GAME CHANGER?
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Track 07: Environment And Climate **1007**

The necessity of new interconnections in multiple ecosystems in the Northeast Italian region between natural hazards and a desired new ecology

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Abstract

Just under 100,000 inhabitants live in the Bassa Pianura Friulana (Lower Friulian Plain), Italy, an area spanning a complex system of artificial and natural infrastructures, located at the northernmost point of the Adriatic Sea and bordered by a vast lagoon. During the summer season, the 130-kilometre coastline hosts over 3 million tourists. At multiple scales, the hydrographic system faces increasing anthropogenic pressures and is hierarchically structured, which may not align effectively with the efficient functioning of the territory. Consequently, the area is persistently exposed to risks from unexpected climatic events, resulting in significant imbalances such as floods, droughts, and storm surges. Artificial water management networks, however, do not fully mitigate the operational challenges of the territory.
This article initiates a discussion on research efforts, exploring tools, projects, and potential solutions to enhance the resilience and adaptability of artificial territories in response to transformations in both coastal and inland urban areas. The research aims to identify and highlight the conflicts between human and natural spaces, drawing on insights from Urban Political Ecology studies rather than a design-driven approach as often seen in landscape urbanism.

Keywords: climate change, planning transition, blue & green infrastructure.

1. Introduction: climatic emergencies

Several recent investigations provide compelling evidence that the boundaries of climate change and biosphere integrity are entering a phase of increasing and interconnected risks. Influential research analyses current phenomena - climate conditions and temperature trends - identifying a threshold of 2.7°C global warming, which will be exceeded during the 21st century unless substantial emission reductions are implemented. Only under these conditions could air quality improvements be achieved, potentially reversing temperature trends after approximately 20 years, with positive effects on various climatic factors over extended periods (Brondizio et al., 2019; IPCC, 2023; Pörtner et al., 2022).
Since the early 2000s, the worsening systemic changes have directly contributed to nearly a doubling of global disasters, predominantly driven by climate change. Approximately 90% of these events are hydro-meteorological in nature, while the deadliest catastrophes stem from geophysical events.[1] The urgent nature of the matter is also emphasised by the United Nations,

[1] If countries do not implement a prevention approach that incorporates risk reduction into decision-making in all sectors, the number of global disasters is likely to increase significantly each year, from 400 in 2015 to 540 in 2030. This would represent a 40% increase. In the past two decades, for example, earthquakes and tsunamis have been

which in recent years has intensified efforts to guide climate-vulnerable countries in adopting Disaster Risk Reduction protocols (Albrito P., 2023). Shifting conditions and persistent climatic imbalance are pushing planet Earth beyond the safe operating space for humanity. Six of the nine boundaries related to climate and Earth system changes have been violated, underscoring the need to evaluate the impacts of anthropogenic factors on the Earth system within a complex systemic framework. Currently, anthropogenic disruptions to the environment – such as climate change, biodiversity loss, and pollution – are often addressed as isolated issues. This approach ignores the nonlinear interactions and resulting aggregate effects on the overall state of Earth system (Richardson et al., 2023). Extreme weather conditions and adverse atmospheric phenomena are becoming increasingly frequent, exerting a greater impact on daily life, undermining economies, and exacerbating social inequalities [Beck, 1986; 1992; Secchi, 2014]. Time appears insufficient to alter the trajectory of current, uncontrolled development, which is increasingly dependent on the exploitation of natural resources, despite the need for implementing measures to counter worsening conditions. (Heynen, Swyngedouw, 2003). Adverse environmental events and related risks are becoming more and more impactful. For these reasons they need to get comprehensive regulatory frameworks. Compliance with legislation, a commitment to sustainable development programmes through concrete actions aimed at strengthening territorial resilience, and an awareness of the delayed response by public institutions in addressing the climate emergency are essential conditions for tackling the current fragility of territories without further delay. At the national level, Italy is implementing measures that contribute to the enactment of European policies on environmental protection and on adaptation and mitigation strategies in response to climate change. [2]

2. Contexts of ongoing research: iNEST Spoke 4 [3]

responsible for 58% of casualties, causing huge economic losses; in 2022 alone, estimated losses as covered by insurance were around $120 billion [UNDRR, 2020].

[2] Here the list of the Italian government's measures aimed at achieving the European Agenda's climate neutrality goals by 2050: National Strategy for Adaptation to Climate Change (SNAC), which is the act expressly directed to address adaptation at the national level and was issued by the Ministry of Ecological Transition in 2015; Long-term Low-GHG Emission Development Strategies (2021); Plan for Ecological Transition - PTE (2022), which constitutes a National Plan for Adaptation to Climate Change as a tool for coordinating and updating a range of environmental policies, including those on climate change mitigation and adaptation. There are other relevant national acts on climate change adaptation with cross-cutting or sectoral character, including: Cultural Heritage and Landscape Code (2004); Environment Consolidation Act (2006); National Strategy for Sustainable Development (2017); Civil Protection Code (2018); Protect Italy Plan 2019-2021 (2018); Climate Decree (2019), which introduced provisions aimed, primarily, at defining a national strategic policy for combating climate change and improving air quality; National Plan for Hydrogeological Risk Mitigation (2019); National Integrated Energy and Climate Plan (NIPEC); National Plan for Recovery and Resilience - NRP, submitted under the Recovery and Resilience Device under the Next Generation EU (2021); National Plan for Prevention of Heat Effects on Health - Guidelines for Prevention (2019); PP9 Environment, Climate and Health Program - PNP 2020-2025 (2019); National Forestry Strategy (2022); National Biodiversity Strategy 2030 (2022); National Strategy for Sustainable Development 2022 (2023); Guidelines for Climate Audit of Infrastructure Projects in Italy 2021-2027 (2023).

[3] iNEST – Interconnected Nord-Est Innovation Ecosystem model is based on the extensive use of information and communication technologies and digitization, and aims at the development of innovative technologies for people's well-being and the dissemination of culture and economic and entrepreneurial growth. The research was co-founded by European Union – Next Generation EU, grant no. ECS00000043 – CUP J43C22000320006, Piano Nazionale di Ripresa e Resilienza (PNRR - IT), Mission 4 "Education and Research", Component 2, Investment 1.5, Interconnected Nord-Est Innovation (iNEST) Ecosystem, Spoke 4 (https://www.consorzioinest.it/en/city-architecture-and-sustainable-design-2/). In this context, the study being developed by the group of urban planners

iNEST is a consortium based on the extensive use of information and communication technologies and digitization, and aims at the development of innovative technologies for people's well-being and the dissemination of culture and economic and entrepreneurial growth. The research was co-founded by European Union - Next Generation EU. The research iNEST - Spoke 4 has as its object of study is the inter-regional territorial system of Triveneto: the macro-region of northeastern Italy, consisting of Friuli-Venezia Giulia (FVG), Veneto and Trentino Alto-Adige, being a key area for the Italian economy among the richest, with 12% of people,14% of GNP, and 20% of Italian exports (iNEST, 2023). The research team of the Department of Engineering and Architecture (DIA) of the University of Trieste, identified the territory of the Bassa Pianura Friulana (Lower Friulian Plain) as a case study (Figure 1), better defined as a pilot project task. It serves as a pivot between the whole project and its testing.

Figure 1: Low Friulian Plain in the context of Italy.
Source: the authors.

The Lower Friulian Plain serves as a sensitive indicator of physical changes resulting from anthropogenic transformations of the environment and ongoing shifts in climatic conditions, which generate risk situations linked to the increased frequency of extreme meteorological events (ARPA FVG, 2023). Its unique geographical position lies in being a low-lying coastal area facing the northernmost saltwater basin of the Mediterranean Sea, making it directly exposed to fluctuations in sea levels. The small urban centre of Marano Lagunare (45°46′ N; 13°10′ E; 2 m a.s.l.), situated on the shores of its namesake lagoon, is an ideal reference point for this situation. Additionally, the Lower Friulian Plain is characterised by the interplay between the advancing sea along a discontinuous coastline interrupted by lagoons, and an

affiliated with the Department of Engineering and Architecture at the University of Trieste (DIA) for the Spoke 4 - City, Architecture, Sustainable design, research topic 1 e 2. In particular, 11 'Ecosystems' projects were financed in Italy, for a total amount of 1.3 billion euros. These are networks of state and non-state universities, public research institutes, territorial public bodies, other highly qualified and internationally recognised public and private entities. Each Ecosystem intervenes in areas of technological specialisation consistent with the industrial and research vocations of the reference territory, both regional and supra-regional, in order to promote and strengthen the collaboration between research institutes, the production system and territorial institutions. iNEST refers to the Triveneto territory, and is divided into 9 'Spokes', i.e. specific thematic networks. Leader partner of Spoke 4 is the Iuav University of Venice. Active partners in the research are CORILA; CRESME and the affiliated Universities: University of Padua, University of Udine and University of Trieste - Department of Architecture and Engineering (DIA), where, as far as research topics 1 and 2 are concerned, the research unit referring to urban and territorial studies is co-ordinated by E. Marchigiani and sees the participation of S. Basso, P. Cigalotto, M. D'Ambros, T. Frausin.

extensive inland water system comprising rivers with varying seasonal flows and a dense network of irrigation canals that support an extensive agricultural economy.
Approximately 100,000 residents live permanently in this area, and in the summer season, its 130 kilometres of coastline attract over 3 million tourists. The exposure to risks from extreme meteorological events and anthropogenic pressures can lead to significant disruptions in the broad, everyday use of this territory (Figure 2).

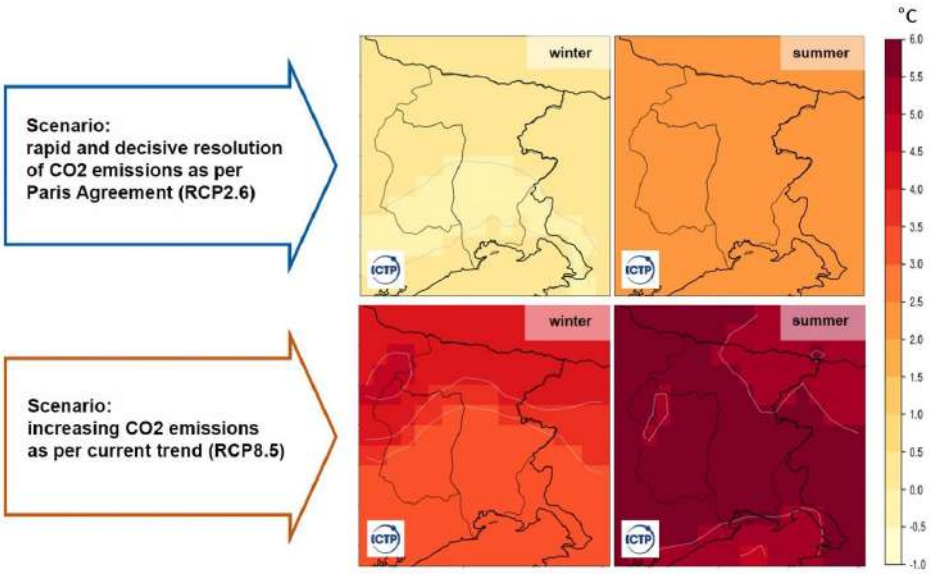


Figure 2: Increase in average temperatures in Friuli Venezia Giulia Region
at the end of the century under two different scenarios (2071-2100).
Source: ARPA FVG Regional Agency, 2018.

3. "Networks" and "ecologies" in the Lower Friulian Plain. Territorial functioning at various scales

The Lower Friulian Plain coincides with a vast intermunicipal territory (754 sq. km, 97,856 inhabitants; ISTAT, 01.01.2023) that corresponds to an extensive inter-
municipal territory encompassing 34 municipalities and situated between the Tagliamento River to the west – one of the main rivers of northern Italy – and the Isonzo River to the east; the Adriatic Sea to the south; and to the north the first inhabited strip
of a low wetland intersected by a line of resurgent waters. The profile between land and water presents a low coastline and a double overlook of a lagoon and marine environment. The coasts

present sandy beaches from marine and fluvial deposition, sloping into the shallow waters of the Upper Adriatic and heavily anthropized at the coastal urban centres of Lignano and Grado. Overall, the lagoon system covers about 16 q km (length 32 km; average width 5 km). It is possible to interpret the structure of this territory through a dual perspective. One approach describes the area in terms of "networks." The other, in a complementary fashion, uses the concept of "ecology" to characterise this territory. Here, we employ the term "ecology" not in a strictly scientific sense, but rather as a descriptive method, akin to the usage adopted by Reyner Banham in the past. [4] Furthermore, as a compelling interpretative metaphor for the complexity of urban habitats, natural ecosystems, and their interconnections, it is essential to clarify that the term "ecology," as applied in this phase of analysis of settlement systems in the Low Friulian Plain, does not imply an ecological interpretation of the natural environment of human beings. It is, however, valuable to refer to Richard T. T. Forman, who has recently explored the concept of Urban Ecology in a way that helps refine the understanding of "ecology" and the approach of "ecological reading" proposed here. [5]

The network system primarily defines the Low Friulian Plain and is structured through four main networks: the *mobility network*, the *environmental net*work, the *energy network*, and the *water network*. The *mobility network* is defined by a complex infrastructure system with different densities. In the east-west direction, major roads and rail routes — forming one of Europe's infrastructural corridors — connect tourist and industrial hubs along the coast. In the north-south direction, there is a more intricately layered local network close to the rivers. Running parallel to the Trieste-Venice route and along the Stella and Cormor rivers is an extensive network of rural roads supporting the slow-paced road network.

The environmental network is defined by the Marano and Grado lagoons and the remnants of lowland forests, which serve as key nodes within a network of protected areas classified under the EU Natura 2000 legislation. Rivers and canals act as potential ecological corridors that extend inland, taking on the character of linear parks (e.g.: Parco dello Stella). The *energy network* defines a territory that is transitioning from being a consumer of externally produced energy to an active player in clean energy self-production. This shift is driven by the rapid expansion of photovoltaic fields, supported by private initiatives, alongside biogas facilities and

[4] Borrowed from the context of natural science disciplines, the term "ecology" has long been part of the vocabulary of urbanism and planning and is used to observe, read and interpret space and place. In particular, the direct, learned, and innovative reference is to the word "ecology" used by Reyner Banham when describing the city of Los Angeles in 1971. In Banham's famous text, "ecology" is understood as a product of the interaction between physical features of a place, environmental elements, climate and forms of living, between physical and cultural landscapes. Banham understands and uses reading for ecologies by considering the different fabrics and structures of an urban setting as a whole. What the author introduces is the idea of considering settlement systems in relation to their own "ecology" that identifies them by inherent socio-spatial characteristics: that is, within a geographical, social and historical context. Reading by ecologies in this sense stands as a method of study and at the same time "an open scheme, suitable for heterogeneous observation and heterogeneous subjects" (Vidler A. in Banham, 2009: XXVIII). It restores the characters and conformation of places according to the perspective of their possible evolution. Reflection focus on the overall configuration of the observed settlement systems. The ecological study presupposes the recognition of possible spatial units, Banham would say.

[5] In Forman's definition, "Urban ecology studies the interactions of organism, built structures, and the physical environment, where people are connected. (...) Built structures are a key to urban ecology. Organism-environment interactions are simple ecology, whereas inserting buildings and roads into the interactions transforms the subject to urban ecology" [Forman T. T., 2014: 3-4]. This assumption moves from the hypothesis that settlement systems are describable as different spatial type mosaics where flows and movements through the mosaic create a dynamic system - again to refer to Forman. (Forman, 2014: 4) and to emphasize the effectiveness and importance of proceeding according to an interpretation and reading by 'ecologies'.

hydroelectric intakes. The *water network* in the Low Friulian Plain is characterised by a scarcity of aqueducts, replaced largely by artesian wells, which are frequently associated with private users.
The extraction from aquifers for residential, industrial, and agricultural purposes is widespread and substantial, leading to increased waste and growing challenges in resource management. The sewage disposal network is connected to a system of wastewater treatment plants, which come under strain during the summer. From a morphological perspective, when observed from a distance, the networks overlap within a framework of complex and diverse structures, shaping the configuration of a sprawling, low-density urban landscape. Within this spatial organization of the territory, reticular system of urban patterns lacking clear geometric order are discernible, featuring clusters of varying sizes that are mostly disconnected from main linking routes (Secchi, 1995).
The "ecologies" of the Low Friulian Plain are conceptually understood as territorial areas where settlement structures are complementary and interdependent, in relation to infrastructure systems and natural elements – the blue and green networks – to which they are linked. As mentioned, this definition is metaphorical, and here it is evoked with a renewed interpretation. The aim is to ascribe to the term "ecologies" a meaning as epistemologically robust as possible. In this context, an "ecological reading" highlights and explores the potential to advance the study of settlement systems by introducing the necessity of adopting new descriptive frameworks. These frameworks would enable a deeper understanding of territorial structures, addressing future interpretative and design challenges. In this context, within the territory, it is possible to describe various intersecting and overlapping territorial ecologies, layered upon one another with multiple points of conflict, understood as "critical frameworks" that draw attention to the interactions between human and non-human agents across different scales, the dynamic relationships between the biosphere, ecosystems, populations, and communities, and their vulnerabilities (Centis et al. 2024). These interactions make the Low Friulian Plain a distinctive case study for exploring the dynamics of a coastal territory, which here extends beyond a conventional urban waterfront to encompass a vast, evolving landscape. From the inland to the coastline, some "ecologies" are recognized: (i) the "productive cities of the European corridor" formed from a large-scale comb-like infrastructure (motorway and railway) of European significance, which connects to the industrial port area of Porto Nogaro. This area is traversed by substantial international commercial flows that extend seaward along the intercontinental routes of the Adriatic; (ii) the "inhabited street" aligned with State Road 14, along which lies a string of service centres and dispersed recent developments that have lost their historical connection with the ancient waterways system. However, these areas remain threatened by opposing phenomena of flooding and the risks associated with the increasing emerging of heat islands in urban context; (iii) the "city on water" which consists of small-scale territorial infrastructures linked to subsistence economies, particularly those associated with inland waters. These include landing stages with minimal facilities designed to accommodate small boats, areas for fishing and lagoon activities, small docks, fishing ponds, and traditional lagoon huts (known as *casoni*). Within the complex interaction between freshwater and saltwater, it becomes crucial to address the relationship between water infrastructure and the inhabited system structure; (iv) "leisure and tourism city" economically based on temporary tourist accommodation in coastal resorts, large-scale tourist camping village, and cultural attraction urban centres (e.g., Aquileia), all of which are threatened by storm surges and rising sea levels. In the background of this portrayal, shaped by interconnected and overlapping ecological systems, one can distinguish the rural settlements and the scattered isolated farmhouses of land

reclamation, largely abandoned and reduced almost to ruins, fallen into disrepair. The conflicts between the various ecologies are concentrated at the land-water interface, along the perimeter surrounding the lagoon, which constitutes a fragile area, radically transformed over the past century and subject to a range of diverse risks.

4. Lower Friulian Plain: the hydraulic machine and blue nets of a high-risk artificial territory

The Lower Friulian Plain represents the northernmost land of the Mediterranean, bordered by a body of saline water and directly exposed to fluctuations in sea level, with varying altitudinal levels. Until the mid-19th century, the landscape was defined by extensive floodplain forests and permanent meadows, [6] which have since been reduced to isolated fragments of natural habitats. Over time, the Lower Friulian Plain has been altered through the drainage of marshes, rivers and streams forced within their own embankments, the construction of canal infrastructure, and, lastly, the practice of agriculture. This has led to a comprehensive and systematic regulation of surface waters and the reshaping of these territories. A new spatial configuration was gradually consolidated, largely through significant land reclamation projects, predominantly carried out during the 20th century. [7] The aim was to make the land agriculturally productive and to strongly structure the territory, reshaping the landscape forms and imposing a new rationalised design of the land composed of a limited number of elements and materials (Feruglio, 1926; Feruglio, Mori, Soresi, 1931).

A system of agricultural enterprises with medium- to large-scale cultivated fields thus characterised the new configuration of the natural and productive open space system, leading to the development of an economy based on intensive monoculture (Felcher, Strazzolin, 2019; Zilli, 2019).

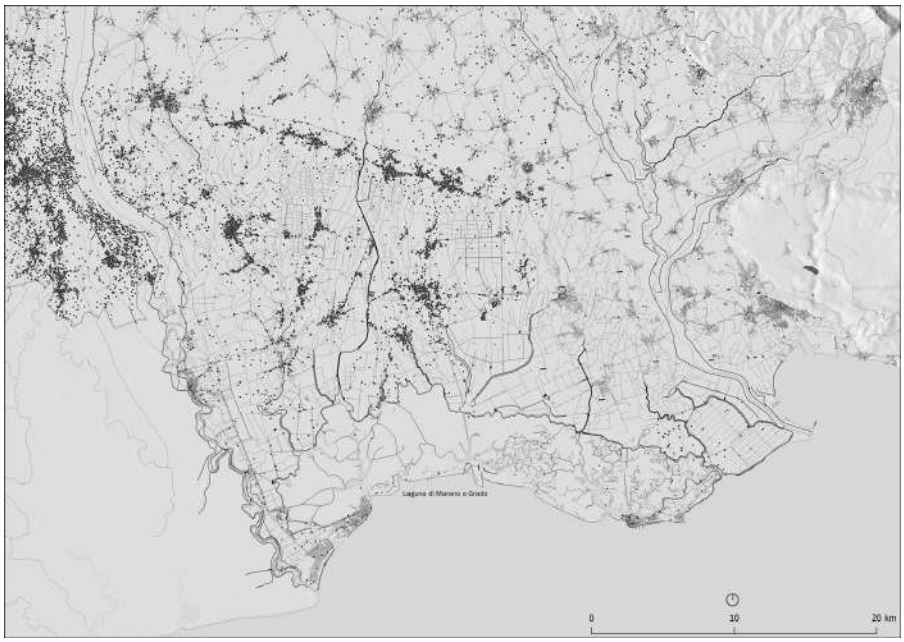
In the management of the territory, the priority has always been the collection of water to control its flow, initially slow and natural, then regulated and distributed in a rationalised manner through irrigation and reclamation works on an ever-increasing scale. The natural order of the past wetland environments has been disrupted and reduced to an artificial order, tending to separate the natural environment from the anthropogenic and agricultural space.

Today, the defining yet almost imperceptible characteristics of this territory are its topography and an extensive, strategically distributed network of mechanical water-pumping stations. The relatively uniform elevation ranges from approximately 10 metres above sea level in the spring zone, gradually descending southward to reach levels around zero hydrometric elevation. In the peri-lagoonal area, the terrain of the Low Friulian Plain falls below sea level. Currently, the Pianura Friulana Land Reclamation Consortium (Consorzio di bonifica Pianura Friulana) is one of the principal monitors and managers of this territory. It oversees coastal defence embankments and conducts maintenance operations across nearly the entire lagoonal boundary, which spans 80 kilometres, along with an additional 500 kilometres of embankments along

[6] From a comparison of Anton Von Zach's Kriegskarte (1798-1805) and Giuseppe Malvolti's Map of Friuli (1818), it is possible to see how wooded areas and stable meadows begin to shrink in extent.

[7] The reclamation of this territory is an ancient fact. In the past, its conformation was modified by natural phenomena (river floods, coastal deposits and bradyseismic movements) and as result of actions to drain swampy lands and marshes. The first systematic and most important operations can be traced back to the interventions made by the Republic of Venice from the 16th century onward.

major rivers flowing in the consortium's jurisdiction. [8] In total, the area under management extends over 78,277 hectares – representing approximately one-tenth of the entire surface of the Friuli Venezia Giulia Region – subjected to constant monitoring and safeguarding measures. [9] Based on the type of water runoff flowing across the area, the Consortium's territory is divided into zones of natural drainage, alternating drainage, and mechanical drainage. [10] In the circum-lagoonal area, 23,700 hectares correspond to depressed zones; here, water must be constantly removed and mechanically lifted by pumps, [11] as the land is situated below mean sea level or below the average hydraulic head of the main watercourses that naturally drain the territory, and, in any case, below the maximum tidal level (CPBF, 2021; Felcher & Strazzolin, 2019; Tosoratti, 1997) (Figure 3). In the second half of the 20th century, the prevailing development paradigm fostered an expansion of the territory, which now reveals an insufficient degree of infrastructure and spatial configurations required to enhance its efficiency and manage its resources effectively, particularly concerning water usage, agricultural land, and the growth of residential settlements. Describing the soil of this territory as a sort of "hydraulic machine", capable of managing water use and drainage with high efficiency, brings to light a paradox. To understand this, it is essential to consider the extensive network of pumps distributed mainly in peri-lagoonal areas,



[8] Example of this are the embankments along the entire lagoon front between the Tagliamento River and the Isonzo River raised to a height of 3 meters above mean sea level after the 1966 flood.
[9] The Consortium also controls the High Plain area above the resurgence line, which covers an additional 123,127 hectares.
[10] Natural and mechanical drainage channels cover a total of 2,228 km.
[11] On the territory of the Lower Friulian Plain there are 33 water-water plants with a discharge capacity of 163 m3/s and a consumption of about 5 million kWh/year; irrigation plants consume 16 million kWh/year.

Figure 3: Built-up areas, hydrographic network, embankments,
water wells, reported water pumps, aqueducts of the Lower Friulian Plain.
Source: the authors with Cristian Crovatto, 2024.

which keep the Low Friulian Plain dry by discharging water into rivers and the sea, preventing potential flooding. Added to this are the increasing demands for potable water for domestic, agricultural, and industrial uses, with substantial extraction from the groundwater table, which risks progressive depletion. [12] Moreover, the water supply and sewage networks require evaluation, as parts need modernisation and are insufficiently deployed to serve the entire urbanised area, particularly with significant gaps in the peri-lagoonal zones. [13]

This paradox becomes evident when observing that, despite extensive infrastructural development, the Low Friulian Plain is inadequately equipped to handle water emergencies (Zini, 2011; Bendoricchio, 2024). The critical environmental conditions are further exacerbated by widespread subsidence and saline intrusion, which are poorly monitored phenomena. [14] One longstanding risk in this region, now intensified by climate change, is river flooding. Hydraulically, this area presents distinctive characteristics (Figure 4).

[12] The left Tagliamento zone is in semi-equilibrium quantitatively because withdrawals are theoretically offset by recharge; however, the drawdown of water to the right Tagliamento zone depletes the quantities available on the left.

[13] The CAFC Spa - Acque del Friuli is in the process of drafting an Aqueduct System Interconnection Masterplan that envisages future scenarios of the aqueduct system in the FVG Region and Eastern Veneto, identifying interconnections and future sources of supply to the system in order to increase the degree of resilience of the entire FVG aqueduct system, and as a single model for monitoring intake works and drafting Water Safety Plans.

[14] Both phenomena are not extensively monitored: there are no updated large-scale data to formulate aions to counteract their effects.

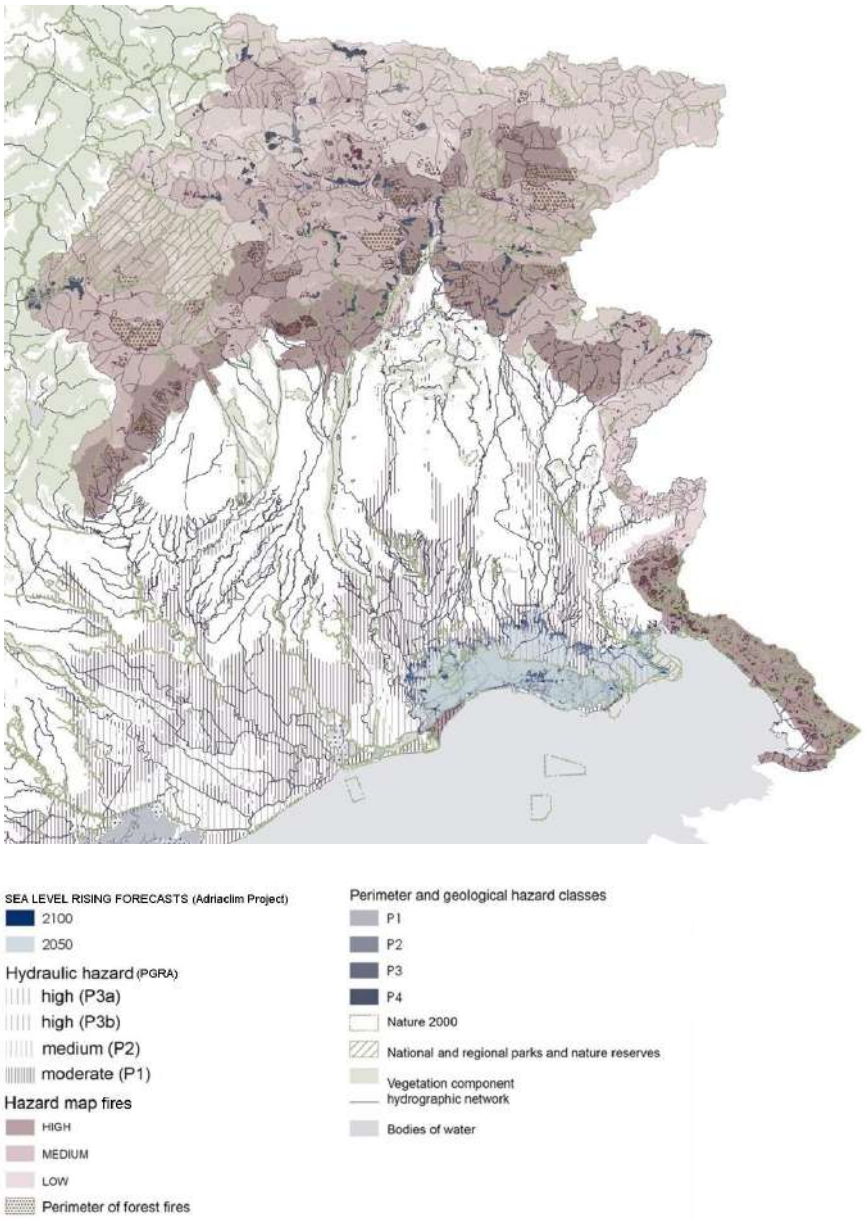


Figure 4: Vulnerabilities in Friuli Venezia Giulia Region.
Source: the authors with Eleonora Ceschin, 2024.

The short distance between the Alps and the sea, high rainfall in mountainous areas, the torrent-like nature of rivers with sudden surges, and the presence of spring-fed rivers have historically led to recurrent flooding issues, exacerbated by current climatic change. Coexisting with risk

has been a long-term feature of lowland territories. The canalisation and embankment works on rivers, predominantly found in these areas, do not provide an adequate solution to problems rooted in the past, nor can they effectively address the increasing risks anticipated in the future. The reduction of river flows due to hydroelectric diversion and other extractive uses appears to have indirectly caused the raising of riverbeds, increasing flood risks during extreme events. In the predominantly artificial hydraulic network of the upper and lower plains, there is ongoing debate to restore and to rewild segments of the "blue network" as an alternative to the construction of "grey infrastructure" solutions, such as flood detention basins. From the perspective of climate neutrality, devising alternative configurations for this territory entails rethinking territorial hierarchies, beginning with the establishment of new spatial relationships between environmental and anthropogenic components within a framework of expansive open spaces (Secchi, 1989). This approach must also acknowledge the current 'environmental phase' of land reclamation (Duca, 2003), which calls for a renewed dialogue with the agricultural landscape.

5. Across the River and Into the Trees: the uses of soil, ecological network and risks

Forests, meadows, rivers, and the lagoon were once the components of a lush, silvo-pastoral environment that characterised the plains below the spring line. The lowland forests, primarily oak woodlands, extended across the intermediate zone, forming
integral elements of a socio-economic system that spanned thousands of hectares until the First World War. Other woodlands occupied the spring belt and riverbanks, with sediment deposits gradually shaping the plains. To the north of the forests lay a belt of wet meadows, springs, and marshes; to the south was the shifting boundary with the lagoon. As recently as 1850, 58% of the circum-lagoonal area was covered by pastures, forests, and marshlands, with only 28% devoted to arable land. Large tracts of communal land allowed an organisation of isolated rural villages within a landscape half cultivated and half uncultivated. The abolition of rights over communal land disrupted this social balance, reducing many community members from land-users to rural proletariat. Simultaneously, by the late 19th century, a class of medium and large landowners and agribusinesses emerged, initiating a transformation of the landscape. With the construction of water pumps along the peri-lagoonal belt from the late 1920s onwards, many transitional wetland areas were reclaimed, while northern zones remained marshy. The hydraulic reclamation planned between the two World Wars was partially completed only after 1950. Meadows and forests disappeared, along with
marshlands, pastures, and ponds that once constituted a complex transitional environment between the open lagoon and cultivated highlands. The current landscape (Figure 5) reflects an industrialised agricultural environment of low ecological value, where only a few remnants of isolated lowland forests remain. Rivers have been channelled, and peri-lagoonal embankments demarcate the lagoon. Some protected areas (Natura 2000 Network) at river mouths preserve isolated sites of great

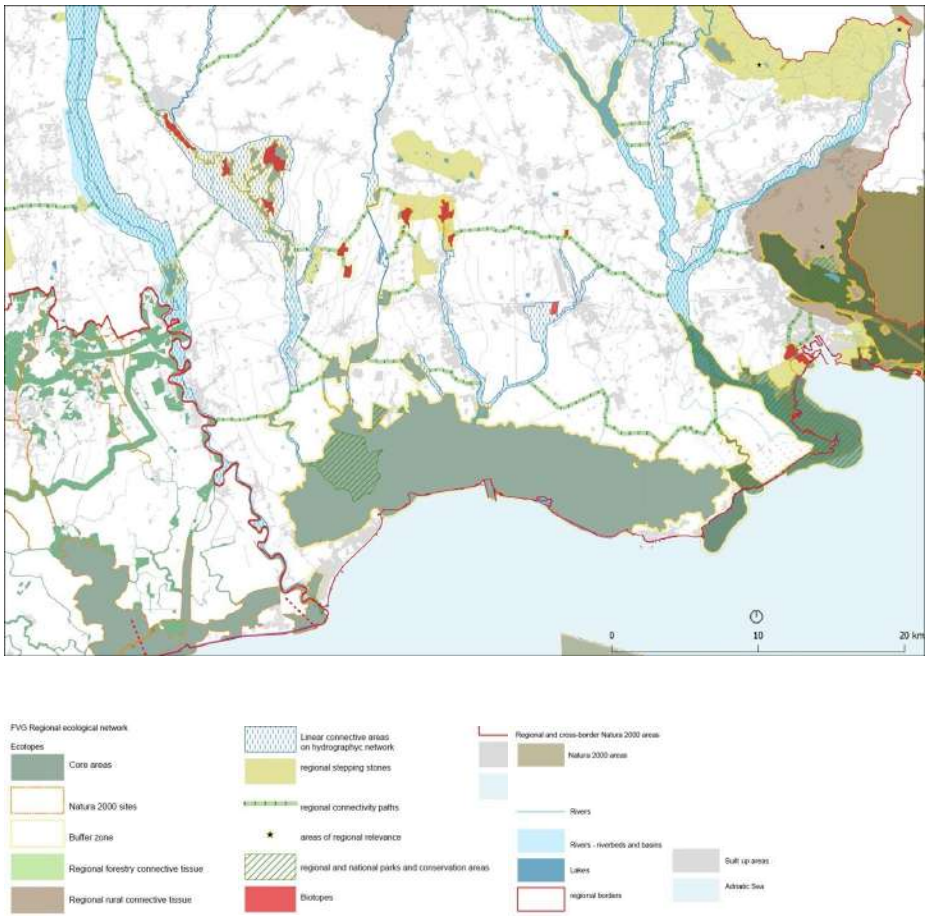


Figure 5: Ecological network of Lower Friulian Plain from the Project of Regional Landscape Plan, 2018. Source: the authors with Eleonora Ceschin and Cristian Crovatto, (elaboration of IRDAT data), 2024.

ecological richness. In recent years, projects have been initiated to strengthen and restore a more extensive ecological network and to reconnect forests, rivers, and the lagoon. A persistent risk, now heightened by climate change, is river flooding, a unique hydraulic challenge in this region. In the same way, Nature-Based Solutions (NBS) are being considered, for example, to address the risks of declining pollinator populations and biodiversity loss, a particularly serious issue in the highly simplified landscape of the Low Friulian Plain dominated by intensive agriculture. Some projects propose solutions involving the restoration and enhancement of landscape heterogeneity and the development of ecological networks of multifunctional natural and semi-natural areas, including forested zones.

6. Networks and ecologies at risk

"Networks" and "ecologies" – describe in paragraph 3 – are subject to severe challenges and increasing risks, with varied implications depending on the morphology and resilience of the affected areas (Figure 6). It is essential to examine the impacts of changes in both natural and human-modified environments in diverse contexts, primarily driven by climate change. A key objective of the ongoing research is to identify the specific impacts and, consequently, the necessary mitigation or adaptation measures to be implemented. While this section does not detail that aspect of the work, it is possible to highlight the most critical issues and project domains within which to construct a framework for reflection on a macro scale of the territory, to guide future work and suggest further avenues for investigation. At present, three key issues can

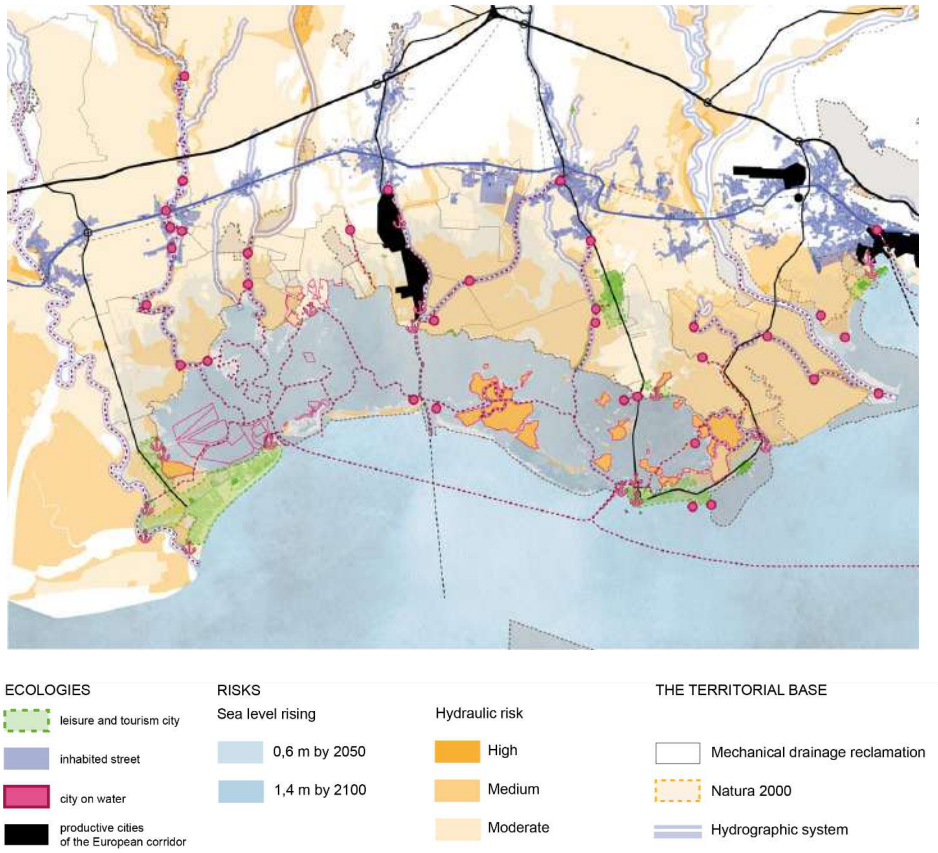


Figure 6: Ecologies, risks, hydraulic hazard (PGRA), Sea level rising forecasts (Adriaclim Project), network of the Lower Friulian Plain (Project of Regional Landscape Plan, 2018).
Source: the authors with Eleonora Ceschin and Cristian Crovatto, 2024.

be considered, without prioritising their order, to structure the perspective: 1) sea-level rise, 2) water abundance and scarcity, and 3) rising temperatures. These are among the most significant

macro-level issues directly affecting the Lower Friulian Plain. Together, these factors contribute to increased risk levels, and their combined impact implies a deterioration in living conditions across different contexts. In particular, the risks associated with rising mean sea levels primarily affect the "leisure and tourist city" and the "waterfront city." These two "ecologies" are impacted differently due to their direct exposure to tidal variability. For instance, on the coast, seasonal storm surges are becoming increasingly frequent, directly impacting urban centres like Lignano and Grado. The western coastal zone, characterised by sandy terrain, offers limited protection to urbanised areas, at the cost of erosion and the need for continual seasonal beach replenishment. [15] To the east, situated on an island, nearly all of Grado's urban area is inevitably exposed to the cyclical effects of tides (Bezzi et al., 2021). On one hand, water scarcity is intrinsically linked to these areas, largely due to the high seasonal influx of tourists, which significantly increases potable water consumption during the summer, concentrating demand during a short period compared to the rest of the year. During the summer season, the number of tourists stays averages over 3 million, primarily concentrated in the two main seaside centres of Lignano and Grado. On the other hand, the abundance of water resulting from heavy downpours predominantly challenges urbanised areas with higher levels of soil impermeability. The peri-lagoonal area, extending towards the hinterland, is also subject to potential flood risks due to the pronounced altimetric depression that characterises it. Continuous embankments protect one-third of the Low Friulian Plain from the average sea level, which is approximately 2 metres above the zero sea level mark. To ensure continuous protection against water intrusion and backflow, there are also 33 pumping stations [16] that enable this extensive territory to remain dry. A network of 2,228 km of natural and mechanical drainage channels further supports its proper functioning. The productive cities within the "European corridor" and the service and residential centres defining the ecology of the "inhabited road" appear to be more protected from the aforementioned emergencies. While not immune to the risks of water accumulation and drought, they are better equipped; unlike the peri-lagoonal areas, which are less serviced, this part of the plain benefits from a more extensive potable water distribution network. Rising temperatures and the resulting formation of heat islands affect the urbanised areas across all the described ecologies, with the greatest impact where proximity to natural areas is limited or where urban greenery is scarce. It can be said that the inner zones—aligned with the ecologies of the "productive cities" within the "European corridor" and the "inhabited road"—where urban mobility is highest due to extensive infrastructure, experience a higher concentration of heat islands as average seasonal temperatures increase.

7. Conclusion

As environmental degradation intensifies and climate change becomes a result of this worsening condition, it is imperative to reconsider environmental networks, especially in coastal regions. Certain issues emerge as evaluation markers in ongoing research, underscoring the need to develop hypotheses that go beyond mere concepts. There is an urgent need to rethink the relationship between humans and the environment, not as a matter of separation, but by

[15] Studies by the Region FVG have estimated the amount of sand needed for seasonal nourishment of the shoreline at 70,000 cubic meters, which grows to 200,000 cubic meters following storm surges). Con-causing the reduction of the sandy shoreline cordon is the confluence of the mouth of the Tagliamento River, which affects a large area, increasing the risks due also of possible freshwater flooding.

[16] The discharge capacity of the water pumps is 163 m3/s. Their consumption is about 5 Million kWh/year.

seeking strategies that foster improved coexistence. This includes exploring new frameworks that complement the concept of networks, such as the mosaic, kaleidoscope, or pluriverse (di Campli, Gabbianelli, 2022). The research is oriented towards a project concept based on relationships between different ecologies, practices, and forms of inhabitation. This presents an opportunity
to rethink networks in relation to climate change by considering at-risk zones as potential new core areas, expanding spaces of naturality. A significant advantage lies in the potential to integrate biodiversity considerations across all areas of planning, rather than confining them solely to green and blue networks. Connecting different areas within the territory to build landscapes does not necessarily require spatial continuity, but rather complex, multi-layered design approaches capable of establishing multidisciplinary, multi-scalar relationships. The spatial challenge is to activate biodiversity and new settlement forms across various ecologies: in industrial areas, residential zones, standardised areas, and particularly in agricultural regions. A priority, on one hand, is to redefine spaces for experimentation where urban and territorial projects can be re-evaluated, initiating a collective debate supported by design explorations and prototype formulations. As Viganò (2023, p.145) notes, "the design of the transition requires changes that we are not politically and economically equipped to implement and legislate." On the other hand, there is a need to develop shared visions and projects across different levels of public administration and multidisciplinary expertise, capable of designing across multiple scales rather than in a fragmented manner. The EU's missions provide clear guidance, offering a new approach to addressing some of Europe's most significant challenges. In this regard, Friuli Venezia Giulia stands out, being one of the few Italian regions to join the first of the five missions, "Adaptation to Climate Change," with the objective of achieving climate resilience by 2030, promoting innovative solutions for climate adaptation, and supporting cities and communities in building a more resilient society.
Planning must manage the coexistence of differences (worlds, species, social groups, etc.) rather than their separation. To this end, the Friuli Venezia Giulia Region established the "Technical-Scientific Working Group on Climate" in 2022. In the case of the Low Friulian Plain, attention is focused on at-risk areas, with 75.2% of the territory vulnerable to flood or sea-level rise risks. The emphasis is on a project centred around the reorganisation of water resources across various scales. For instance, the concept of *a net zero water territory* should become a shared objective, not only for the Low Friulian Plain. In this context, viewing all at-risk areas as project opportunities allows new themes to be incorporated into territorial planning efforts.

Attributions

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