for the economic, social and environmental development of rural areas [31].

The knowledge, constructed in 14 Role Models (RM) and assimilated within the project, was transferred to 6 Replicators (R) across Europe, led to the development of the Ruritage Atlas (an integrated and interactive web-based atlas capable of mapping territories on the basis of human-landscape interactions), of Ruritage Replicator Tool Box &

My Cult-Rural Toolkit (a comprehensive set of good practices and innovative solutions for rural regeneration), Ruritage Serious Games kit, DSS, Regeneration Guidelines (a wide range of tools to promote change and gather feedback from rural communities).

3. The Living Lab research concept in Rural Areas project (LiveRur) [32], coordinated by the Spanish Fundaction Universitaria San Antonio (UCAM), put the Living Lab concept at the forefront of rural development with thirteen Living Lab initiatives in selected pilot areas in eleven countries (Portugal, Azores, Czech Republic, Slovenia, Spain, Malta, Turkey, Italy, Latvia, Austria, France and Tunisia).

The project identifies Living Labs as innovative business models that are currently being developed in rural areas as they foster a more sustainable mobilisation of resources, better cooperation between actors along the value chain and lead to new services. The LiveRur Living Labs use the concept of open innovation in a broad sense, with success/failure rates determined by key empirical research factors.

The main goal of the LiveRur project is to improve the knowledge of business models growing in rural areas, including the understanding of their potential.

2.2 Collaboration Pacts and Patrimonial Communities

Collaboration Pacts are the tool to govern the co-design and shared management of activities, the start of new community enterprises and the redevelopment of buildings and public spaces [33].

There are three possible forms of pacts:

A) Pacts that concern disused buildings, made available for redevelopment interventions and the creation of new services and activities.
B) Pacts that involve public places (schools, social and welfare services, cultural spaces, etc.) that have a potential for greater use than the current ones.
C) Pacts that promote the care and shared use of public spaces, green areas, under-utilized facilities, even proposed by citizens (Art.118, co. 4, Cost; Regolamenti sull'amministrazione condivisa dei beni comuni).

These actions introduce a procedural technique based on "collaborative dialogue" as they favours the construction of non-authoritative (horizontal, collaborative, cooperative) relations between the government and the inhabitants of the cities, and/or the enabling of forms of cooperation between the inhabitants and other local actors [34].

This implies that different actors interact on an equal footing, which, in turns, requires changes in the action and mentality of both public, social and private actors. Public administration is thus transformed into a platform for fostering the construction of these cooperative relationships between different urban actors. The practice of pacts of collaboration wants to be a "push" between communities and other local actors ready to take a level of risk and invest a significant amount of time as "civic entrepreneurs."

Hence, collaborative pacts represent an unprecedented form of institutional innovation and public governance that leverages a non-authoritative form of action by the city government. Pacts should enable active citizenship and collective action by inhabitants as a new way of governing and managing urban resources, services, and local infrastructure.

Patrimonial (or heritage) community is defined as a set of people who value features that identify and characterise the cultural heritage, that they consider relevant and commit themselves, within the framework of public action, to support and transmit the contents and expressions of heritage to future generations [35]. Belonging to a heritage community is, therefore, connected with the fact that all the people who are part of it, and recognise a value to the cultural heritage that they themselves have contributed to define and safeguard. Heritage communities, in fact, are committed to representing, transmitting, and enhancing this value without discrimination or selectivity on the basis of ethnicity, class or geographic location with all forms of expression and communication channels that are available to them, including the most advanced and performative digital technologies.

The idea of heritage as a shared cultural capital and as a fundamental right of citizens, proceeds with the empowerment of the subjects that are part of the heritage communities as direct bearers and custodians of the heritage itself [36].

The heritage communities' recognition around cultural resources and identities sets the context for dialogue and alternative settlement of conflicts. This allows the development of the intercultural policies' dialogue, democratic debate and cultural inclusiveness. At the same time, it becomes necessary to use the knowledge and skills learned and passed on as resources for development, and to actively engage Member States in a community-based and participatory approach, like the one of LL, to the care of cultural heritage.

3 An Open Laboratory for the Vulture Park, the Experimentation of a Rural Creative HUB

Our goal is to make the Vulture Regional Park a model of study and experimentation of a Rural and Creativity Lab, but attributing to it a transdisciplinary [37] aspect with a "place-based and people-oriented" approach [38]. The LL model in this case will be applied in the form of a "rural laboratory" where the economy of inner areas, culture and innovation live in a sustainable perspective as a heritage community. From this point of view, virtuous solutions of production and consumption, inspired by the organisational model of community-based social enterprises play a fundamental role [39].

The global process which is stressing our rural and environmental systems, business, processes of social inclusion and local economic development, aims to be a pilot for a new organisational model. It will help to bring out the potential of innovation that comes from the areas considered "inner" and to connect them with the external system of innovations.

The experimentation of the LL methodology in the Vulture region starts from the experience of the PRIN Sound project [40], which aims to understand how the connection of the urban/territorial dimension with the place-based innovation approach, determines "nodes" [41], as activators, of innovation and knowledge.

The project is at its early stage and therefore we still do not have results nor a concrete timeline. However, in the following section (Sect. 3.1), we describe the four main hubs that have been identified as LLs in the Vulture Park, briefly highlighting the methodology and the planning, the audience to which they are dedicated, the actors taking part in them as well as their main deliverable [42], objectives and goals.

3.1 Hubs and Activities

The project sees the creation of four main hubs, each structured into activities that are perfectly functional and correlated with each other, starting from the identification of needs and ending with the definition of community assets based on the use of living labs [43]:

1.Community Hub - to promote the re-appropriation of physical and relational spaces by the community. A path of Inclusive Governance, capacitation and community engagement to live together the community hub as a public good. A bottom-up construction site. As main deliverable of this hub, we foresee the realisation of a map of all the spaces belonging to the Vulture Park area, including both forests and urban territories. Moreover, we aim to use the advocacy principle whereby different territories can be rented at a symbolic very low price by young business managers under 40, that in return commit themselves to enhance the local supply chain and local products. This allows the flowering of new industries, while preserving the local craftsmanship and regional excellence, and, at the same time, it is a great growth and learning process for young entrepreneurs.

2.Rural-cultural Hub - a shared experimentation space for new generative welfare practices through the hybridization of culture, citizenship, and agriculture. The main products of this hub will be community-supported social farming and distribution of products from the fields, co-production of storytelling workshops, research/action of the territory, immersive paths and experiential agricultural workshops. Specifically, village fairs with diverse performances - culinary shows, labyrinths, storytelling, etc. – will be organised. During these fairs, the hub will provide a space for experts to discuss on a meta level the situation and the possibilities of the development of villages and perspectives in front of the urban-rural cooperation in the context of growing urbanism and global economic crisis. This will certainly contribute to enhance the tourism in the region too.

3. OpenScience Hub - a study centre on open innovation applied to the environment and creativity and sustainable development. This hub will be an on-site research observatory that will allow exchange of information and new collaborations between students/researchers and farmers/citizens/local artisans. Another goal will be to create new and specific training paths to create and qualify professional profiles able to accompany territories in the definition and management of development projects based on creativity and social innovation, responding to local needs and specificities. This will also further help in obtaining funding through participation in regional, national, and European calls for proposals.

4. Creativity and digital Hub - to experiment with social, cultural and agricultural innovation practices and contribute to feeding the reflection and knowledge produced by communities of change, community-hubs and researchers in Italy. The main deliverable of this hub will be the creation and publication of a sharing platform for the development of local economies and the advertisement of the activities carried out in the other hubs and, more in general, in the park.

An important objective of this hub and the previous one is the mentoring of young people under 40, which will also be formed and prepared by researchers and professors of the LUPT centre and the various Universities in Basilicata. The hubs are perfectly in line with the digital and green transformation, in particular developping a human-centric approach to digitalization, in order to achieve an inclusive and thriving global digital society that at the same time, respect, valorise and enhance the potential of rural and green areas.

The creativity-based model of innovation that we have planned for the Vulture park (also sketched in Fig. 2) is coherent with the broader trends that define innovation itself. Indeed, the main difference with respect to traditional innovation policies is not so much in the object of the policy but in the way we view the innovation-related processes that policy is acting on. Traditional innovation theories describe a linear progression that starts with an idea that is then developed [44].

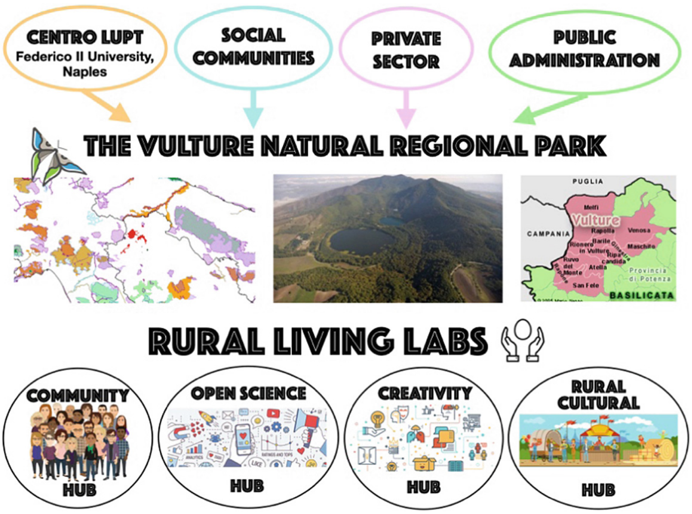

Fig. 2. Rural and Creativity HUB's model for the Vulture Regional Park

3.2 Risks and Critical Aspects

The Project described in this essay, is still in an early stage of its development. Hence, a detailed risk and criticality analysis has not yet been carried out.

However, in this paragraph, the most common risks associated with the Living Lab model and its application in rural areas, and which could occur in the specific case of Vulture are highlighted. Generally speaking, participation within the Living Lab is a fundamental aspect for the success of the project, and as such, it also represents a risk, which may be logistical (albeit positive) if participation is larger than expected, but more often negative if it is lower.

As already described in the introduction, in fact, for Living Labs to be successful, it an active participation of multiple actors, who make their own resources (human, financial, assets, etc.) available to the network, is indispensable. It is even more fundamental that the activities are 'inhabitant-friendly' and specifically designed with and for the population basin to which they are dedicated. A series of preliminary meetings has therefore being organised between the L.U.P.T. Centre and the park communities with a view to cooperation and co-creation of activities.

It is also impossible to establish rigid rules to be imposed on the stakeholders for governance. Appropriate communication is therefore indispensable for smooth and elastic planning and the proper implementation of hubs and activities. There are numerous plans and strategies that can be implemented to ensure smooth internal communication between stackholders and thus avoid problems of poor planning and conflicts. The scheduling of monthly meetings, grouping the partners by category rather than by type, could facilitate the creation of synergies; quarterly reports could demonstrate the positive trend (but also highlight the criticalities and aspects that need to be corrected/revised) of the experiments, as well as the professionalism and commitment of the experimenters and stimulate investment also by private individuals; the creation of a web platform, if used correctly, has the potential to guarantee the dissemination of all the news concerning Living Labs (new experiments, events, etc.) to all interested stakeholders quickly and concisely.

As far as governance is concerned, by eliminating the distinction and separation between producers and consumers, it is possible to activate a mechanism of equal cooperation that creates the theoretical and methodological infrastructure necessary to unite collaborative pacts and heritage communities.

Finally, one of the greatest critical issues that must be addressed in the realisation of the project is the availability of funds, both private, from partners and private companies, and public, from research institutions. These funds are indispensable for hiring new personnel, purchasing hardware and software, as well as for publicising activities and sharing results. The L.U.P.T. Centre is already moving in this direction, negotiating the allocation of dedicated funds for this pilot programme.

4 Conclusions

This essay presents a pilot program application of a Living Lab to the Vulture Park, in Basilicata. Living Labs are tools that support cities and regions in their transition to a resilient and sustainable future based on open and inclusive innovation. They are a key element in enabling citizens to co-create their cities and regions while improving their ecosystems through emerging technologies. Therefore, as laboratories of open innovation environments, they engage all stakeholders to address real problems and co-create concrete, long-term impacts that can be scaled up.

In our opinion, it's not too much to claim to be today in an "invisible cultural revolution", indicating the start of a phase of acceleration of economic development, based on new technologies (digital transition) and the new centrality of information and knowledge in production processes [45]. At the same time, the world is nowadays forced to face the huge threat of climate change and environmental degradation. Hence, it is urgent and necessary to design and implement reforms that support the green transition and that contribute to achieving the goals of the European Green Deal. It is also necessary to design new procedures in central and local administrations establishing new structures and guidelines that are needed for implementing green policies. To overcome these challenges, the European Green Deal Search for available translations of the preceding is Europe's new growth strategy, which will transform the Union into a modern, resource-efficient and competitive economy. The European Green Deal aims to make Europe climate neutral by 2050, boost the economy through green technology, create sustainable industry and transport, and cut pollution. Turning climate and environmental challenges into opportunities will make the transition just and inclusive for all.

The production and consumption of culture favour an enhancement of the social fabric (in terms of community cohesion, quality of human relations, feeling of trust, willingness to cooperate, sense of territorial identity), which transforms local identity into a key concept for safeguarding the cultural peculiarities of the territories. It also establishes a close relationship between creative processes and supports "identity policies" that enhance the cultural authenticity of places [46].

The fact that these phenomena are taking place precisely in the era of economic globalization, confirms the thesis that they represent a natural reaction to the cultural homogenization. The internationalization of markets, in fact, reinforces the role of places through a twofold order of consequences: one of a social kind, which tends to safeguard and respect culture, the survival of the most distinctive popular expressions, cultural heritage, and feelings of social belonging. The other is economic, and gives new vigour to products that are given a strong symbolic value, nourished by details that have to do with culture, traditions and local taste.

The rural and creativity lab's model proposed for the Vulture Park, dealing with the theme of economic, social and environmental resilience of the innermost areas of the Vulture, is therefore intended as an experimentation in the internal areas. This is one of the first cases in which the living lab methodology is directly applied to a natural park, with a people-oriented and place-based approach, build with and for the users. In fact, it consistes of 4 hubs which are specifically designed for and co-created by the communities of the parks. Directly from the needs of the territories, the necessity to strengthen and consolidate networks between operators of the same sector with related sectors and with subjects of the knowledge system clearly emerges to promote innovation and internationalization and to increase the spread of training. The experience will lead to the definition of some pilot cases of heritage community [47].

The idea behind the Vulture Park Rural Creative Hub project, and any other project based on the LL model, must be to enhance the identity of the community, the needs of the area, keeping intact the objectives that the public administration proposes in common with the community. Hence, the current effort to involve the real users of the landscape, the people who inhabit it: the "Framework Convention of the Council of Europe on the value of cultural heritage for society" [48], signed by Italy in 2013, considers landscapes as fully belonging to the cultural heritage and able to highlight the cultural essence of the territory. Since they enhance the relationship between the environment and the communities, they need to be self-preserved, and their value needs to be transmitted to future generations.

Our pilot project is clearly and completely inserted in the framework of the main European and international policy lines. For instance, looking at the Sustainable Development Goals in the Global Agenda for Sustainable Development approved by the United Nations, to be achieved by 2030, one can find concrete definition of new development models that are sustainable in their three dimensions – environmental, economic, and social. Moreover, one of the main aims of the European Green Deal and the 9th European

Framework Programme for R&I 21–27 "Horizon Europe", is to improve the well-being of citizens and make Europe climate neutral by 2050.

However, this vision requires a fundamental basis: a wide and complete knowledge of what it is necessary to respect, protect and enhance. In particular, contexts such as those of inland areas, present a differentiated ecological and social forms, with sectors still active in their continuity of use but threatened by deconstructive dynamics attacking the territory [49].

Participation must therefore be a way to involve the local population more, and to create an endogenous type of destination management that takes into account the needs of the community. In fact, within the community, there are shared objectives which simplify the use of participation. Participatory economic development focuses on the community itself and therefore differs from the traditional approach to economic development that tends instead to attract resources from outside.

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Gastronomy and Tourism in Remote European Areas: Toward a Food and Wine Atlas of the Metropolitan City of Reggio Calabria

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Abstract. The European Union, apart from its well-developed socio-economic regions, is also characterized by marginal, remote rural areas, where the difficult socio-economic conditions and gentrification are the basis of an increasing phenomenon of depopulation and territorial abandonment. In some of these areas, sometimes, not only the development of inland and/or mountainous areas is complex, but also coastal development is not easy, and it calls for synergies between regional authorities, enterprises, universities, schools, and, more in general, local private and public stakeholders. In such vulnerable areas, there is a greater necessity to build proper governance systems, where local communities and public and private stakeholders have the responsibility to meet, discuss and actively participate as public-private partnerships (PPP) in local development processes. In such a context this paper highlights some of the research themes that have been developed in the research project on Gastronomy and Tourism in remote European Areas with particular reference to the creation of a gastronomic Atlas, still under development, of the Italian area of study, the Metropolitan Town of Reggio Calabria.

Keywords: Local Governance · Gastronomy · Food and Wine Atlas · Rural Development

1 Introduction

The European Union, apart from its well-developed socio-economic regions, is also characterized by marginal, remote rural areas, where the difficult socio-economic conditions and gentrification are the basis of an increasing phenomenon of depopulation and territorial abandonment. In some of these areas, sometimes, not only the development of inland and/or mountainous areas is complex, but also coastal development is not easy, and calls for synergies between regional authorities, enterprises, universities, schools, and, more in general, local private and public stakeholders. In such vulnerable areas there is a greater necessity to build proper governance systems, where local communities and

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public and private stakeholders have the responsibility to meet, discuss and actively participate as public-private partnerships (PPP) in local development processes. However, unfortunately, all these different actors have different perspectives, priorities, languages, and, therefore, often it is not easy to synergize, especially in a delicate framework where wrong investment priorities of investment may result in further deterioration of already delicate socio-economic environments.

The rural development programmes that have been implemented in Europe since the 1990s have consolidated the vision of local-territorial development promoted through participatory and bottom-up processes, by drawing up development policies that are calibrated to the actual needs and characteristics of the territories. This change has led to the abandonment of the traditional top-down approach to move towards development processes which involve more stakeholders in the planning stages. This implies the decentralization of decisional power through participatory activities that make it possible to define development strategies which take into account a wide variety of perspectives. In this context, the Leader programme, in the form of a Community Initiative in the first three programming cycles, has taken on over time the characteristics of an Approach, in the logic of mainstreaming. This transition was aimed to strengthen and consolidate the typical peculiarities of the participation and the capacity to plan bottom-up strategies for the development of the territory. Within the Leader programme, Local Action Groups (LAGs) represent the "territorial governance of rural development" (Tola 2010), which give concrete form to local development policies by planning and subsequently implementing Local Action Plans (LAPs). LAGs play a key role in organizing and carrying out joint activities between the members of the Socio-economic Partnerships (PSE), the promoters of the LAPs, in order to identify the strategic priorities to be pursued for the development of the areas concerned. Since the previous Eu programming periods in coastal areas, the European Union has introduced the Fishery Local Action Groups (FLAGs), as governance systems involving a greater plurality of local actors for the realization of local development plans based on the valorization and diversification of the activities around the fisheries (Marcianò & Romeo2016). This type of endogenous development empowered local rural and fisheries communities promoting tourism and diversification activities in rural and coastal European areas, thus increasing complexity according to the principle of relatedness (Hidalgo et al. 2018).

It is still uncertain which role universities can play in this changing environment which is moving strongly towards a bottom-up development approach that tries to overcome the boundaries of top-down approaches, combining the strengths of private and public actors. As has been recently highlighted by Trencher et al. (2013, 2014, 2017), there is a growing debate about the new mission of the academic world to achieve what is called "sustainability co-creation" between universities and society in a place-based perspective. Partnerships and collaboration "between academia, industry, government and civil society are now seen as a prerequisite for the knowledge flow and knowledge exchange" (Trencher et al.). This depicts a role where the university "collaborates with various social actors to create societal transformations into the goal of materializing sustainable development in a specific location, region or societal sub-sector" (Trencher et al. 2014). In this context the university, through Action Research, is called on to craft useful knowledge and bind it to societal action. Moving in this new paradigm of "sustainability co-creation, greater emphasis is given to knowledge production as a vehicle for creating solutions to societal problems and triggering societal transformations towards greater sustainability" (Trencher et al. 2014). Since in this situation knowledge is a key resource, the role of the university becomes fundamental to foster the creation of networks between research, local government and stakeholders in a bottom-up perspective through collaborative research (Rinaldi & Cavicchi 2016; Marcianò & Romeo 2019).

In such a context this paper highlights some of the themes of research carried out in an Heritage Plus Research Project on Gastronomy and Tourism in remote European Areas, with particular reference to the creation of a gastronomic Atlas of the Italian area of study, the Metropolitan Town of Reggio Calabria.

2 Gastronomy and Tourism in Remote European Areas: A Case Study

In a recent European Research Project on Gastronomy and Tourism in Remote European Areas (the Gastrocert project), a Consortium between four universities was formed including two universities that had already worked together in a previous cooperation project between Lags: the UK West Highlands College and the Mediterranean university of Reggio Calabria, and two academic partners coming from Sweden, and Spain, the University of Girona and the University of Mid Sweden.

The general objectives of Gastrocert were to "explore (i) how the development of local gastronomy can help to protect rural heritage values; and (ii) how entrepreneurial culture can enhance locally produced food as a value-added touristic experience. The objectives included understanding the important role that food plays in cultural identities and the promotion of local and regional traditions. The project also emphasized the significance of local knowledge, skills and practices regarding heritage assets and how experiential journeys through cultural landscapes promote gastronomic tourism". The Gastrocert project focused on three remote areas of Scotland, Sweden and Italy, while in Spain the area of study is situated in the highly developed Catalonian region.

The focus of the Italian Unit was the Province of Reggio Calabria. The research approach was oriented toward building a common vision for the whole Province of Reggio Calabria, an area that was recently included among the Italian Metropolitan Towns. The Province of Reggio Calabria has a rich cultural heritage and typical agro-food products that are closely linked to the territory, its history, and its culture. The research project, formulated within the Agricultural Department of the Mediterranean University of Reggio Calabria, provided a review of the experience of the local authorities, aimed at enhancing the cultural and gastronomic heritage of the territory, in the Province of Reggio Calabria where it is possible to distinguish the following homogeneous areas (see Fig. 1): the Strait area, the Costa Viola, the Gioia Tauro Plain, the Ionian side, and the Grecanica area. The historical, ecological-environmental, socio-economic assessment of the territory of the Province of Reggio Calabria was the basis for the definition of local development strategies for this area and the redefinition of food and wine routes/itineraries aimed at enhancing local resources and traditions and promoting the territory.

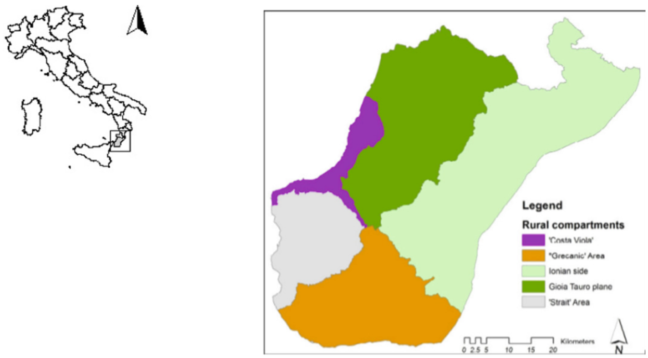

Fig. 1. Area of study

Several research activities have been conducted on the coastal and rural local governance systems and integrated development plans are being experimented within the current EU programming period in the study area. Particularly, in the western side of the study area, the main integrated planning activities have been oriented towards the definition of the medium-term strategies of the two main governance systems already active in the area, the LAG Batir and the Stretto Coast FLAG. In the past few years, research planning activities have been conducted in both the rural areas (Calabrò et al. 2005; Marcianò & Palladino 2013; Cozzupoli et al. 2013; Musolino et al. 2018, 2020) and in the coastal area (Marcianò & Romeo 2016, Di Staso et al. 2020). In the rural area, the results of a cooperation project between some European LAGS (the Landsare project) were useful for the definition of a new local development strategy for the area. In the western coastal area of the Province of Reggio Calabria, research was conducted on economic and relational aspects of the fisheries communities (Romeo et al. 2016; Palladino et al. 2016). During the Gastrocert project new research was conducted in order to widen the diversification perspectives of fisheries communities (Palladino et al. 2019a) and their social networks (Palladino et al. 2019b) in order to find the main weaknesses of such communities and define a new integrated development plan for the period 2014–2020.

Another area under investigation is the Ionian side, also known as the "Locride area", a very a marginal area in Calabria where no previous research has been done in support of the development of local governance systems, at least from the Agricultural Department of the Mediterranean University. Instead, it occurred that, in the previous EU programming period, the implementation of the development plan carried out by the local LAG was beset by administrative problems, and the LAG was dismissed. Therefore, in the new EU programming period 2014–2020, it was very important to make a joint effort to start a new process of integrated development in the area, in order to support the creation of a new local governance system that could define an overall development strategy for the whole Ionic area. This process required a prolonged effort, also supported by the Gastrocert project, which ended in a new local development plan for the area that is currently being implemented (Marcianò & Romeo 2019).

Research activities have also been conducted to highlight the motivations behind the consumption of local food by means of different exploratory surveys carried out at the local and international level. The analysis of the consumers' point of view is important in order to see if the local agro-food products meet the requirements of the potential consumers. The research was based on a methodology for mapping consumer preferences for local products which was tested for a meat product (Nicolosi et al. 2016d). The methodology is based the Multiple Correspondences Analysis (MCA) method, and it helps to identify the motivations underlying the consumption of local food. Other applications of the methodology have been undertaken in order to analyse the consumer point of view on fresh local fish and stockfish in different Southern Italian regions (Nicolosi et al. 2016a, 2016c). Two other applications of the methodology concerned transnational comparisons between Italian and Spanish consumers (Nicolosi et al. 2019a) and Italian and Swedish consumers (Nicolosi et al. 2019b).

In addition, several in-depth case studies were conducted at the territorial, enterprise or product level. In this way, the phenomenon of tourism combined with food and wine products has been deepened and contextualized in the wider context of local development and cultural and environmental heritage. In particular, Ascioti et al. (2019) provide an Ecosystem services evaluation that presents an Economic value assessment of forest carbon sequestration and atmospheric temperature mitigation in the area of study. In another study, Nicolosi et al. (2016b, 2016e) focus on coastal villages, traditional viticulture and gastronomic tourism, investigating the dynamics of the terraced heroic viticulture and fishing companies of the Costa Viola. Di Gregorio et al. (2019) focus on the possibility for the territories in Aspromonte to exploit their religious heritage for tourism. There a pilgrimage route has become interesting from an environmental and naturalistic point of view. In another study, Bianco and Marcianò (2019) a use quali-quantitative methodology in order to build participatory ecotourism development strategies in a Nature Reserve in Calabria.

3 Towards a Food and Wine Atlas of the Metropolitan City of Reggio Calabria

The goal of one of the activities of the Gastrocert project consists of the construction of a database of local products in the Province of Reggio Calabria, whose area corresponds to the Metropolitan City, and the identification of suitable tools for their enhancement. The first phase of this study focused on the "recognition" of the main historical-artistic, environmental, landscape, cultural and tourist resources of the territories of the province of Reggio Calabria. A database has been created to support territorial marketing actions; this database is structured on two levels:

- A collection of databases relating to the environmental, landscape, ethnological, cultural, demographic and socio-economic components;
- A systematic collection of databases on the particular topic on which the territorial marketing action, the provincial gastronomic heritage, is concentrated.

An important research activity was the classification and mapping of all the gastronomic products existing in the study area. Each gastronomic product was assigned to a category and the production municipalities were identified. For the theme of gastronomy it is important to consider the services useful for its promotion, the dedicated events, the itineraries, and the presence of related narratives.

In the second phase of the study, we focused on the analysis of the most suitable tools for a territorial marketing action with gastronomy as the starting point, identifying an App for the web with a strong interaction with social channels, a most suitable way to disseminate the values of the territory by offering visibility to the gastronomic heritage that is waiting to be enhanced in the context of the original agro-forestry activities.

The methodological reflection was followed by a phase of application experimentation, during which the Gastronomic Atlas of the province of Reggio Calabria was started. This Atlas aims to fully illustrate the topic of gastronomy relative to the area of the Province of Reggio Calabria and represents a collection of information and materials all presented in map form.

3.1 The Data Collection

The first phase of the study-research focused on the “recognition” of the main historical-artistic, environmental, landscape, cultural and tourist resources of the territories of the Province of Reggio Calabria. The first step was to develop some tools that would allow the recovered data to be collected and returned quickly and be easily accessible. We have chosen to use the geodatabase Access, organized, for each LAG, for the 98 Municipalities of the province and for various types of tourism resources and services.

A possible database supporting territorial marketing actions should, first, consist of at least two levels:

- a basic level, to synthetically collect databases on the environmental, landscape, ethnological, cultural, demographic and socio-economic components;
- a peak level, to systematically accommodate the databases on the particular topic on which the territorial marketing action is concentrated (in this specific case, the provincial gastronomic heritage).

Clearly these two levels are closely related, and indeed the second is almost a logical consequence of the first, based on the opportunities that can be highlighted through the information collected and presented through the basic level, since:

- the characteristics of the environment, the fruitful possibilities already there, and place, the local peculiarities can generate the identification of homogeneous territorial basins in which additional opportunities can be framed (and add value), as proposed through the peak level database; and
- the recipient who is interested in mountain excursions, and bird watching, rather than the beaches of the coastal resorts, will first of all want to have information on the topics of interest and collateral attractions (presence of parks or Natura 2000 areas, historical sites, and accessibility) that constitute the points of reference of the local

environment and in some way also the basic information set of a field with strong environmental value.

Alongside the basic information set, the top level is where special opportunities are offered, linked to the environmental context and capable of enhancing it. These include the gastronomic productions already included in tourist itineraries or local activities such as sustainable tourism, aimed at enhancing the environmental and cultural value of the Province, and which will therefore generate income.

3.2 The Territorial Resources

As far as resources are concerned, this work has been able to take advantage of the extraordinary knowledge heritage implemented by the LAG Batir as part of the "Atlas of the Lower Tyrrhenian Reggino Landscape" project; it is a cognitive framework aimed at the identification, description, interpretation, and representation of the many and different landscapes present in the area of the Lower Tyrrhenian area of the Province of Reggio Calabria (Albanese G. 2001; Barreca et al. 2014; Cozzupoli F. & Vita F.C 2014, 2015; Di Fazio S. & Fichera C.R 2001; Gulisano G 2008a, Gulisano G 2008b, 2009; Marcianò C 2013; Marziliano et al. 2016, Careri et al. 2021).

The Gastrocert geodatabase borrows the structure prepared for resource data from the Landscape Atlas, with some insertions and small changes necessary in consideration of the differences existing between the territories investigated and the different purposes for which these two products were implemented.

Following the scheme already defined by the project "Atlas of the Lower Tyrrhenian Landscape", the resources are classified using a hierarchical scheme, which produces a typical tree structure, of a recursive or nested type, where the clusters of the highest levels are aggregations of clusters of the lowest levels of the tree. At the highest level, resources are divided into two specific areas: natural heritage and cultural heritage. Each of these areas is then broken down into categories and each category is, in turn, divided into types.

In addition to the specific elements, the framework of resources is completed by the Protected Areas and the areas for the protection of biodiversity (the Natura 2000 Network). These resources are treated separately for purely geographical consideration, being defined by well-defined polygons, even if, in the case of some Sites of Community Importance, the dimensions are so small they could be safely considered to be point elements. The classification system used for resources is shown in Table 1.

With regard to the descriptive sheets of the individual assets, in this case the scheme prepared by the Landscape Atlas was also used. The following information is associated with each asset:

Designation – Type – Category – Municipality – Address – Properties - Current destination – History - Short description - Valuable movable and immovable property - Open to the public – Accessibility - Tourist relevance - Level of perception - Conservation status – Sitography – Bibliography.

Table 1. Classification of natural and cultural heritage

Heritage	Category	Typology
Natural heritage	Geomorphological assets	Belvedere - Waterfall - Quarry / mine - Fossil deposits - Cliff - Fiumara - Geosite - Gorges - Grotto - Lake - Stone monument - Rock - Springs - Thermal springs - Beach - Marine terrace - Summit
	Naturalistic assets	Monumental tree - River landscape - Forest landscape
Cultural Heritage	Fortified architecture	Castle - Defensive walls - Tower
	Industrial architecture	Power plant - Factory - Spinning mill - Furnace - Oil mill - Slaughterhouse - Mill
	Architecture for the tertiary sector and services	Library - Fountain - Mausoleum - Monument - Town Hall - Museum - Orphanage - Square - Bridge - Sanatorium - Theater - Thermal baths - Municipal Villa
	Religious goods	Abbey - Chapel - Church - Convent - Aedicule - Monastery - Bishop's Palace - Sanctuary
	Rural goods	Charcoal – Farmhouse – Masseria
	Archaeological heritage	Archaeological area - Necropolis - Sites of Magna Graecia
	Residential architecture	Historic center - Abandoned historic center - Historic building - Villa

3.3 The Gastronomic Resources

In addition to information on landscape heritage, the Gastrocert database contains specific data sets relating to gastronomic heritage.

Traditional Food Products. One of the main research activities was the classification and geo-location of the entire list of officially registered Traditional Food Products (TFPs, or Prodotti Agro-alimentari Tradizionali, PAT, in Italian). (Cafiero et al. 2019).

The 2019 revision of the list of TFPs (Mipaaft 2019), included 268 products for Calabria. The production area of each product ranged from just one or a few municipalities to the entire region. Careful review of the information available from various sources[1] allowed Cafiero et al. (2019) to reconstruct the list of municipalities ("comuni")

[1] Summary cards for each of the products included in the list used were originally published on a website of the *Assessorato all'agricoltura of the Regione Calabria* (www.assagri.calabria.it/qualita) and on the portal of the *foodinitaly* project (www.foodinitaly.com) managed by the

where each of the products is traditionally obtained, allowing for a geo-localization of all Calabrian TFPs. What emerged is a picture of a region with a very rich heritage of traditional foods, the result of encounters between centuries of traditions and cultures from the Mediterranean basin, Northern Europe, and the near East. The various peoples who have inhabited Calabria over the millennia have clearly also left their heritage embedded in the culinary traditions of the region.

The focus on the products of the Metropolitan City of Reggio Calabria, excluding those that are typical of other provinces, led to reducing the initial number of products from 268 to 195. Further, only 89 of those 195 products are found in the restricted area covered by the Atlas. Finally, the exclusion of those products that are produced in the entire Metropolitan City area, led to a final list of 66 *highly specific* products. These products were grouped into eight categories of: (A) meats and offal; (B) fish; (C) breads pastries and sweets; (D) fruits and vegetables; (E) cheeses; and (F) prepared dishes, (G) oils and fats, and (H) non-alcoholic beverages, distilled drinks and liquors, as defined by Mipaaft (1999) (Table. 2).

Table 2. The main gastronomic products of the Metropolitan City of Reggio Calabria

Category	Nr. of products
Meats and offal	4
Fish	10
Breads, pastries and sweets	35
Fruits and vegetables	5
Cheeses	6
Prepared dishes	4
Oils and fats	1
Non-alcoholic beverages, distilled drinks and liquors	1

A synthesis of the classification and geo-spatial information is contained in Fig. 2, which overlaps the geographical map which shows the five macro areas that comprise the Metropolitan City of Reggio Calabria (Piana di Gioia Tauro, Costa Viola, Area dello Stretto, Grecanica, and Locride), together with a "network" of the municipality/product pairs. The size of the products' nodes in the represented network is based on their degree: the larger the size of the product node, the more municipalities are involved in the production of that particular product.

A very relevant aspect that characterizes the food heritage of what is now the Metropolitan Area of Reggio Calabria is the high degree of "typicality". Despite the strict criteria for the selection of specific products, only 9 of the 97 municipalities did

Fondazione Qualivita. These websites are no longer accessible, but the material has been made available again through a dedicated Web page at: http://portale.regione.calabria.it/website/organizzazione/dipartimento8/subsite/qualita_promozione/pat/

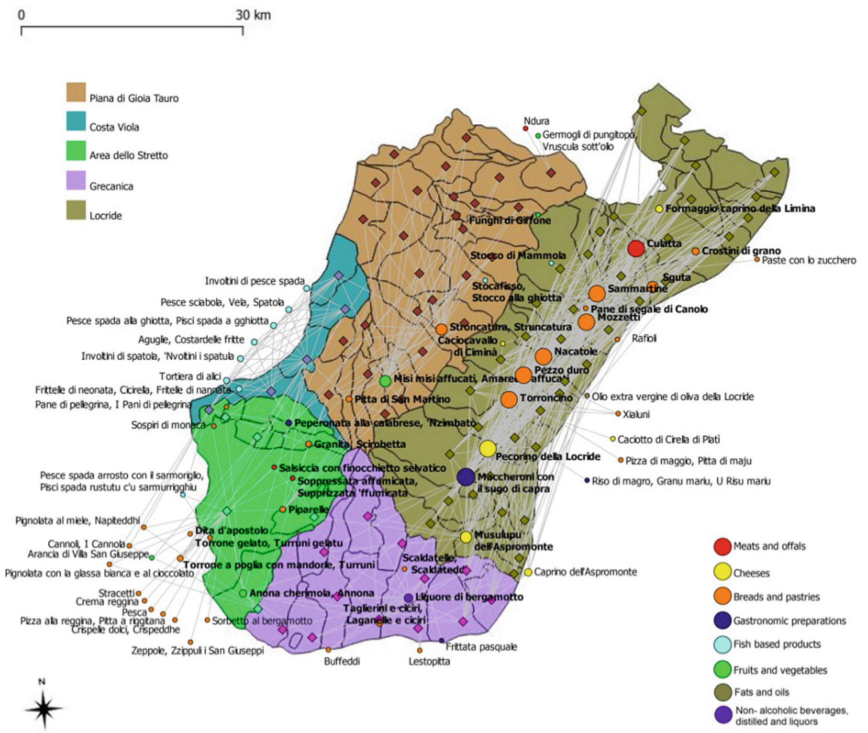

Fig. 2. Combined map of the Metropolitan City of Reggio Calabria and the network of traditional food products (adapted from Fig. 1 in Cafiero et al.2019)

not host at least one of the highly specific products. As a result, the map of specific products by municipality is a very dense one, with only nine isolated nodes, all belonging to the Strait Area and the Piana di Gioia Tauro, arguably the less rural among of five areas. A more detailed description of the database relating to the gastronomic productions of the area is available in Cafiero et al. 2019.

Wine and Gastronomy Itineraries and Other Resources. With respect to the theme of gastronomy, in addition to the products, it seemed useful to consider the services useful for their promotion, the dedicated events, the itineraries, and the presence of related narratives.

The choice to insert these elements in the database arises not only from the consideration that these are important aspects of the culture of the territory, but also from the belief that increasingly, together with the catering, they affect the choices involved in visiting and using a territory, such as those elements capable of involving the visitor through experiences and emotions.

The inclusion in the database of the accommodation available in the Province seemed useful in order to complete the picture of the potential of the target territories. This was also done with a view to enhancing the rural heritage and diversifying the agricultural economy through the development of sustainable tourism activities, in line with the environmental and economic profile, consistent with the rural identity of the territory.

Finally, the food and wine itineraries have been included in the database as tools capable of networking the various resources of a territory, resulting, according to the target audience, in multiple thematic itineraries.

The itineraries, selected by eliminating those that are too general, without any indication of the planned stages or that, with just different names, retraced the same routes, were divided by their distribution in the different municipalities, means of transport used (bike, car, foot, mixed), typology (historical-artistic and cultural, religious, food and wine, nature, cycling and sporting itineraries), and web presence.

Finally, the local legends and folk tales have been collected in a table with an indication of:

- their locality and municipality;
- a short description;
- an essential bibliography and sitography;

For the other resources - events, typical products, hospitality and catering - the general filing was deemed sufficient.

3.4 Creation of a Web App Dedicated to Gastronomic Products

Territorial marketing stands for the set of cardinal tools for the promotion of the territorial space and its landscape heritage in particular. Therefore, one of the fundamental components of territorial marketing concerns communication: not only in an external (promotional) sense to attract new resources, but also in the internal sense, since the action of territorial marketing, in order to be effective over the long term, must be based on the consent of all the actors involved and on the transparency of all the interests at stake (Bloise et al. 2017). It thus becomes necessary to identify the best communication strategy, so that the territory and its gastronomic tradition are considered as a product that can be promoted and advertised adequately, by adapting the language and tools according to the intended recipient.

It is precisely from these assumptions that the idea was born to set up a web App dedicated to the gastronomic heritage, integrated with the whole complex of environmental, cultural and landscape values. It represents an attractive way to spread the values of the territory and to increase the visibility of a gastronomic heritage that is waiting to be exploited together with the original agro-forestry activities. This combination put the individual gastronomic products in their regional context, thus giving for the web browser the opportunity to appreciate not only the characteristics of each individual product, but also the overall quality of the area where these products are made.

The Gastronomic Atlas of the Province of Reggio Calabria aims, on the one hand, to fully illustrate the topic of gastronomy relating to the area of the Province of Reggio Calabria; and, on the other, it represents a collection of information and materials combined in maps.

The Atlas was implemented using the ArcGIS Online platform, based on Esri's Cloud infrastructure, which enables the management of geographic information, such as maps, data and geospatial applications made available by Esri, the Esri user community, and GIS users all over the world. ArcGIS Online can be defined as the social network of geographic information. Using the ArcGIS Online tools, it is possible to create Web

Map Applications, that is, simple web applications for consulting geographic data, also integrated with base maps or the maps of other users. Among the different application models made available by ArcGIS Online, the ones that appear most interesting for the construction of the Atlas were the story maps. The story maps allow you to tell stories that inform, involve and inspire the public, combining web maps with narrative texts, photos, and other multimedia elements.

The Gastronomic Atlas of the Province of Reggio Calabria uses the Story Map Series model, which allows a series of maps to be presented via cards. In addition to maps, images, videos and web content can also be included to make the App more engaging; other apps can also be used among the web contents, creating a Chinese box system. The App has six sections, one main, which describes the area as a whole, and five dedicated to the gastronomic productions of the three LAGs, the FLAG, and the Strait Area.

For the main sheet, intended for the description of the territory as a whole, a Cascade story map is used. The Cascade app model allows, through a full-screen scrolling, to combine narrative text with maps, images and multimedia content in an extremely immersive experience. In a Cascade story, sections containing texts and multimedia content can be interspersed with 'immersive' sections that fill the screen with maps or 3D scenes.

The story map describes the territory in four sections:

1. Territory;
2. Environment
3. Culture
4. Traditions

After this overall presentation of the provincial territory, the subsequent cards are each dedicated to a study area for which the gastronomic products present are described.

The study areas considered are:

- LAG Batir;
- LAG Grecanica;
- LAG Terre Locridee;
- FLAG dello Stretto;
- Strait of Messina area.

Each of these tabs allows the user to view a Journal story map that describes the gastronomic products related to that territory. The Journal app template is ideal when the user wants to combine descriptive text with maps and other embedded content. The initial index contains the sections that users can scroll through. The sections correspond to the categories used for the division of gastronomic products.

Obviously, the complete list of Categories is not always found in a form relating to a specific territory; this is explained by the absence of products related to that Category in that particular territory.

Each section contains, in the left panel, the list of gastronomic products relating to that specific category in relation to the territorial portion of the form. In the right part a Gallery of maps is displayed; for each product the relevant map will be presented; the Map Gallery displays a preview of the map; clicking on it displays the map with the

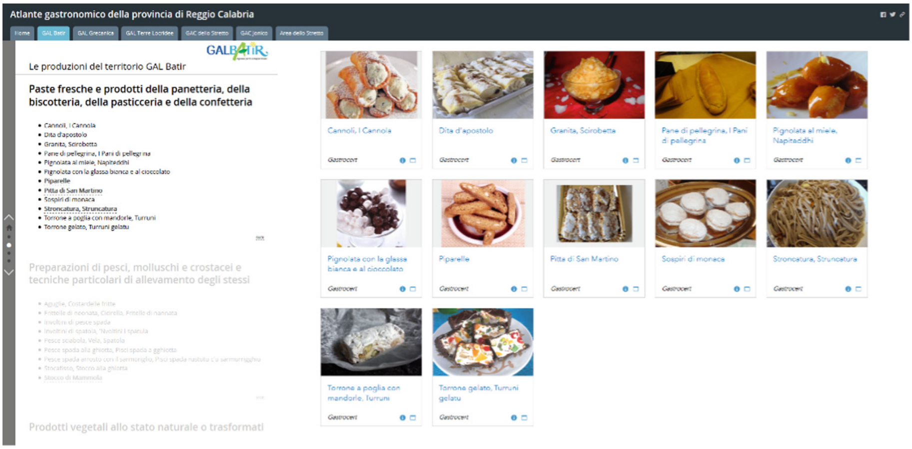

Fig. 3. Browsing the section relating to the products of the LAG Batir, those relating to the category "Fresh pastas and products from the bakery, biscuits, pastry and confectionery" are listed.

associated territory of the product considered, in addition to the other territorial attractors (environmental, historical-cultural heritage, etc.).

The App has six sections, five of which are dedicated to the gastronomic productions of the 3 LAGs, the FLAG and the Strait Area.

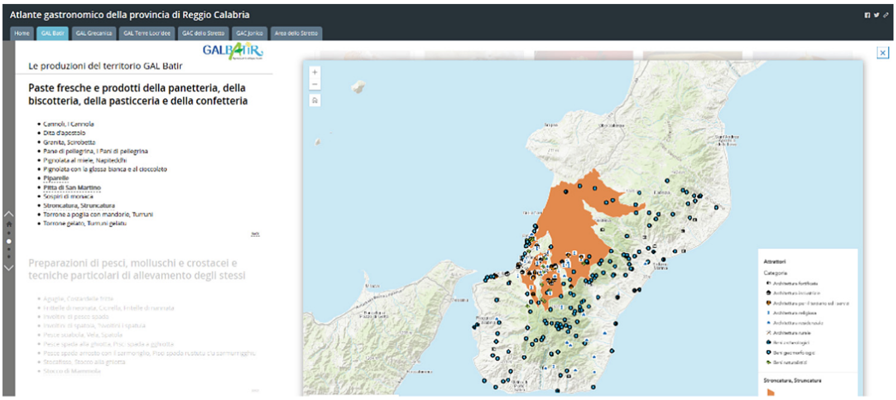

Fig. 4. The maps of the individual products show the production area and the other landscape resources present

4 Conclusions

One of the priority objectives in the development programme of the European Union concerns rural heritage, which represents one of the most complex and heterogeneous aspects in the context of European societies. The opportunity offered by the Gastrocert project is part of a new interpretation of the territory, seen as a whole, involving: tangible and intangible resources, public and private "actors", actions aimed at promoting and communicating the territory, especially with a view to tourist enhancement. In this context, through a Research-Action approach, universities can undertake stimulating creative diversification paths to be contextualized within local development processes. All this is necessary to reduce the gap existing between the different types of actors involved in the regional, sub-regional, business, or municipal development processes. In fact, there is a need to build a common language between the different actors and to reduce the gap between "thinkers and operators", academics and entrepreneurs, sometimes engaged at different levels, who are not communicating effectively with each other. The cause of this gap can be found, on the one hand, in the lack of relationships, or in the inability to build adequate networks between academia and professionals, and, on the other, in communication problems caused by an overly technical approach and a one-way academic language (Santini et al. 2017; Marcianò & Romeo 2019, p. 35). Active participation can facilitate mutual knowledge between the various stakeholders in order to build adequate and effective synergies in the development processes, in both the planning and implementation phases. In this context, there is a strong need for academics to test themselves in different contexts to co-create sustainable development solutions, that is, dynamic, creative and collaborative strategies that can be adopted at the level of local communities that strive to develop diversification activities related to their principal activities in this time of great economic and environmental challenges.

The starting point of the Gastrocert research project was found in the various integrated local development experiences carried out in the province of Reggio Calabria by the local action groups (LAGs), the local fisheries action groups (FLAGs) and the agri-food quality district (DAQ) (Marcianò et al. 2014), who joined the project as associated partners. Various synergies have been activated with the associated partners, in the territorial analysis, territorial animation and/or concertation activities, phases that constitute the main activities in the integrated development planning processes. In this context, it was possible to pursue, together with these public-private local action groups, a common path of action-research, which led to the definition of development strategies that will be implemented in the various territories in the coming years.

Among the various studies cited, one project activity concerned the establishment of the Food and Wine Atlas presented in this study which should be further developed by extending it to the company level. The tool could be used at a spatial planning level, for example, to provide a map of the Province of Reggio Calabria which highlights the areas where multiple attractors overlap, starting from the gastronomic products themselves, and also take into account the other "tourist, environmental, archaeological-historical-cultural, religious" attractions. Further research and development activities are needed to develop this tool and link it to the implementation phase of the local development plans carried out by the Local Action Groups (LAGs), Fisheries Local Action Groups (FLAGs) and Food Districts of the Metropolitan Area of Reggio Calabria.

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