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Bridging Gaps – Urban Planning for Coexistence

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Along the concentrated efforts of the Association of European Schools of Planning (AESOP) to Open Access scholarly planning debates, the young academics network of AESOP continues to publish its international peer-reviewed open access e-journal, *plaNext*. *plaNext* provides prospective authors an opportunity to engage their ideas in international planning debates as well as make their research available to the wider planning audience. *plaNext* invites authors to submit original work that includes: empirical research; theoretical discussions; innovative methodologies; case studies; and book reviews on selected books, textbooks, or specific topics dealing within planning.

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Editors of Volume 16

Acknowledgment

The Editorial Board of *plaNext*, together with the editors of this Special Issue, would like to express their sincere gratitude to all reviewers for their invaluable contributions. Their thoughtful engagement and constructive feedback, especially in support of young scholars, have significantly strengthened the quality and clarity of the articles, enriching this volume comprehensively.

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VOLUME 16, SPECIAL EDITION

Bridging Gaps – Urban Planning for Coexistence

This special volume of *plaNext* brings together peer reviewed papers from the 18th AESOP Young Academics Conference, *Bridging Gaps Urban Planning for Coexistence*, held at Politecnico di Milano in March 2024. It reflects shared concerns about widening disconnections in planning theory and practice, including gaps between social groups, policy sectors, spatial scales, knowledge systems, and human and non-human actors. Against a background of climate stress, social inequality, and institutional fragmentation, the contributions explore how planning can support forms of coexistence that are socially just, environmentally grounded, and institutionally feasible. The papers span diverse empirical contexts and approaches, addressing energy, climate adaptation, housing, and historically embedded spatial inequalities. Together, they question planning models centred on technical optimization or hierarchical decision making, and instead emphasize relational perspectives, historical awareness, and plural forms of knowledge. By contributing to wider debates on resilience, sustainability transitions, and planning ethics, this volume offers a platform for emerging scholars while inviting reflection on planning as a practice of negotiation and coexistence across social, spatial, and institutional boundaries. Additionally, this issue of *plaNext* also includes two papers from the open call.

Content

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Notes on Contributors

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Editorial: Bridging gaps – urban planning for coexistence

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Framing the debate: bridging gaps in planning

Today, urban planning attempts to address trans-scalar issues while dealing with the increasingly complex socio-environmental, economic, and cultural challenges that demand specific, innovative, sustainable, and inclusive solutions. The 18th AESOP Young Academics Conference, titled *Bridging Gaps: Urban Planning for Coexistence*, was organized and hosted by a group of PhD candidates at the Polytechnic University of Milan (Politecnico di Milano) in March 2024. The conference was conceived as an open platform, designed specifically by and for early career researchers to engage with these challenges. It aimed to address the theoretical and practical gaps within urban planning, seeking ways to transform them into constructive dialogue and interdisciplinary collaboration opportunities. In a world shaped by environmental crises, urban-rural tensions, socio-economic disparities, and the diverging relationship between academia and practice, the conference offered a unique and safe space for young academics, including master's and doctoral students, postdoctoral researchers, and other early career scholars, to critically rethink urban planning as a tool for coexistence. Participants explored new ways to address these challenges and bridge the identified gaps in the planning discourse through their research, methodologies, and case studies.

Coexistence, the broader theme of the conference, was approached as a dynamic and multifaceted concept, including the relationships between urban and rural environments, different species, academic disciplines, and planning methodologies and practices (Jreij et al., 2025). The idea of coexistence recognizes the urgency of aiming for sustainable interactions among diverse actors, whether human or non-human, institutional or informal, spatial or conceptual. The conference was structured into five thematic tracks and three roundtables, each addressing a different but interconnected aspect of urban planning. In addition, the three roundtables facilitated in-depth discussions that bridged the thematic divides: the first linking sustainable urban-rural transitions (Tracks 1 and 2), the second one exploring the academia-practice relationship (Tracks 3 and 4), and the third focusing on Track 5's overarching framework and its implications for the discipline. Track 5 served as an umbrella theme and encapsulated the broader discussion on coexistence, integrating insights from the other four tracks.

The relevance of this theme is timely in the current academic and practical landscape. As cities and regions navigate the growing pressures of climate change, sociopolitical instability, and economic inflation, discussing planning for coexistence becomes an urgent necessity. Moreover, this changing context requires new frameworks for planning education and for young academics (Varış Husar et al., 2023). The 18th AESOP Young Academics Conference discussions underscored how planning must evolve to address these challenges, fostering inclusivity, adaptability, and resilience. The conference served as an experimental space for such discussions, bringing together young researchers from diverse geographical backgrounds to question the status quo, propose new frameworks, perspectives, and methodologies, and highlight overlooked topics and themes in planning discourse (Jreij et al., 2025).

This special issue seeks to put some of the topics discussed and initiated during the conference into the spotlight. It aims to highlight some key themes, debates, and, in some cases, findings while also providing an opportunity for the young researchers to develop further the ideas sparked by the event and publish their work. By bringing together a selection of papers presented at the conference, this issue hopes to tighten some gaps in urban planning research, spark new discussions, and encourage a more reflexive and engaged approach to planning for coexistence. Ultimately, the goal is not to reflect on the conference's

outcomes but to contribute to a broader and timely dialogue that challenges the boundaries of urban planning and envisions a more inclusive and sustainable future.

Current debates and emerging gaps in urban planning for coexistence

The current debates in contemporary urban planning are linked to complex problematic challenges that include social and spatial segregation and a lack of accessibility of city services (Moreno, 2024); urban traffic congestion and air pollution (Xu et al., 2024); environmental degradation (Newig & Fritsch, 2009); urban biodiversity loss (Lazzarini et al., 2024; Nilon, 2023) and depletion of natural resources (Atutxa et al., 2024). These issues are deeply intertwined with various gaps in both the theory and practice of urban planning, which influence local authorities' policy priorities and, more broadly, hinder institutional capacity to effectively address citizens' needs, particularly in disadvantaged communities, where local needs often become "lost in transition" (Hysing, 2015).

In the context of local communities' need to have a voice in the planning process, a significant challenge lies in effectively leveraging public participation to support the socio-ecological transition of cities (Sauer et al., 2015). Furthermore, public spaces play an important role in promoting social inclusion and community cohesion (Mehan, 2024). At the same time, participatory processes may become exclusionary arenas, where powerful stakeholders dominate decision-making while less resourced actors struggle to have their voices heard. The primary challenge, therefore, is to ensure both accountability and inclusivity in participatory spaces, interpreting these as open collaborative grounds for multi-stakeholder interaction where also the potential conflicts arising should not be perceived negatively but rather recognized as a natural and constructive part of stakeholder interaction and engagement (Durham et al., 2014).

While participatory arenas significantly impact the determination of just planning processes, it is equally essential to foster participation within local administrations to engage various sectors in the policy-making process. This special issue highlights another practical gap: the sectoral nature of territorial planning structures and mechanisms, whose fragmentation often makes it difficult for plans and planning policies to drive transformation across different policy sectors in an integrated and cohesive manner (Mahmoud et al., 2025).

Some researchers have attempted to bridge these gaps between theory and practice using several approaches and methodologies (Flyvbjerg, 2006). The main challenge lies in developing a transdisciplinary framework for urban public policy (Creutzig et al., 2024) that can build bridges between academia and public administration, making sure that research can positively influence policy-making processes, as well as bring together technical, social, and scientific knowledge directly relevant to municipal policy. Indeed, in both cases, stakeholder collaboration is crucial and allows for the contribution of different, sometimes contested, goals, interests, values, and models in the process (European Commission: Directorate General for Research and Innovation, 2023). Emphasis on forms of partnership as vehicles for mobilizing the collective governance capacities of local actors is highlighted by Bulkeley et al. (2021, p. 7), who pointed out that "moving forward requires building capacity for a range of actions from public engagement to partnerships, equipping urban actors with the tools and resources to […] generate outcomes that are transformative for people and places".

In this context, the opportunity to overcome silos and fragmented urban planning lies in inclusive co-creation and co-planning processes, where all stakeholders from various policy sectors within the public administration share responsibility for policy implementation

(Mahmoud, 2024), while also fostering collaborations with civil society and the private sector. Indeed, multi-level modes of territorial governance between the local communities and institutions, civil society, academia, and local authorities are critical in overcoming the discrepancies related to policy provision, implementation, and monitoring (Bulkeley et al., 2019).

Contributions of the special issue

This special issue brings together four papers that examine urban planning through the lens of coexistence. By addressing spatial, social, and environmental dimensions, these contributions highlight the limitations of existing planning paradigms and present novel methodologies for fostering more inclusive and sustainable urban futures.

The first paper, by Luís Carlos Martins Mestrinho de Medeiros Raposo, examines the role of the seascape in shaping the public acceptance of offshore wind farms in Portugal. By showing how conflicts emerge when stakeholders with strong ties to the sea are excluded from decision-making, the paper stresses the importance of recognizing the agency of the seascape itself as a relational actor. It calls for energy planning approaches that engage more directly with the place-based non-human dimensions of space.

Two papers investigate questions of climate resilience and sustainability transitions. Lucia Chieffallo develops a heterogeneous data processing method that integrates climatic and non-climatic information to support urban planners in addressing heatwaves and has been tested in the Italian municipality of Lamezia Terme. Her approach illustrates how combining multiple data sources can strengthen adaptation planning by identifying priority areas and defining tailored responses. Mirjam Sophie Mauel and Elisabeth Beusker focus on the German context of serial retrofitting, analyzing it through the multi-level perspective to assess its transformative potential for the building sector. Their contribution shows how industrial prefabrication and standardized components could accelerate the diffusion of low-carbon housing solutions but also emphasizes the political and institutional support needed to make this innovation mainstream. Together, these two papers highlight the promises and challenges of system-based and technical approaches to resilience, raising questions about how to better connect them to social equity and participatory governance.

The final paper, by Seyed Alireza Seyedi, Saeid Khaghani, Rouhollah Mojtahedzadeh and Asma Mehan, offers a historical perspective by tracing the architectural evolution of British-owned oil company towns in Iran from 1901 to 1951. Their analysis of Abadan and Masjed Soleyman shows how colonial urban models, from bungalow housing to garden city principles, produced racially and socially segregated environments. This paper demonstrates how the legacies of colonial planning continue to shape socio-spatial inequalities today and invites reflection on the need for historically aware approaches in contemporary planning.

A central question or recurring theme emerging from these contributions is how planning can reconcile top-down strategies with bottom-up, community-led initiatives. While several papers advocate for greater inclusivity and participatory approaches, they also point to institutional, political, and structural barriers that limit such engagement. This conclusion raises important considerations for future research and practice: How can planning methodologies better integrate diverse knowledge systems, including indigenous and non-human perspectives? What mechanisms facilitate more effective collaboration between policymakers, researchers, and local communities? How can historical insights be mobilized to design more equitable and context-sensitive planning interventions?

Closing remarks on planning for coexistence

Recent scholarship points out the importance of integrating social justice into urban climate change planning. For instance, studies have documented that urban climate initiatives often inadvertently exacerbate social inequities, particularly when neoliberal ideologies guide planning processes. Such evidence emphasizes the need for planners to adopt frameworks that prioritize equity and inclusivity (Varış Husar, Mehan, et al., 2025; Varış Husar, Tulumello, et al., 2025). At the same time, the politics of expertise in planning are being redefined, as long-dominant technical and comprehensive approaches are increasingly questioned by demands to value the lived, everyday and insurgent knowledge of communities and marginalized groups (Holston, 2008). This shift signals an important move toward democratizing planning and grounding interventions in the realities of diverse actors.

The articles in this issue resonate with this ongoing transformation. They remind us that resilience cannot be understood solely through technical solutions, but must also be rooted in social relations, cultural contexts, and historical trajectories. They show that while innovative tools, systemic approaches, and technological advances can strengthen planning, they will only achieve their full potential if combined with participatory, equitable, and historically conscious practices.

As such, this special issue contributes to widening the scope of planning scholarship by bringing in perspectives that connect local struggles to global transitions, technical innovation to cultural meaning, and historical critique to future-oriented practice. Its insights are relevant not only for academic debates but also for policymakers, practitioners, and community actors who seek to bridge gaps in planning theory and practice.

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The seascape as an actor in the public acceptance of offshore wind farms

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This study explores the role played by the seascape in the public acceptance of nearshore and offshore wind farms. The transposition of onshore wind farms to the sea has been defended as an alternative to mitigate resistance, assuming that, by locating them offshore, opposition would be halted. However, research indicates that this is a misconception, as offshore sites do not guarantee a problem-free solution for wind farms, and conflicts can persist even when wind parks are planned to be installed away from populated areas. The study discusses how the seascape can be perceived differently by various stakeholders and emphasises the importance of considering it as a key factor in the success of the planned exploration. The proposal of offshore wind parks along the coast of Portugal is used as a case study to analyse how it was received by different sectors of society. Findings reveal that stakeholders with strong ties to the seascape were not included in the decision-making process from the very start, which led to fierce opposition in areas where sea uses are deemed to be in conflict. It is therefore argued that the non-human agency of the seascape should not be ignored, since it can form relations. It is suggested that a comprehensive understanding of the seascape could help build better-informed decisions, as its environmental characteristics and functioning, and the social construct that is formed between different groups and the seascape, are capable of shaping the stakeholder group and influencing the social acceptance of an energy project.

Keywords: energy seascapes, contested places, infrastructure planning, more-than-human

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Introduction

The decarbonisation of the energy sector is seen as an essential step towards achieving the emission reduction targets set forth in international climate change agreements. Under this new paradigm, among other options, finding and implementing new renewable energy sources capable of replacing fossil fuels is a major component of the clean energy transition (European Parliament, 2018). However, whereas it is quite consensual that the meeting of climate goals requires a phaseout of fossil fuels and greater use of renewables, it is also known that the transition is not exempt from challenges. Research has shown that green energy projects can be as socially and environmentally conflictual as fossil fuel projects, as the shift to green energy is not inherently socially and environmentally benign and can, as a result, trigger mobilisation of citizens capable of influencing the results of the project (Temper et al., 2020).

Wind energy has been acknowledged as crucial to meeting the EU's decarbonisation objectives and providing clean, affordable, and safe electricity (European Commission, 2023). Notwithstanding the important role of wind energy, resistance to the development of onshore wind farms is increasing in some countries, and it has been noticed that large-scale undertakings fail due to a lack of support or opposition in society (Firestone & Kempton, 2007). This is because, commonly, a parcel of the public perceives on-land turbines to be a negative element in the landscape (Ladenburg, 2008). The transposition of onshore wind farms to the sea has been pondered as an alternative to reduce or eliminate the disamenities associated with on-land turbines (Henderson, 2002; Ladenburg, 2010), a characteristic deemed to improve the public's perception of offshore wind parks when compared to their on-land counterparts. Indeed, developers have already praised the advantages of relocating wind farms to the sea, as the choice is weighed to present fewer conflicts and have fewer conditions linked to the occupation of the territory (Windplus & Ecobase Consulting, 2015). This trend is so steady that it has already been noticed that the construction of offshore wind installations could become Europe's most extensive technical development in marine habitats at the beginning of the 21st century (Merck & von Nordheim 2000 cited in Garthe & Hüppop, 2004).

Nonetheless, Haggett (2011) notes that the assumption that offshore sites are problem-free surrogates for onshore wind farms may be a misconception and suggests that it is rather naïve to assume that opposition would be halted as conflicts can persist even when wind turbines are planned to be installed over the sea and away from populations.

This study is in line with the interpretation that offshore wind farming, although capable of mitigating some of the impacts associated with onshore wind farms, is not an indisputable solution and its public acceptance cannot be taken for granted. Rajabifard et.al. (2005) recall that the marine environment contains a multitude of resources, but at the same time it is also extremely complex, subject to contradictory economic, social, and environmental pressures and demands. The same authors argue that when dealing with competing interests, achieving a balanced outcome requires information with an inherent spatial dimension. This means that there must be clear spatial certainty about the location and extent of rights, restrictions and responsibilities in the marine environment (Binns et al., 2004). However, they caution that this may not be easy to define, given the mobile nature of maritime boundaries and the three-dimensional character of the marine environment, where different activities take place on the sea surface, in the water column and below the seabed.

Following this logic, this study revisits the discussion on how to balance the different interests arising, on the one hand, from the exploration of a renewable resource at sea and, on the other hand, from other uses of the sea, as well as the protection of the marine environment. It examines the issue through the lens of the spatial implications of different seascapes that may

exist in marine space and suggests that the seascape itself should be considered as an actor in the shaping of a solution. Given that different stakeholders can relate differently to the same marine space, and that multiple seascapes can coexist within the same disputed area, it is here argued that the spatial analysis, overlap and integration of different seascapes could serve to build a better-informed decision and reduce the sea footprint of the offshore wind project.

Methods

This study briefly reviews the state of knowledge on the uptake of green energy transition projects based on wind energy, both onshore and offshore, and the role that seascapes and landscapes have played in the outcomes of such projects. In addition, the proposal for offshore renewable energy zones along the coast of Portugal is used as a case study to assess its public acceptance among different stakeholders. Portugal was chosen for this study because of its political relevance, as it alone detains almost half of the European Union's Exclusive Economic Zones under its jurisdiction (República Portuguesa, 2021; Leitão et al., 2014). Furthermore, the country already has extensive maritime spatial planning legislation in place, both at the European and national levels, and is now starting to apply the instruments advocated in the legislation, some of them for the first time, as in the case of the allocation of areas for offshore wind farms. Therefore, the case study can be useful in assessing how the provisions proposed in the planning legislation are observed when it comes to translating them into reality, as is happening in Portugal at the time of this study regarding the allocation of areas for renewable energy at sea.

Desk research was carried out to analyse documents produced in the open public hearing process that followed the disclosure of the proposal drafted by the Working Group that was indicated by the Portuguese State to manage the planning process. Semi-structured face-to-face interviews were conducted with a small sample of representatives from the fishing sector to assess their perceptions and positions. The first group selected for interviews was an artisanal (small-scale) fishing association representing around 40 boats operating off the coast of Viana do Castelo, one of the most productive areas for offshore wind energy and one of the most controversial sites for the fishing community. The second group was another artisanal fishing association operating in the Minho estuary The choice of this particular group of stakeholders was motivated by the fact that the European Parliament (2021) has already stated that the exploitation of offshore wind resources must be carried out in a way that is compatible with other uses of maritime space, mainly fishing, and that decisions on the installation of offshore renewable energy production must involve all stakeholders in the area, in particular the fishing communities and their organisations. In addition, the same resolution argues that special attention should be paid to the interests of fisheries and aquaculture and that these groups should not be marginalised (European Parliament, 2021).

Not against but neither subscriber: The tricky problem of acceptance of wind farms

Some authors (Temper et al., 2020) observe that, when it comes to wind and solar energy, communities are not mobilising against renewable energy itself, but against the ways in which the technologies are implemented and the lack of due process in implementation. Walker (1995) also mentions that often the literature reveals that individuals and groups are not intrinsically against wind energy but rather opposed to the scale, location, or other characteristics that a particular development may have.

Warren et al. (2005) recall that conflicts between development and landscape conservation have a long history, and although the debates on wind energy share some of the

characteristics of previous environmental controversies, they differ from the previous ones in a relevant particularity that can make acceptance (or the lack of it) a complicated problem: in the case of wind energy, there are strong “green” arguments on both sides of the debate. The same authors explain that, on the one hand, some environmentalists defend wind farms due to their “clean energy” credentials, while, on the other hand, opposition may be raised due to their landscape impacts. Still, others are caught in middle ground, supporting renewable energy in principle but opposing specific wind farm proposals, so the authors conclude that the wind controversy is characterised as a “green-on-green debate”.

Another layer of complexity is added when it comes to renewable energy landscapes, of which wind energy is one type, as these have the innate characteristic of being site-specific (Pasqualetti & Stremke, 2018), i.e., location options are guided according to a specific set of conditions existing in each landscape or seascape, such as wind resource availability in any case and sea-bottom depth in the case of nearshore and offshore farms (Bray et al, 2016) (Figure 1). Hence, the environmental peculiarities of the site, which condition the exploration, are the first reason why we could consider the landscape or the seascape as an actor in the energy project.

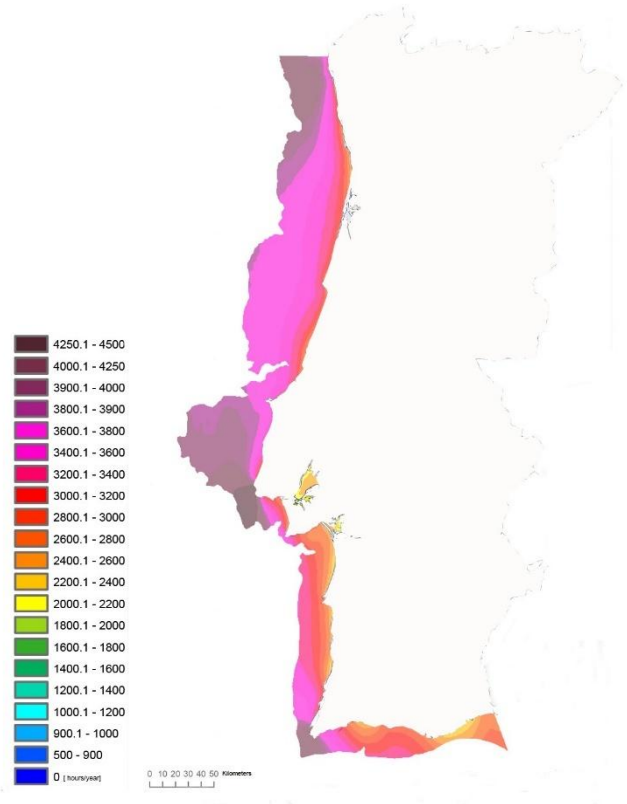

Figure 1. *Atlas of the offshore wind potential along the coast of Portugal (the legend shows wind blow frequency by hours/year). Source: Costa et al. (2010)*

Altogether, it is a fact that public perception and acceptance are seen as crucial to the development of wind energy (Devine-Wright, 2005; Wustenhagen et al., 2007), and that positive social opinions about renewable energy cannot be taken as a guarantee of immediate acceptance of proposed projects. While there may be public support for renewable energy, the physical, environmental, social and economic impacts of a particular project may be controversial and undermine initial support. Here we should bear in mind Pasqualetti &

Stremke's (2018) observation that energy landscapes are co-constructions of space and society, and the appearance, location and recognition of energy landscapes evoke a wide range of perceptions and responses.

As Greider & Garkovich (1994, p. 1) recall, "landscapes are symbolic environments created by human action from a particular perspective and through a particular filter of values and beliefs", meaning that landscapes are not only formed by their objective qualities but can also be understood as a social construct (Balık & Balık Lökçe, 2019). Thus, the standard definition of the seascape as "the spatially heterogeneous area of the coastal environment that can be perceived as a mosaic of patches, a spatial gradient, or some other geometric patterning" (IPBES, 2021) fails to acknowledge its subjective qualities, which can only be perceived when someone relates to it. We prefer to adopt the definition proposed by Nuttall (2021, p. 3) which states that "a seascape is a constructed cognitive place consisting of the physical sea and the coastal zone encompassing the range of practices undertaken by human agents with or within this place". In this regard, Allen (2011) suggests that we should not consider landscape as only a "human" or only a "natural" construct, but as a combination of both. In this sense, as with landscapes, different groups may have different relationships with the seascape, once that relation is established according to the characteristics of the site and to their own social connectedness, defined as the potential or actual link between people and the environment (Hilman et al., 2008). Therefore, the social construct formed between a given society and the seascape is a second reason for recognising the latter as an actor to be considered when planning maritime infrastructure.

The proposal for offshore renewable energy deployment areas along the coast of Portugal and its reception by the public

Wolsink (2010) reminds us that the logic behind the idea of the greater and easier acceptability of offshore wind farming is based on the notion that the choice would avoid impacts on the landscape and questions why we should consider possible impacts on the seascape to be something of lesser importance. The same author points out that, at least for nearshore developments, the theme of visual intrusion, a major concern of projects on land, still stands as a relevant issue capable of raising resistance to OFW. We here expand this discussion and argue, by using the example of the proposal for offshore wind farm areas along the coast of Portugal, that not only visual intrusion, but in addition, other issues that influence the acceptance of onshore projects such as environmental concerns, local ecology and concurrent uses of space can also apply to the case of OFW. In short, in the end, we might not be avoiding conflicts but, instead, transferring them from land to the sea.

The decarbonisation of the economy and the energy and climate transition, in close conjunction with the targets set by the EU for cutting emissions and the growth of renewable energy, reinforced by the REPowerEU plan, led the Portuguese Government to set a target of 10GW for offshore renewable energy by 2030 (GTOffshore, 2022). To achieve this objective, in September 2022, an Inter-ministerial Working Group composed of representatives of the government, the ports and the energy sector was created for the planning and operationalisation of electrical production centres based on renewable energy sources of oceanic origin or location. Their mandate was to, notably, propose a set of spatialised areas to be allocated to electricity production in accordance with the National Maritime Spatial Planning and to distinguish "preferred" areas, as defined in the REPowerEU plan (República Portuguesa, 2023). It was considered essential to ensure the participation of all interested parties through a public hearing of the preliminary proposal for the spatialised areas identified by the Working Group (Figure 2) and, to this end, a consultation was opened for 30 days to formulate suggestions and collect contributions (República Portuguesa, 2023).

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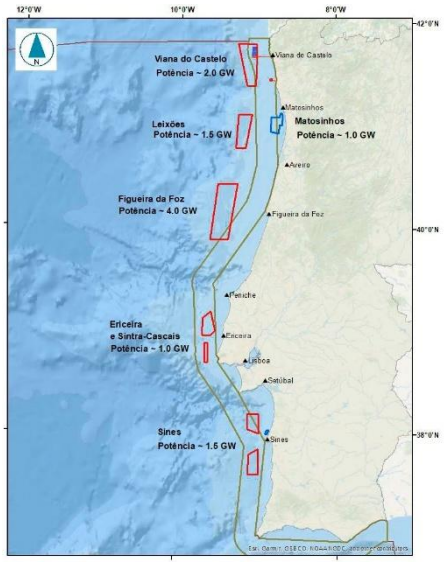

***Figure 2**. Preliminarily proposed nearshore (blue) and offshore wind farm areas (red) and respective indicative powers. Source: GTOffshore (2022)*

A first concern identified by stakeholders was the potential spatial conflicts between the suggested location of some areas and their overlap or proximity to sensitive marine areas under any type of environmental protection or with the possibility of being classified as such in the future (Figure 3). It was suggested that the selection of areas should not only be based on technical-economic aspects of production but also include ecological criteria, and the lack of knowledge of public entities about the reality and conditions of the territory was criticised (GEOTA, 2023).

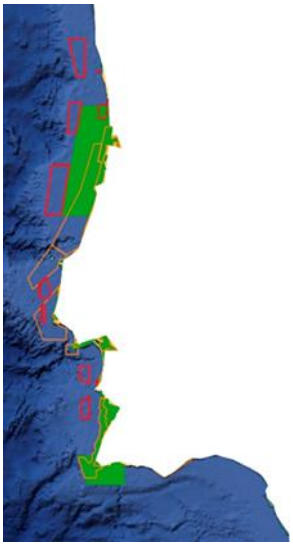

***Figure 3.** Overlap of proposed nearshore and offshore wind farm areas (red) and Limits of Special Protected Zones – ZPE (orange) and Sites of Community Interest – SIC (green). Source: SPEA (2023)*

The superposition of the proposed Sintra–Cascais area of exploration and the Cabo-Raso Special Protected Zone was particularly not well received among the public. Despite the conditions underlying the delimitation of the proposed areas suggested that the areas should preferably be located outside administrative services such as Nature Conservation Areas and the National Ecological Reserve, an exception was made for the area of Sintra–Cascais

(Figure 4).

***Figure 4**. Overlap of proposed Sintra–Cascais offshore wind farm area (red) and Cabo Raso Special Protected Zone–ZPE (green). Source: GTOffshore (2023)*

The exception was justified by the Working Group because the chosen area is "located close to urban areas with high energy consumption (Lisbon Metropolitan area) and because it is in one of the areas with the greatest energy resources" (GTOffshore, 2022). Different stakeholders manifested their opposition to the exception made in favour of the Sintra–Cascais exploration area and questioned the prioritisation of technical and economic aspects over the needs of the marine environment (GEOTA, 2023; SPEA, 2023; de Medeiros Raposo, 2023) considering the economic-driven justification for the potential impacts on the marine fauna as a reductive and irresponsible conception (SPEA, 2023). Still, it was highlighted that the exception made to the Sintra–Cascais area was predominantly based on a socioeconomic logic of exploitation and, therefore, did not observe the principle imposed by the Maritime Spatial Planning Framework Directive, which states that planning should rest on an ecosystem approach (European Parliament, 2014) and also inverted the logic given by the Marine Strategy Framework Directive, which states that "by applying an ecosystem-based approach, priority should be given to achieving or maintaining good environmental status in the Community's marine environment" (European Parliament, 2008).

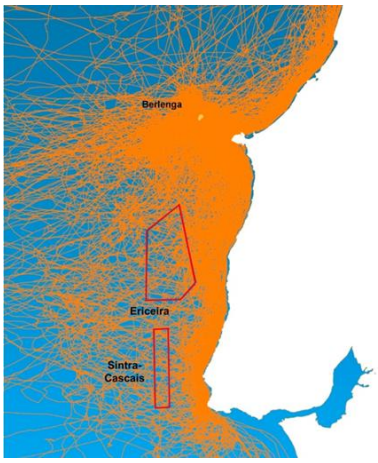

***Figure 5**. Geolocation of feeding routes of Cory´s shearwaters (Calonectris borealis) between the Berlengas archipelago and the entrance to the Tagus (estuary). Source: SPEA (2023)*

A second identified concern regards the cumulative and still little studied effects brought by OFWs to local marine ecology, especially avian fauna, such as removal and disturbance, collision, barrier, destruction, and habitat modification, and their implications for nesting and migratory species (SPEA, 2023). Stakeholders highlighted the need for a better understanding of spatial usage within the location or vicinity of exploration areas as practised by different species (Figure 5).

During the public consultation process, there was a considerable degree of opposition to the proposal of nearshore exploration areas, with surrounding municipalities like Matosinhos and Porto, stakeholders with relevant political power, expressing concerns over the visual impact of wind farms on the seascape (Negócios com Lusa, 2023). For instance, the Porto City Council has expressed its disagreement regarding the location of the Matosinhos exploration area, which was situated a mere three kilometres away from the "Site of Public Interest of Foz Velha". The local authority feared that a near-shore wind park could potentially result in a significant visual and landscape impact, which might interfere with the relationship the protected public area establishes with the encompassing landscape, including the Douro river mouth and the sea (Porto Canal, 2023).

Finally, there have been heated discussions about and opposition to the concurrent uses of marine space, particularly among fishermen (O Minho/Lusa, 2023), a group that unanimously contested the preliminary proposal for deployment areas (GTOffshore, 2023; Associação de Pescadores Ribeirinha de Viana, personal communication, September 2023; Pesqueiras Associação de Pescadores do Rio Minho, personal communication, September 2023). The exploitation of offshore and nearshore wind energy is a topic of great concern for fishermen operating at the mouth of the river Minho and on the coast of the district of Viana do Castelo - until now the only ones in Portugal who have had experience in dealing with the changes imposed by an infrastructure of this type installed on the coast with the experimental project "WindFloat Atlantic". In addition, the proposed area is also a matter of interest for the fishermen who use the "Pesqueiras", the fishing grounds of the river Minho (Pesqueiras - Associação de Pescadores do Rio Minho, personal communication, September 2023) even though these sites may be located up to 90 km away from the proposed exploration area (Figure 6). The reason for this is that the latter group relies on anadromous species, such as the sea lamprey and shad, which migrate between the sea and the river basin, and it is currently unknown what impact OFWs could have on these endangered and vulnerable species (DGRM, 2023a).

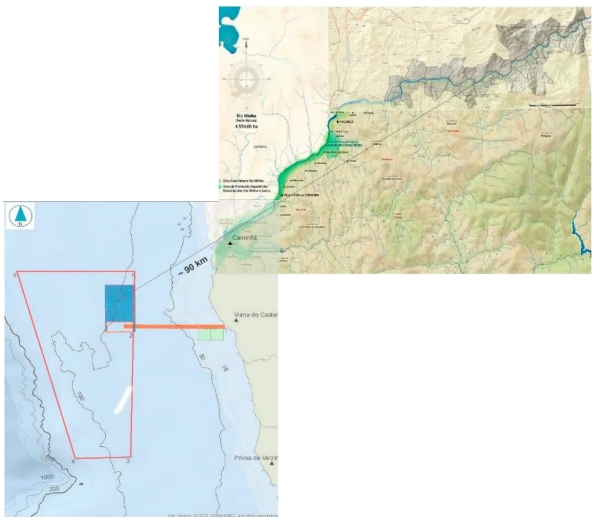

***Figure 6**. Location of "Pesqueiras"- fishing grounds of the river Minho (gray, top right) and Viana do Castelo preliminarily proposed offshore wind farm area (bottom left). Source: GTOffshore (2022) (left); Maria Fernanda Pacheco (2013) (top right)*

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The revised proposal

After conducting public hearings and supplementary sectoral meetings, the Portuguese government adjusted the suggested locations by redesigning, suppressing or splitting some areas and moving the polygons further away from the coastline (Figure 7), citing reasons related to commercial fishing, nature conservation, and national defence (GTOffshore, 2023). Despite the changes, some stakeholders, such as the Viana do Castelo fishermen's associations, opposed the result and protested that it did not fully reflect the agreement reached during the making of the plan, regretting that the polygon area still affects one of the most important fishing grounds of the region, the one known as "Secos de Viana" (Agência Lusa, 2025).

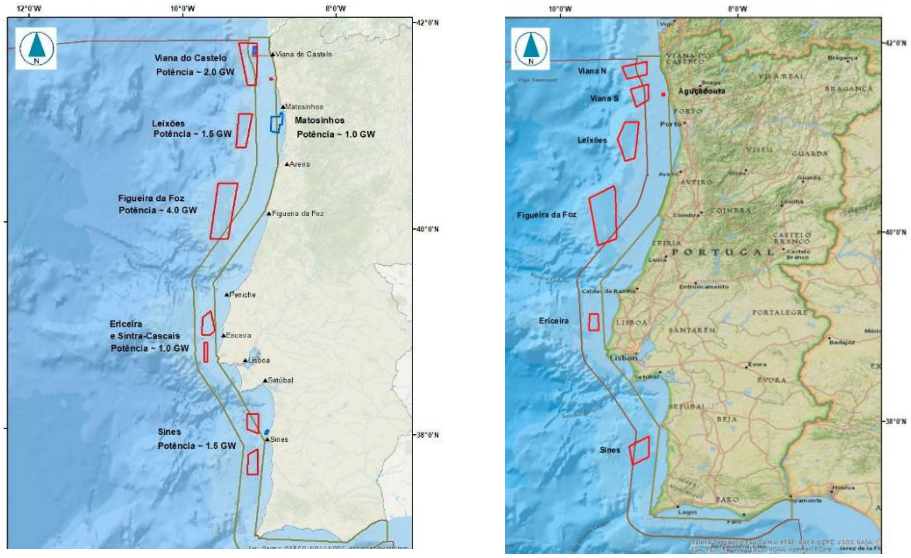

Figure 7*. Comparison of oreliminarily proposal (left) and final proposal (right). Source: GTOffshore (2022) (left) DGRM (2023b) (right)*

Discussion

The EU strategy to harness the potential of offshore renewable energy for a climate-neutral future recognises that the fulfilment of its goals will require the identification and use of a much larger number of sites for offshore renewable energy production (European Comission, 2020). However, the same strategy also assumes that spatialisation is a delicate process, as the ecological and socioeconomic impacts of exploiting designated sea spaces must be carefully balanced while also integrating other uses of the sea. We argue that a balanced outcome requires a comprehensive understanding of the seascape, recognising that the productive energy seascape is only one aspect of it, while others may also exist. It can be seen from the case that, initially, only the productive energy seascape was considered, while during the public consultation and supplementary meetings other types emerged according to the different stakeholders and networks involved (Table 1).

***Table 1**. Comparative view of the different relationships with the seascape. Author: Luís Carlos Martins Mestrinho de Medeiros Raposo*

Stakeholder	Seascape trait	Defining characteristic	Mediator
Offshore Energy Explorers	productive (wind resource)	wind potential	wind/sea bottom
Environmental NGO	existence	protected area	marine ecosystem
Environmental NGO	existence	fauna corridor	avifauna
Viana do Castelo fisheries	productive (fishing grounds)	fish habitat	ichthyofauna
Minho Estuary fisheries	productive (fishing grounds)	fish habitat	anadromous species
Municipality	cultural (scenic)	view	seascape

Interests are derived from the network of relationships established between stakeholders and the seascape in a variety of ways. Some of these relate to the qualities of the seascape, while others relate to its functioning. A number of these interests are mediated by the way the territory is used, not by the stakeholders themselves, as might initially be thought, but by non-human species. This phenomenon has been demonstrated by the examples of the Berlengas archipelago, where the proposed “Ericeira area” was later suppressed, and the coast of Viana do Castelo, where a particular fishing ground still sparks controversy. Furthermore, in the case of the Minho estuary, the way in which the anadromous fish use the marine territory has considerably expanded the area in which there are stakeholders in the development of the offshore project. Consequently, when planning the spatial arrangement of maritime infrastructure such as offshore platforms, it is essential to recognise a three-dimensional space that is embedded in a network of social relations between different actors operating within a broad ecosystem that includes human and non-human users of the seascape.

Thus, as shown, the allocation of space to support maritime infrastructure is likely to be more comprehensive if, as suggested by Fang et al. (2024), it is conceived in terms of the vertical stratification of the sea and considers its heterogeneous and distinct sub-layers composed of the space above, below and at the sea surface. Each component of these different layers, such as wind potential, sea bottom configuration, fish habitats, anadromous species, bird feeding grounds, can influence how different groups relate to the seascape and ultimately how they respond positively or negatively to the arrival of a new sort of seascape such as an energy seascape dominated by wind farms. This perspective may require changes in the way maritime planning is approached. For example, biodiversity is often viewed as a passive recipient of the planning process, and non-human agency is not recognised, even though, as we have seen, non-human entities can significantly influence the relationship. This was exemplified by the importance attributed to the present seascape characteristics and its relationship with the public realm, as evidenced in the case of Porto.

In this context, the quality of the urban environment is inextricably linked to the preservation of the current seascape *status quo*, and the seascape functions as a symbolic environment, mediating the relationship between the city and the sea. To mitigate this complexity, Jay (2012) proposes a relational approach, where space is seen as a dynamic sphere of interactions rather than a static plane for organising and mapping things. In fact, the European Parliament (2021) has already stressed the importance of early spatial planning to address both the placement and the layout of OFWs in a way that includes all the relevant stakeholders

and calls for effective participation to be set up at an early stage, to reduce and avoid conflicts. Nevertheless, the case study demonstrates a phenomenon that has been identified in the literature: in sustainable transition processes, there is a tendency to focus more on human agency and less on non-human agency (Contesse et al., 2021). What derives from the case is that when non-human agency is considered in spatial planning, it is mainly in economic terms of productivity (in this case wind potential and sea bottom configuration). However, as demonstrated, it should be noted that non-human agency may influence other stakeholder relationships with the seascape, expanding this group both in terms of its diversity and territorial extent. In addition, the case study shows that the process can easily take an economically driven approach[1], and that extensive participation may only occur at a later stage, leading to mistrust and avoidable conflicts.

Conclusion

Based on the analysis of the case study, it is likely that seascapes can be as controversial as landscapes in the planning of wind farms. This study reinforces what has already been noted in literature, that OFWs cannot be seen as a simple solution to mitigate resistance to onshore wind farms, as marine areas, like their land counterparts, can be seen as contested places. The case study also revealed that, despite recommended best practices and political guidance, stakeholders with strong ties to the seascape were not involved in the decision-making process from the earliest stages. This has led to mistrust and strong opposition in areas where the use of the sea is seen as conflicting, as in the case of the “Secos de Viana” fishing grounds, which remain controversial even after the legal diploma (República Portuguesa, 2025) approving the spatial allocation of the exploration areas has been sanctioned.

Given the urgent need to develop energy infrastructure at sea, future research should focus on investigating best practices or models for early stakeholder identification, including non-human stakeholders as suggested by Hernandez-Santin et al. (2023) and foster early engagement, as the public hearing tool has shown its limitations in building trust among stakeholders. Finally, it has been shown that certain aspects of the seascape, such as the dynamic flows that take place above and below the water level, cannot be overlooked when assessing the location of a marine infrastructure, as they have a non-human agency and are capable to influence how the different groups would relate to the seascape and have the potential to greatly affect how we measure the footprint of the project. This paper contributes to the field by demonstrating that the environmental characteristics associated with the seascape and the social construct formed between society and the seascape are capable of conditioning project viability and acceptance. It highlights the fact that the planning of offshore wind infrastructure is not only about considering how the spatial arrangement affects stakeholders, but also about understanding how the actor-network relationship is formed in such a way that the seascape itself is an actant capable of shaping this relationship with the public, resulting in the composition of the stakeholder spectrum and the level of social acceptance of a project.

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[1] The composition of the Interministerial Working Group supports this evidence.

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Towards a heterogeneous data processing method to support planners in increasing climate resilience: An application on urban heat waves

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The urgency of addressing climate change-induced risks is internationally recognised. However, urban and territorial contexts do not yet appear ready to face this challenge. Based on the state of the art, this research proposes the definition of an innovative method for mapping heterogeneous data to support planners in increasing climate resilience. The application of the research project presented in this paper focuses on heat waves in the urban area of the Municipality of Lamezia Terme (Calabria Region, Italy). Taking into account climatic and non-climatic information, the results are useful for planners to identify priority areas and subsequently define an action plan containing appropriate adaptation measures.

***Keywords*:** urban planning, climate change, adaptation, urban heat waves, Italy

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Introduction

Planners are committed to increasing the liveability of the urban and regional environments (Sheikh & van Ameijde, 2022), holistically addressing (Schirru, 2018; Kramar et al., 2019; Uehara, 2019; Declerck et al., 2023) the complex challenges posed by contemporaneity. Among these, the rapid climate changes require a rethinking of urban and regional development models, aimed at stimulating the resilience of infrastructures and communities (Marschütz et al., 2020). Internationally, climate-related risks pose a major threat to urban safety, infrastructure stability and socio-economic sustainability (Sun et al., 2021). In recent years, the notion of resilience has become highly popular in both research and practice (Wardekker, 2021), firmly entering the discipline of urban planning, which is committed to addressing the vulnerabilities and cities' exposure to present and future hazards, particularly related to climate change effects (Caldarice et al., 2021). In the context of climate change, the concept of resilience is inherently malleable (Wardekker, 2021), sometimes being uncertain and controversial (Taylor & Bhasme, 2021), as it can be framed in different ways, emphasising different problems, causes, and solutions. In general, the most resilient areas are those with the highest levels of adaptive capacity.

According to Zhan-Yun (2021), integrating climate change adaptation goals into spatial planning has become an international mainstream policy. He highlights a number of problems and challenges related to the implementation of effective adaptive planning, linked, for example, to the mismatch between climate change risk assessment and spatial planning scale, the lack of coordination mechanisms of adaptation and mitigation strategies, and the imperfection of technical standards. Although the author refers to the Chinese case, the picture he outlines also appropriately describes the situation in many European countries (Greiving & Fleischhauer, 2016), including Italy. In fact, despite the increasing attention to urban resilience, its implementation at the local scale and the required increasing ambition are still lagging (Caldarice et al., 2021), also due to a lack of dialogue among researchers (the scientific level), policymakers (the normative level) and practitioners (the operational level).

From a regulatory point of view, Italy approved the National Climate Change Adaptation Plan in 2023 to guide the planning of adaptation policies at the national and, above all, regional and local levels, in the short and long term. However, based on a first analysis of the document, this does not seem to provide precise operational guidance in relation to its local implementation, which, however, appears necessary. In fact, currently, only a few Italian cities, and especially large ones, have implemented local climate adaptation plans.

Taking these needs into account, this paper presents some results of a research project funded under the University of Calabria's competitive call—Rectoral Decree 1101/2022 of 29/07/2022. The project aims to increase the climate resilience of infrastructure and communities, alludes to the need to put in place appropriate planning measures to adapt urban and territorial contexts to contain climate change impacts (Cobbinah, 2021), extending this reflection to rural and coastal areas and not only to urban areas. The research activities, also presented during the 18th AESOP Young Academics Conference in Milan in 2024, are divided into three main phases, some of which are partially presented in this paper. The first phase includes the analysis of the state of the art in order to deepen the theories and the main results of existing research in the literature and identify any gaps to be filled. The second phase coincides with the definition of a digital platform to evaluate and map the domains of local risk to climate change (Palermo et al., 2025) and the development of the subsequent action plan containing the abacus of adaptation measures. The third phase refers to the application and validation of the results and consists of testing the research product in local sample contexts.

Conceptually, the main reference for the research project is the contribution of the 2022 Intergovernmental Panel on Climate Change (IPCC), which assesses the impacts of climate change and identifies four key risk categories for Europe (Pörtner et al., 2022). The first risk relates to heat waves, which have adverse effects on human life, ecosystems and society, affecting mainly urban areas. Literature studies on climate change predict that global warming will increase the severity, duration, and frequency of heat waves. Therefore, understanding the evolution of the phenomenon is a central issue with high relevance for society (Chitsaz et al., 2023). The second risk relates to agricultural production because changes in climatic events such as temperature and rainfall significantly affect the yield of crops (Malhi et al., 2021). The third risk relates to the scarcity of water resources, which requires a refocus on reliable and sustainable water supplies, especially in arid and semi-arid regions, which are the most water-deprived regions in the world (Shevah, 2015). The fourth risk is induced by increased frequency and intensity of flooding because, also according to Kundzewicz (2005), over time, hydrological variables, such as precipitation, river flow, soil moisture and groundwater levels, display strong spatial and temporal variability.

These four categories constitute the characterising elements of the general climate change risks framework, which is the subject of the theoretical and methodological study published in Palermo & Chieffallo (2024) and briefly described below. However, this paper will refer only to heat wave risk linked to the increase in average temperatures (Beasley et al., 2023; Jeong et al., 2023) and to urban morphology (López-Casado & Fernández-Salinas, 2023; Naserikia et al., 2023; Venerandi et al., 2023). For these reasons, this risk is particularly high in urban areas. Urban planning responses are crucial to improving the capacity of cities and communities to deal with significant temperature variations across seasons (Jeon et al., 2023). To this end, this study proposes the application of the above-mentioned digital platform, which facilitates the integration between climatic and non-climatic information, useful for planners to identify priorities for action in the context of experimentation.

Background: lessons learned from the state of the art

As part of the general research project, to identify the main lines of research (RQ) for the four key risk categories defined by the sixth assessment report of the IPCC (Pörtner et al., 2022), a multiple Systematic Literature Review (SLR) process was conducted to explore quantitatively and qualitatively the state of the art in the period from 2013 to 2023 in the international context. By accessing the Scopus electronic literature database and applying specific inclusion and exclusion criteria for documents, a bibliometric network was extracted (Figure 1) consisting of 2,085 relevant documents (600 relating to heat wave risks, 392 relating to risks for agricultural production, 240 relating to risks of scarcity of water resources and 853 relating to the risks arising from flooding). The analysis of the documents' main information shows a growth rate of scientific production of around 20 %. The selected documents are, on average, signed by 5 authors and have an average of citations per document close to 30.

The data of the bibliometric network were collected and organised to elaborate synthesis results in graphic and tabular form. A Cluster Analysis (CA) technique has been applied to the set of keywords contained in the selected documents. CA is a purely statistical technique of typological research that allows one to interpret the selected literature from a qualitative point of view, identifying homogeneous thematic sub-classes based on different characteristics (Green et al., 1967). In this case, the co-occurrence of keywords is considered to be representative of the contents of the documents. The results allow the generation of research hypotheses on possible latent structures that contribute to the characterisation of the research topic. To this end, the VOSviewer software was used to extract the cluster map with the

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keywords that co-occur more than 28 times in the Network Visualisation (Figure 2). As anticipated, this paper refers only to the results relating to heat wave risk. This choice is motivated by the increasing frequency and intensity of the phenomenon in urban areas, confirmed by the literature.

RQ(I) «What are the main lines of research related to heat wave risks?»

Timespan	Sources	Annual Growth Rate
2013:2023	266	21.04%
Authors	**Authors of single-authored docs**	**Co-Authors per Doc**
2839	36	5.75
Author's Keywords	**References**	**Average citations per Doc**
1584	35074	29.7

RQ(II) «What are the main lines of research related to risks for agricultural production?»

Timespan	Sources	Annual Growth Rate
2013:2023	201	25.47%
Authors	**Authors of single-authored docs**	**Co-Authors per Doc**
1866	24	5.12
Author's Keywords	**References**	**Average citations per Doc**
1286	25431	32.29

RQ(III) «What are the main lines of research related to the risks of water scarcity?»

Timespan	Sources	Annual Growth Rate
2013:2023	140	19.95%
Authors	**Authors of single-authored docs**	**Co-Authors per Doc**
1083	14	4.85
Author's Keywords	**References**	**Average citations per Doc**
832	16513	28.48

RQ(IV) «What are the main lines of research related to the risks produced by floods?»

Timespan	Sources	Annual Growth Rate
2013:2023	302	24.03%
Authors	**Authors of single-authored docs**	**Co-Authors per Doc**
3633	38	4.94
Author's Keywords	**References**	**Average citations per Doc**
2463	51792	22.79

Figure 1. *Main information on SLR documents. Source: author's elaboration of Bibliometrix results*

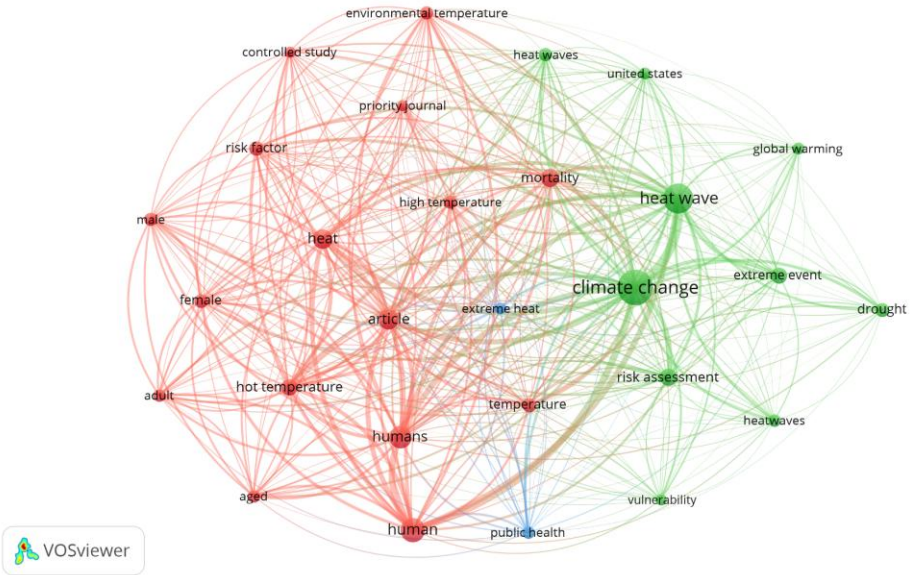

Figure 2. *Network Visualisation related to RQ(I). Source: author's elaboration of VOSviewer results*

Three thematic clusters of literature about heat waves emerge from the bibliometric network. They are characterised by different colours. Cluster 1 (in red) concerns climate-related risks'

environmental characterisation. Cluster 2 (in green) concerns heat wave assessment tools. Cluster 3 (in blue) concerns the effects of extreme heat on public health.

Documents of cluster 1 highlight how some elements (such as the orographic complexity of the territory) can profoundly influence the rainfall regime and the change in temperatures during the year. To these, additional "environmental" factors related to land use are added, such as the layout of buildings and other structures (Demdoum et al., 2023) within the urbanised area, and the presence of vegetation, which has mitigating effects on the surface temperature (Ossola et al., 2021).

The most recent literature of cluster 2 contains different risk assessment methods that mainly refer to temperature and humidity (Arshad et al., 2020; Cho, 2020; Cotlier & Jimenez, 2022; Wu et al., 2022; Dayan et al., 2023; Quesada-Ganuza et al., 2023), which are among the main variables influencing environmental stress (Infusino et al., 2021). The expectation that climate change can further exacerbate extreme weather events such as heat waves is of primary concern to policymakers and scientists (Vanderplanken et al., 2021). For this reason, urban planning instruments require a strategic view that enables the integration of climate change variables within ordinary knowledge frameworks.

Finally, considering cluster 3, the effects of extreme heat waves on health appear related to many interrelated factors. The extreme climatic events that have occurred in recent years show the inadequacy of cities in facing the changes (Bassolino & Verde, 2023), which seriously affect health and social systems and threaten ecological diversity worldwide (Klingelhöfer et al., 2023). Urban heat islands are frequently formed. This is a microclimatic phenomenon that especially affects urban areas, resulting in significant temperature increases in the local microclimate that can amplify heat waves, causing thermal discomfort and a reduction in the levels of quality of life (Leal Filho et al., 2021). Literature researches appear to be mainly oriented towards identifying the most vulnerable population, including the elderly, children and fragile subjects suffering from cardiovascular and respiratory diseases. Identifying the population and locations that are under high risk is important in urban planning and design policy making as well as health interventions (Cheng et al., 2021).

From a general point of view, the deepening of the clusters related to the other three risk categories defined by Pörtner (2022), not covered by this paper, has revealed the presence of more or less strong correlations with environmental characteristics, social, and economic aspects associated with urban, rural and coastal areas. Heat wave risks are a priority issue in urban areas, risks to agricultural production and water scarcity are important in rural areas, and flood risks are crucial for coastal areas. This result represents the starting point for the definition of the research product, which cannot consider the risk categories separately but must be oriented towards their integration. Selected literature has highlighted the existence of sector studies aimed at individual risk categories conducted by specialists (Al-Omari et al., 2024; Benami et al., 2021; Dubey et al., 2021; Huang et al., 2024; Sun et al., 2022). For this reason, a single multi-risk framework was defined in the research project, which is easily applicable by urban and regional planners. The framework still allows detailed analyses to be carried out on individual risk categories referring to specific areas of study. In this regard, this paper offers an in-depth analysis of heat waves which particularly affect urban areas.

Data and methods

The general research project aims to fill a specific gap in the literature, which is the lack of an integrated and operational tool to support planning activities aimed at increasing climate resilience by intervening as a priority in the most vulnerable sites. To this end, vulnerability is

the component of climate risk on which attention is focused. According to the sixth assessment report of the IPCC (Pörtner et al., 2022), vulnerability represents the result of the interaction between climate change sensitivity and the adaptive capacity of a system or region. Based on evidence provided by the SLR, this research proposes a heterogeneous processing method for data acquired, including climatic and non-climatic information relevant for spatial planning (Daniels et al., 2020), to fill the most relevant decision-making needs. In particular, climatic information describes the component of sensitivity, while non-climatic information refers to the adaptive capacity. The aim is to integrate this information into the digital platform for assessing local climatic vulnerability, creating charts, tables, and spatial mapping of data.

As anticipated, this paper focuses on the phenomenon of heat waves, which is among the most relevant extreme climatic events due to the effects on society, agriculture and the environment (Molina et al., 2020). In recent decades, unprecedented extreme summer heat waves have occurred in Europe, and they have exhibited an increasing trend since the 1970s (Zhang et al., 2020). Similar weather conditions have also affected Italy (Fontana et al., 2015), with particularly intense effects in urban areas, but also in rural areas, where they negatively affected agricultural production (Di Blasi et al., 2023).

As part of the general climate change risks framework (Figure 3), climatic and non-climatic information for the development of the digital platform for assessing local climatic vulnerability with respect to heat waves is explained below, including technical definitions and descriptions.

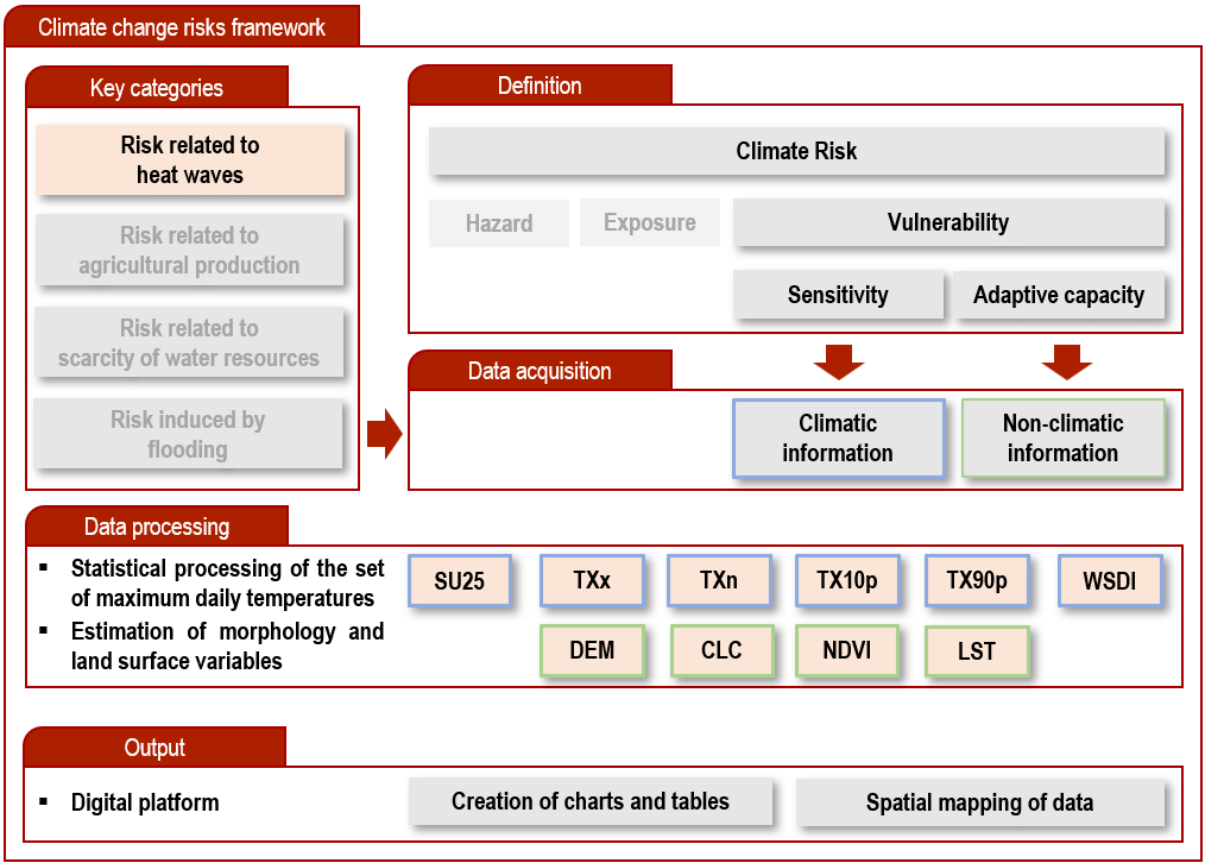

Figure 3. *Diagram of the general climate change risks framework with operational workflow (data acquisition, data processing and output) related to heat waves. Source: author's elaboration*

Climatic information consists of indices useful in describing changes in the intensity, frequency and duration of temperature (Peterson et al., 2001; Zuccaro & Leone, 2021). Climate is an abstraction obtained by statistically processing the set of meteorological variables in order to develop appropriate climate indices (Mariani, 2006). These indices are recommended by the ccl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI) and are identified among the most representative of the Italian climate (Francini et al., 2020), also by the National Institute for Environmental Protection and Research (called ISPRA). The research has identified the following indices to characterise the observed climate trends (Palermo et al., 2025):

- SU25, the annual count of days when the daily maximum is above 25 °C;
- TXx, the annual maximum value of daily maximum temperature;
- TXn, the annual minimum value of daily maximum temperature;
- TX10p, the annual percentage of cold days (a cold day occurs when the temperature is less than the 10th percentile of the daily annual series);
- TX90p, the annual percentage of hot days (a hot day occurs when the temperature is greater than the 90th percentile of the daily annual series);
- WSDI, the duration of a warm spell (a “warm spell” is defined as at least 6 consecutive days where the daily maximum temperature exceeds the 90th percentile of the daily annual series).

SU25, TX10p and TX90p are threshold indices. TXx and TXn are absolute indices. WSDI is a duration index. These indices allow one to trace the local climate profile of the context of interest, based on the acquisition of the time series of the maximum daily temperatures recorded by monitoring stations equipped with a thermometer. The indices can be calculated for each year of observation according to their definitions.

This information is then compared with non-climatic information. Among these, land cover data recorded by Landsat satellite images (Pappalardo et al., 2023) are very important, as they allow for the calculation of the Normalised Difference Vegetation Index (NDVI) and the estimation of Land Surface Temperature (LST) according to the formulations of Yuan & Bauer (2007) and Stathopoulou & Cartalis (2007). The NDVI index measures the vigour and density of vegetation. The LST index represents the temperature of the Earth’s surface. At this stage of the research, the outputs refer to individual indices, as the definition of the synthesis procedure useful for developing the vulnerability mapping is being validated.

Results

The research identifies the Municipality of Lamezia Terme (Calabria Region, Italy) as a case study, in order to investigate a representative context of urban, rural and coastal areas. Focusing on heat waves, the study area coincides with the urban area identified in Figure 4. This study area hosts about 78 % of the entire municipal population in a territory that extends for 1,375 ha (8.6 % of the municipal area) with an altitude between 100 and 340 m above sea level.

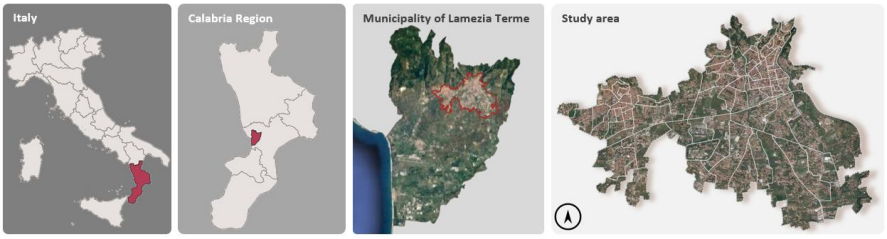

Figure 4. *Location of the study area. Source: author’s elaboration*

Climatic information

Climatic information is compiled on the basis of official data measured over a 10-year time span. These data are provided by the Regional Environment Agency (called ARPACAL) and consist of the maximum daily temperatures (Figure 5) recorded from 2014 to 2023 by the ARPACAL station number 2940 called “Nicastro-Bella”, active in remote control and located near the study area.

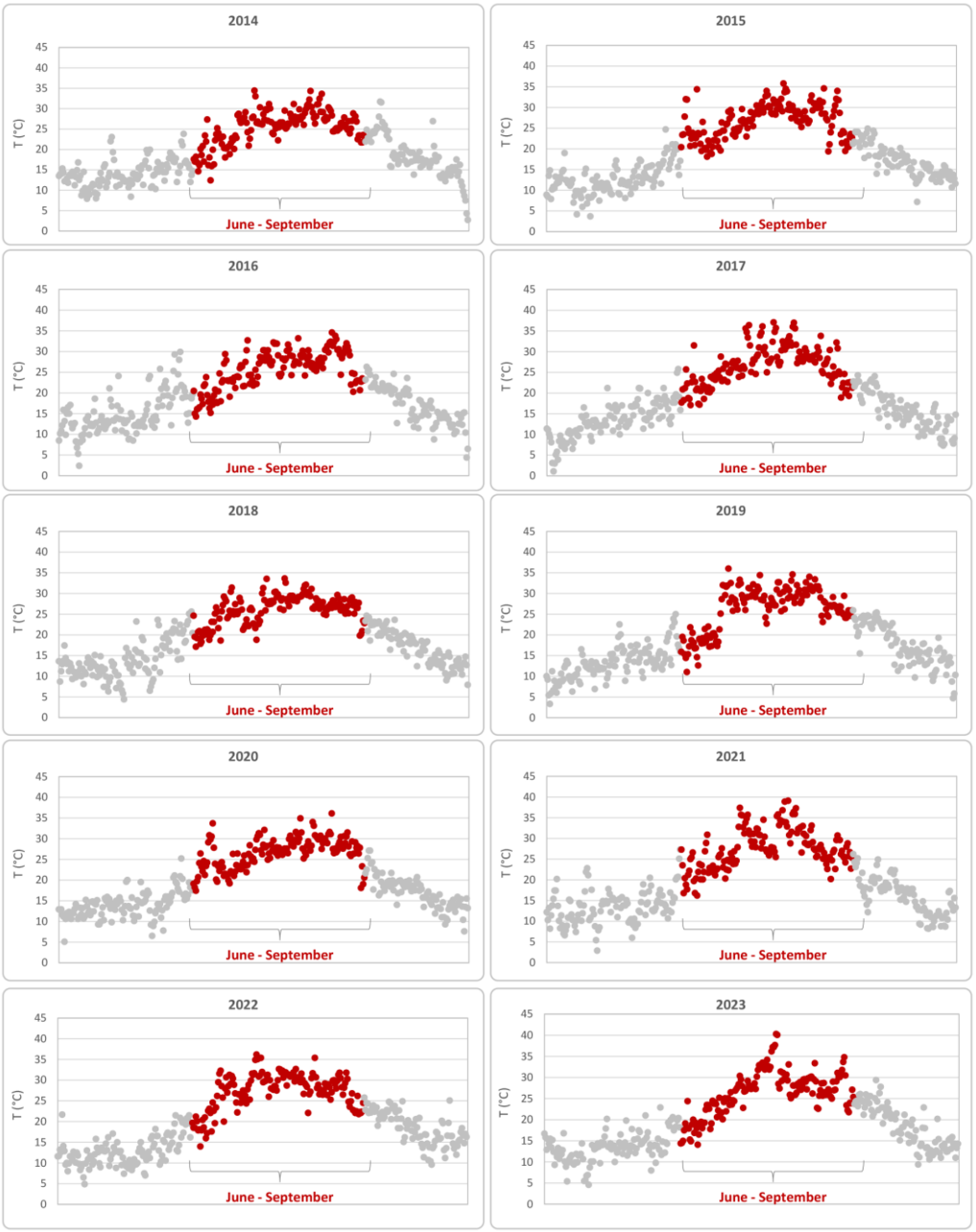

Figure 5. *Annual graphs of the time series of maximum daily temperatures. Source: author’s elaboration of ARPACAL data*

Table 1 contains the climatic information obtained by statistically processing the time series of maximum daily temperatures.

Table 1. *Climatic information. Source: author's elaboration*

ID	Unit of measure	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
SU25	Days	105	94	97	95	109	111	111	112	115	108
TXx	°C	34.4	35.8	34.6	37.1	33.6	36	36.1	39.1	36.2	40.3
TXn	°C	4.3	3.7	2.4	1.1	4.4	3.3	5.1	2.9	4.9	4.6
TX10p	%	9.8	9.8	9.8	9.8	9.6	9.6	9.6	9.3	9.6	9.6
TX90p	%	10.1	9.6	10.1	9.8	10.1	11.5	9.8	9.8	9.8	9.6
WSDI	Days	14	0	19	20	13	0	8	30	16	27

Non-climatic information

Further analysis of the area yielded non-climatic information. The main results are shown in Figure 6.

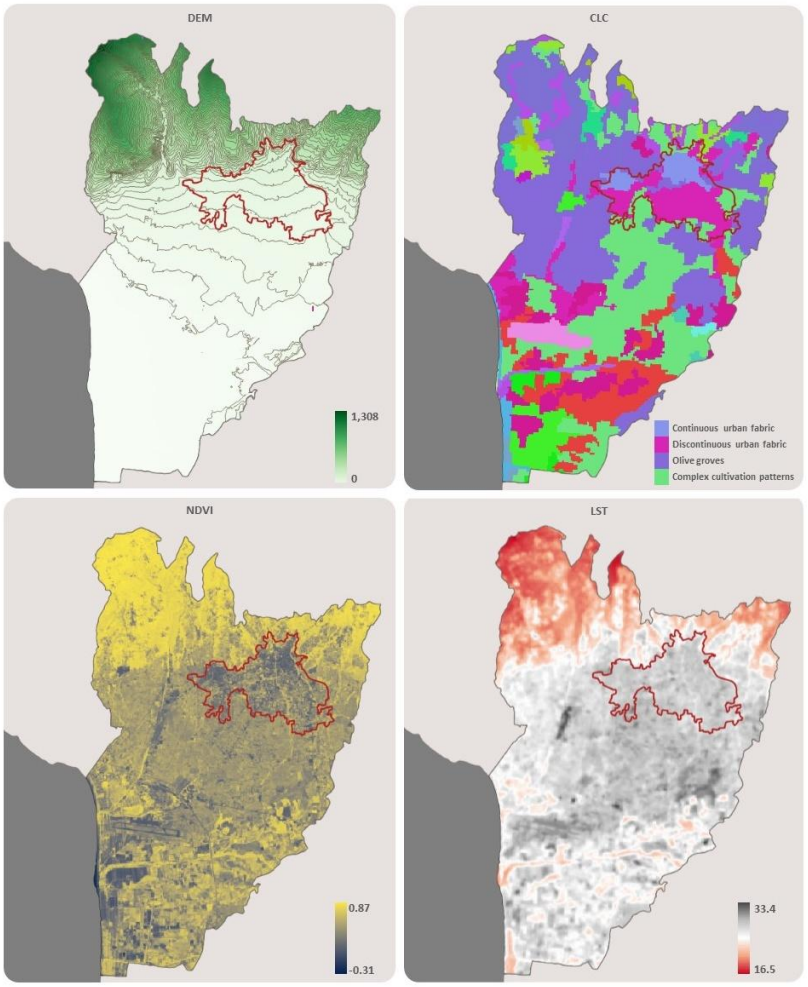

Figure 6. *Mapping of non-climatic information. Source: author's elaboration*

The non-climatic information was obtained in a Geographic Information Systems (GIS) environment and concerns four factors. The first factor is the orographic profile of the territory, reconstructed through the Digital Elevation Model (DEM), with a regular grid at a spatial resolution of 5 meters, from which it was possible to digitise the contour lines in vector format by setting the desired spatial range.

The second factor is land use, analysed using data from the Corine Land Cover (CLC) programme. This classification is useful because urbanisation has been contributing to the intensification of urban heat islands (Hellings & Rienow, 2021). The third factor coincides with the Normalised Difference Vegetation Index (NDVI), one of the most widely used vegetation indices in the literature, that effectively illustrates the spatial distribution and growth status of vegetation (Spruce et al., 2011; Wang et al., 2023). Finally, the last factor coincides with the Land Surface Temperature (LST) that fluctuates more and more rapidly, causing climate change and degradation of human life on a local-global scale (Sarif et al., 2022). The NDVI and LST factors were mapped by processing satellite images for bands 4, 5 and 10 of Landsat 9, taken on 27 August 2023, when the ARPACAL station “Nicastro-Bella” recorded the highest temperature of August.

Discussion and conclusion

This research has addressed heat wave risk as one of the climate change risk categories (Pörtner, 2022), with a focus on urban areas. However, as anticipated, the overall research product will be oriented towards the integration of the four risk categories, also extending the analysis to rural and coastal areas. Therefore, the results presented here relate only to some of the elements that will flow into the digital platform for the assessment of vulnerability to climate change and the development of related mapping. The results represent some of the climatic and non-climatic information relevant for decisions in relation to heat waves or the identification of specific adaptation measures.

The climatic information has been obtained by elaborating the time series of maximum temperatures, of which the descriptive statistics are reported below (Table 2), useful for the discussion of the results.

Table 2. *Descriptive statistics on climatic information. Source: author’s elaboration*

Index	SU25	TXx	TXn	TX10p	TX90p	WSDI
Mean	103.9	36.2	3.5	9.6	10.0	13.8
Standard error	2.4	0.5	0.4	0.1	0.1	2.9
Median	106.5	35.9	3.7	9.6	9.8	15.0
Mode	111.0	35.8	3.7	9.8	9.8	0.0
Standard deviation	8.3	1.9	1.3	0.2	0.5	10.2
Sample variance	69.7	3.6	1.6	0.0	0.3	103.6
Kurtosis	-1.4	1.0	-0.5	0.0	8.6	-0.9
Asymmetry	-0.4	1.1	-0.6	-0.9	2.8	-0.1
Range	25	6.7	4	0.5	1.9	30
Minimum	90	33.6	1.1	9.3	9.6	0
Maximum	115	40.3	5.1	9.8	11.5	30

The highest temperatures are recorded during the extended summer period, from June to September (the highest temperature ever in the reference period is 40.3 °C, recorded on 24

July 2023), with episodes of intense and prolonged heat increasingly frequent. The periods of heat are identified by the WSDI index, which expresses the duration, in number of days, of periods consisting of at least 6 consecutive days in which the temperature is greater than that associated with the 90th percentile annual series. In the climatological period considered, on average, these periods last 13 days, but the results are very variable. In fact, while in some years there are no warm periods (2015, 2019), more recently, such periods had values much higher than the average value, with peaks of 30 days in 2021 and 27 days in 2023. Similar trends are also recorded for other indices, such as SU25, which expresses the number of days per year in which the temperature exceeds 25°C, reaching its peak in 2022, equal to 115 days. With regard to climatic information, future development of the research plan will extend the climatic reference period by analysing the average values of climatic quantities over a longer period of time, equal to thirty years. In addition, it is also intended to take into account further time series, namely those relating to minimum temperatures and precipitation, in order to derive appropriate representative indices.

Compared to non-climatic information, the information presented in the paper represents only some of the factors that affect the urban microclimate, contributing to the phenomenon of heat island in areas with high soil consumption and low tree cover. Future developments of the research foresee defining analytical activities of synthesis and aggregation of the aforementioned factors, to offer an integrated vision of the entire informative patrimony and provide more useful information to support the planning choices.

Indeed, the elaboration of the information proposed in this study could provide a guideline for building climate-resilient infrastructures and communities. In addition to identifying priority areas for action, the results help to define an action plan containing appropriate adaptation measures. The results obtained considering individual parameters can support administrations in defining intervention priorities and can also be easily integrated into existing GIS. Specifically, the research aims to promote climate-adaptive planning in local contexts, starting with the identification of the most vulnerable areas where climate-effective interventions can be supported, including the morphological reconfiguration of urban spaces aimed at, for example, increasing tree cover and removing high-emissivity surfaces. For example, in this specific case, the following actions are required on the settlement system:

- promoting the containment of soil sealing;
- supporting the development of green infrastructure;
- indicating requirements for materials that limit the heat absorption of buildings and soils;
- starting experimental building adaptation.

The methodological approach resulting from the study of literature described in this paper, albeit synthetically and still in progress, meets the ambition of the research to define a scalable framework that can guide the planner in choosing the most appropriate adaptation actions according to the characteristics of the context. This goal is essential to efficiently plan and implement resilient contexts, avoiding irreversible environmental, economic, and social problems in the foreseeable future.

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Serial retrofitting as a bottom-up innovation for sustainability: Application of the multi-level perspective

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Serial retrofitting represents a crucial advancement in urban sustainability, addressing cost increases, resource constraints, and labour shortages within the building sector. “Energiesprong Deutschland”, coordinated by the German Energy Agency (dena), is a pioneering initiative for the retrofitting of 1950s–1970s multi-family housing through cost- and time-efficient solutions utilising industrial prefabrication and standardised components.

Within the study, the role of serial retrofitting as a transformative innovation within the energy transition is assessed using Geels’ multi-level perspective, examining its establishment and potential for future system change within the context of the “Great Transformation”. The analysis reveals six interdependent feedback loops governing diffusion dynamics: performance monitoring, scalability dynamics, financial maturation, market co-evolution, market acceptance, and social acceptance.

Serial retrofitting remains positioned within the early diffusion phase of the multi-level perspective framework. The study identifies three targeted intervention pathways: regulatory harmonisation, cultural transformation within the construction sector and innovative financing mechanisms. To expedite regime reconfiguration, various measures are required at political, institutional, social, cultural, research, and market levels. Serial retrofitting offers a future-oriented solution for transforming the building sector in alignment with the political agenda. By combining integrated technical, economic, and social efforts, it promises significant contributions to the decarbonisation and sustainable development of the building stock.

Keywords: energy transition, retrofitting measures, building stock, multi-level perspective, urban sustainability

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Introduction

The energy transition represents one of the greatest challenges of the 21st century, with the building sector being a critical focus due to its contribution of 40 % of energy consumption and 36 % of greenhouse gas emissions globally (Königstein, 2024). In Germany, the building sector accounts for approximately one-third of CO_2 emissions (Thamling et al., 2023).

Adopted in 2015 as part of the UN Climate Change Conference, the Paris Climate Agreement is a multilateral treaty that obliges signatory states to limit the increase in global average temperature to below 2°C compared to pre-industrial levels (UNFCCC, 2023). The "European Green Deal" (EGD), a key component of the European Union's "Agenda 2030", aims for greenhouse gas neutrality by 2050. This target is legally binding under the provisions of the European Climate Law (EU, 2023; Schubert et al., 2023). A particular emphasis is placed on the promotion of energy efficiency and affordability in existing buildings and on the "Renovation Wave" strategy, which aims to increase the renovation rate from 1 % to 2 % by 2030. Additionally, the Energy Performance of Buildings Directive (EPBD) aims to establish a harmonised system of energy efficiency classes across the EU. This directive focuses on buildings with the highest energy consumption, categorised as "worst performing buildings" (WPB) (EC, 2020; BPIE, 2024).

Germany has aligned its climate protection goals with these international commitments. The Climate Protection Act of 2019 sets binding targets for reducing emissions and establishes a path to net greenhouse gas neutrality by 2045. It mandates reducing greenhouse gas emissions by at least 65 % by 2030 and 88 % by 2040 (Umweltbundesamt, 2023). Germany has established building energy efficiency requirements in phases since 1977, beginning with prescriptive thermal standards and evolving to performance-based codes following EU directives in 2002. The Building Energy Act (GEG) aims to reduce energy consumption and CO_2 emissions in the building sector whilst encouraging the use of renewable energies (EnEV-online, 2020). Furthermore, the Climate Action Programme 2030, initiated in 2019, contains interdisciplinary measures to reduce CO_2 emissions, including the implementation of a carbon price for transport and heating (Bundesregierung, 2019).

Since its inception in 2017, the German Energy Agency "Deutsche Energie-Agentur (dena)", supported by the German Federal Ministry for Economic Affairs and Energy, has been addressing these challenges through the "Energiesprong Deutschland" initiative by developing a new market sector within the retrofitting industry. In Germany, serial retrofitting focuses on multi-family houses built between the 1950s and 1970s, which account for 53 % of German households (Schumacher et al., 2023). Following the successful completion of the pilot phase, the innovative retrofitting approach is planned to be extended to other building types. Whilst the Netherlands has progressed beyond the pilot phase, similar initiatives are developing in France, the UK, Italy, Canada and the United States (Hermann et al., 2021; Energiesprong International, 2023).

Current state of serial retrofitting in Germany

Germany has adopted the Dutch "Stroomversnelling" strategy, which was launched in 2010 to renovate high-consumption buildings to net-zero standard. This strategy involves using digitalised and standardised processes, prefabricated roof and facade modules, and modernising building technology (dena, 2023). This approach, known as serial retrofitting, addresses labour shortages, gas dependency, and rising inflation and energy costs whilst promoting low-carbon urban development.

In Germany, “Energiesprong” acts as an independent market development team assisting housing and construction companies in developing advanced retrofitting solutions. The building’s suitability is evaluated based on specific criteria including storey count, building cubage, solar-to-living space ratio, minimum living space of 1.000 square metres, and energy consumption of approximately 130 kWh/(m²a) (dena, 2024). The retrofitting process begins with precise 3D measurement to create a “digital twin”, followed by digitised planning and prefabrication of modules. The facade and roof modules are prefabricated to reduce on-site time and minimise disruption for tenants. After on-site assembly of the prefabricated modules, the monitoring phase begins (Hörnemann, 2023). Based on these requirements, the German market comprises an estimated 500.000 suitable buildings with three million residential units, representing an estimated market volume exceeding €100 billion (Yildiz et al., 2022). Projections indicate potential savings of 158 TWh in final energy and around 36 Mt of CO_2 between 2022 and 2050 (Hermann et al., 2021).

Currently in the initiative’s pilot phase, eleven projects (194 residential units) have already been successfully completed as of June 2023, with twelve projects (433 residential units) under implementation and a further 102 projects (9.496 residential units) in the planning phase (dena, 2023). The pilot projects are promoted in a targeted manner to raise awareness of the benefits and potential and to encourage service providers to enter the market segment.

Financial support mechanisms include Europe-wide funding instruments, such as the “Interreg Mustbe0” programme, which supported the first pilot projects (Interreg, 2021). Germany’s “Federal Funding Programme for Efficient Buildings” (BEG) provides loan subsidies and repayment incentives for nationwide projects, alongside specialised bonuses for serial retrofitting (e.g. EE Class Bonus, SerSan Bonus) and worst-performing buildings (WPB bonus) (ÖkoZentrum NRW, 2023). Additional funding has been allocated by the Federal Ministry of Economics and Climate Protection (BMWK) through the “Federal Funding for Serial Retrofitting” programme and state-specific subsidies such as North Rhine-Westphalia’s “RL MOD NRW 2023”. In combination with the federal subsidy, repayment discounts of up to 55 % are available (BAFA, 2023; MHKBD NRW, 2023).

Literature reviews on sustainable and serial retrofitting

The need for sustainable building retrofitting as a pillar of the energy transition is widely recognised in both academic and policy discourse. A substantial body of research has demonstrated that the retrofitting of energy-inefficient buildings contributes to a reduction in the carbon footprint, thereby ensuring greater future-proofing of buildings and reducing dependence on fossil fuels (Königstein, 2024; Eßmann et al., 2022; Helmrich et al., 2021). Furthermore, the retrofitting of energy-inefficient buildings has been demonstrated to provide long-term economic benefits through savings in energy and operating costs (Galvin, 2023; Sebi et al., 2018; Henger et al., 2017).

When looking more closely at the topic of serial retrofitting, we can find a large number of market studies and publications on the barriers and potentials for serial retrofitting of the German multi-family building stock. Existing studies predominantly focus on market dynamics. These studies quantify the green premium for energy-efficient properties and project cost savings through industrialised retrofitting methods such as prefabricated facades and modular components (Agora Energiewende et al., 2024; Yildiz et al., 2022; Hermann et al., 2021). However, they focus primarily on economic and technical paradigms. The emphasis falls on quantifiable outcomes such as CO_2 reduction targets or scalability challenges (e.g. shortage

of skilled labour, federalism, supply bottlenecks). Less attention is paid to the transformation process itself. Nevertheless, this is crucial for comprehending whether a niche innovation can transform into systemic change and how serial retrofitting can influence future systems. To date, the transformation process of serial retrofitting has not been analysed in the existing literature—a gap that this study addresses using the multi-level perspective (MLP).

Objective

Within the study, serial retrofitting is assessed as a transformative innovation towards the "Great Transformation" (see below) in Germany. This study applies Geels' (2002) multi-level perspective to analyse how serial retrofitting transitions from niche innovation to regime reconfiguration in Germany's building sector. It examines the interdependencies between niche innovations, regime structures, and landscape pressures as well as phase-specific barriers to diffusion, including economic, institutional, and cultural challenges. Policy-industry interventions required to align funding mechanisms, regulatory frameworks, and stakeholder incentives with Germany's 2045 decarbonisation targets are also examined. By integrating the MLP framework with case studies, the study aims to identify leverage points for accelerating systemic adoption while critically evaluating the approach's limitations in addressing socio-political dynamics.

Procedure and methodology

In this study, serial retrofitting is examined with a particular focus on energy transition. To fulfil the study's objective, a step-by-step approach is taken. First, serial retrofitting is defined as a transformative innovation based on the characteristics of the Wuppertal Institute for Climate, Environment and Energy (Fischedick et al., 2021). Second, the MLP framework is applied to provide an abstract view of serial retrofitting in a socio-technical system. This allows for a conceptual mapping of the complex, multi-dimensional interactions that lead to transformation at the level of building construction, through interfaces with civil society, culture, politics, industry, technology, and the market. The comprehensive application of the MLP framework was enabled by the literature review, market analysis and stakeholder interviews, which provided empirical data to analyse the interactions between niche innovations, regime structures and landscape pressures.

This study employed a triangulated approach comprising literature research, market analysis, and expert interviews to examine the German serial retrofitting market. The literature review followed a systematic methodology, prioritising peer-reviewed articles and reports from recognised institutions, such as the German Energy Agency (dena), published between 2015–2025, to capture contemporary developments in sustainable building modernisation and serial retrofitting.

The market analysis focused on German multi-family housing constructed between 1950 and 1970, as these structures require urgent energy-efficient retrofitting and constitute a significant portion of the residential building stock (Statistisches Bundesamt, 2022). As part of the market analysis, 14 pilot projects implemented by eight total solution providers, each specialising in a unique approach, were analysed in order to assess the practical implementation and potential of serial retrofitting. The pilot projects were systematically documented in the form of case studies. Each case study describes the project and provides general information about the project size and the stakeholders involved. The measures implemented were listed and categorised by building envelope and system technology. A comparative analysis of the projects was undertaken to gain insights into the supplier market and technological innovation integration.

The empirical study employed a qualitative research design, using semi-structured and semi-qualitative expert interviews as the primary methodological approach. The interviews incorporated a set of standard questions derived from a preliminary questionnaire, complemented by open-ended discussion components. This approach was designed to facilitate the participants' elaboration on their experiences and perspectives. The interview guide was developed both deductively from the study's objectives and inductively from the existing literature. The guidelines covered topics such as planning and execution challenges, optimisation potentials and success factors in serial retrofitting. Five respondents participated in in-depth online interviews lasting between 50 and 90 minutes. The participants were selected based on their involvement in the previously conducted case studies and their demonstrated expertise as industry professionals in serial retrofitting. Selection criteria included direct experience with prefabricated retrofit projects, decision-making roles, and active participation in project leadership positions. The participants came from different backgrounds such as engineering and business economics, ensuring diverse professional perspectives on technical and economic aspects of serial retrofitting. The sample encompassed diversity across company types, organisational scales and market approaches within the German serial retrofitting sector. Respondents represented various business models and organisational structures, ranging from established market participants to innovative specialist providers. In consideration of the emergent status of the German serial retrofitting market in June 2023, theoretical saturation was achieved efficiently as the limited number of active market participants enabled comprehensive coverage of key stakeholder perspectives.

Data was collected through audio recordings, followed by transcription and analysis using MAXQDA software. The qualitative content analysis (according to Kuckartz and Rädiker, 2022) allowed for a systematic categorisation of statements into hierarchical categories. This approach identified recurring themes central to the interaction between niche and regime, ensuring an in-depth analysis of the data and a foundation for developing interventions to scale up serial retrofitting in the German market.

Transformation research

This study adopts the Wuppertal Institute's concept of "transformation research". Transformation research seeks to address societal impacts of climate change by framing them within the so-called "Great Transformation" (Fischedick et al., 2021). The term "Great Transformation", coined in 2011 by the German Advisory Council on Global Change (WBGU), describes a far-reaching process of ecological, technological, economic, institutional, and cultural upheaval in the 21st century. The need for transformation is urgent due to the impact of climate change on society, which provides a limited timeframe for the transformation process. The transformation requires the involvement of all relevant stakeholders, who share the responsibility for implementing the transformation processes (Schneidewind, 2019).

A transformative innovation is defined as having global and long-term transferability to society, either directly or indirectly, due to its complexity and high leverage effect. Such innovations employ radical approaches to achieve greenhouse gas neutrality and resource conservation and prioritise high-impact changes that have the potential to shape or transform systems (Fischedick et al., 2021). This study analyses the characteristics identified by the Wuppertal Institute in relation to serial retrofitting.

Multi-level perspective

In the study, the multi-level perspective is used to analyse a complex transformation process of a socio-technical system. The MLP is a theoretical analysis tool that simplifies the complexity, multi-layered nature and non-simultaneity of transformation processes. It

combines a systemic perspective and self-dynamic processes with an actor's perspective to depict the scope for action, thus enabling the understanding of comprehensive transformation processes through abstraction. The application of the MLP in this study enables the categorisation of the socio-technical system and the consideration of the current status of market implementation, as well as the relevant impulses for reconfiguration of the regime. The MLP distinguishes between three levels of system transitions (see Figure 1), which are in constant interaction and mutually influence each other, thereby enabling the analysis of interactions between developments from niches and changes to the landscape level (Schneidewind, 2019; Best, 2019).

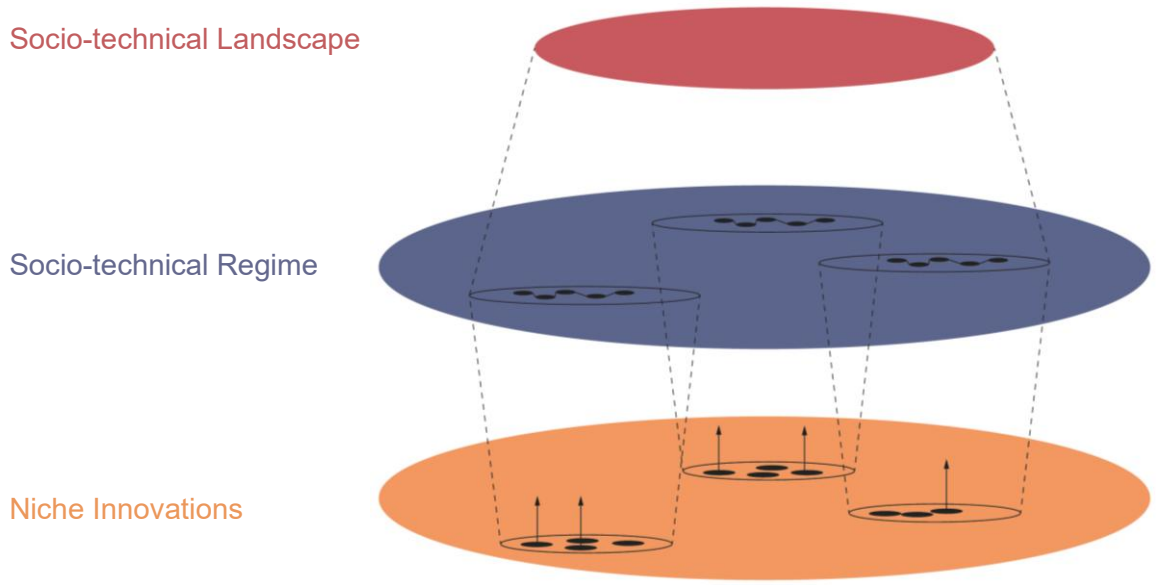

***Figure 1**. Levels of the MLP. Authors' illustration based on Geels (2002, p. 1261)*

"Socio-technical Landscape": This level refers to the fundamental and overarching developments and trends that are difficult to influence in the long term. It represents a stable process that is characterised by everyday experiences and long-term developments. Global power shifts, economic crises, wars, and environmental changes have a significant impact on the subsystems, determining the direction and pace of transformation processes.

"Socio-technical Regime": This level describes the institutional structures in place. Changes may progress slowly due to the framework that maintains the status quo and restricts the scaling or spread of innovations. Transformation processes take place at the regime level and result from the mutual influence of all three levels. Therefore, the regime level is defined as the central observation level. When so-called "windows of opportunity" open up, the regime can be influenced by the impact of niches or transformation processes.

"Niche": This level refers to technological innovations aimed at social change, which involve "deviations" from existing structures. Niches play a crucial role in transformational change, and the influence of their innovations is maximised when they are independent of surrounding systems: This level allows learning and development processes to take place in a protected framework and provide shelter for innovations that may not yet be selected by the mainstream market.

The MLP has been widely adopted for the analysis of socio-technical transitions. While the framework provides a structured approach to understanding niche-regime-landscape interactions, its application reveals theoretical and methodological limitations that require critical examination (Geels, 2019). A primary critique focuses on the technological bias of the framework. Critics argue that the model overemphasises technological advancements, while neglecting social and political factors (Bögel et al., 2022; Geels, 2020). Moreover, the model's deterministic approach, where transformation processes are assumed to follow a predetermined transition path structured around linear phases of emergence, diffusion and reconfiguration, has been criticised for its potential to oversimplify the complex, contested nature of real-world transitions (Olbrich et al., 2024). Critics also note that the model is not explicitly validated through the use of empirical data (Cherp et al., 2018).

Whilst the technological focus and phased structure of the MLP are open to criticism, these limitations are addressed by the adapted application in three ways. First, the analysis integrates findings from market stakeholder interviews. Second, the study describes non-linear feedback loops in the diffusion of the retrofitting approach. Third, the study proposes suitable interventions to promote acceptance and broad implementation. The theoretical framework of the MLP is thus well suited for analysing serial retrofitting in the context of the energy transition and is able to deliver important results despite the admitted theoretical simplifications. The combination of semi-qualitative interviews with a market analysis was chosen in order to capture the subjective challenges of the stakeholders (interviews) on the one hand and the structural market dynamics (market analysis) on the other. This methodological approach was undertaken to facilitate a nuanced and comprehensive understanding of the intricate interactions between niche regimes.

Application of the methodology: Bridging the MLP framework and empirical insights

Examination of the characteristics

To qualify as a transformation process, serial retrofitting must fulfil the characteristics defined by the by the Wuppertal Institute mentioned above (Fischedick et al., 2021).

Significant contribution to greenhouse gas neutrality and resource conservation

Serial retrofitting addresses the urgent need to decarbonise Germany's residential building stock by targeting energy-intensive multi-family houses. The approach uses prefabricated modules and integrated renewable energy to reduce operational energy demand, embodied carbon, and fossil fuel reliance. Empirical evidence from pilot projects has demonstrated a reduction in transmission heat losses and overall heating energy consumption, thereby contributing significantly to the achievement of climate neutrality goals. However, achieving broader implementation requires policies that incentivise the use of sustainable materials and mandate lifecycle carbon accounting in retrofitting projects.

High impact depth instead of niche impact

Pilot projects, such as the LEG Living Lab (Gottschalk, 2020), have demonstrated the potential for serial retrofitting to be scaled from buildings to neighbourhoods, thus addressing both energy efficiency and social equity. Stakeholder interviews highlight the potential for enhancing housing quality while aligning with Germany's 2045 climate goals. However, barriers such as regulatory delays and limited funding must be addressed (Mauel et al., 2024). To facilitate the adoption of this approach at scale, policymakers should consider streamlining permitting processes, expanding funding programmes such as RL MOD NRW, and fostering public-private partnerships.

Radical disruptive innovations instead of incremental innovations

Serial retrofitting integrates digital technologies and prefabrication, marking a paradigm shift in construction. The approach has been shown to reduce project timelines and enhance cost efficiency, addressing critical challenges such as labour shortages and rising material and energy costs. Systematic solution approaches and holistic considerations aim to create synergies for economic viability and efficiency gains. Nevertheless, stakeholder resistance to digitalisation remains a barrier. The adoption of targeted training programmes and subsidies for the implementation of digital tools are identified as a key strategy to foster industry-wide acceptance of these innovations.

System innovations instead of a purely technological approach

The success of serial retrofitting depends on its holistic approach that integrates technological advancements with tenant well-being and value chain optimisation. Monitoring systems and tenant management align retrofitting with environmental goals and tenant satisfaction. Policy interventions must prioritise cross-sectoral collaboration, incentivise circular economy practices, and establish platforms for knowledge exchange among stakeholders.

System-changing or system-shaping character

Serial retrofitting has begun to reshape the construction industry by introducing new market players, including start-ups focused on innovative solutions. The industry adapts to political demands by developing production capacities, which drive both temporal scalability and efficiency. Systemic transformation is further supported by political support in the form of funding programmes such as the “Federal Funding Programme for Efficient Buildings” (BEG) and the “Federal Funding for Serial Retrofitting” (BMWK) programme. Policymakers must reduce market uncertainties through standardised frameworks for retrofitting components and long-term funding commitments.

Realistic feasibility

Pilot projects confirm the feasibility of serial retrofitting but reveal challenges in terms of cost competitiveness and rapid cost amortisation. The approach’s technical feasibility is enhanced by its country-specific adaptation, addressing local needs and opening new markets for further development. Policymakers must promote international knowledge transfer and adapt funding mechanisms to support diverse market needs.

Application of the multi-level perspective

By analysing socio-technical transformation processes, conclusions can be drawn regarding the multidimensional interactions between society, culture, politics, industry, technology and the market. This conceptualisation of socio-technical systems is not a spatial analysis but an abstraction, with the three phases of the MLP being ideal-typical and frequently overlapping in practice (Schneidewind, 2019).

At the niche level, processes are driven by “pioneers” and society, focusing on integrating new technologies and products into conventional retrofitting practices—a development catalysed by current construction industry challenges. The different levels of transformation are intertwined and contribute to the gradual integration of niche innovations into the regime, thereby enabling systemic change. Public relations and inter- and transdisciplinary cooperation function as leverage mechanisms that can influence social and institutional value

systems (Best, 2019).

In addition to the linear developments that can be observed within the MLP framework, non-linear feedback loops also play a central role. These loops emerge through iterative and recursive interactions between the three levels of the MLP. As illustrated in Figure 2, these loops are not static but dynamic and influence each other over time. For instance, technological innovation at the niche level can be reinforced by market reactions at the regime level. Concurrently, institutional adjustments at the landscape level establish novel framework conditions, which in turn exert a feedback effect on the niche and regime levels. These non-linear interactions result in developments, including scaling effects, path dependencies and emergent properties. These processes are of critical importance in understanding transitions in socio-technical systems, as they can have both accelerating and inhibiting effects (Vargo et al., 2020; Rogers et al., 2005).

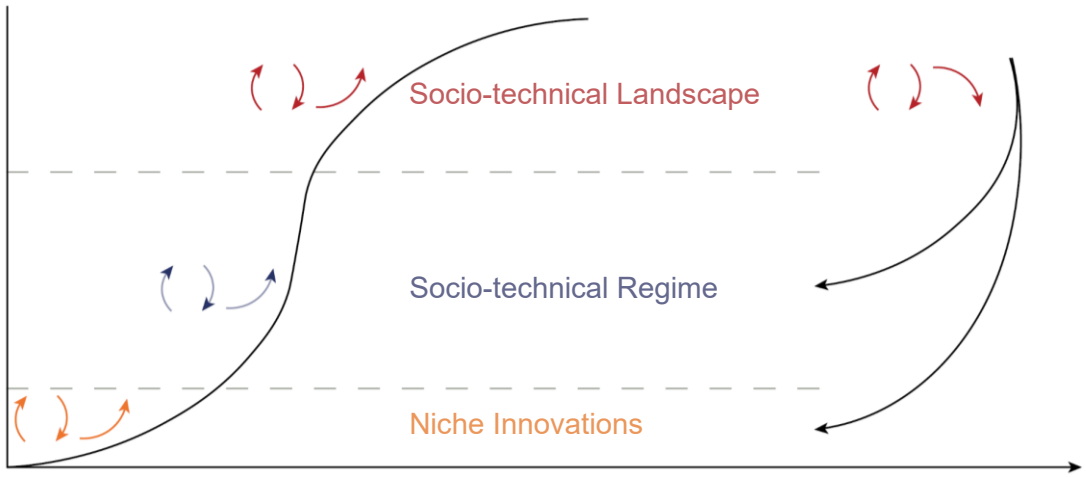

Figure 2. *Non-linear feedback loops in innovation diffusion. Authors' illustration based on Vargo et al. (2020, p. 532)*

Within the social subsystem "housing and infrastructure", serial retrofitting spans the three levels of the MLP and is defined by its social function, as buildings significantly influence quality of life and residents' wellbeing. Serial retrofitting represents a bottom-up transformative process initiated by long-term changes at the landscape level. The socio-technical regime consists of the building and utilities industry, user and implementation preferences, the orientation of market players, the training system for planners and the willingness of housing associations to invest (see Figure 3). The landscape level consists of the global trends and influencing factors that manifest themselves as external influences on the other levels. These include the climate crisis, the political agenda, the housing and energy crises as well as urbanisation, the shortage of skilled workers, inflation and rising energy costs.

The MLP is based on a dual-axis system. The horizontal axis represents the progression of time and the vertical axis represents the increasing structuring of social systems. The horizontal axis comprises three sequential phases. First, "emergence" occurs when an innovative technology or approach develops. Second, "diffusion" happens between the regime and niche levels as the system gradually changes. Third, "reconfiguration" takes place when a new regime emerges, shaped by long term niche influence (Victor et al., 2019).

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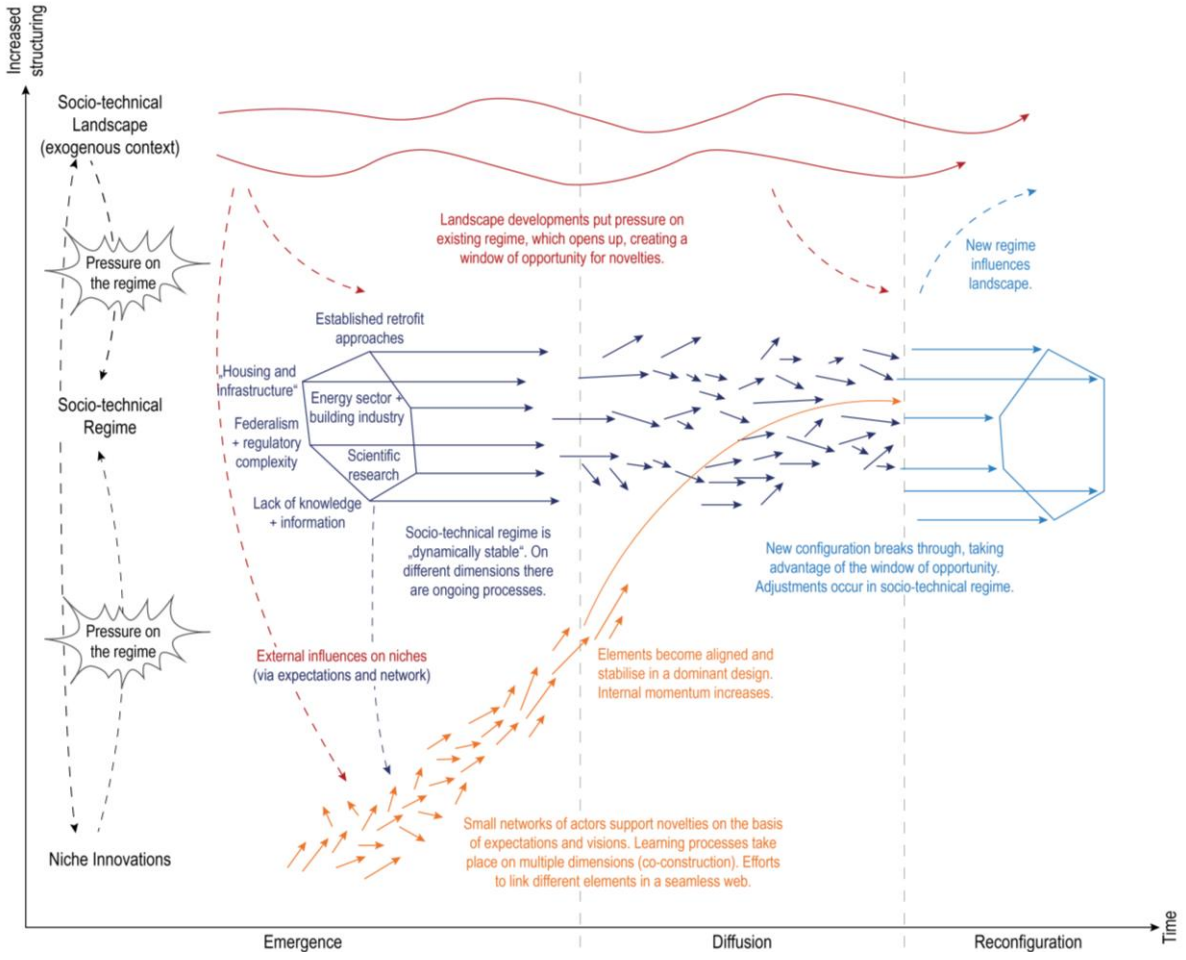

Figure 3. *Transformation process of niche innovations. Authors' illustration based on Geels (2002, p. 1263)*

As part of the market analysis presented earlier in the study, the structural framework conditions and dynamics of the supplier market, as well as the integration of innovative technologies, were assessed. The pilot projects are of particular relevance to this study, as they highlight the role of niche innovation and pioneering work. A detailed analysis of the project case studies provided insights into the technological and organisational approaches as well as the challenges and potentials of market entry. These findings were located at the niche level, as they represent the experimental phase of innovation and show how serial retrofitting is assessed as a new technology in a protected framework. The expert interviews conducted with industry stakeholders provided a valuable complement to the existing body of literature with qualitative data on the perceptions, challenges and opportunities of serial retrofitting. The results of the interviews enabled an in-depth analysis of the interactions between the niche and regime levels. Notably, the interviews exposed institutional impediments, including regulatory challenges and cultural resistance to digitalisation and innovation. These findings contributed to a more comprehensive understanding of the diffusion processes from the niche to the regime. Furthermore, the study assessed the influence of external factors, including political guidelines, on the transformation process.

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Phase 1: Emergence

The emergence of serial retrofitting as a niche innovation is driven by landscape-level pressures, most notably the political narrative surrounding climate change. This pressure for change affects political, socio-economic and technological elements of the housing and infrastructure subsystem. Although climate change itself has not directly initiated the transformation process, the Paris Agreement and subsequent national commitments have translated environmental concerns into actionable policies. These include the establishment of more stringent energy standards, sectoral emission reduction targets, and regulatory frameworks aimed at decarbonising the building sector. Stakeholder interviews reveal that this political impulse has increased awareness among housing associations and market players of the urgency of sustainable retrofitting solutions. However, despite the strong interest in serial retrofitting, housing associations sometimes shy away from the high initial investment, illustrating the tension between niche and regime that is typical of MLP. In addition, there is an increasingly critical attitude among citizens towards fossil fuels and the use of non-renewable resources, as well as growing social awareness of sustainability, which is driving the need for innovation (see Figure 4).

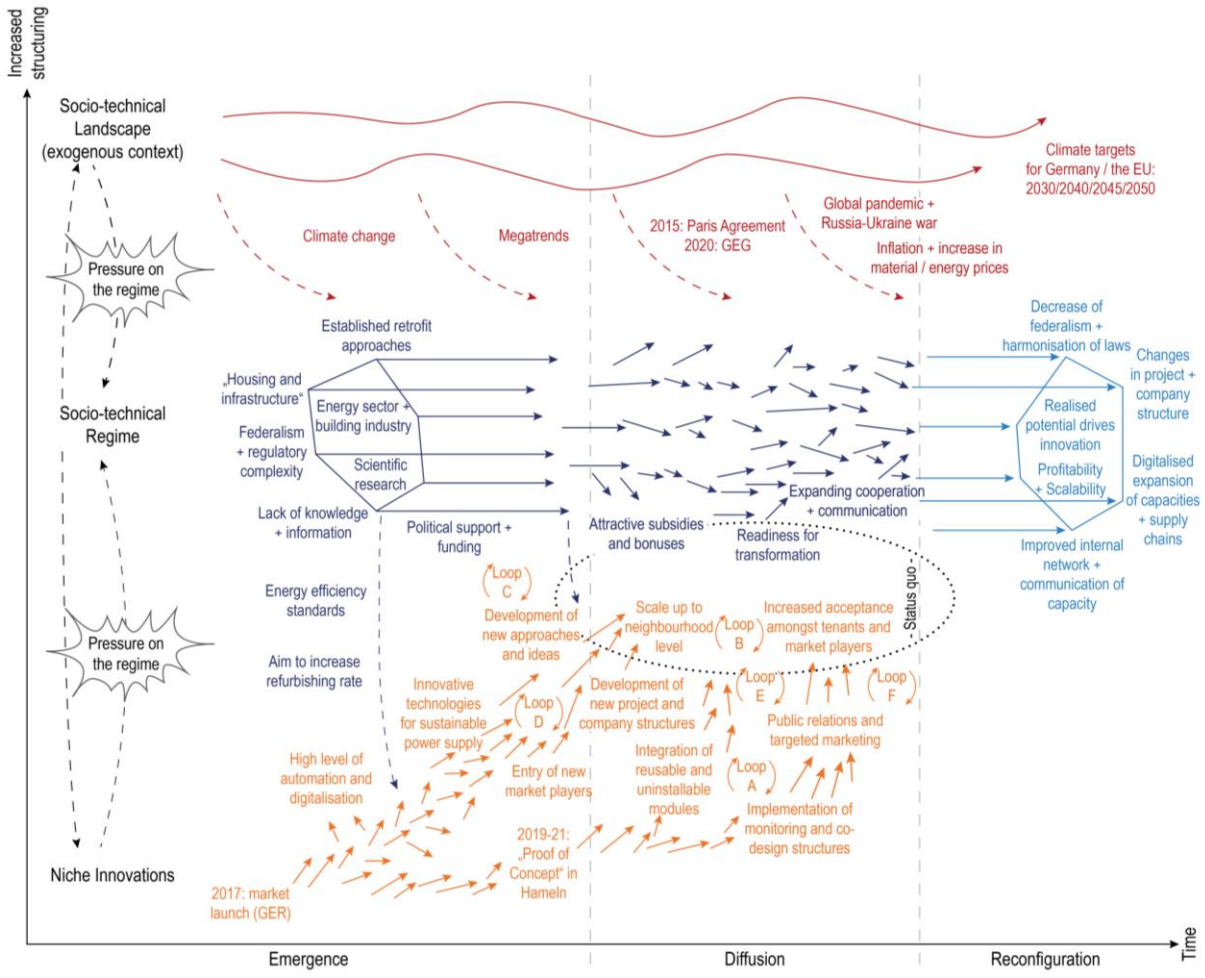

Figure 4. *Transformation process of serial retrofitting. Authors' illustration based on Geels (2002, p. 1263)*

Moreover, the emergence phase of serial retrofitting is characterised by the initiation of pilot projects that serve as protected niche environments to evaluate technological and organisational innovations. Technological innovations are crucial to this phase: the integration of prefabrication processes, digitalised planning tools and renewable energy systems has enabled a shift towards serial retrofitting as a scalable approach. In contrast to conventional retrofitting, serial retrofitting uses industrialised workflows to streamline processes and reduce on-site disruptions. The market analysis, however, has identified significant obstacles that hinder the adoption of this approach on a broader scale. These include limited production capacities and substantial initial investment costs.

Phase 2: Diffusion

Serial retrofitting is currently transitioning from niche innovation to broader diffusion within Germany's socio-technical regime. Pilot projects, including those under the "LEG Living Lab" initiative, have demonstrated its scalability from individual buildings to neighbourhood-level retrofits and have served as the first signs of a reorganisation process. The pilot projects have demonstrated the potential for systemic change by integrating innovative technologies and fostering collaboration across value chains. For instance, neighbourhood-level retrofitting initiatives have been identified as opportunities for economies of scale and synergies with district heating systems.

Furthermore, large existing market players are adapting their companies towards serial retrofitting, and new market players are emerging. The competitive environment between companies is leading to increased innovation in technology, implementation, and design approaches to serial retrofitting. The factors contributing to the broad adoption of serial retrofitting are diverse, including rising energy and heating costs, a shortage of skilled workers, and increased information provided by market participants and dena.

As mentioned above, non-linear feedback loops are crucial to diffusion processes. In the context of serial retrofitting six interdependent feedback loops (A–F) could be identified through 14 case studies and five expert interviews. These loops collectively drive systemic change through dynamic interactions between technological, economic, and social factors (see Figure 4). The feedback loops can be categorised into two analytical categories, reflecting their primary operational domains within the socio-technical system. The system-building dynamics (Loops A–D) include supply-side mechanisms that construct and structure industrialised delivery capacity, such as performance learning (A), scale effects (B), financial maturation (C), and market co-evolution between specialised providers and regulatory frameworks (D). The dynamics of acceptance and adoption (Loops E–F) are concerned with the demand-side mechanisms that embed practice within organisations and communities. Market acceptance in housing associations (E) and social acceptance among tenants through co-design (F) are two such examples.

System-building dynamics

Loop A—Performance monitoring: Prefabricated modules become more efficient through recursive data exchange between digital twin simulations and building monitoring systems. This process enables iterative refinement of component standardisation, while hybrid manual-automated workflows accommodate building-specific irregularities. By analysing the planning and construction process, learnings can be drawn for the next project, work processes can be improved, and standardised solutions can be developed.

Loop B—Scalability dynamics: Costs can be decreased through economies of scale as project scale transitions from single buildings to neighbourhood clusters. This phenomenon, however, remains unevidenced in the current market analysis, likely due to the early stage of diffusion.

Stakeholders have suggested that bundled retrofits can reduce the manufacturing costs of facade and roof modules. Thereby reducing implementation costs and, indirectly, reducing apportionable costs for tenants. Over time, this can increase acceptance among tenants and promote the wider implementation of serial retrofitting.

Loop C—Financial maturation: The interdependency between cost efficiency and funding is rooted in the principle that the maturation of a given approach typically leads to enhanced operational efficiencies. As serial retrofitting becomes more established, economies of scale, optimised processes, and accumulated expertise will reduce overall implementation costs. Consequently, the reliance on high levels of external funding to overcome developmental challenges and establish infrastructure decreases over time.

Loop D—Market co-evolution: Furthermore, the emergence of new specialised solution providers shows how early success in a niche market can be a catalyst for competitive diversification. The diverse approaches illustrate how market entry triggers technological specification. This dynamic environment, in turn, exerts pressure on the regime level to adapt its regulatory framework in order to facilitate retrofitting and ensure compliance with the overarching requirements defined by the landscape.

Acceptance and adoption dynamics

Loop E—Market acceptance: Housing associations frequently favour established approaches due to their familiarity and perceived reliability. Information campaigns, such as those conducted by dena and market stakeholders, seek to demonstrate the technical feasibility of the approach through pilot projects. Successful implementations generate normative evidence that redefines innovation thresholds in housing governance frameworks. As more projects are successfully completed using serial retrofitting, the approach gradually gains acceptance within the industry, transitioning from being perceived as an “innovative” approach to becoming part of mainstream practice.

Loop F—Social acceptance: Tenant acceptance has been shown to increase when co-design mechanisms are used to incorporate tenant feedback and concerns into retrofit planning. This approach fosters a sense of inclusion and collaboration amongst residents. Housing associations can ensure transparent communication by explaining the benefits to tenants, such as reduced energy costs and higher building standards. By addressing potential fears or uncertainties early in the process, housing associations can reduce resistance and build trust among tenants. Such co-design mechanisms enable housing associations to modify serial retrofitting to align more closely with tenants’ wishes.

These non-linear feedback loops demonstrate mutual reinforcement across diffusion dynamics. Performance learning (A) supports scalability (B), which, when combined with process optimisation, enables financial maturation (C). Industry diversification and regulatory adaptation (D) sustain organisational acceptance (E). Furthermore, tenant acceptance (F) exerts a significant influence on organisational decisions, thereby encouraging continued investment in performance learning (A). Information flows from dena and market participants, thereby intensifying these interconnections across the regime.

In conclusion, the diffusion of serial retrofitting within Germany’s socio-technical regime has not yet been completed, with system transformation characterised by dynamic tensions between facilitating and constraining factors. Stakeholder interviews have highlighted the need for targeted communication strategies to foster acceptance of innovative practices. Although institutional support through funding programmes has facilitated early diffusion,

existing funding and procurement frameworks require substantial enhancement for large-scale implementation. The findings indicate that without addressing these systemic constraints, large-scale implementation will remain limited despite positive developments in learning processes and stakeholder acceptance.

Phase 3: Reconfiguration

The reconfiguration phase remains aspirational, as serial retrofitting has yet to become cost-competitive with conventional modernisation methods or established as a routine practice within the regime. Stakeholder interviews have revealed persistent challenges, including lengthy administrative processes and discrepancies between client expectations and financial realities. Moreover, the ongoing presence of cultural resistance to innovation continues to hinder the widespread adoption of this approach.

This analytical investigation shows that serial retrofitting, as a transformative innovation, has the potential for systemic change. While active learning-by-monitoring and organisational acceptance facilitate uptake, underdeveloped economies of scale and emergent financial maturation constrain cost competitiveness. Market co-evolution and social acceptance are developing inconsistently across German regions and cities. Some housing markets advance faster in developing serial retrofitting capacity and gaining tenant acceptance, while others lag behind due to fragmented supply chains, varying state and municipal regulations, and persistent digitalisation scepticism within traditional construction firms. This uneven development hinders a uniform national rollout. Acknowledging this, it is important to recognise the need for targeted interventions across multiple levels in order to surpass the threshold for reconfiguration of the socio-technical regime. These interventions must be implemented at various levels, encompassing political and institutional changes, social and cultural shifts, and advancements in research and market improvements (Mauel et al., 2024). The implementation of such changes has the potential to stimulate market growth and generate a multiplier effect, which may result in a restructuring of the regime.

Results

Geels' (2002) multi-level perspective provides a robust framework for analysing the transformative potential of serial retrofitting, delineating its emergence as a niche innovation, the challenges of diffusion, and the aspirational reconfiguration of regimes. This section synthesises empirical findings from pilot projects and stakeholder interviews to map phase-specific barriers and propose targeted interventions aligned with socio-technical transitions. Serial retrofitting, as a transformative innovation, faces distinct barriers at each phase of its development within the socio-technical system. These barriers are rooted in economic, institutional, and cultural challenges, which hinder its progression from niche innovation to regime reconfiguration.

Barriers to systemic diffusion

The diffusion of serial retrofitting is characterised by significant institutional and market barriers that hinder its systemic integration. Housing associations, which hold a significant proportion of Germany's multi-family housing stock, are reluctant to adopt serial retrofitting due to the perceived risks associated with high upfront costs and untested processes. Stakeholder interviews reveal that housing associations continue to rely on established retrofit approaches, which compounds this reluctance. Housing associations perceive these established approaches as "safer" and "more dependable" despite the fact that they cannot meet climate targets independently. This conservative stance persists despite evidence from pilot projects and reports by institutions such as the German Energy Agency (dena, 2023) demonstrating

serial retrofitting's capacity to achieve 80–90 % energy savings.

Stakeholder interviews reveal a paradox: while landscape pressures incentivise innovation, construction firms remain risk-averse due to the perception that serial retrofitting's inherent challenges are incompatible with existing workflows. Unlike traditional retrofit approaches, serial retrofitting requires changes to procurement processes, digitised planning and prefabrication, and on-site execution methods. Consequently, construction firms must integrate digital planning tools and prefabricated components into their workflows, a process which demands upskilling and cultural shifts within the industry.

Federalism further exacerbates these challenges. Germany's decentralised governance structure results in fragmented regulatory frameworks across the sixteen states, leading to disparities in building codes and permitting processes. These disparities make it more difficult for solution providers to implement standardisation. Moreover, prolonged approval timelines and administrative complexities extend serial retrofitting's normally short timeframes.

Economic barriers also persist. The social benefits of serial retrofitting, such as reduced energy poverty and enhanced living standards, remain unmonetised within current funding structures. Total solution providers encounter difficulties aligning client expectations with financial realities, as certain stakeholders are reluctant to shoulder the additional costs associated with these broader societal impacts. Process optimisation and economies of scale that could be realised if projects were to be bundled at neighbourhood levels remain unrealised.

Intervention pathways for accelerated regime reconfiguration

In order to overcome the identified barriers and accelerate the transition from diffusion to reconfiguration, a comprehensive set of intervention pathways needs to be implemented. These pathways should address the specific challenges at each level of the socio-technical system whilst fostering synergies between niche innovations, regime adaptation, and landscape pressures.

At the political and institutional level, the intervention framework should prioritise the harmonisation of regulatory frameworks amongst federal states in order to reduce administrative complexity and accelerate permitting processes. The research findings suggest that the establishment of a national standardisation framework for serial retrofitting components would significantly reduce market uncertainties and facilitate economies of scale. Furthermore, policy interventions should evolve beyond the current funding mechanisms to include a more nuanced approach that recognises and monetises the social benefits of serial retrofitting, such as reduced energy poverty and improved living standards.

Social and cultural interventions are equally crucial for overcoming resistance to innovation within the construction industry. The findings indicate that targeted training programmes and knowledge-sharing platforms would address the skills gap in digital planning and prefabrication. Furthermore, the use of co-design mechanisms that incorporate tenant feedback into retrofit planning would increase social acceptance, as evidenced by the positive feedback loop identified in the analysis of stakeholder interviews. The development of inclusive communication strategies that emphasise both the environmental and economic benefits of serial retrofitting would further contribute to wider acceptance among housing associations and tenants.

The findings also highlight the need for market-level interventions to address the economic barriers to uptake. The formation of public-private partnerships has the potential to reduce the financial burden on housing associations by sharing the initial investment costs. The establishment of neighbourhood-level retrofit programmes would enable economies of scale, thereby reducing the per-unit cost of serial retrofitting. Furthermore, the development of innovative financing mechanisms, such as energy performance contracting, would ensure that the financial incentives of the various stakeholders are aligned with the long-term benefits of serial retrofitting.

The six interdependent feedback loops identified in the MLP—performance monitoring, scalability dynamics, financial maturation, market co-evolution, market acceptance, and social acceptance—provide a framework for understanding how these interventions can reinforce one another. For instance, improved performance monitoring (Loop A) has been found to enhance market acceptance (Loop E), which in turn attracts more market entrants and enables scalability dynamics (Loop B). This suggests that interventions should be designed to amplify these positive feedback loops whilst mitigating the negative ones.

Cross-sectoral collaboration has been identified as a critical factor for successful implementation of these intervention pathways. The research findings indicate that closer cooperation between housing associations, construction firms, technology providers, and policymakers would facilitate the development of standardised approaches and shared knowledge. Furthermore, the transfer of knowledge on an international scale, particularly from countries such as the Netherlands where serial retrofitting has moved beyond the pilot phase, would provide valuable insights for overcoming specific barriers in the German context.

Discussion and conclusion

Serial retrofitting represents a promising approach to address Germany's building decarbonisation challenges. It offers significant potential to enhance energy efficiency and living standards whilst reducing greenhouse gas emissions. The analysis confirms its status as a transformative innovation according to the Wuppertal Institute's criteria and positions it within the diffusion phase of the MLP framework. The identification of six interdependent feedback loops provides a framework for understanding the complex dynamics driving diffusion. The analysis of barriers highlights institutional, economic, and cultural challenges that must be addressed to achieve regime reconfiguration.

Coordinated interventions across regulatory, financial and cultural domains are essential to effect transformative change. Regulations must be harmonised, innovative funding mechanisms must be introduced, and cultural shifts within the construction industry must occur. These processes must proceed in parallel to create conditions conducive to widespread adoption. As serial retrofitting continues to evolve, ongoing research and critical evaluation will be essential to ensure that its implementation advances not only environmental sustainability but also social equity and economic prosperity. The transformative potential of this approach lies not merely in its technological capabilities but in its capacity to catalyse systemic change across Germany's housing and construction sectors.

In consideration of the study's limitations, it should be noted that several limitations must be acknowledged when interpreting the findings. The reliance on expert interviews and current market analysis provides limited insight into long-term dynamics, particularly regarding economic viability and scalability. The application of the MLP framework, whilst illuminating, inherits the theoretical limitations identified by critics, particularly regarding potential technological determinism and the underemphasis of social and political factors. The study partially addresses these concerns by advocating for policy-industry interventions and

acknowledging socio-political risks. The focus on multi-family housing constructed between 1950 and 1970 ensures analytical coherence but potentially limits the generalisability of findings to other building typologies or construction periods. Furthermore, the specific institutional frameworks and market structure characteristic of the German context may lead to findings that are not directly transferable to other national contexts.

The findings indicate several potential avenues for future research. First, longitudinal studies that track the evolution of serial retrofitting towards reconfiguration should provide insight into the operation of feedback loops over time and the response of barriers to policy interventions. A mixed-methods approach, integrating quantitative market data with qualitative assessments of institutional change, could be employed in these studies.

Second, research on the socio-economic dimensions of serial retrofitting is essential to understand the differential impacts across income groups and to ensure equitable access and distribution of benefits. In accordance with the results of this study, a fundamental analysis of serial retrofitting in a socio-economic context is being planned. The aim of this analysis is to examine the economic and social implications in order to further investigate its feasibility and social acceptance in Germany.

Finally, evaluations of policy instruments, incentive structures, and regulatory frameworks would guide policymakers in designing mechanisms to promote equitable implementation. Empirical studies and cross-national research would enhance understanding of the dynamics shaping serial retrofitting's transformative potential.

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From bungalows to garden cities: The architectural evolution of British-owned oil company towns in Iran (1901–1951)

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Following the discovery of oil in southwestern Iran, an unprecedented form of settlement emerged in the region. The company towns of Masjed Soleyman (Masjid-i-Suleiman) and Abadan were built in dependence on the British-owned oil company APOC, later AIOC. The development of these cities between 1901 and 1951 reflects broader socio-political dynamics between the Company and local population. By considering both intra-company factors as well as national and international events, this research proposes a periodization aligned with shifts in the Company's policies. It studies the architecture and urbanism of each period in accordance with the socio-political context. Initially, the settlements were temporary and, like the first infrastructure, extremely limited and rudimentary. However, with the expansion of oil operations, the settlements and infrastructure became more advanced. From the unprecedented juxtaposition of buildings for European staff, bungalows that bore traces of British colonial architecture, a complex structure emerged. Yet the peak of this complexity emerged with the further development of these settlements into garden cities, another hallmark of colonial architecture and urbanism, marking a transition from the mere adjacency of individual buildings to planned neighborhoods. The analysis conducted shows how these built environments functioned as identifiers and tools of class and racial segregation.

Keywords: oil heritage, urban segregation, colonial architecture, British oil company, Iranian studies, Abadan, Masjed Soleyman

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Introduction: Iran, Britain, and the quest for oil

Granting the D'Arcy Concession, and consequently, the discovery of commercial amounts of oil in Iran can be considered one of the pivotal moments in the modern history of Iran. With the granting of this concession, the possibility of British activity in the exploration and exploitation of oil in the "Protected Territories of Iran", except for the five northern provinces bordering the Russian Empire, was provided (Iranian Oil Industry Photo Bank, n.d.). Discovering commercial amounts of oil in Iran's southwest significantly increased Britain's influence in this region and not only deeply impacted British Iranian relations but also played a notable role in shaping the modern Middle East (Kashani-Sabet; 2022). Iran's oil also reached further than Iran's borders, which had significant consequences for Britain, particularly in shaping its military fuel supply and global energy strategy. On the eve of World War I, the British navy's fuel was changed from coal to oil-based fuels, and its leading supplier was the newly established oil industry located in Iran, which became possible after Britain ensured access to Iran's massive oil reserves (Reguer, 1982: 135). However, Iran's oil importance was not limited to military-related aspects but also economic ones. In the final years of British monopoly in Iran's oil industry, the Abadan refinery was considered the largest refinery in the world, and oil assets in Abadan constituted British most concentrated investment outside of Britain (Bamberg, 1994).

Although the mentioned investment undoubtedly benefited Britain, it had significant consequences in oil-rich countries of the Middle East (Ehsani, 1999). In Iran, particularly from the Reza Shah Pahlavi era onward, a considerable portion of the government's revenue was derived from the oil industry, although there have been many changes in the way this revenue is calculated. Before the nationalization of the Iranian oil industry in 1951, the initial basis for calculating Iran's income from the oil industry was the D'Arcy Concession, which in 1933 was substituted by the 1933 Agreement. Since both agreements primarily favored British interests, and the British government often failed to fully honor the responsibilities outlined in them, these arrangements reveal that Britain's activities in Iran extended far beyond typical foreign investment. The use of the term "nationalization" in reference to the 1951 oil industry takeover reflects not only a political shift but also acknowledges the prior depth of British control over Iran's oil sector.

This research aims to establish a new chronological framework of key events that shaped the Anglo-Persian Oil Company's strategies and infrastructure development, with a focus on how architecture and planning evolved under British influence from 1901 to 1951. Due to limited access to corporate archives and visual documentation, this study is primarily based on secondary sources. However, it offers a spatial and architectural interpretation that synthesizes these materials to provide a new analytical perspective on oil urbanism in Iran.

Periodizing British Oil Company activities: key phases of town development (1901–1951)

The British-owned Company shaped massive infrastructure for over half a century in southwestern Iran. Generally, after discovering oil in commercial quantities in a specific area, the British-owned Company settled there by establishing technical and residential facilities. This strategy led to the formation of new towns. The foundation and development of these towns were deeply dependent on the British-owned Company, which can be described as oil-related company towns. These company towns provided a unique platform for the British-owned Company to manifest its values and status through construction. In the meantime, the most essential oil-related company towns were Masjed Soleyman (Masjid-i-Suleiman) and

Abadan. Masjed Soleyman (Masjid-i-Suleiman) was the center of oil extraction, and Abadan was the center for oil refining and dispatching. Therefore, the construction in these two company towns is expected to reflect the values and status of the British-owned Company over its long years of activity in Iran.

The construction activities of the Company in Iran, over approximately half a century from the D'Arcy Concession in 1901 to the nationalization of the Iranian oil industry in 1951, can be periodized based on the most significant events that directly impacted the Company's performance and commitments. These include the D'Arcy Concession in 1901, the discovery of oil in Masjed Soleyman (Masjid-i-Suleiman) in 1908, the purchase of Company shares by the British government, the beginning of World War I in 1914, the 1933 Agreement, World War II in 1939, and the nationalization of the Iranian oil industry in 1951. This paper divides the Company's activities into five periods, beginning with the granting of the D'Arcy Concession in 1901 and continuing through to the nationalization of the Iranian oil industry in 1951. Each period reflects changes in the Company's approach to construction, planning, and political engagement. This periodization helps to reveal how architectural and urban strategies were adjusted in response to both internal company needs and broader political events.

This periodization is essential not only for organizing the historical narrative but also for analytically tracing the evolution of oil urbanism in Iran. Rather than presenting a static model of development, the five phases reflect how the Company continually adapted its architectural and spatial strategies in response to shifting political, economic, and labor dynamics. Major geopolitical events, such as the World Wars, the 1933 Agreement, and the growing nationalist movement, shaped the Company's legal position, resource allocation, and relationship with the Iranian state and society. Each period corresponds to a distinct phase of urban development, from rudimentary extraction camps to formalized residential layouts and segregated colonial townscapes. The timeline, therefore, serves as both a historical frame and a conceptual lens through which the spatial logic and socio-political functions of these towns can be better understood.

Exploration period: Temporary settlements and the absence of permanent infrastructure

The exploration period is years before oil was discovered in commercial and investable quantities. During this period, exploration teams explored the areas of Chia Sorkh, Shardin, Mametin, and Masjed Soleyman (Masjid-i-Suleiman), but only Masjed Soleyman (Masjid-i-Suleiman) yielded favorable results (Ferrier, 1982). Due to the uncertainty about discovering commercial amounts of oil, there was no reason for a long-term settlement during this period. Therefore, temporary settlement was on the agenda for the explorers, so they lived in tents or primitive shelters (see Figure 1).

Figure 1. *Remains of shelters in Mamatein, Source: Iran Petroleum Museums and Documents*

Formation period: the establishment of initial villages

With the discovery of oil in Masjed Soleyman (Masjid-i-Suleiman) and the assurance of abundant oil resources, a different type of settlement based on long-term presence was put on the agenda, which can be considered as the period of formation and development of the initial villages. One of the first actions of the British organization was to select a suitable location in Masjed Soleyman (Masjid-i-Suleiman) to build the first village for residence (BP Magazine, 1972). Thus, the initial core of the Masjed Soleyman (Masjid-i-Suleiman) company town was formed in an area of about one square kilometer, with two hundred to two hundred and fifty inhabitants (Rostampour, 2016). Although most scholars have considered the formation of this village solely for the residence of the company's foreign employees, the lack of information about its exact location has left it shrouded in ambiguity (Mehan, 2025). It appears that the constructions were focused on operational sites and oil wells, and due to their dispersion, it is impossible to imagine a cohesive village or town (see Figure 2).

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Figure 2. *A view of Masjed Soleyman (Masjid-i-Suleiman) during the formation period, Source: Iran Petroleum Museums and Documents*

In addition to Masjed Soleyman (Masjid-i-Suleiman), the site of oil extraction, Abadan also emerged as a vital operational center due to its role in oil refining and the logistical dispatch of petroleum products. In fact, following the discovery of oil in Masjed Soleyman (Masjid-i-Suleiman), the issue of transporting refined oil was raised. After investigations by the Burma Oil Company specialists, Abadan was considered the most suitable area for establishing a port and building a refinery (Ferrier, 1982). Moreover, the pipeline route from Masjed Soleyman (Masjid-i-Suleiman) to Abadan was also designed. Despite differing opinions on the status of Abadan's residents before the Company's investment, the construction of the Abadan refinery undoubtedly signaled a transformative shift in spatial organization and labor settlement patterns (Ehsani, 2014). The Company's highest priorities at this time were completing the pipeline, constructing the refinery, and increasing its productivity. However, the initial settlement cores were also formed in Abadan and on both sides of the refinery. The western side of the refinery was the Braim village, where European employees lived, and on the eastern side of the refinery was an area known as Coolie Lines, where Indian workers resided, and to the east of Coolie Lines, Iranian workers lived in primitive shelters (see Figure 3). Meanwhile, the available maps of the Abadan refinery from 1910 and 1913 show two different depictions of the Braim village and Coolie Lines and do not provide information about the Iranian workers' area (see Figure 4). This variation is probably because these maps focused on the Abadan refinery's technical facilities. Furthermore, it is possible that not every element illustrated had been built yet when these maps were drawn. This latter possibility increases when we examine these maps alongside available photos and reports, all of which confirm the scarcity and dispersion of the constructed buildings.

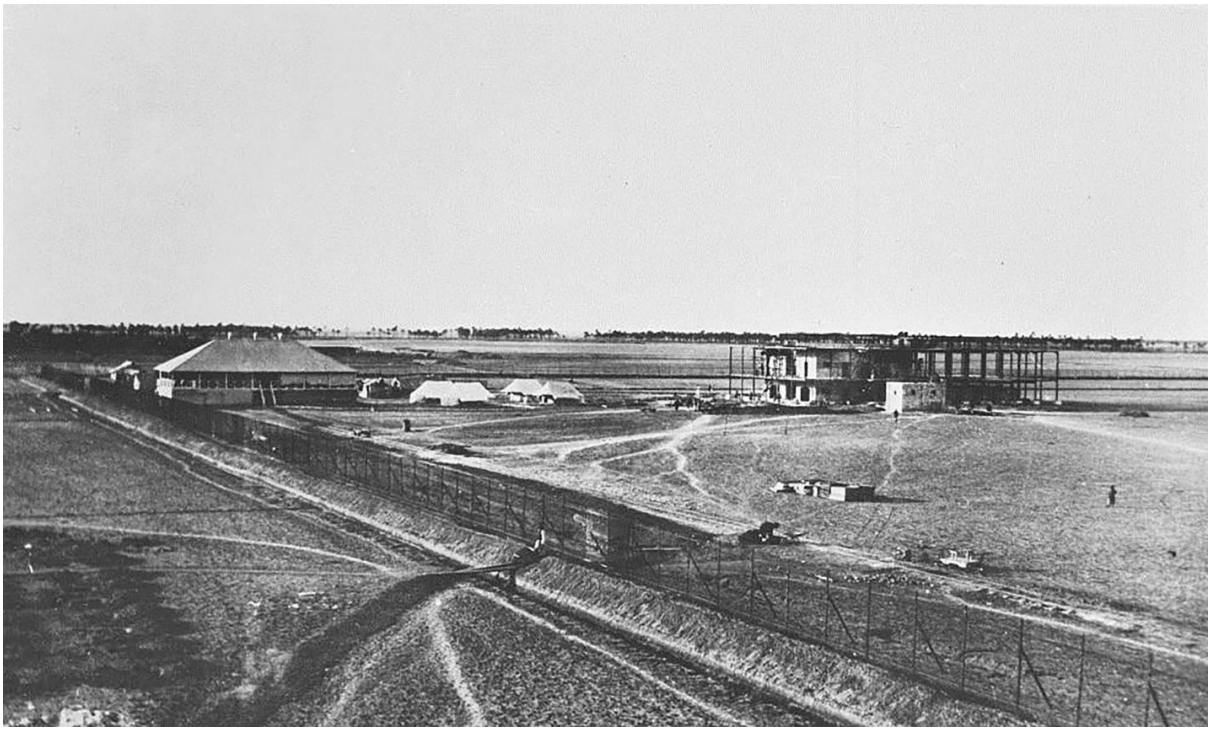
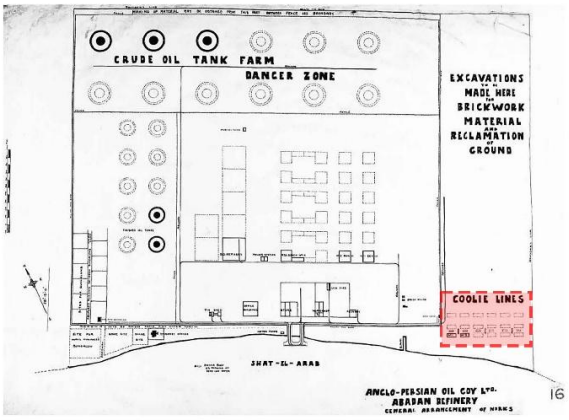


***Figure 3**. Constructing a bungalow in Braim Village in 1911. Source: British Petroleum (BP) archive*



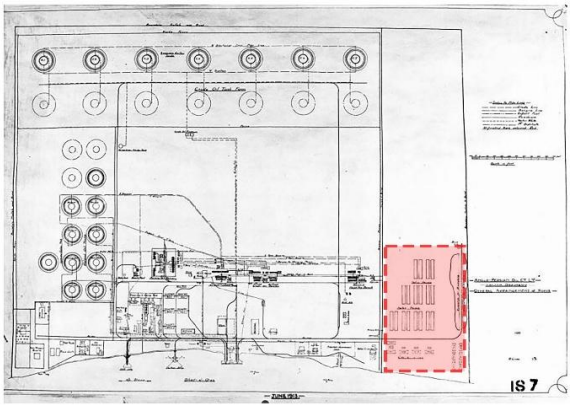


***Figure 4.** Maps of Abadan in 1910 (left) and 1913 (right) Source: BP archive*

Initial development period: expansion of discriminatory infrastructure

With the completion of the construction and equipment of technical infrastructure, a significant development occurred in the Company's activities. The years between World War I and the 1933 agreement can be considered the initial development period, which led to discriminatory infrastructure expansion. The population of workers employed in Masjed Soleyman (Masjid-i-Suleiman) clearly shows the extent of development in this area during this period. The town, founded in 1909 with two hundred to two hundred and fifty inhabitants, had about 20,000 local workers employed in the oil industry by 1922 (d'Ortigue, 2003). However, the cores of Masjed Soleyman's (Masjid-i-Suleiman) residential areas emerged partly in response to the location of oil wells and partly shaped by the topography. The town grew linearly along the uneven

slopes of the mountains, with the highest social classes settling in the best areas and the lowest classes in the worst ones (Abbasi Shahni, 2003).

Numerous infrastructures were established in Masjed Soleyman (Masjid-i-Suleiman) during this period, including new buildings, metalsmiths' workshops, carpentry workshops, electricity generation station, and gasoline manufacturing factories. Additionally, numerous warehouses filled with oil industry and construction supplies, drilling equipment, garages, telephone, telegraph, and wireless and wired communication facilities were established. A railway was also constructed from Dareh Khazineh into the town to transport heavy tools, pipes, and industrial machinery (Habibinejad, 2021). However, the developments mentioned appear scattered and practically show a lack of meaningful connections among newly established facilities. The dispersion of buildings and facilities in Masjed Soleyman (Masjid-i-Suleiman) is implicitly evident in the writings of Khosrow Khan Bakhtiari around 1921. Bakhtiari did not consider the buildings and facilities constructed as a cohesive complex, stating that the British people *built several buildings in Masjed Soleyman (Masjid-i-Suleiman)* (Bakhtiari, 1977). Additionally, according to Bāvar (2019), due to the topographical conditions of the area, the city's neighborhoods were disjointed, with each group of buildings separated from others by hills or valleys. The various neighborhoods were so hidden among the hills that they lost visual connection with each other (Bāvar, 2019). Therefore, it seems that Masjed Soleyman (Masjid-i-Suleiman) was a collection of separate neighborhoods formed from diverse components rather than a city composed of an intertwined whole (see Figure 5).

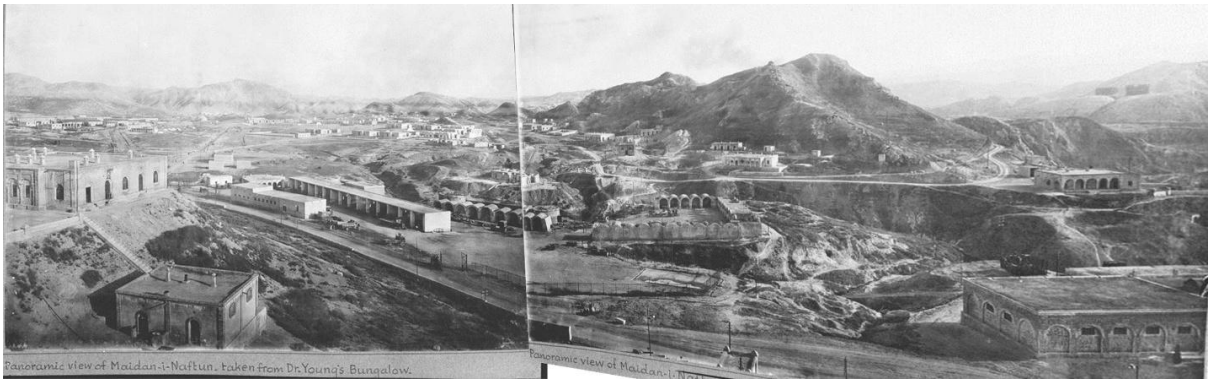


Figure 5. *A view of Masjed Soleyman (Masjid-i-Suleiman). Source: Iran Petroleum Museums and Documents*

The situation in Abadan was very similar; the infrastructure surrounding the refinery expanded significantly, particularly after Sir John Cadman, then the British government's oil advisor, visited Abadan in November 1924. He reported that by 1929, Abadan had greatly transformed regarding the quality and quantity of technical equipment, work regulations, and the camaraderie between workers and engineers (Forouzandeh, 2019). Despite this, there was a discriminatory situation between high-ranking employees and workers during this period. In the early 1920s, Braim village evolved from a collection of scattered buildings into a network of expandable streets, gradually including large two-story bungalows for senior employees, dormitories for foreign staff, and a range of public facilities such as equestrian clubs and numerous parks. Establishing Braim as a green oasis in the desert was a massive undertaking, requiring the transport of materials and a large workforce for gardening and irrigation, as well as hiring specialized gardeners who had formerly worked in Kew and New Delhi (Crinson, 1997).

In such a situation, many workers lacked company housing and lived in deplorable conditions in shacks. In parallel, the Company faced a persistent challenge in Abadan: the presence of a *non-company population*, a term used to describe Iranian job seekers, small vendors, and the homeless who settled informally near company townships. These groups, excluded from company services, often provided non-specialized labor and self-organized communities along the city's margins (Porteous, 1970; Zandieh, Hekmat, & Maghsoudi: 2021). According to the first drawn map of Abadan's non-company urban fabric from 1928, "Abadan City" was intertwined and separated from the workers' homes in the east of Coolie Lines by a newly built park (See Figure 6). This area was a very dense urban fabric consisting of indigenous buildings that existed before the refinery's establishment and a multitude of new houses for workers who worked inside and around the refinery, for whom the company had not provided sufficient housing (Crinson, 1997). Various forms of discrimination were evident in these areas. While Braim benefited from superior amenities and welfare services, prevailing westerly winds carried industrial pollution away from the neighborhood. After passing over Braim, these winds moved toward the refinery and subsequently transported polluted air over the Coolie Lines and Abadan City, disproportionately exposing these areas to environmental harm.

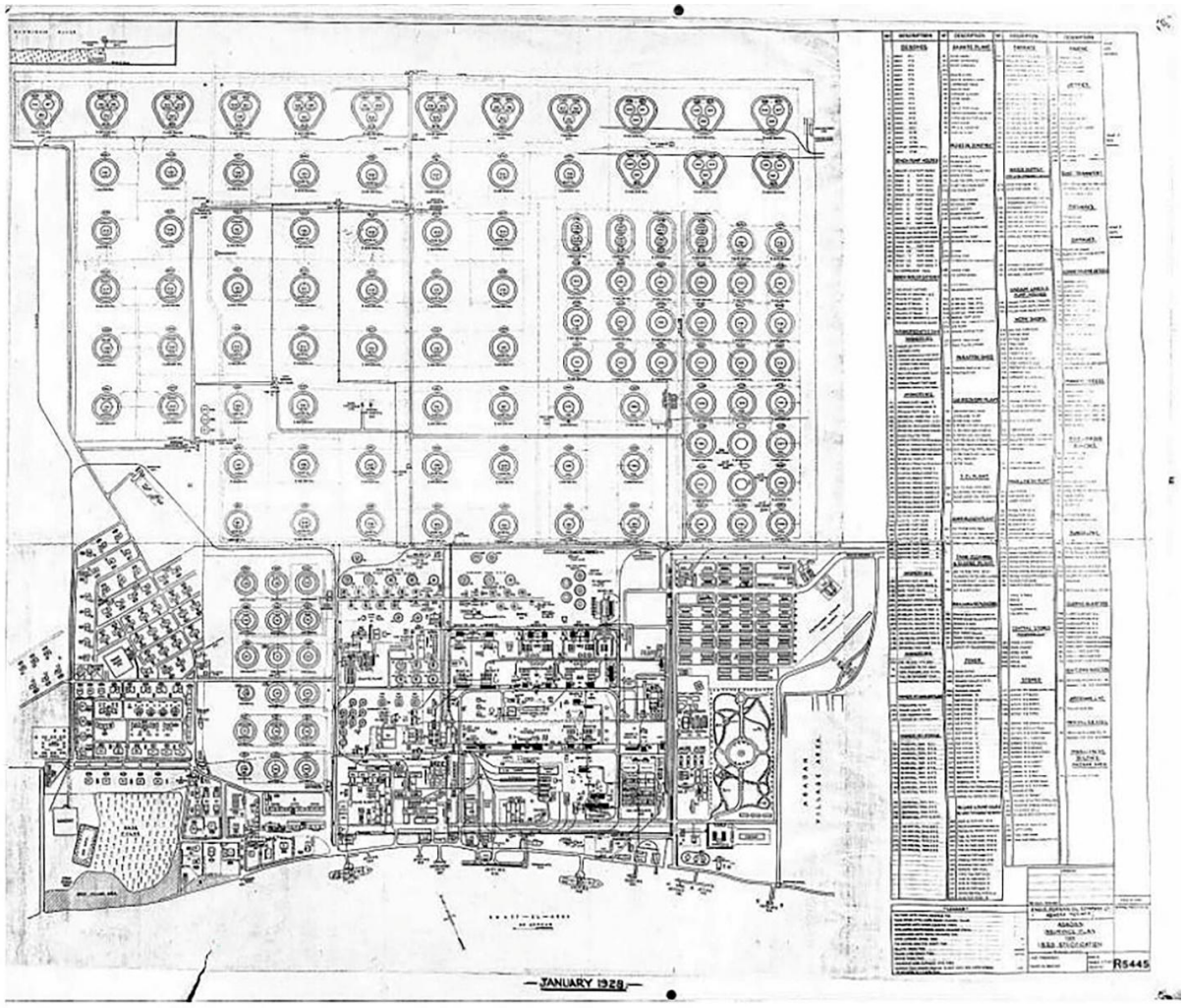


Figure 6. *Map of Abadan in 1928. Source: BP archive*

Secondary development period: Large-scale construction under the supervision of specialists

After the 1933 Contract was signed, new relations developed between the Company and the Iranian government, which included commitments related to construction, especially regarding employee housing. Consequently, construction took place at a faster pace and on a larger scale. Despite the Company's unwillingness to invest in housing projects, housing construction increased due to some governmental and Iranian worker pressures (Rostampour, 2016). In this period, the monopoly on designing large single residential units for senior managers ended, and the design of worker housing units was put on the agenda. Accordingly, with the increase in housing construction and the allocation of housing units to workers, the density of housing units per hectare also increased, and in addition to bungalows, a new type of housing unit called row houses emerged. These houses were located within structured urban grid networks and, in some instances, arranged radially along wide main streets. Approximately 4,500 housing units were built from 1934 to 1939 (Ferrier, 1982). Consequently, the scale of design extended beyond individual buildings. During this period, the employment of professional architects brought urban design issues and regional planning perspectives to the forefront. Accordingly, the latest technical and theoretical innovations were applied in designing new spots, making these areas, especially Abadan, a platform for implementing the latest urban planning theories of that era. Consequently, the concepts of streets and squares in their modern sense entered the Iranian urban planning field. In other words, from this time until the nationalization of oil, the built environment surrounding the oil industry changed from several single buildings to company towns (Rostampour, 2016).

In Masjed Soleyman (Masjid-i-Suleiman), specifically after the 1933 Contract, since 1934, a program for creating a township and providing welfare for employees was developed, and several elementary schools were established. During these years, the Company also established administration offices such as finance, gendarmerie, district office, and police (Abbasi Shahni, 2003). In Abadan, the Company established hospitals, schools, and training centers that were in line with service infrastructure development (Ehsani, 1999). However, the Company's buildings in Abadan before the 1930s were very utilitarian These buildings were primarily functional and lacked symbolic or monumental architectural features that might otherwise embody corporate authority, ideological intent, or cultural integration. The Company did not feel the need to show the unity of its industry-focused activities through architectural works, except in a functional administrative building (Crinson, 1997). Nevertheless, regarding the changes resulting from the 1933 Contract, the Company realized the need for extensive advertising through architecture and urban planning. Consequently, professional architects, including James Mollison Wilson, were employed in developing old neighborhoods and planning new ones. The planning of newly established areas in Abadan was influenced by the policy of population dispersion to counter threats and social disorders resulting from the city's population increase. These areas were designed as dormitory areas. Therefore, the design solution was to create separate townships (British Petroleum Archives, n.d.). In this period and until the late 1940s, considerable neighborhoods in Abadan emerged, forming like oases, piece by piece; these classified neighborhoods were connected only through pathways and practically lacked any overall plan for connection. Thus, Braim was expanded to house European employees, and South Bawarda also emerged for them. Segush Braim, Amirabad, and North Bawarda were also formed for non-European employees (see Figure 7). Bahar, Farahabad, Bahmanshir, Ahmadabad, and Jamshid emerged for workers. Except for Jamshid and Ahmadabad, all neighborhoods were designed by Wilson following the principles of the Garden City movement (Crinson, 1997).

Figure 7. *Left: Braim neighborhood in Abadan. Source: BP archive; also seen in Haghighi (2015). Right: South Bawarda, designed by Wilson based on the Garden City concept. Source: Wilson Mason and Partners; also seen in Crinson (1997).*

Leading to the nationalization of oil period: consequences of World War II, nationalism, and the shadow of communism

Despite the efforts to improve the status of Iranian employees and workers during the secondary development period, World War II changed the predicted equations. The war duplicated the need for fuel for Britain and its allies, increasing the necessary workforce for the Company. Consequently, the demand for housing for the increased workforce also rose, and the Company failed to meet this challenge in wartime conditions. Despite the widespread repression during World War II, which included the deployment of British marines in the Company after the Allies left Iran, Iranian employees, especially workers, expressed dissatisfaction with discriminatory conditions and living standards, particularly regarding housing and health-related infrastructure, culminating in the major strike of 1946 (Lesani, 1978). Moreover, the influence of the Tudeh Party among workers, who had communist visions close to the Soviet Union and anti-British colonialism sentiments, pushed the Company to provide housing solutions for them. During this period, the Company's actions initially focused on changing the internal structure of some existing houses from two bedrooms to three bedrooms and then constructing a type of quick and cheap house known as Arken. The Arken was a residential building that housed several units under a single roof. During this period, the Company's houses benefited from infrastructure services such as drinking water and sewage pipelines, electricity, and cooling devices. However, the Company's effort to provide housing for workers was still insufficient. According to reports from various visitors, housing was consistently identified as the Company's primary problem during the period from 1946 to 1950, including in discussions within the British Cabinet. In 1950, only 5,498 out of 30,521 Iranian company employees in Abadan lived in company houses, most of whom were high-ranking employees (Rostampour, 2016) (see Figure 8 and Figure 9).

This period was also shaped by broader historical forces. The Great Depression influenced British investment strategies, while Iranian state-led industrialization and military reforms under Reza Shah affected labor conditions and settlement policies. During World War II, the Allied occupation of Iran brought British military presence to Abadan, further complicating the urban landscape and intensifying geopolitical control over the oil-producing regions.

Figure 8. *European neighborhoods in Masjed Soleyman (Masjid-i-Suleiman). Source: Masjed Soleyman (Masjid-i-Suleiman) Oil Museum*

Figure 9. *Aerial view of Abadan. Source: Elling (2015)*

From tent to town: the evolution of oil company settlements

During the exploration period, temporary settlement was on the explorers' agenda, so they lived in tents or primitive shelters. Accordingly, there is no evidence of architecture beyond shelters and urban planning. During the formation period, scattered buildings formed the initial cores of the villages. Therefore, the scarcity of buildings clearly indicates a lack of urban planning concepts. During this period, the Company prioritized completing technical facilities, including the pipeline and the Abadan refinery. Despite the importance of the initial location of neighborhoods in separating European residential areas from Indian and Iranian workers, it seems the inner structure of the residential area was not considered especially important. Therefore, individual buildings were important during this period, so a specific type of residential building called a "bungalow" was used.

During the initial development period, welfare infrastructure was also considered in addition to the development of technical infrastructure. However, this development was practically limited to improving the living quality of European employees, so they lived in houses with amenities. In contrast, Indian workers lived in barrack-like buildings, and Iranian workers lived in primitive shelters resembling huts (Alam & Babadi, 2015). The discrimination between the income and living conditions of European employees and Iranian and non-Iranian workers even led to strikes by Indian workers in 1920 and 1922, the former resulting in an increase in their income and the latter in their dismissal (Ferrier, 1982). Additionally, with the rise of the new government in Iran and the increase of the influence and power of the central government in Khuzestan, Iranians also protested in 1921 and 1929, expecting support from the powerful new government against the discriminatory policies of the Company (Rostampour, 2016). In fact, from 1925, when the influence and power of the central government were established in Khuzestan, Iranian employees, who felt that the central government was their guardian, were no longer willing to endure the previous humiliating conditions (Fateh, 1976). The 1933 Contract effectively brought about a change in conditions. Thus, the initial development period can be named the period of discriminatory infrastructure expansion, which was still focused on single buildings or, more precisely, bungalows. During this period, neighborhoods formed primarily due to the juxtaposition of single buildings rather than as a result of comprehensive planning.

During the secondary development era, extensive construction under the supervision of specialists led to the structured formation of major neighborhoods in Abadan and Masjed Soleyman (Masjid-i-Suleiman). This period was about organizing the chaos and disorder from the previous era, resulting in scattered and exclusive neighborhoods for different classes of European and Iranian employees. During this time, the employment of professional and internationally experienced architects, particularly James Mollison Wilson, significantly influenced the formation of these neighborhoods, which followed the garden city idea and resulted in extensive greening. While earlier phases of greening in Braim included the establishment of parks in Abadan, it was in this period that Braim was consolidated as the city's most prominent residential enclave (Karimi, 2013). In fact, greening during this period was not limited to high-ranking foreign employees' neighborhoods but also occurred in neighborhoods built for Iranian employees and workers, resulting in much more extensive greening than in previous periods. Finally, the period leading to the nationalization of the oil industry was deeply influenced by the consequences of World War II, nationalism, and actions taken against communism. Construction in this era continued in the previous period despite changes in the internal space or type of housing used.

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Green oases and concrete barracks: the spatial politics of oil urbanism

The architectural evolution of the Company settlements, from bungalows to garden cities, embodies a larger history of colonialism, power, and inequality. Comparable modes of spatial segregation and company-planned settlements were visible in other oil cities across the region, including at Kirkuk (Iraq), Awali (Bahrain), and Ahmadi (Kuwait), where British or American companies emulated identical colonial urban policies. Such a paradigm, rather, might add a different dimension to understanding oil urbanism as a global phenomenon. This transformation was more than just an exercise in architecture or urban development but may lie at the heart of a Company's geopolitical and socio-economic agenda as a force for the British Empire, with oil as the focal point of British power in the Middle East. The physical structures and urban layouts of these towns mirrored and reinforced the hierarchical power relations between the Company and the Iranian workforce, often exacerbating social divisions and perpetuating systemic exploitation. Architecture was, in this manner, a control mechanism as much as a divider of populations. The building of bungalows, that iconic of colonial architecture, was the first phase of this exercise. Bungalows were markers of colonial architecture, built as abodes for British engineers and members of senior staff, reinforcing power imbalances between British elite and Iranian labor force. Such geographical segmentation, as a reality between living structures for workers in Iran and that for Iranian workers, served as a reinforcer between races or between classes, as it literally, as well as metaphorically, segregated British from Iranians, as a reality, between colonizers and colonized. This division was not an incidental byproduct of urban planning but a deliberate effort to maintain British dominance and control over Iranian workers. Housing high-level British staff members in relatively luxurious bungalows, with Iranian labor force as a result being allocated temporary abodes or overpopulated barracks, was a manifestation of wider colonial subjugation, as well as social ranking.

As the oil industry expanded, so did the company towns, moving beyond the simple bungalow villages into more complex urban arrangements. This, however, did not translate into a democratization of resources or space. Instead, segregation and disparity, which characterized early development, continued, manifesting as unequal access to amenities and infrastructures. While British employees benefited from modern housing, public facilities, and well-maintained green spaces, Iranian workers remained poverty-stricken with access to few services. Garden city inspired planning, which, albeit lauded in history of architecture for community well-being as its central tenet, was employed selectively in such company towns. The concept of the garden city, which aimed at optimizing living conditions, was practically reserved for almost exclusive application to residential areas for Europeans, further entrenching social inequalities and underlining exclusivity of British colonialism. The introduction of garden city planning did not merely reflect the Company's growing wealth or ability to invest in better infrastructure. It was a strategic concession towards calming growing unrest amongst workers. However, this strategy failed to address the underlying issues of systemic exploitation, inequality, and racial segregation. The "green oases" designated for British employees sharply contrasted with the overcrowded and poorly serviced areas where Iranian workers lived, fostering resentment and amplifying class conflict.

Furthermore, the spatial organization of these towns, particularly in Abadan and Masjed Soleyman (Masjid-i-Suleiman), was not accidental. The Company used urban planning as a mechanism of control, designing the towns in such a way that workers' movements could be monitored and contained. This urban spatial segmentation, coupled with Company control over housing, medicine, and other basic services, provided the Company with a form of paternalistic governance over the towns, maintaining order while optimizing work extraction.

Strikes during the 1920s and 1940s, instigated by grievances over housing, wages, and conditions of work, highlighted weaknesses in the Company's paternalistic approach. Iranian workers, emboldened by the nationalist movements, began challenging the discriminatory practices. The inadequacy of the Company's responses to these challenges is evident in the architecture and urban planning of the period. While continuing to construct new houses as well as enlarge existing installations, Company efforts were mostly stopgap measures that failed to address profound inequalities in the towns. Construction of rapid, inexpensive units such as the Arken, to accommodate several family units under a single roof, was indicative of Company desperation to fulfill housing needs of swelling workforces without changing fundamentally the hierarchical structure of the towns. Therefore, by 1951, when the Iranian oil industry was nationalized, the garden city neighborhoods that once stood as symbols of modernity and advancement were now emblematic of the deep-seated inequalities that had fueled decades of discontent. The spatial segregation, discriminatory practices, as well as unequal distribution of resources, which characterized architecture development of these towns ultimately contributed to their downfall.

Finally, the building process of the oil company towns of Iran was much more than a narrative of architectural progress; it was a complicated and disputed process inextricably linked with wider dynamics of imperialism, exploitation of labor, and opposition. While the evolution from bungalows to garden cities may suggest a trajectory of urban refinement and sophistication, this transformation was underpinned by deeply unequal power relations and a colonial logic that prioritized British interests over the well-being of Iranian workers. Therefore, the legacy of these towns is not one of architectural achievement but of social injustice. Future research could further delve into visual as well as spatial recordings of such enclaves in maps, plans, as well as photographs. Additional inquiries might also address infrastructure systems like healthcare, water, and waste management, as well as everyday lived experiences and the role of non-company actors in shaping urban development.

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Conflicting agricultural territories and unsolved public problems. The case of Val di Non in Italy

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Beginning with UN Agenda 2030, the European Commission has recently adopted many strategic policies, such as Farm to Fork, Biodiversity Strategy, and Common Agricultural Policy (CAP). These documents set up important objectives to cope with environmental and climate challenges. The study uses a quantitative and qualitative research methodology to provide an empirical analysis of the land-use changes and landscape modifications in an important area of apple production in Italy, such as Val di Non in the Trentino Region. The aim is to reflect upon the gap between policy formulation and implementation through spatial planning. Recently, some of the most important Italian agricultural associations protested against the forced reduction of the use of pesticides set in place by new common policies. A closer look at our case study tells us that the local system of production is unlikely to change if territorial planning does not problematize the rising social demand for more sustainable policies and practices in agriculture. Some empirical implications suggest the need for planning tools capable of addressing social demand. In other words, creating conditions for mutual interaction between planning and practices to imagine new ways of living together in a territory of monoculture.

Keywords: territories of monoculture; planning; social conflict; public problems; European policies

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Introduction

This paper presents the results of a case study conducted by the author in so-called "territories of monocultures" such as Val di Non in the Trentino Region, an important area of apple production in Italy. It aims to provide empirical evidence for the landscape and land-use modifications generated by the apple orchard expansion, which has resulted from many factors: such as, soil and climate factors, the territorialization of the Common Agricultural Policy (CAP) and the strong tradition of cooperation[1]. To do so, the research will be conducted through a case-study analysis, to provide the first in-depth analysis of the phenomenon within the field of planning. More in general, the research is part of PhD research. To date, no attention has been devoted to the specific landscape and land-use changes generated by the intensified use of land for apple-growing. In recent years, an explicit concern has risen about the impact that intensive agriculture can generate on human settlements (Basso & Vettoretto, 2020). Some examples are the hills where wine is produced, the apple orchards, and hazelnut production areas. Agricultural practices are driven by economic interests with a capital-intensive approach, which often turns land use against the needs of local citizens. In what we call "territories of monocultures", specialized agro-industry has triggered a significant environmental, landscape, and social impact, as well as health issues connected to the massive use of chemicals. Frictions and contradictions between different narratives, values, and territorial aspirations (i.e. economic development, promotion of tourism, landscape conservation, and citizens' demand for a higher quality of life) have become evident through growing social conflicts and protests.

The first part will focus on the methodological approach. The PhD research activity was used as a moment of exploration and data collection. The "exploratory" approach of the case-study used both quantitative and qualitative analysis, to give a detailed description of apple production in the Trentino region. At a more general level, the second part of the article starts with an analysis of the main EU policies and strategies, in particular the CAP, to understand their contribution to the creation of monoculture, and to what extent territories of monocultures have been framed in those policies. Furthermore, the article seeks to expand the scientific research that specifically takes into account the relationship between fruit growing and land-use. Moreover, some relevant theoretical contributions in the field of territorial and social studies will offer various interesting interpretations within globalization and urbanization processes. The third part will discuss data collection and data analysis gathered from the statistical and geographic database. On the one hand, it seeks to reconstruct both the long-term historical factors that brought about the emergence of the specific fruit economy. On the other, quantitative information will be intertwined with interview excerpts to better comprehend the significance of the data collected. Preliminary results (fourth part) will be achieved by intuitive understandings gleaned from being in the field and data analysis. Finally, the conclusion will outline some key elements observed during the research: monocultures as factories, lack of planning tools capable of problematizing (social) demand, interaction between housing and agriculture, and the need for general regional development and safeguarding strategies in the drive to create a new way of living together in a territory under pressure.

[1] The history of cooperation in Trentino is long-established. The first cooperative was founded at the end of the XIX century by Don Lorenzo Guetti. The cooperation survived through two World Wars and the fascist regime. Nowadays, the system is organized on three levels: the cooperative, the consortium (with which cooperatives are associated), and the Federation through the role of political representation at institutional level, technical accounting assistance, auditing, supervision, and promotion of the territory. Both the cooperatives and the consortiums are part of the Federation. Four main sectors characterize the cooperation system: Consumer, Credit, Agriculture, Labour-Service-Social-Housing (Coop.Tre., 2006).

Methodology

This study is based on both qualitative and quantitative analyses that were carried out in parallel between June 2022 and December 2022. The research methodology is based on an "exploratory" approach to the case-study (Yin, 2014). In the Italian context, the case study approach has been mainly used to inquire into problematic situations in urban contexts and project developments[2]. The aim of the case-study is more about learning by probing rather than trying to prove anything. (Gelli, 2002). Moreover, the case-study attempts to understand how people experience their world at a particular point in time and in a particular context (Merriam & Grenier, 2019). Evidence in the case-study method is varied: documents, artifacts, interviews, and observations. In particular, the evaluation is based on:

- local and national newspapers such as: L'Adige, Il T Quodiano, Gazzetta delle Valli, La Voce del Trentino and Nos Magazine;
- information on the producer websites (Assomela, APOT and Melinda websites) regarding quantitative trends in apple production, and agricultural practices used;
- analysis of official planning documents and tools;
- a series of 16 in-depth interviews with people directly involved in the main events. An initial selection of subjects took place from an analysis of actors and stakeholders. Interviews were planned with local activists, traditional and organic farmers, representatives of trade associations, local political and institutional actors, and researchers involved in the area;
- direct observation and participation in events organized by activists and local producers[3];
- a collection of quantitative data on production, exports, types and sizes of companies, land cover and their expansion over time, available on the provincial institute of statistics (ISPAT), and the regional geocartographic portal;

The case of Val di Non has brought to light interesting elements concerning the forms of land-use of the highly industrialized and densely equipped "hinterland" of monocultures. To succeed, the field of investigation will be set on a problematic situation or a social demand for public intervention. The public policy analysis forces the researcher to understand when there is a problem at stake, and who is dealing with it. In particular, in the explorative qualitative research analysis, findings are part of an inductive process, and the final product of inquiry is richly descriptive (Merriam & Grenier, 2019).

First theoretical interpretation for monocultures

Territorial and social studies have not sufficiently explored rural territories in terms of globalization and urbanization processes. For this reason, my research focuses on a different dimension and meaning of "rural"; it can be defined as "territories of monocultures". In these territories, the production of space has been shaped by economic and political forces. Nevertheless, social fractures are not rare, and different interests and narratives have come to light, related to different forms of power. Due to this, some authors argue that any locality is conceived as an expression of land-based elites (Molotch, 1976). Additionally, these territories have undergone massive land-use and socio-economic changes as a result of the intensification of specialized, export-oriented agricultural productions (Brenner & Katsikis, 2020, 2023). In what we call "territories of monocultures", specialized agro-industry has

[2] Some authors who apply this method are: Balducci (1988), Fareri (2009), Basso (2017).
[3] I.e.: Pomaria 2022 (October 15-16t, 2022); *Dal fare al dire, come comunicare la sostenibilità* – APOT (January 27, 2023); *Primo Maggio Ecologista – Marcia Stop Pesticidi* (May 1, 2023).

triggered significant environmental, landscape, and social impact, as well as health issues connected to the massive use of chemicals. As already said, friction and contradictions between different narratives, values, and territorial aspirations (i.e. economic development, promotion of tourism, landscape conservation, and citizens' demand for a higher quality of life) have become evident through growing social conflicts and protests.

Furthermore, the meaning of monoculture has been given little academic attention within urban studies so far. This is probably because the idea of monoculture is quite intuitive. Indeed, its negative meaning originated from the association with intensive agriculture which is often used as synonymous with the term "monoculture". The term "intensive" refers to those activities that make abundant use of chemical input, favouring a few crops or just one over others, with inevitable consequences on biodiversity, landscape, and the environment, such as hydro-geological disruption or water contamination problems (Reho, 2017). Likewise, the term monoculture correlates, on the one hand, to possible environmental impacts on agriculture; on the other, to economic advantages, economies of agglomeration, an industrial approach, and the concentration of a supply chain, etc. (Franco et al., 2022). Besides this, monoculture is also associated with the term rural. At first glance, rural recalls a mental space that offers seductive geographies for recreation and tourism, but also different scenarios for a renewed quality of life that balances farmers' and citizens' needs. Nonetheless, monocultures call for a repositioning of the term rural, when its meaning can no longer be attributed to the imaginary of a charming countryside populated by peasants, but to artisanal activities, product processing, industrial and commercial manufacturing, services or logistical activities, etc. (Vallerani, 2021).

From a policy point of view, it is important to consider why and how monocultures have managed to spread so widely in some parts of Europe. To answer this question, the paper starts from overall comprehension of the CAP key elements. CAP is the first *ante litteram* European policy before the establishment of the European Union itself. The point is to understand whether there is institutional awareness about the issues raised by "territories of monocultures" and if so, to what extent this has translated into concrete policies or if it remains merely a discursive-rhetorical tool.

Public policies at European level

In Europe, the Common Agricultural Policy (CAP) is the most important policy on agriculture and rural development. This paragraph will examine its origins and evolution. Before entry into force of the Maastricht Treaty in 1992, the CAP represented the most important European policy, because of its capacity to endure among European policies with a particularly relevant weight and role. Further, it remains unaltered in its market and income short-term support; and last, for its exceptional capacity to remain for some 25 years as the only European policy in economic and social fields. If the CAP had been abandoned, we would have lost the opportunity to keep alive the whole European common project (Sotte, 2021). Since its inception in 1962, the general structure has remained the same (Sotte, 2022). The CAP is based on two important pillars: the first is about economic farming support and Market Price Support (MPS); while the second is a structural policy for rural development. The historical core of the CAP was to develop farming capacity, knowledge, and technology to overcome the underdevelopment of agricultural and rural territories. Despite a gradual shift of policy focus from traditional market price support towards sector-wide and non-commodity policies, the MPS remains an important policy for Europe agriculture. According to OECD (2006), rural areas have undergone an important transformation due to an extraordinary increase in agricultural productivity, modernization of the supply chain, fewer farmer-producers, and

concentration of production in relatively few places. Moreover, in some regions, farmers sign contracts with big food companies to deliver products on a pre-set schedule. This implies a supply chain and business re-organization of agriculture. Agricultural subsidies have contributed greatly to the abovementioned transformation. However, they were not intended to trigger rural development directly, because they focus on a small segment of the rural population (mainly farmers) rather than places. In fact, EU agricultural price support tends to favour the regions where farms are larger and more productive, rather than those more peripherally located.

> MPS is the only type of support that simultaneously affects production and consumption of a commodity and as such has the greatest potential impacts on production, consumption and trade, and can have a negative effect on rural economy and the environment. (ibid., p. 45)

More recently, to enhance farmers' bargaining power, the EU has adopted two programmes for supply chain support: Producer Organizations (POs) and an Association of Producer Organizations (APOs). These programmes are at the basis of the success of the monocultural productions. Places such as Val di Non are great examples of cooperation models, and in some cases already existed before POs and APOs were created. This is demonstrated by the relative success over time of those agricultural sectors that have been less subsidized with direct income aid, and which have benefited from structural interventions or the organization of supply chains. This applies to sectors or products such as wine, fruit and vegetables, flowers, pork and poultry products, and agritourism. This has occurred when farmers have been able to become entrepreneurs, aiming at efficiency and competitiveness (Sotte, 2021).

After the launch of Farm to Fork (F2F) and Biodiversity (BD) strategies, several studies[4] have analysed the possible effects of European policies directly related to agricultural systems and food production. Although these studies admit that they face some methodological limitations, they provide valuable insight into the possible threats and strengths of these new policies.[5]

The Italian Association of apple producers took this topic into serious consideration. They are concerned that the F2F and BD objectives will put the entire Italian sector of apple producers at risk. The Wageningen University pamphlet (Bremmer et al., 2021) has developed four scenarios in which the EU Green Deal, F2F, and BD objectives are combined. The study assessment shows that policies will have a strong impact. EU imports will have to compensate for the decline in EU exports and an increase in prices. Impacts on trade will be larger than production and product quality will be affected. The impact will be higher for perennial crops (orchards, vineyards, etc.) because annual crops will have more options to compensate and reduce negative impacts related to a decline in production. Farmers' revenues will be affected, and the need to develop protection mechanisms to cover the additional costs is recommended.[6]

The EU is trying to set a new vision for rural areas aiming to reassess their role in current society and to define a new life for them. This new vision is in synergy with the EU Green Deal objectives and the EU Territorial Agenda 2030. Despite the fact that the long-term vision is based on an integrated approach, demographics remain an essential and relevant territorial

[4] The document is available at https://knowledge4policy.ec.europa.eu/publication/factsheet-green-deal-targets-2030-agricultural-production-studies_en

[5] It is not the objective of this paper to cover the limitations declared by those studies, which offer a policy simulation analysis, while the present paper is based on empirical research.

[6] The study declares some limitations on potential impacts on animal production as well as consumer behaviour. Therefore, results might be overestimated.

indicator for the sustainable development of rural areas (Szydarowski et al., 2021). In contrast, demographics in territories of monoculture is not an issue.[7] All these places are based on the globalized agro-industrial system of agricultural production. For example, monocultures are framed only in the context of their economic value through market policy, but they do not respond to the second CAP pillar on rural development and the EU Green Deal objectives. From this perspective, it can state that the issue of monoculture territories is still not clearly defined in the EU rural agenda.

The Trentino-Alto Adige/Südtirol Region

Apple production in Italy is mainly concentrated in the northern part of Italy, the Trentino-Alto Adige/Südtirol Region (Figure 1). The region produces about 1.5 mln ton/year of apples, which is about 75% of national production. Apple production is protected by the designation of origin label, approved by the Ministry of Agriculture, such as Protected Designation of Origin (PDO), or Protected Geographical Indication (PGI). The agriculture in this area is important from the point of view of exports and for its connection to the global value chain.

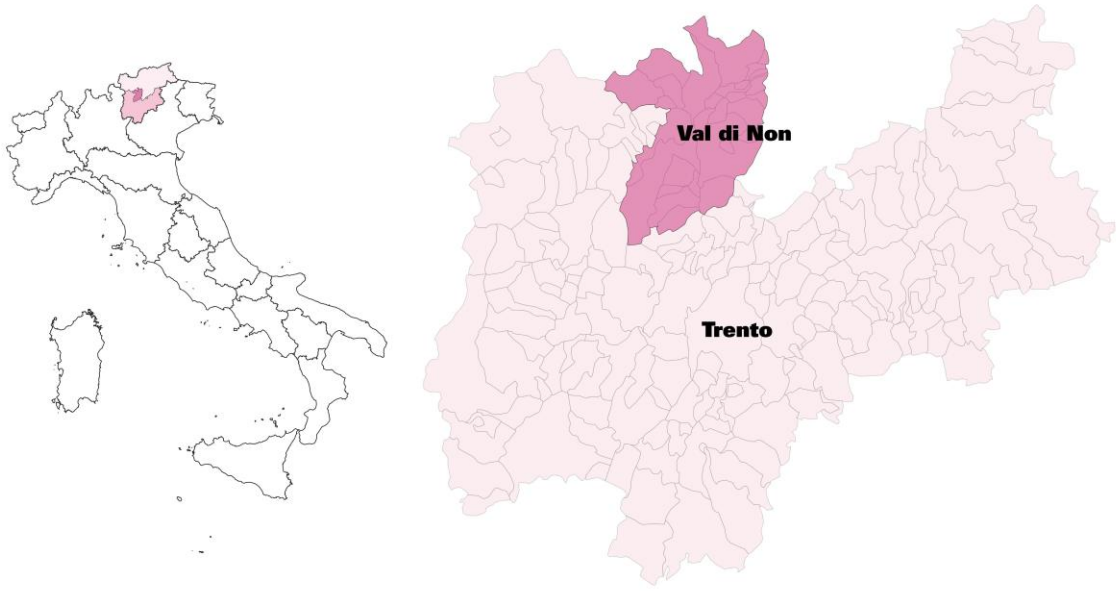

***Figure 1**. On the left part, the Trentino-Alto Adige/Südtirol Region in Italy. On the right, the Autonomous Province of Trento and the Val di Non community. Source: author*

The Region is divided into two autonomous provinces: Trentino (Autonomous Province of Trento) and South Tyrol (Autonomous Province of Bolzano). Their special status of autonomy transfers the main competencies (political, legislative, administrative, and fiscal institutions) from the region to the two provinces. In particular, as regards Trentino the main actor in the territorial governance and planning is the Autonomous Province of Trento. Like the other Italian regions, the Province of Trento is responsible for planning and enacting laws for the government of the territory. As regards provincial planning, local bodies, in charge of local planning, must adapt their plans to the provincial's objectives and regulations. Concerning the financing system, it mainly derives from the State, through the devolution of fixed shares (a

[7] Population (inhabitants) from ISPAT database: 38.257 (1951); 37.798 (1961); 35.980 (1971); 35.203 (1981); 35.204 (1991); 36.510 (2001); 38.938 (2011).

very high percentage, usually 9/10 of the tax revenue collected locally) of state taxes and fees collected locally.

Since this territory has one of the highest levels of per capita GDP in Europe, and very high average household incomes, the agriculture GDP is about 13% of the total provincial amount. Two sectors contribute to the GDP: fruit-growing and viticulture. Within this framework, fruit-growing is about 33% of the total gross saleable production, mainly consisting of apples. As said at the beginning, the location of most of the apple production (at least 70%) is in Val di Non (Figure 1). According to the distribution of power among local actors, this concentration significantly marks the role of the apple system in the local, regional, and national policy-making game and impacts on social conflicts.

Val di Non: the Land of Apple

The Val di Non community consists of around 39.000 inhabitants, distributed in 23 municipalities (many of them below 1.000 inhabitants), where apple production is part of the traditional economy (Figure 2). In the middle of the Alps, this territory is a sprawling, low-density, socio-spatial region composed of small towns, villages, historical buildings, and rural and natural areas. The specificity of this apple-growing valley is the Protected Designation of Origin PDO “Mela Val di Non”, produced exclusively in this place, and nowhere else in the world. The internationally famous “Mela Val di Non” comprises the following varieties of apple: Golden Delicious, Renetta Canada, and Red Delicious. In Val di Non, the apple orchards have been present since the 19th century. Initially, the fruit-growing was made of isolated trees within polyculture agriculture and was mainly oriented toward self-consumption (Tizzoni, 2013).

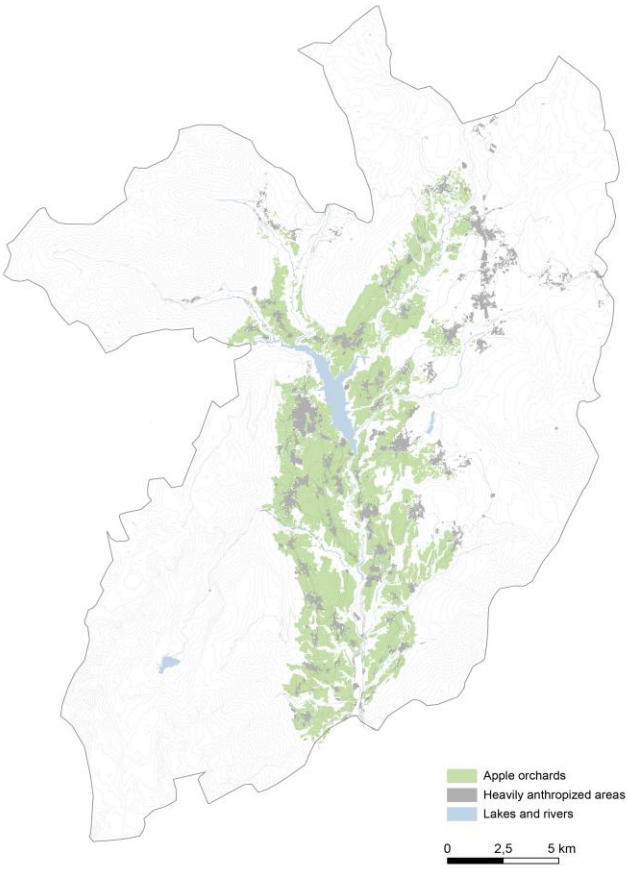

***Figure 2**. Apple orchards and heavily anthropized areas in Val di Non. Source: author*

After the Second World War, the agricultural activity was still highly diversified, but the valley gradually started to greatly increase its apple production. The industrial approach to apple production can be dated around the 1960s, with more than 5,000 independent farmers. During the 1970s, there were 40 small fruit warehouses in the valley. The apple orchards expansion can be dated to the same period, with a particular acceleration in the following decade. Major land reclamation began mainly in the 1980s, with 50-100 ha at a time (Figure 3 shows a small example of contemporary land reclamation in Val di Non). Meanwhile, 16 cooperatives were created to improve the cooperative system.

***Figure 3**. Deforestation of 2 hectares of public wood and geomorphological modifications to the mountain in 2019 for the planting of new orchards in Tuenno (TN). Source: Comitato per il Diritto alla Salute Val di Non. Used with permission*

Another important step related to the transformation of Val di Non is associated with the foundation of the Melinda consortium in 1989 (the company name changed in 1996 as a result of an important CAP reform) through the association of all 16 cooperatives operating in the valley, while the Protected Designation of Origin (PDO) “Mela Val di Non” was recognized by European Union in 2003. During the 1990s, the supply chain was reorganized, and large-scale commerce was centralized; while in 1993 the producer organizations in the Trentino region were gathered under an “umbrella” organization called APOT[8]. Today, the Melinda consortium includes more than 4,000 producers (farmers), with almost 7,000 hectares of apple orchards

[8] APOT stands for “Association of Producer Organisations of Trentino” founded in 1993. Today, members of APOT are: Melinda, La Trentina, Società Frutticoltori Trento (SFT), and Co.P.A.G. consortium. With this membership base, APOT represents about 90% of the total fruit-growing sector in Trentino.

in the whole valley (Figure 2). Apple governance is structured locally through Melinda, regionally through APOT, and nationally and at European level through Assomela[9].

Land use changes and territorial organization

According to the Province of Trento Institute of Statistics (ISPAT), we observe an almost unchanged situation since the 2000s. In 2010, the Utilised Agricultural Area (UAA)[10] in Val di Non amounts to 14.921 hectares, of which permanent crops account for about 46%. More specifically, the apple orchards occupy 6.738 hectares, accounting for 45% of the UAA. From 2000 to 2010, the area occupied by apple orchards was reduced by a few units, from 6.827 ha to 6.738 ha (-0.0016%), but the total area under permanent crops increased slightly from 6.877 ha to 6.899 ha (+0.003%) (Figure 4).

Today, fruit farming can be defined as the most traditional agricultural practice, with the presence of about 6.898 ha[11], most of them cultivated with apple trees, accounting for about 46,24% of the UAA (Figure 5). Ninety-nine per cent of the orchards' surface is served by a drip irrigation system which means around 27.000 km of pipe length[12]. It is interesting to note that the incidence of apple cultivation is roughly the same as in the Prosecco DOC[13] area which is 47,84% of the total agricultural area (Basso, 2018). Based on the latest available census of 2010, land use in the valley does not show great diversification, but rather substantial uniformity concerning apple production.

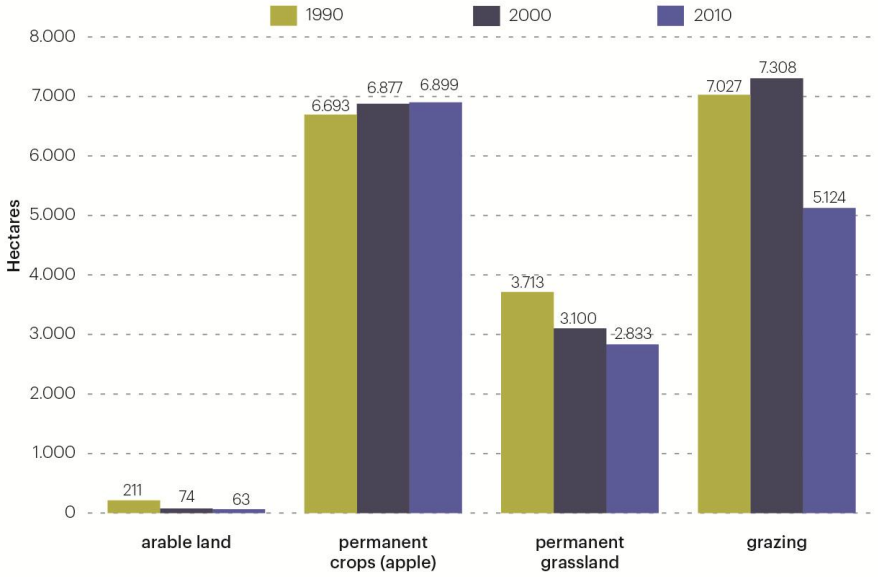

***Figure 4**. Land-use changes that occurred between 1990 and 2010 – Val di Non. Source: author's elaboration on ISPAT data*

[9] See http://www.assomela.it/index_en.html
[10] For further information about the meaning: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Utilised_agricultural_area_(UAA)
[11] This data is updated to 2014. See "Allegato 5 – Piano Territoriale di Comunità" available at https://www.comunitavaldinon.tn.it/Servizi/Piano-Territoriale-di-Comunita
[12] The transition from slow sprinkler irrigation to drip irrigation is well explained in this article available at this link: https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/23799
[13] Italian sparkling wine produced in the province of Treviso, an area 50 km north of Venice (north-eastern Italy).

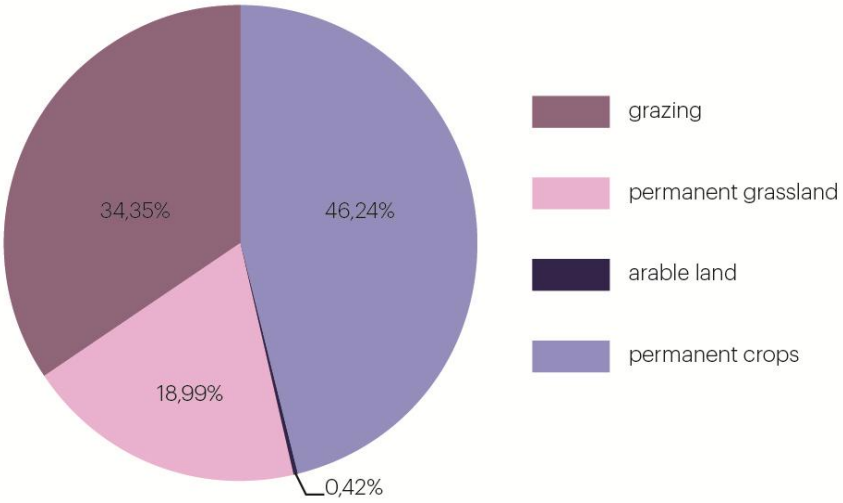

***Figure 5**. Utilized Agricultural Area in 2010 – Val di Non. Source: author's elaboration on ISPAT*

Regarding the relationship with the urbanized area, the apple orchards still have a significant impact on the territory. If we compare 2.079 ha of "Heavily anthropized areas" (*Aree fortemente antropizzate*)[14], which is about 3,49% of the total surface of the valley (around 59.700 ha), with the total amount of orchards, around 6.898 ha, we observe a much higher percentage of land-use, around 11,50 %, of apple production. The relevance of orchards reveals a clear necessity to relate agriculture and housing in terms of space in the organization of the land-use of the valley.

Val di Non has the highest number of agricultural enterprises, with 2,339 units, while its predecessor, Vallagarina, has just 969 agro-enterprises. The following graph shows how the vocation of the Val di Non is clearly agricultural and particularly related to fruit-growing, when compared to the other 16 valley communities. Through interviews with local farmers, it was possible to ascertain the different types of farms, according to the average dimension of their fruit orchards: 1) Agricultural farmer with orchards of approximately 3-6 ha (more than 300 hours/year); 2) Agricultural and livestock farmer with orchards of approximately 3-6 ha (more than 300 hours/year); 3) agricultural farmer with orchards of approximately 0.5-1 up to 2 ha (less than 300 hours/year). On average, 1 hectare of orchard costs 50 €/m2 up to a maximum of 80-100 €/m2, while woodland costs 2 €/m2, and grassland around 10 €/m2. Yet, in one hectare 3.000-4.000 apple trees can be planted; and production can reach 500 to 900 cwt (hundredweight), according to apple variety. A standard orchard can hold 598 cwt of wood, 300 cwt of concrete stakes, 14 cwt of steel wire and 6 cwt of polyethylene for the nets.[15]

Export and supply-chain

The global economic and commercial success of the "Mela Val di Non" is the result of a long-term social construction process. In the last 20 years, apples have become a worldwide product on global markets, and their demand has increased both nationally and internationally.

[14] According to the Trentino Landscape Observatory (*Osservatorio del paesaggio trentino*) "Heavily anthropized areas" represent those territorial contexts in which agricultural use or a condition of naturalness is no longer detectable, regardless of their physical state and surface treatment. This indicator includes historical settlements, new urbanized areas, industrial areas, mobility network, quarries, landfill and waste management plants.

[15] This information was gathered through interviews with farmers and local activists.

In 2021, Trentino Alto-Adige's exports were worth €97.3m (+21.6% in 2019 to €547m) and went tto Germany, the Czech Republic, the UK, India, and Saudi Arabia. Jams and fruit juices grew by 4.5% in 2019, thanks mainly to France, Belgium, and Spain. In addition, as of 2016-17 Melinda and Assomela (the Italian Apple Producers Association) have been negotiating/trading with South-East Asia.

> We [Melinda] have 70% of the Italian market, the ratio is the reverse for them [VOG and VIP][16], 30% in Italy and 70% abroad. Everyone would aspire to the Italian market, but that's clearly where we have been investing in communication for more than 20 years, and in the mind of the Italian consumer is Melinda the first brand they recognize (interviewee 12).

The apple supply chain is organized through local and regional input (machinery and tools of production), and global output (apples and processed products). Some on-field observations about the supply-chain functioning mechanisms suggest an increasing role of machinery in agricultural production (Galli, 2023). It is possible to state that the agricultural and economic set up is structured in such a way as to invite comparison to Benetton, making it a sort of "Benetton of apples"[17], where one actor, in this case, Melinda consortium, manages a whole series of small, microscopic actors. Half a hectare of land is indeed a very small portion, but the overall effect is important.

Preliminary results from on-field research

An unsolved public problem

The first explorations through interviews and on-site visits have led to a greater awareness of the territorial/spatial relevance of apple growing. The first interviews were with members of grassroots movements (the longest-lived, starting in 2007, being the Committee for the Right to Health in Val di Non - *Comitato per il Diritto alla Salute in Val di Non,* followed a few years later by the Association Alta Val di Non – Sustainable Future - *Associazione Alta Val di Non – Futuro Sostenibile*) and the economic sector, widely documented in the local, national and foreign press and reporting the advancing of apple orchards and the massive use of pesticides, putting the public health of valley residents at risk. Indeed, the main problem perceived by local movements concerns public health, and they demand public intervention, which is addressed mostly by APOT and the Melinda consortium, and not by the authorities. The local committees work scientifically and produce dossiers and presentations with data to support their claims. In a standard Val di Non apple orchard, the average number of chemical treatments in 2009 of formulated products (f.p.) was 81.1 kg/ha, while of active ingredients (a.i.) was 51.5 kg/ha (Ioratti et al., 2011, p. 547), against a national a.i. average in agriculture of 8,38 kg/ha (ISTAT, 2009). Despite the high quantity of chemicals used in Val di Non orchards, from 2009 to 2021 the average amount of active ingredients in agriculture in the Province of Trento decreased from 47.01 kg/ha to 38,82 kg/ha (ISTAT, 2021). This reduction has concerned Val di Non too.

[16] VOG and VIP are the two main Producer Organizations in South-Tyrol region.
[17] Benetton is a global fashion brand based in Ponzano Veneto (Treviso province), founded in 1965. The reference to the Benetton multinational enterprise is related to its productive organization model made of an important network of small and medium enterprises. This network is an example of the so-called industrial districts developed in the mid '60s, in the Northeast region of Veneto, and in many other parts of Italy. Today, the brand owns a worldwide network of shops, with a centralised model of management.

***Figure 6**. Apple landscape. Source: author*

In describing briefly, the problematic situation perceived as a public issue, we can easily recognize the traditional collective structuring process problem.[18] Besides that, we also find a tendency to "proceduralize" conflict, pitting internal parties against each other to seek consensus (Crosta, 2010), the result being that the situation has not found any solution yet. Nevertheless, the divergence among groups becomes an opportunity to address the different interests at stake and the diverse means of living in the valley. Therefore, the call is to find a new way of co-habiting (citizens, housing, and orchards).

The data on the infrastructure discussed in the paragraph "Land use changes and territorial organization" has a clear impact on the landscape (Figure 6), but its planting does not require any kind of landscape authorization at municipal level. Moreover, the infrastructure is facilitated by incentives and subsidies from provincial public funds. For example, a drip irrigation system can be subsidized by up to 80%. The major critical issue highlighted by the interviews and field observations is the mix of orchards and houses: spreading techniques using atomizers that generate the so-called "aerosol" effect causes great disturbance to

[18] Crosta (2010, p. 134) in his text recalls the five stages outlined by Herbert Blumer (1971) about the definition of the collective problem, briefly reported as follows: 1) The recognition of the problem's existence; 2) The legitimation of the social problem; 3) The transition to action through public debate, events, and the use of mass media. All this helps the problem's redefinition; 4) Arrangement of an official plan of intervention; 5) Implementation.

homes or public spaces in the proximity of the fields. The mingling of orchards and housing leads to the question of how urban planning (does not) treat(s) fruit-growing.

> Town planning is a tool in the hands of politicians, who act according to the demands of the moment. If a farmer wants to build his house near the field he owns, he asks the administration, and the administration approves a variant to the plan that allows him to build. The problem of not turning into building area the land enclosed in the urban fabric is that you have to pay the local municipal tax on that land, and this tax becomes a hindrance to cultivation (interviewee 2)

After many protests and public events, APOT scheduled a series of round tables that lasted from 2016 to 2021. The local committee and many other stakeholders were invited, and the meetings are part of the annual project *Trentino Frutticolo Sostenibile*[19]. The project includes annual meetings (such as external audits) with local actors, in order to discuss fruit-growing. At these six round tables, the committee made proposals, but they went partially unheeded. The producers tried to demonstrate their efforts in improving the productive process and the use of pesticides in relation to the European, national, and local rules. Nevertheless, no agreement was found, and according to the local committee, the round tables turned out to be a total failure because the use of chemicals in orchards still disturbs homes, damages health and the environment, and impacts the landscape. Besides that, a tacit request from the local committee was to rethink the interaction between settlements and agriculture (Figure 7), which indirectly calls into action the role of the public institutions, especially the Autonomous Province of Trento and local municipalities, in charge of planning and programming. Except for some agreements between apple producers and the Provincial Environmental Protection Agency for water discharge quality monitoring, in the last few years other public institutions have never actively participated in the debate. The external audit continued but in 2021 the last meeting between producers and the committee was held.

***Figure 7**. The image illustrates the interaction between apple orchards and urban settlements, detailing the territorial organization of the valley. Source: adapted from Google Earth*

[19] The project started in 2016 and is still ongoing. It is promoted by APOT, CIF (Consorzio Innovazione Frutta) and FEM research centre (Fondazione Edmund Mach).

Planning in the Land of apple

In the EU and North America, the history of planning has always conceptualized the relationship between city and countryside from an anti-urban or pro-rural point of view. However, planning policies and regulations aimed at protecting agricultural areas from city expansion have never had a clear and explicit concern about the impact that intensive agriculture can generate on human settlements (Basso & Vettoretto, 2020). Sometimes, when the countryside is linked to global networks and becomes an agro-industry, the pro-rural vision can be challenged. Starting from these assumptions, the study examines whether the issue of fruit monoculture is problematized in the local planning tools and laws. Reading the Provincial Law n. 15/2015 for the government of the territory (Legge Provinciale di Governo del Territorio, 2015), it is clear how the gap lies upstream of the regional planning process: the issue of land occupation due to apple cultivation does not enter the text of the law.[20] We can therefore state that the problem does not exist, or at least is not perceived by the planning tools; for instance, highlighting how land policies do not deal with the issue of apple monoculture.

The Provincial Urban Plan 2022 keeps the layout of agricultural land unchanged by dividing it into “agricultural areas” (Art. 37) and “valuable agricultural areas” (Art. 38). The difference between them is minute. The central issue is that Provincial Law 15/2015 exempts orchards, or any other land preparation work, from any landscape assessment unless they are included in the “environmental protection area” (Art. 64, P.L. 15/2015) (Figure 7 shows clearly the impact of hail on the landscape). However, orchards included in these protected areas are quite a small portion of the total. Moreover, the apple orchard planting phases clearly show a process of urbanization: for example, the irrigation system involves around 4km of polyethylene pipes per hectare which is about 27.000 km covering 99% of the total orchards’ surface, and land reclamation works may involve up to one-metre-deep excavation. In the latest Provincial Urban Plan (PUP), the focus on agricultural areas is mainly on the possibility of building agricultural or agritourism facilities.

> This aspect is a handicap, because under the previous Provincial Law of 2008, agricultural areas could not be built on; but with the latest law of 2015, the possibility was introduced for the farmer, with reference to the hectares he owns, to build a productive structure of a maximum of 400 cubic metres, to be used for housing. (interviewee 5)

The sense of the Provincial Law and the Provincial Urban Plan is perhaps more productive and does not problematize agricultural area under the issue of landscape. Basically, the current PUP simply follows the direction traced with the first one in 1967, maintained in the subsequent updates of 1987 and 2008, where the aim was to find a new balance between mountain areas and urban centres, supported by lively social mobility, through the concept of “urbanized countryside”[21] (Zanon, 2018).

Conclusions: what future awaits the land of apple?

This paper has briefly traced the origins and recent evolution of one of the most important regions for apple production in Italy, using both qualitative and quantitative methods. The previously illustrated land transformation shows a greater and capillary organization of the agricultural sector in the Trentino region. The strong cooperation tradition added to important

[20] In art. 78 land reclamation works connected with normal agricultural activity (lower than one-metre-deep) do not require permission.

[21] The first mention of the concept of “urbanized countryside” (*campagna urbanizzata*) was made by Giuseppe Samonà, an important Italian architect and urbanist. He was also the project leader of the first Provincial Urban Plan dated 1967.

investments from the Common Agricultural Policy has transformed this area into a literal "green factory" with a perfect and flawless supply-chain. So, the capillary agricultural structure, a long tradition of cooperation practices, and a well-established supply chain might provide some interesting points for reflection. For instance, in the context of the global market, these types of areas have been stimulated like never before.

As said, territories of monocultures are becoming "factories" completely incorporated into "metropolitan devices". However, it is interesting to see how the development model of widespread production is articulated in many ways, according to local specificity. Analogies can be drawn with the diffuse industrial development model that existed in the Veneto region between the 1970s and 1980s, which showed a similar organization. Besides that, the representatives of the apple economy show their great capacity to assure quality and sustainability of fruit. Thanks to their producers and network of technical expertise, Melinda can control the sustainability of the production process and the biodiversity of the entire valley[22]. Nevertheless, a counter-narrative has emerged from a network of environmental organizations, committees and associations who have been speaking out for many years against the geomorphological modifications of the valley, the hydrogeological risks connected with the expansion of apple orchards, the impoverishment of the landscape, and the impact of chemical products on public health and the environment. Accusations include the fact that they limit individual mobility, and cause noise and smell during the treatment period. From the clash of the two visions about the development of the valley, we can consider a couple of aspects: on the one hand, the planning devices do not take into sufficient consideration the interaction between urban settlements and agricultural practices; on the other, public institutions, in particular the Autonomous Province of Trento, should extend their approach beyond simple control and monitoring and be willing to enter into the public debate. In addition, the planning system shows clear a contradiction between the general conception of agriculture as an element at risk to be protected and the problems created by agricultural practice revealed by the empirical evidence. Furthermore, the existing apple market is sometimes more convenient than traditional building, which imposes significant levels of infrastructure on the ground and landscape. For this reason, we can again affirm that – today – this kind of agriculture is nothing but urbanization; additionally, territorial planning does not problematize the rising social demand for more sustainable policies and practices in agriculture.

To sum up, planning tools often construct an upstream knowledge that separates depictions (land uses that it depicts in its documents) from practice (i.e. the actual land use that emerges from social conflicts). Thus, the case study demonstrates a common aspect in Italian town planning, where planning activity fails to implement what it represents. Following Crosta's reasoning, if policies (including urban planning policies) are collective construction, what is depicted in the plan must be considered a hypothesis and not just an affirmative statement.[23] All this generates a tendency to reduce policy-making to decision making, separating the construction of knowledge from decision and action, with the consequence of not problematizing the plan's choices and without reducing impairments in society either. A final recommendation would be to tackle the issue of fruit growing within ordinary urban planning schemes to integrate sectorial decisions on land-use into the general strategies of regional development and protection able to challenge the (conflictual) practices and to imagine a new way of living together in the valley.

[22] In the last few years, Melinda has added another layer to their sustainability discourse related to energy saving thanks to the unique underground warehouses in the Dolomite caves.
[23] The statement "policies as hypothesis" (Crosta, 2010, p. 135) is an explicit reference to John Dewey's approach to public problems.

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Designing infrastructure beyond the urban-rural divide: Comparative lessons for the European territorial palimpsest

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This article explores how insights from past and present North American infrastructure projects can inform the rethinking of infrastructure's role in the transformation of European 'dispersed territories', i.e. low-density urban-rural configurations. Framed by the concept of the "territorial palimpsest", this paper adopts a qualitative, comparative case study approach to examine how infrastructure design can mediate the urban-rural divide. Through diachronic analysis, it considers several twentieth-century infrastructural imaginaries and contemporary projects. While acknowledging the fundamental socio-political and spatial differences between North American urban sprawl and European dispersed territories, the selected cases offer critical insights into the role of infrastructure as a catalyst for socio-ecological and spatial change. Each case is examined through a common analytical lens to uncover how infrastructure is conceived and deployed. The paper concludes by distilling lessons for the European context, including the importance of integrating design ambition with feasibility, engaging with governance structures, embracing multifunctional and hybrid strategies, and re-evaluating existing conditions as opportunities. These insights aim to support a more adaptive and interdisciplinary understanding of infrastructure as a catalyst for resilient and inclusive spatial transformation beyond the traditional urban-rural dichotomy.

Keywords: urban sprawl, dispersed territories, urban transformation, green infrastructure, landscape architecture

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Introduction: Sprawl, dispersion and the palimpsest territory

Both European and North American territories are facing spatial design challenges that are related to infrastructure and the tension between urban and rural. Global challenges such as changing climates, declining biodiversity, and renewable energy transitions are not to be solved in cities alone. Moreover, the dichotomous urban-rural divide has proven to be redundant in an age of "planetary urbanisation" (Brenner, 2014) and "horizontal metropolises" (Cavalieri & Viganò, 2019). An increasingly globalised world has given rise to literature in architecture, landscape and planning during the 1990s and 2000s that studies these 'neither urban, neither rural' conditions more often than not with their relation to infrastructure, both in North America (Bruegmann, 2005; Graham & Marvin, 2001) and Europe (Corboz, 1990; Indovina et al., 1990; Neutelings, 1990; Smets, 1986).

Notwithstanding the global attention to the urban-rural divide (Carlow, 2016), the scope of this article is narrowed down to the Euro-American context, to build further upon prominent body of literature and research on territories characterised by sprawl and dispersion and to reflect on those "travelling concepts" (Vicenzotti & Qviström, 2018). This article examines how past and present North American infrastructure projects can inform the rethinking of infrastructure's role in spatial transformation within European dispersed territories. More specifically it asks: *what insights can be gained from past and present North American infrastructure projects in rethinking infrastructure's role in the transformation of European dispersed territories?*

Despite common confusion, the post-war suburban (mostly residential) sprawl most prevalent in North America should be distinguished from some of the mixed-used dispersed patterns that have existed since the Middle Ages in Europe. The latter can be understood as a palimpsest territory, the result of historical layered systems of housing, agriculture, politics, ecology, industry and so on. We use the term palimpsest to describe the layered character of these European territories, where historical spatial, social, and infrastructural systems coexist and overlap. This palimpsest metaphor is adopted from Corboz, who stated that the land, "heavily charged with traces and with past readings, seems very similar to a palimpsest" (Corboz, 1983, p. 33). This metaphor gained prominence in the field of urban-rural development up to today, which is illustrated by the recent special issue of *Urban Planning*—"Territories in Time: Mapping Palimpsest Horizons" (Cavalieri & Cogato Lanza, 2020). As a new paradigm to understand urbanisation, the palimpsest metaphor draws attention to ever-evolving systems that shape the physical environment.

The exhibition *Countryside, The Future* and the international research collaboration behind it are examples of the re-emerging interest in the 'non-urban' in the urban design field (Koolhaas & Bantal, 2020). Even though large amounts of land are responsible for and have potential for (sustainable) energy production, growing food, ecosystem services and so on, they are often neglected in architecture, planning and landscape research. Several scholars have addressed the planetary urbanisation thesis from a rural perspective, criticizing the marginalisation of rural places (Brown & Schafft, 2019; Phillips et al., 2022; Wang et al., 2023), and explicitly drawing attention to their future (Woods, 2019). In this context, the urban-rural divide itself has been questioned, acknowledging the "spatial interdependence" of both (Lichter et al., 2021).

When attempting to classify what is urban and what is rural, it becomes clear that the rural cannot be neglected. In the United States, where only 2 % of the land use is classified as 'urban',[1] it becomes inevitable to take the other 98 % into account when addressing today's

[1] Using the threshold of 1,000 inh/mi^2 or 386 inh/km^2, including suburban areas in this category (The McHarg Center, 2019).

large-scale challenges (Figure 1). However, as this 2 % of the U.S. land houses 82 % of the population (World Bank Group, 2018), often "climate change, racial equity, access to the outdoors, immigration reform, and local production are all thought of as largely urban issues" (Burnette, n.d.). While 82 % of the total United States' population lives in an urban area, this is 75 % for the European Union (World Bank Group, 2018) (Figure 2). This seems to suggest that the European and North American context are very similar. At the same time these numbers lack local specificity in particular for dispersed territories. For example, in the same dataset Belgium's population is indicated at 98 % urban, the highest in the European Union group and 12th globally (World Bank Group, 2018). However, a study in Flanders, Belgium's most populated region, indicates that only 24 % of the population lives in city centres (Vermeiren et al., 2019, p. 57).[2] Interestingly, this 24 % of the Flemish population in city centres also takes up 2 % of the land (in reference to the U.S. 82 % of the population in 2 % of the land). Although parallels can be drawn, one should be careful to not overgeneralize these quantitative observations.

This comparison suggests that the thresholds for what is considered an urban density are distinctively different (386 inh/km^2 in the U.S. vs 5,000 inh/km^2 in Flanders). Not only does this confirm that the urban-rural divide as a dominant paradigm has become redundant, but it also exemplifies the need for case study research to relate the North American discourse with the European one, putting quantitative research in a qualitative context (Vicenzotti & Qviström, 2018).

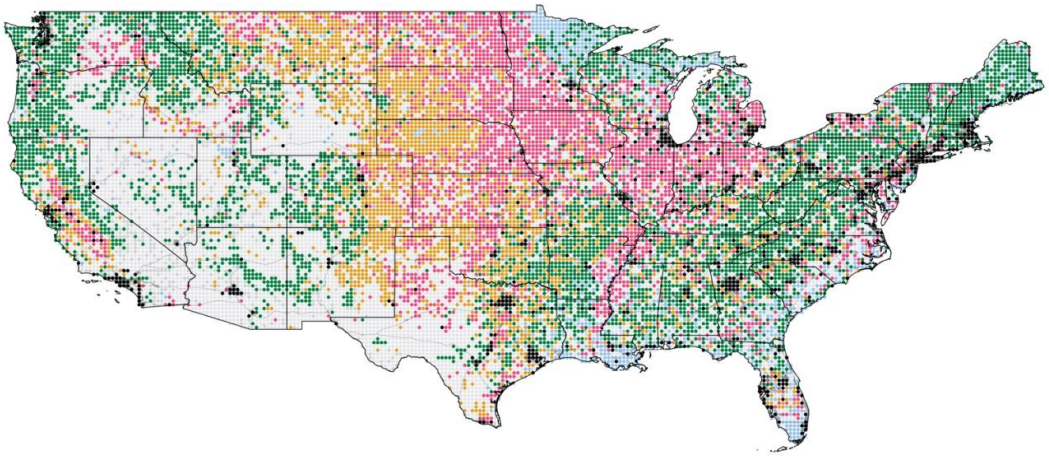

***Figure 1**. Land use in the United States mainland. Black = urban areas, green = forests, blue = wetlands, pink = agriculture, orange = grassland + pasture, light grey = shrubland, dark grey = other. Source: The McHarg Center for Urbanism and Ecology at the University of Pennsylvania (The McHarg Center, 2019) https://mcharg.upenn.edu/2100-project-atlas-green-new-deal*

[2] Using the threshold of 50 inh/ha or 5,000 inh/km^2 (Vermeiren et al., 2019).

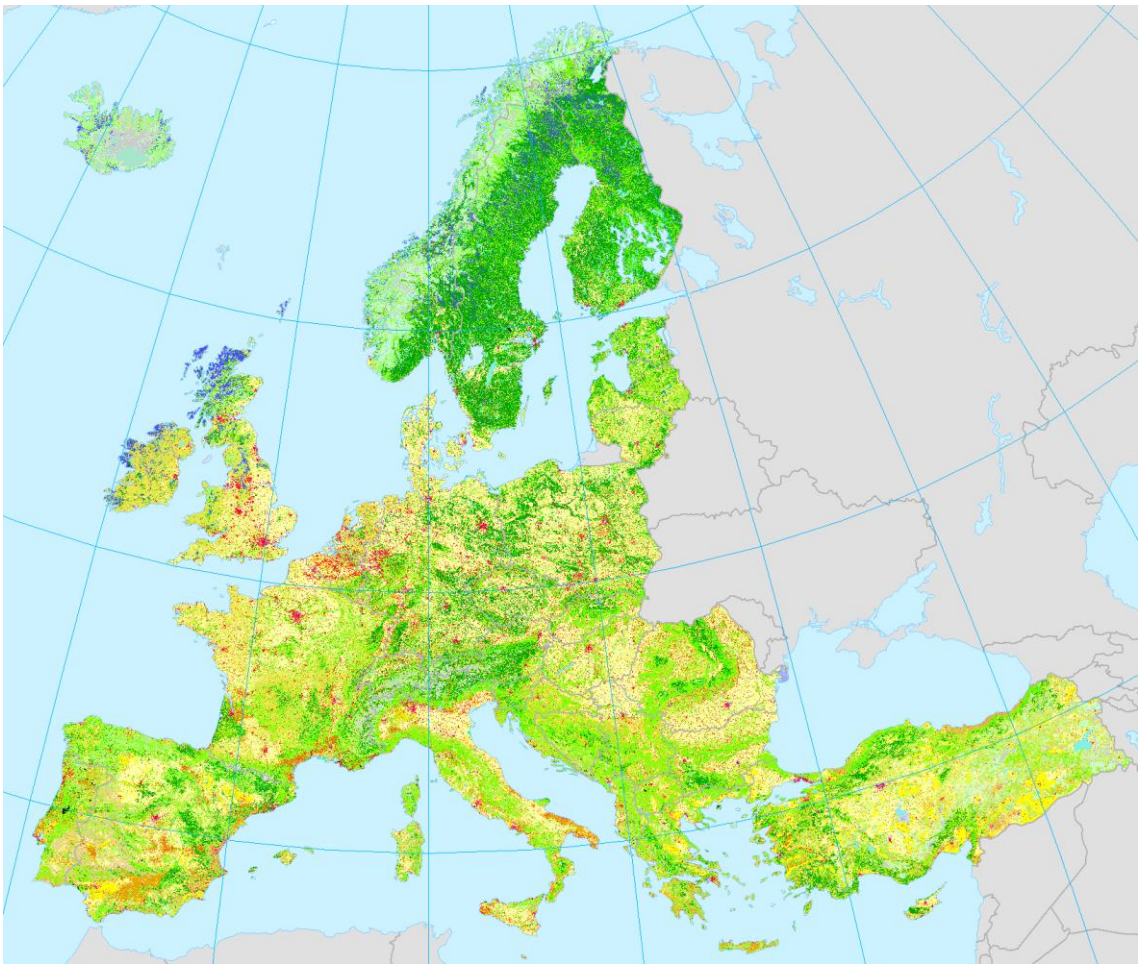

***Figure 2**. Land use in Europe through Corine Land Cover 2018. Red = urban, yellow = agriculture, dark green = forest, light green = shrubland, black/grey = open spaces with little or no vegetation, blue = wetlands, purple = industry. Source: European Environment Agency, 2018*

In the context of sprawl and dispersion, physical infrastructure is often seen as one of the main drivers of an unsustainable type of urbanisation (Bruegmann, 2005; EEA, 2016; Graham & Marvin, 2001; Vermeiren et al., 2019). As underlying systems, these infrastructures play an important role in the spatial development of dispersed territories (Leemans, 2024). This article explores this role in the urban-rural divide by studying Euro-American imaginaries and research projects dealing with design questions from a diachronic perspective. It is not meant as a systematic review or quantitative study. Rather, by making use of cases and best practices, lessons are drawn for a specific European dispersed territory characterised by dense networks of infrastructure (Figure 3). This area reaches from Rotterdam in The Netherlands through most of Belgium to Lille in the north of France and has been defined as one of the two largest clusters of sprawl in Europe: “(1) north-eastern France, Belgium, the Netherlands and part of western Germany; and (2) in the United Kingdom between London

and the Midlands" (EEA, 2016, p. 14). In this context, this article will also refer to All City/All Land (AC/AL), a condition largely coinciding with this cluster that emphasises the redundance of the urban-rural distinction as it has elements of both (Gheysen et al., 2017, 2019; Gheysen & Van Daele, 2016).

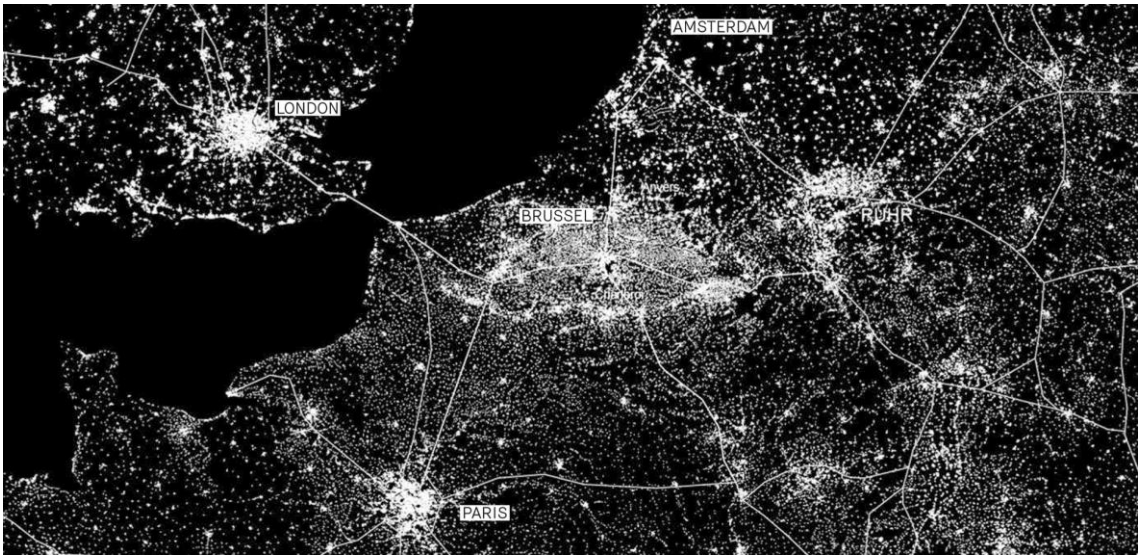

***Figure 3**. All City/All Land is a condition that emphasises the redundant urban-rural divide coinciding with one of the largest clusters of dispersion, reaching from Rotterdam in The Netherlands though most of Belgium to Lille in the north of France. Source: Studio 012 Secchi-Viganò in Dejemeppe & Périlleux, 2012, p. 31.*

Addressing the role of infrastructure imaginaries and cases: Research aims and methods

This article addresses the question: what insights can be gained from past and present North American infrastructure projects in rethinking infrastructure's role in the transformation of European dispersed territories? Through a comparative and diachronic analysis of infrastructure imaginaries and cases, from early twentieth-century visions to contemporary landscape-based interventions, the article explores how infrastructure can operate as a catalyst for socio-ecological resilience and integrated territorial planning. The aim is to reflect on the transformative potential of infrastructure in overcoming traditional urban-rural dichotomies in the specific context of European dispersed territories.

This paper adopts a qualitative, comparative case study approach to explore how infrastructure design can mediate the urban-rural divide in dispersed territories. Rather than a systematic review or quantitative analysis, the methodology is based on interpretive analysis of selected design projects and theoretical imaginaries across temporal and geographical contexts. Although there are similarities in the spatial configuration of and building typologies in American suburban sprawl and European dispersed territories, their socio-spatial and cultural context is very different. Without "over-generalising" or "over-localising" (Healey, 2012), comparative studies can still be relevant tools to learn from the different design approaches, definitions and socio-economic contexts and to look at best practices (Vicenzotti & Qviström, 2018).

The cases were selected based on three main criteria: (1) their relevance to dispersed or low-density urban-rural territories, (2) their engagement with infrastructure as a design and

governance tool, and (3) their potential to yield transferable insights between the North American and European context. The following questions functioned as a guide to interpret each case:

- What is the territorial condition or spatial context in which the project or imaginary emerged?
- How is infrastructure conceived or deployed in this case: as a technical system, a social tool, a spatial design, or a hybrid?
- What socio-political or ecological challenges does the case address?
- What vision of society, territory, or urban-rural relations is embedded in the project?
- What design strategies or interdisciplinary approaches are used?
- What value or lesson does this case offer for rethinking infrastructure in the European dispersed (palimpsest) context?

The structure of this paper is threefold. First, three twentieth-century cases from North American and European research literature are put into relation with infrastructure and the urban-rural tension. Second, two contemporary cases in the United States are discussed. Third, lessons are drawn from the North American context for the European dispersed palimpsest territory.

Reflecting on three twentieth-century infrastructure imaginaries and their role in the urban-rural divide

This article builds further on earlier research that illustrated that infrastructure networks have historically played a major role in enabling territorial transformation of a dispersed territory (Leemans et al., 2023). Keeping in mind the difference between sprawl, a post-war suburban phenomenon mostly used in the North American context, and dispersion, originating from pre-industrial patterns in Europe, it is interesting to discuss literature on exemplary design projects at the intersection of architecture, planning and landscape, focusing specifically on the role infrastructure has played in the urban-rural divide. Below, three different approaches or models are discussed which make use of mobility infrastructure as a way to address (1) social inequalities, (2) democracy and (3) a changing economy in the context of the urban-rural tension.

Reframing collective mobility infrastructure as a social equaliser: Rowntree's Lessons from Belgium (1910)

Territorial condition and context. At the turn of the twentieth century, Belgium presented a unique example of a spatially dispersed territory, where industrialisation unfolded not in dense metropolitan centres, but across a fine-grained network of towns and villages. This was supported by an extensive public transport system of railways and tramways, which connected the dispersed urban-rural fabric (De Block & Polasky, 2011; De Decker, 2020).

Infrastructure as a social tool. British sociologist Benjamin Seebohm Rowntree interpreted this model as a potential solution to poverty in industrial Britain (Rowntree, 1901, 1910). He observed that Belgium's collective mobility infrastructure, combined with subsidised land tenure policies, allowed working-class families to own homes with gardens and commute affordably. Infrastructure here was not merely a functional system, it was central to a broader socio-political model that decentralised opportunity and wealth.

Socio-political challenge addressed. Rowntree's analysis responded to deep social inequalities in Britain, where urban density exacerbated poverty and limited access to housing (Thane, 2018). He saw in the Belgian model a viable alternative: a 'right to the city' reframed

as the right to access, mobility, and ownership, distributed across territory rather than concentrated in urban cores.

Embedded vision of society and territory. The Belgian example reflected a vision of a more equitable society, where infrastructure was leveraged to redistribute social and economic opportunity. It also prefigured a spatial model beyond the urban-rural divide: a networked landscape where location did not determine exclusion.

Design strategy and spatial logic. The structure of the Belgian system (high-speed railways for regional connections and tramways for local access) exemplifies an infrastructural layering that enabled a middle-class lifestyle in a low-density, semi-rural setting.

Relevance to contemporary European contexts. For today's European dispersed territories, Rowntree's reading of Belgium (Figure 4) offers a historical precedent for using infrastructure as a tool of spatial justice. While that model ultimately proved ecologically and financially unsustainable, its social ambition (to equalise access across a non-metropolitan landscape) resonates with current calls for integrated, multifunctional, and inclusive infrastructure planning in dispersed territories like AC/AL.

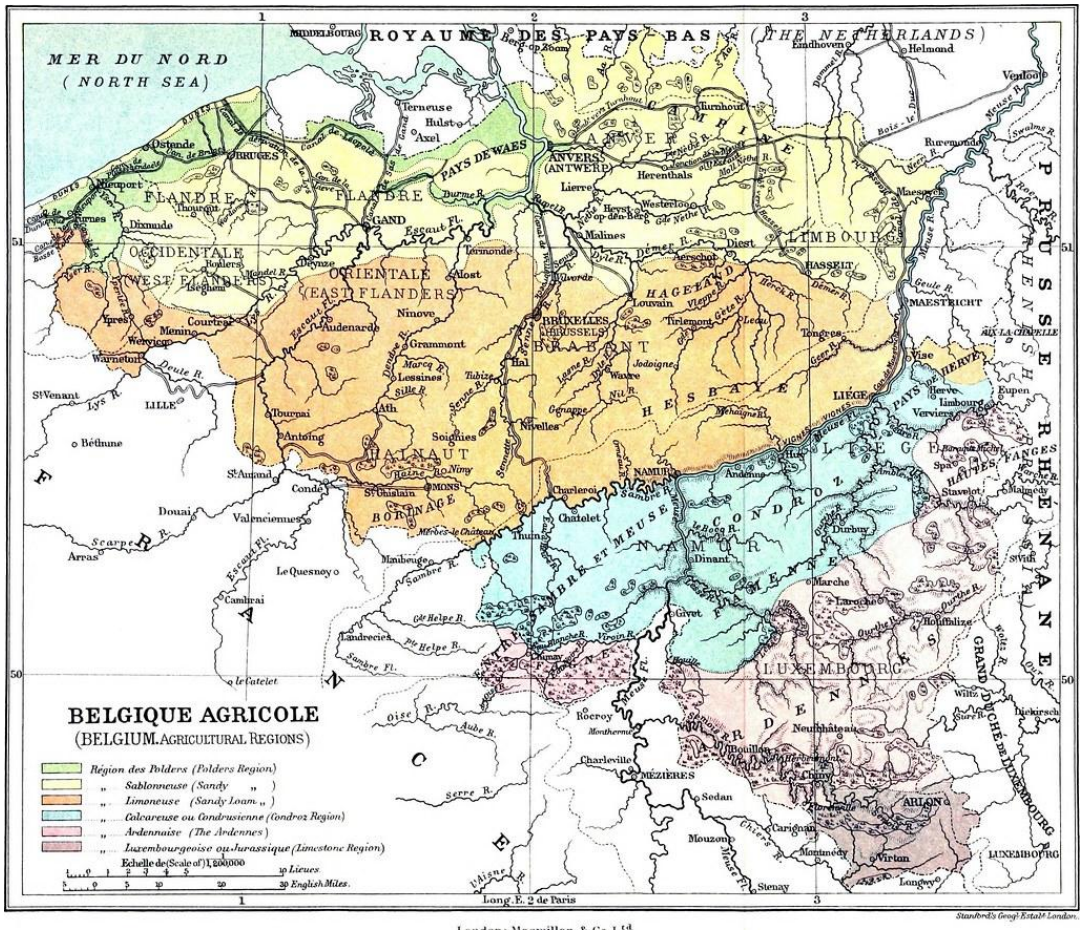

***Figure 4**. In his book "Land and Labour: Lessons from Belgium" Rowntree (1910) describes Belgium through different angles, starting with a geographical and physical study and relating this to the socio-political and economic context. He sees the combination of the land ownership system with the extensive railway infrastructure as a way to fight poverty.*

Democracy through individual mobility: Frank Lloyd Wright's Broadacre City (1932)

Territorial condition and context. Emerging during the early twentieth century, Broadacre City was Frank Lloyd Wright's provocative response to the rise of industrialised, centralised cities and the modernist ideal of urban density (Wright, 1932a, 1932b). In a rapidly motorising United States, where suburbanisation was beginning to reshape the landscape, Wright proposed an alternative model: a territorially dispersed yet ideologically unified vision for American life.

Infrastructure as a societal vision. In Broadacre City, infrastructure (particularly the automobile and road networks) became a key enabler of individual autonomy and democratic participation. Wright envisioned a future in which every family would own at least one acre of land and rely on personal vehicles for mobility. Roads replaced rails as the connections of a low-density, horizontally distributed society, where decentralisation would ensure equal access to land, work, and self-determined lifestyles (Figure 5).

Figure 5*. Plan of The Living City (1958) by Frank Lloyd Wright, showing the territorial organisation of Broadacre City. The drawing illustrates Wright's vision of a dispersed, yet ideologically unified settlement pattern structured around individual mobility, where roads and automobiles underpin a democratic, low-density society. Source: Avery Classics, Avery Architectural & Fine Arts Library, Columbia University*

Socio-political challenge addressed. Wright's proposal sought to dissolve the hierarchical structure of the industrial city, advocating instead for a more egalitarian society grounded in property ownership, technological progress, and spatial freedom. His critique of congested

metropolises positioned Broadacre as a radical vision of democracy through land and infrastructure.

Embedded vision of society and territory. Broadacre City reflected a deeply individualistic conception of democracy. One in which the citizen, empowered by car ownership, could flourish outside the strict logic of the city. It imagined a society where decentralisation was not just spatial but political, with infrastructure enabling dispersed civic agency and freedom from centralised control.

Design strategy and spatial logic. The plan combined agricultural plots, residential areas, public services, and industrial facilities into a patchwork held together by roads. Its design strategy rejected the compactness of modernist cities in favour of a polycentric, low-density settlement pattern. Despite the fact that Broadacre City was never realised in its entirety, Wright did design and build several Usonian Houses, which can be considered as architectural "prototypes" of his larger-scale plan (Gheysen & Leemans, 2023), as an incremental mode of building the democratic landscape.

Relevance to contemporary European contexts. Although never realised at scale, Broadacre City continues to resonate in debates on infrastructure, mobility, and decentralisation. Not only in this vision, but also in reality individual mobility infrastructure played an important role in (the planning of) urban sprawl in twentieth-century North America (Graham & Marvin, 2001; Kim, 2022; Newman, 2016; Renne, 2016). For European dispersed territories the project is both cautionary and instructive. It illustrates the double-edged nature of individual mobility infrastructure: as a liberating force but also as a potential driver of ecological unsustainability and social fragmentation. Nevertheless, its attempt to redefine infrastructure as a platform for democratic life beyond the urban-rural dichotomy remains a valuable provocation.

Reclaiming industrial infrastructure for the knowledge economy: Cedric Price's Potteries Thinkbelt (1964–1966)

Territorial condition and context. The Potteries Thinkbelt project emerged in a context of economic transition: the decline of Britain's industrial manufacturing base and the rise of a post-industrial knowledge economy. Set in the dispersed, post-industrial landscape of Stoke-on-Trent (historically known as 'the Potteries') the project proposed a radical reinvention of a decaying industrial territory marked by abandoned railway infrastructure and fragmented urban settlements. Historically, the Potteries had profited from amongst others the distribution and export options that came with the construction of railways (Shaw, 1829; Thomas, 1936; Weatherill, 1971).

Infrastructure as a repurposed system. Rather than constructing something new, Cedric Price envisioned reactivating the disused railway network to host a decentralised, mobile university system. Infrastructure in this proposal was not simply transport; it became a medium for knowledge transfer, social regeneration, and spatial innovation.

Socio-political and economic challenges addressed. The project responded to two intersecting challenges: the obsolescence of centralised educational institutions in a technologically evolving society, and the spatial and economic redundancy of former industrial regions (Brick, 1992; Saumarez Smith, 2019). Price's vision critiqued the rigidity of traditional campuses and suggested that learning should be as adaptive and networked as the emerging economy it served.

Embedded vision of society and territory. The Thinkbelt projected a new model of society in which education was democratised, mobile, and embedded in the everyday life of a dispersed territory. The railways would be put back in use to connect housing, libraries, factories, and laboratories by mobile units designed as classrooms (Figure 6). It reimagined the university as a decentralised infrastructure reflecting a broader ambition to adapt industrial regions for a more knowledge-based future.

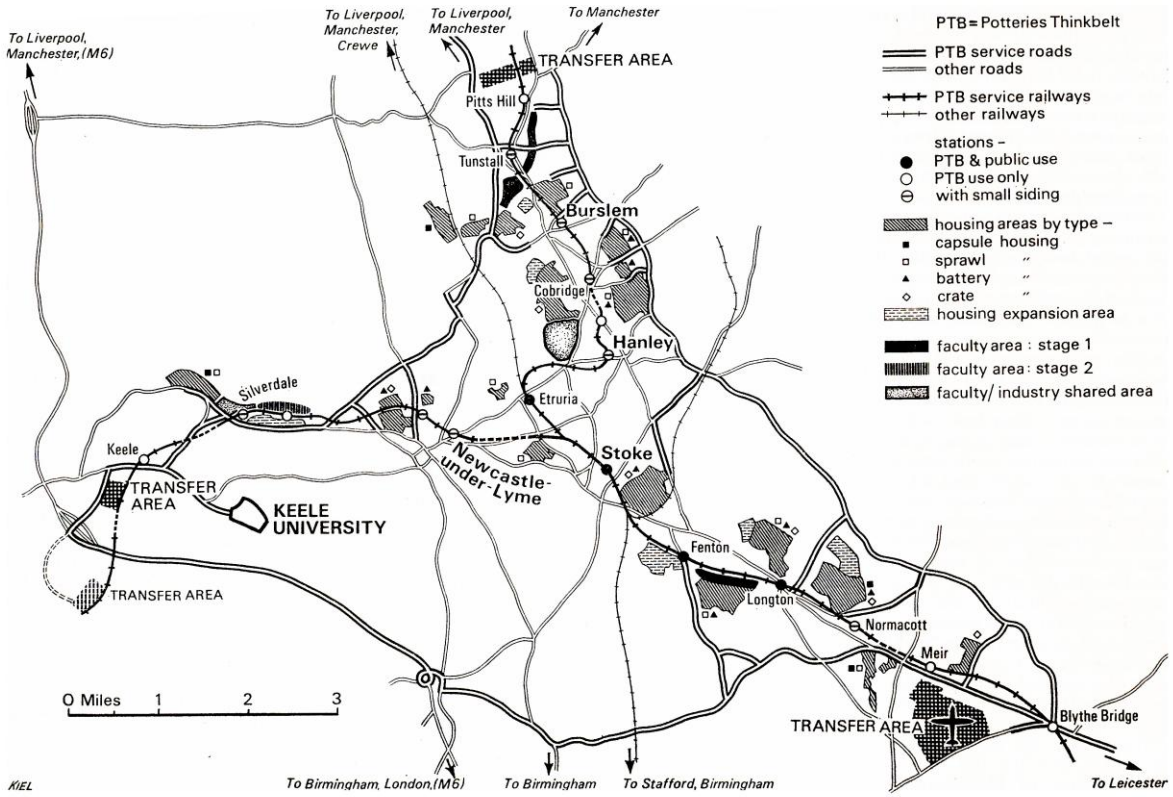

***Figure 6**. The Potteries Thinkbelt project envisioned a new university system and linked different elements in the North Staffordshire towns that formerly formed the centre of the pottery industry in England. Source: Canadian Centre for Architecture collection, 1964-1966 / Hardingham & Rattenbury (2007)*

Design strategy and spatial logic. Spatially, the project embraced dispersion as an asset rather than a constraint. It leveraged the physical distances between towns to create a modular, scalable educational system. The linearity of the railway infrastructure became a design advantage, enabling learning to move across the landscape rather than remain fixed in space. In doing so, it exemplifies an infrastructural imaginary grounded in flexibility, openness, and hybridity.

Relevance to contemporary European contexts. Although never realised, the Potteries Thinkbelt resonates strongly with contemporary European dispersed territories like AC/AL. It offers an early precedent for reimagining abandoned infrastructure system capable of supporting new forms of collective life. Unlike many current European infrastructure retrofits that focus primarily on leisure or heritage value (Leemans, 2024, pp. 158–161), Price's vision aimed to restore infrastructure's public function, not for transport, but for social and economic renewal. This conceptual shift remains highly relevant today, as planners seek to activate

underutilised networks to address contemporary challenges in education, equity, and territorial cohesion.

From vision to implementation: Contemporary North American cases in infrastructure design

The historical imaginaries discussed above illustrate how infrastructure design has historically been used to project visions that move beyond the urban-rural dichotomy. While these projects were often speculative or unbuilt, they reveal how infrastructure can operate as a catalyst for broader socio-economic and territorial transformation. These imaginaries also challenge the persistent notion that "the design of infrastructure was historically determined by problem-solving and guided by autonomous parameters such safety, feasibility and efficiency, independent of an overall urban vision" (De Block, 2016, p. 374).

Today, territories characterised by dispersion and sprawl face increasing ecological and socio-political pressures, from biodiversity loss and climate risks to increasing costs of maintenance and governance complexity. In response, the focus of infrastructure design has shifted towards ecology, giving rise to what is commonly referred to as 'green infrastructure' in planning and landscape discourse (Mell, 2008; Vitiello, 2017). However, such ecological approaches have also been criticised for operating within a narrow, "self-referential discourse" focusing on aesthetics or performative sustainability without engaging meaningfully with deeper socio-political dynamics (De Block, 2016).

As De Block (2016) argues, ecological infrastructure must be understood as a radical and contested space, one that engages with politics, equity, and governance as much as ecology. Simultaneously, design culture in North America has fostered integrated, visionary approaches, particularly within landscape architecture. The field's maturity in combining spatial design with political and ecological thinking has produced large-scale infrastructure projects that operate as multilayered tools: simultaneously spatial, social, and policy oriented. The following two cases are examined for their ability to demonstrate this integrated potential and to offer transferable insights for rethinking infrastructure in European dispersed territories.

Reconnecting the fragmented urban fabric: The Atlanta Beltline (1999-ongoing)

Territorial condition and context. Atlanta, Georgia, is often cited as the most sprawling metropolitan area in the United States (Ewing & Hamidi, 2014; Hamidi et al., 2015). Characterised by car dependency, fragmented urban development, and sharp socio-spatial inequalities, the city's urban fabric has been deeply shaped by mid-twentieth-century planning logics that privileged highways and suburban growth. Historically, infrastructure investments, particularly road systems, were used as tools of segregation, displacing communities through so-called urban renewal policies and redlining practices (Kim, 2022; Kruse, 2019; Renne, 2016).

Infrastructure as a social and ecological connector. The Atlanta Beltline project reclaims a 22-mile loop (35 km) of abandoned railway infrastructure to create a hybrid system of public trails, greenways, parks, and potential transit lines. The original four beltline railroads fell into disuse in the mid-twentieth century when trucks became more convenient for goods transportation (Badami et al., 2006). Originating from a 1999 master's thesis by Ryan Gravel, the project was envisioned not simply as a mobility upgrade, but as a socio-ecological framework to reconnect historically divided neighbourhoods and reimagine the city's future around more inclusive and sustainable infrastructure (Gravel, 1999).

Socio-political challenges addressed. The Beltline responds to a confluence of spatial and political challenges: car-centric planning, socio-economic segregation, and ecological degradation. It aims to counteract the long-term effects of infrastructural exclusion and create a 'public' infrastructure that restores spatial justice and access to green space, mobility, and economic opportunity.

Embedded vision of society and territory. At its core, the Beltline articulates a vision of collective infrastructure, one that reconnects rather than divides, and which challenges the legacy of infrastructure as a tool of control. It represents a strategic reimagining of what public infrastructure can do: not only move people, but repair urban fractures, redistribute investment, and build common ground across difference.

Design strategy and spatial logic. The project's circular form and use of existing railway corridors reflect a logic of adaptive reuse, turning former industrial infrastructure into multifunctional collective space. Its phasing over time, enabled through grassroots activism, public-private partnerships, and design competitions, illustrates a flexible yet visionary approach that balances design ambition with incremental implementation.

Relevance to contemporary European contexts. Despite facing criticism for falling short of its original equity goals, particularly in relation to affordability and gentrification (Samuel, 2022), the Beltline remains a compelling model of "strategic catalyst infrastructure" (Gravel, 2016). For European dispersed territories like AC/AL, it demonstrates how abandoned or underutilised infrastructures can be reactivated not just for environmental benefit, but also to advance social cohesion and reframe infrastructure as a societal project. It also highlights the need to embed spatial transformation within broader political processes, a key lesson for projects operating within complex, layered urban-rural contexts.

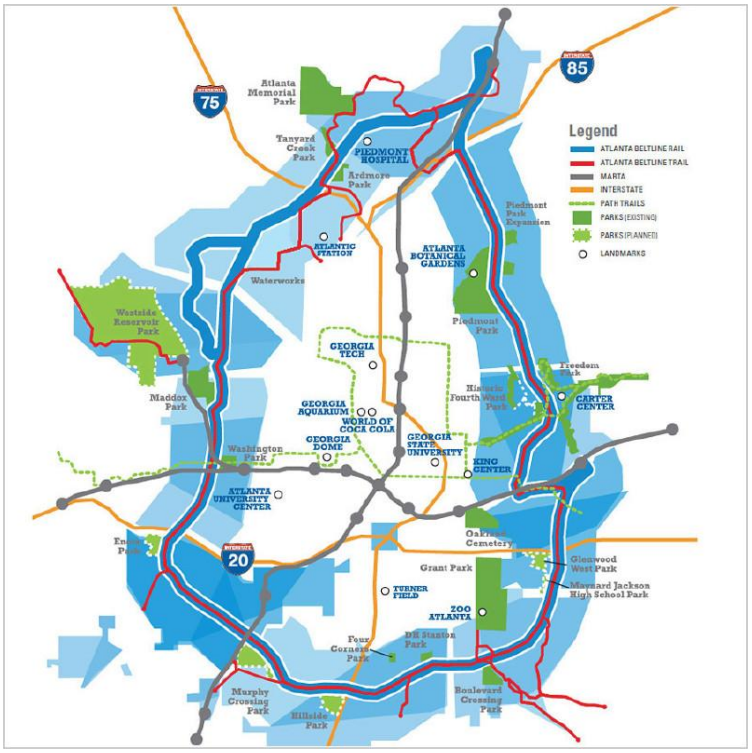

***Figure 7**. The Atlanta Beltline is a project with spatial interventions and at the same time has socio-economic and political ambitions. The map shown here is an earlier version from the early-to-mid 2010s and includes some designations and alignments that have since evolved. It nonetheless illustrates how the Beltline was envisioned to engage with its surroundings. Source: Atlanta BeltLine, Inc. (ABI)*

Recovering ecosystems while building community: Public Sediment for Alameda Creek (2018 – ongoing)

Territorial condition and context. Located in the sprawling suburban periphery of the San Francisco Bay Area, Alameda Creek occupies a transitional zone between dense residential development and ecologically significant tidal Baylands. Historically shaped by agricultural land use and later suburban expansion, the creek was canalised and disconnected from its ecological functions. This hydrological fragmentation was exacerbated by upstream dams, which trapped sediment critical for sustaining the coastal wetland ecosystems that buffer the Bay Area against sea level rise and storm impacts.

Infrastructure as living system. Public Sediment for Alameda Creek reimagines infrastructure as a 'living system' integrating ecological restoration with social connectivity and public space. Developed for the "Resilient by Design: Bay Area Challenge" in 2018 by the landscape architecture firm SCAPE and a broad interdisciplinary team, the project aims to reconnect sediment flows, aquatic habitats, and suburban communities. Its central design feature is a reconfigured creek cross-section: a hybrid of ecological and social infrastructure that channels sediment and fish, while providing trails, seating, and access for local residents.

Socio-political challenges addressed. The project addresses both environmental degradation and social fragmentation. It challenges the legacy of exclusionary infrastructure that often cuts across socio-economic divides, proposing instead a shared space that links ecology and equity. By transforming the creek from a hard boundary into a site of public interaction and ecological regeneration, the design intervenes in the socio-political geography of suburban sprawl.

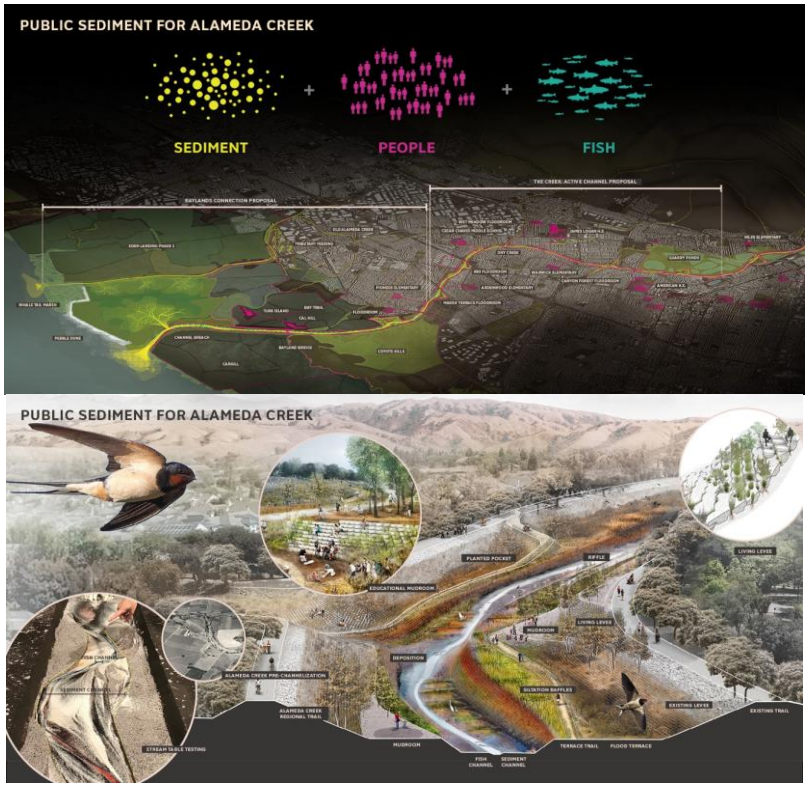

***Figure 8**. Public Sediment for Alameda Creek is a project both on the scale of the watershed (to connect with the Baylands) and the creek (to create an active channel). It brings together community engagement, flood protection, and ecological benefits. Source: SCAPE Team (www.scapestudio.com), 2019*

Embedded vision of society and territory. Public Sediment reflects a vision of infrastructure that transcends monofunctional utility. It adopts a process-based design logic: viewing infrastructure not as a fixed artefact but as a process, i.e. dynamic, participatory, and adaptive. By foregrounding sediment as a design medium, the project articulates an expanded understanding of territorial systems that are simultaneously natural, social, and political.

Design strategy and spatial logic. The intervention is modular and multi-scalar, ranging from the micro-detail of a "living levee" to a regional sediment management strategy (SCAPE, 2018). The creek is redesigned to support a narrowed sediment and fish channel, flanked by flood terraces and vegetated berms that double as public amenities. Educational initiatives, including community science tools like DIY sediment sensors, anchor the project in local stewardship and participation.

Relevance to contemporary European contexts. For European dispersed territories such as AC/AL, Public Sediment offers a model for reintegrating natural processes within suburban infrastructures through proactive, systemic design. It illustrates how ecological restoration can serve as a platform for new forms of public infrastructure that engage communities, restore landscape functions, and reconfigure urban-rural relations. Moreover, the project's participatory and multiscale design process presents a valuable precedent for rethinking infrastructure as an adaptive framework embedded in both ecological and social life.

Lessons for the European palimpsest territory

The contemporary cases of the Atlanta Beltline and Public Sediment for Alameda Creek offer valuable insights for the European dispersed context and the territory characterised by AC/AL. While the socio-political and spatial conditions differ significantly, there are also similarities to be found. Just like in Atlanta, there are many abandoned nineteenth- and twentieth-century railways still present in this territory, linking different types of land use and inhabitants. And just like in the Baylands, a lot of former agricultural territory has been redeveloped into residential allotments while waterways were canalised. Additionally, both projects were implicitly or explicitly focused on the redevelopment of infrastructure in the context of an urban-rural tension. In this regard, there are several lessons to be learned on the role of infrastructure design in dispersed territories in the twenty-first century.

1. ***From creative vision to feasible action***

A first lesson lies in the balance between ambition and feasibility. Both the Beltline and Alameda Creek projects originated in creative, open-ended design contexts (a student thesis and a design competition) yet evolved into large-scale public projects. Their initial speculative nature did not prevent eventual institutional support; rather, their boldness and clarity of vision helped gain traction among policymakers and funders. As Gravel (2016, p. 143) notes, such projects must be "bold enough to be worth […] efforts and realistic enough to be accomplished". In the European AC/AL context, this highlights the potential of design-driven explorations, especially within academic and competition settings, to initiate broader, policy-relevant conversations about infrastructural futures.

2. ***Engaging with governance and the "dark matter" of planning***

A second lesson lies in engaging with the governance systems that shape territorial transformation. Kate Orff (2016, p. 16) refers to this as a "a deep dive into dark matter", "[t]hat is, most of the hard work does not come in the form of visible landscapes that we can inhabit

or photoshop, but rather as modifications to invisible regulatory, administrative, permitting, and political systems that determine how, what, and where we build".

This "dark matter" or urban governance is inevitably very different in the US from Europe. The way cities (including territories characterised by sprawl and/or dispersion) are governed and administrated are directly related to their specific history of land use, spatial transformation, power relations, social movements, and so on. This also emphasises the role of infrastructure as a public work, constructed for the 'public good', as a specific product of urban governance (De Block, 2016; Graham & Marvin, 2001). Considering European dispersion as a result of a *longue durée* palimpsest, and North American urban sprawl as a more recent, post-war phenomenon, this results in fundamentally different urban governance (Beghelli et al., 2020; Herrschel, 2014; Jouve, 2005). However, it is important to go beyond the post-political idea of infrastructure (De Block, 2016) and engage with the socio-economic and political context in these design projects. In the European palimpsest, where infrastructure is entangled with historical land uses and spatial fragmentation, this engagement must be context-sensitive and attuned to local power relations and administrative complexity.

Dimension	Atlanta Beltline	Public Sediment for Alameda Creek	Relevance for AC/AL, the European palimpsest territory
Origin & context	Grassroots-driven reinterpretation of former railways in a sprawling, racially segregated city	Design competition-based project in a suburban watershed disconnected from its ecological base	Existing abandoned infrastructures and canalised landscapes in AC/AL can serve as starting points for territorial regeneration
Project type	Circular greenway with transit, public space, and ecological restoration goals	Watershed-scale ecological restoration with public space integration	Supports the idea of hybrid, multifunctional infrastructure as a territorial strategy
Main challenges addressed	Spatial segregation, car-dependency, infrastructural inequality	Ecological degradation, sediment disconnect, lack of public engagement with infrastructure	Comparable issues in AC/AL: fragmented governance, ecological decline, lack of collective infrastructure vision
Design strategy	Adaptive reuse of existing infrastructure; phased implementation; overall spatial vision	Modular and multi-scalar design; sediment as a design material; participatory and interdisciplinary approach	Encourages AC/AL actors to reframe existing conditions as opportunities for adaptive design and civic engagement
Socio-political engagement	Strong grassroots advocacy and eventual policy backing; challenged by gentrification and equity concerns	Collaborative governance model; integration of community science and education	Highlights the need to navigate Europe's layered governance structures while fostering civic involvement
Key lesson	Infrastructure as a societal connector and platform for territorial justice	Infrastructure as living system integrating ecology, public space, and participation	Infrastructure in dispersed territories can become a catalyst for inclusive, ecological, and imaginative transformation when approached in an integrated way

***Table 1**. Comparative table: lessons from North American infrastructure projects for European dispersed territories*

3. *Designing hybrid and multifunctional landscapes*

A third lesson concerns the hybrid character of infrastructure in both case studies. Rather than having just a singlepurpose (e.g. transit or flood control), the Beltline and Alameda Creek combine ecological, spatial, and social functions. Their success is rooted in the formation of interdisciplinary teams, blending landscape architecture, engineering, participatory design, and policy expertise, and in their ability to work across scales and disciplinary boundaries.

This resonates with emerging European discourses on multifunctional landscapes and crossing urban-rural divides (Selman, 2009) and suggests that infrastructure in AC/AL should similarly be reframed not as a technical intervention but as an integrated landscape strategy. A potential lies especially in the edges of linear infrastructures, spaces that can become active ecological and social interfaces rather than residual zones. This requires a design attitude that appreciates the design potential of particularly linear infrastructure beyond its technical functionalities, and becomes an integrated element of a landscape, interacting with and tapping into the different land uses that it crosses.

4. *Reframing the existing condition as an opportunity*

Finally, these North American cases offer a shift in design attitude: from viewing dispersed territories as a problem of “loss” or “lack” (Gheysen, 2020, p. 199), towards recognising their potential. Rather than erasing or replacing existing systems, both projects strategically work with what is already there (abandoned railway lines, sediment flows, social narratives) and transform them into platforms for regeneration. This is a particularly relevant shift for the AC/AL condition. Here, existing infrastructures, though often fragmented and underused, could become the foundation for resilient, adaptive, and inclusive territorial projects, if approached through the lens of transformation rather than deficiency.

Conclusions

This article explored how infrastructure can operate as a design instrument for addressing the urban-rural divide in dispersed territories, using historical and contemporary case studies from North America to draw lessons for the European palimpsest territory, particularly the AC/AL context. By analysing both speculative imaginaries from the twentieth century and critical cases of implemented projects from the twenty-first century, this article has revealed how the role and meaning of infrastructure have shifted across time and space.

Historically, infrastructures were mobilised to pursue broad socio-political ideals: from combating poverty through collective mobility (Rowntree’s Lessons from Belgium), to envisioning democratic decentralisation via car-based autonomy (Broadacre City), to supporting economic transition through educational infrastructure (Potteries Thinkbelt). These cases illustrate how infrastructure has always carried more than a technical function and served as a vehicle for societal vision.

Contemporary cases such as the Atlanta Beltline and Public Sediment for Alameda Creek demonstrate a new kind of infrastructural vision: one that merges spatial design with ecological restoration, social inclusion, and regional governance. These projects illustrate the potential of infrastructure to operate as a strategic catalyst for socio-ecological transformation, particularly in fragmented, low-density landscapes. They also show that success relies not

only on physical design, but on interdisciplinary collaboration, political engagement, and integration across spatial scales.

In the context of European dispersed territories, these lessons are particularly urgent. The challenges of abandoned or ageing infrastructure, ecological degradation, and socio-spatial fragmentation are deeply embedded in the palimpsestic fabric of places like AC/AL. Yet, as this paper argues, these very conditions also hold potential for transformation, if approached through ambitious, feasible, and interdisciplinary design strategies.

Ultimately, the case studies analysed here function not as templates but rather as analytical lenses, revealing how infrastructural projects can be rethought as platforms for public life, ecological resilience, and social justice. The methodological approach (combining comparative case analysis with a diachronic lens) supports the article's broader aim: to reposition infrastructure as a flexible, political, and spatial tool capable of shaping more sustainable and inclusive futures across the urban-rural divide.

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