iNEST – Interconnected Nord-Est Innovation Ecosystem: General Frame of the Project and Activities of Young Researchers at the University of Trieste

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Index

RT1 ↦ Strategic plan for the development of the construction and sustainable design sectors

RT2 ↦ Technological solutions for the construction and sustainable design sectors

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Water as a Framework for Resilience: Designing Territories for the Ecological Transition[1]

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↦ ABSTRACT

The research aims to contribute to the definition of new planning paradigms aimed at fostering ecological transition and achieving climate neutrality. It focuses on the relationship between territorial resilience and water management, which—shifting from a risk factor to a design framework—serves to redefine the interconnections among settlements, infrastructures, and landscapes. Through this perspective, the study promotes a circular, self-sufficient, and resilient territorial model. The investigation is applied to the territories of the Lower Plain of Friuli Venezia Giulia, with the objective of attaining climate neutrality at both urban and regional scales.

1 The research is carried out at the DIA, Department of Engineering and Architecture of the University of Trieste, in close relationship with Paola Cigalotto and Teresa Frausin and the coordination of Prof. Elena Marchigiani.

Among the environmental challenges affecting the macro-region of North-East Italy, issues related to its complex hydro-system represent one of the most critical areas of investigation. Certain dynamics offer valuable insights into the extent of the ongoing transformations, against the backdrop of trend scenarios indicating a rise in the frequency and intensity of extreme events (IPCC, 2023; Pörtner, 2022; Richardson et al., 2023). Rising sea levels and water stress constitute two of the primary drivers of climate-related risk. On the one hand, the coasts of the Upper Adriatic are compelled to adapt to the progressive increase in mean sea level (ABDAO, 2022); on the other, territorial transformations are occurring as a result of declining water reserves, a direct consequence of prolonged droughts and the gradual yet continuous retreat of Alpine glaciers (ARPA, 2018, 2023a, 2023b; Mariani et al., 2022).

In response to these phenomena, diverse urban contexts must adopt mitigation and adaptation measures aimed at safeguarding and sustaining both settlements and natural ecosystems, through the implementation of differentiated strategies and actions. It is therefore imperative to develop forward-looking approaches capable of addressing potential emergency conditions arising from reduced precipitation, increased drought frequency, and the consequent depletion of water resources—factors that will likely render water progressively scarcer for civil, agricultural, and industrial uses (Zini, 2011; Zini et al., 2023). The management of the blue network—conceived as an environmental infrastructure, both natural and artificial, hydrographic and hydraulic—emerges as a key instrument for enhancing territorial resilience and for reconfiguring the spatial organisation of human-made landscapes.

Methodologically, the research is articulated across three principal levels: cognitive, analytical, and proactive. Each phase contributes to clarifying the complexity of the topic under investigation, with the overarching aim of promoting a transition from a territorially centralised model to one that is partially self-sufficient—capable of flexibly regulating its own water, energy, and biological cycles. The cognitive part illustrates the relationships between water networks, infrastructure, ecology, and human settlements. The analytical part investigates existing regulatory and design frameworks, highlighting the fragmentation among sectoral instruments and the limited integration between engineering approaches and nature-based solutions.

The overarching objective is to reconceptualise living spaces by taking water—and its multiple meanings, interactions, and dynamics—as the starting point. This entails shifting its perception from a risk factor to a key element underpinning transition-oriented projects, thereby identifying potential alternative strategies for reconfiguring urban spaces and natural environments towards adaptive management of water resources in conditions of both scarcity and excess.

Reflecting on alternative models of water storage, distribution, and discharge enables the definition of potential fields of action through which urban planning may propose new spatial configurations, integrating green networks and mobility systems into coherent territorial frameworks. The design phase advances hypotheses for spatial reorganisation, calling for integrated planning capable of incorporating a range of solutions—soft, green, grey, and hybrid—to enhance the adaptive capacity and resilience of the territory (Centis et al., 2023).

Based on the availability and accessibility of specific data and information, the research develops exploratory hypotheses and territorial configuration models aimed at testing the implementation of alternative approaches to those derived from previous plans and projects. In this regard, the construction of a renewed conceptual horizon begins with an examination of significant cases in the evolution of selected territories and exemplary practices—identified both at the national and international scales—reflecting on innovative approaches to water management.

The identification and cataloguing of projects and best practices are intended to establish a comprehensive framework that delineates salient elements and characteristics for the development of

alternative operational models applicable to specific parts of the territory. Spatialising the design of new living environments thus becomes both a crucial and urgent task, enabling a redefinition of the relationship with water resources in their multiple forms. This entails reimagining where and how water may be collected, distributed, and reused within a renewed conceptual and design perspective (Viganò, 2024).

To implement the research framework, a detailed focus was adopted on the Lower Plain of Friuli Venezia Giulia, selected as a pilot study area and regarded, in the long term, as a site of inevitable transformation (Centis et al., 2023; Cigalotto, D'ambros, 2025). At present, the Lower Plain presents itself as a dispersed settlement system—a sprawling urban condition with variable densities—hosting approximately 100,000 inhabitants (source: ISTAT, 1 January 2023) and extending over roughly 70,000 hectares between the Tagliamento River to the west and the Isonzo River to the east, bounded by the Adriatic Sea and the Grado and Marano Lagoon to the south, and by the first inhabited belt of the humid lower plain intersected by the SR 252 Regional Road to the north.

Within these so-called 'lowlands', two markedly distinct types of water converge: the fresh, cold spring waters and the saline marine waters. Their interaction has historically shaped the area's diverse habitation patterns, where, from the early twentieth century to the present, successive processes of construction, expansion, and abandonment of inhabited spaces have taken place (Cigalotto, D'Ambros 2024a; D'Ambros, 2024).

The research identified this historically reclaimed area as a key case, analysing the principal phases of its territorial evolution. It highlighted the defining characteristics that render it an artificially maintained dry landscape, where substantial volumes of water continue to be extracted through natural and mechanical drainage systems. The study area is further affected by coastal erosion and by frequent, often intense extreme events—such as storm surges and flooding from overflowing watercourses in low-lying areas—resulting in prolonged waterlogging that exerts considerable pressure on the lagoonal peripheries, located either below sea level or within two metres above it.

Within this complex framework, it becomes essential to envision new spatial configurations capable of enhancing the performance of water infrastructures and their interrelations with settlements and human activities, in response to changing rainfall patterns and prolonged periods of drought. The collection and storage of substantial volumes of rainfall occurring over short timeframes, together with the reuse of greywater, demand advancements in the ways settlements and networks are conceived, constructed, and redeveloped. This entails reimagining the territorial structure according to integrated logics, shifting the notion of regeneration from the architectural to the territorial scale, thereby opening possibilities for new and more resilient forms of habitation.

The examination of regional projects and plans addressing these challenges has led to the identification of a spectrum of intervention typologies—ranging from 'natural to artificial' and from 'concentrated to diffuse'. This enables a critical reinterpretation and mapping of ongoing transformations, revealing the weaknesses that arise from the often inconsistent application of instruments and regulations across different planning levels. Such inconsistencies hinder the development of coherent territorial management strategies aimed at constructing integrated systems and projects. The municipal urban plans of the area, for instance, depict a fragmented territorial image composed of juxtaposed zones, where the intended spatial continuity is frequently disrupted by conditions and morphologies that lack mutual coherence.

When infrastructural and environmental frameworks are observed at the territorial scale, a different interpretative perspective emerges—one that reveals overlapping and intersecting territorial systems (Cigalotto, D'Ambros 2024b). From the hinterland to the coast, distinct spatial features coexist within a metropolitan continuum, interpretable as multiple territorial layers superimposed

upon one another, marked by points of tension and interdependence linked to ecosystemic cycles (Cigalotto, D'Ambros, 2024a). Within this context, it becomes possible to discern recurring urban materials that serve as instruments for reformulating a renewed territorial palimpsest, recontextualising reclaimed areas as 'territories of reuse'.

Across this continuum, the research reflects upon a spectrum of interventions, ranging from containment and protection works to nature-based solutions, conceived to restore ecological functions and mitigate vulnerability through the enhancement of ecosystem processes.

The classification of the assessed measures can be further articulated into four principal categories: soft, green, grey, and mixed. 'Soft measures' encompass regulatory, management, and governance instruments that indirectly contribute to risk reduction and adaptation through policies, agreements, and monitoring mechanisms. 'Green solutions' are based on the enhancement of green and blue infrastructures, the conservation of habitats, and the activation of ecosystemic processes such as natural water retention or wetland restoration.

'Grey infrastructures' correspond to conventional engineering interventions—such as embankments, artificial canals, coastal defence systems, and aqueduct networks—which directly influence the physical dynamics of the territory, often imperceptibly altering soil configuration and quality, and at times posing risks of irreversible degradation of its natural regenerative capacity. Finally, 'mixed solutions', though less frequent, integrate multiple components, hybridising technological and natural approaches to increase the effectiveness, resilience, and long-term durability of interventions.

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