

Mobile justice in the face of climate change on the North Adriatic coast.

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Abstract

The North Adriatic coast has been profoundly shaped by centuries of interaction between human activity and natural dynamics, with major transformations accelerating since the 19th century. Today, this territory faces escalating risks, intensified by climate change and decades of extractive development. This paper adopts the lens of mobility justice to analyze the region's vulnerabilities and opportunities, focusing on three river transects: Stella, Corno-Aussa, and Natissa. Combining historical analysis, policy review, fieldwork, and design experimentation, the study explores a transition from rigid, unsustainable models toward adaptive, plural, and regenerative futures. It positions urban and territorial design as strategic tools to redistribute spatial opportunity, restore degraded ecologies, and ensure fair access to mobility and resources. The resulting project scenarios offer site-specific strategies that integrate climate resilience, intermodal connectivity, and ecological restoration, reimagining the North Adriatic as an amphibious, relational landscape shaped by both human and more-than-human agency.

Keywords: Climate Change; Mobility, Mobile Commons; Spatial Justice; Adaptation

Introduction

The North Adriatic coastline has experienced profound transformations since the late 19th century, shaped by the dynamic interplay between human interventions and natural processes. Early land reclamation projects converted wetlands into arable land, while the development of coastal tourism and the expansion of infrastructure for the terrestrial movement of people and goods further reconfigured the region's landscapes and economies. Today, this territory is confronted by multiple, intersecting crises: declining agricultural productivity, the exhaustion of mass beach tourism, and ongoing demographic shrinkage. These challenges are compounded and increasingly intensified by the accelerating impacts of climate change, which will be particularly intense on this low-lying coast, where lagoonal, deltaic, estuarine, and artificially reclaimed landscapes coexist and overlap.

These challenges resonate with the three interrelated crises identified by Mimi Sheller (the climate, the urbanization, and the refugee crisis), which she argues are deeply interconnected and rooted in a shared structural cause, what she terms "the politics and power relations of (im)mobilities" (Sheller, 2018: 1). In response, she calls for a move beyond "sedentary theories of justice", advocating instead for a perspective that treats "injustice as an unstable configuration that moves across scales and realms" (Ibid: 33). Thus, with respect to earlier frameworks of spatial justice (Soja, 2010) and the just city (Fainstein, 2010), themselves grounded in foundational work from the 1960s onward (Lefebvre, 1968; Harvey, 1973), Sheller proposes to use a mobile ontology that allows justice to be understood not as a fixed condition, but as a dynamic process of emerging relationships that re-make spaces and subjects.

Such a reconceptualization requires expanding the very subject of justice to include diachronic processes, different spatial scales, and the interplay of different phenomena and subjects. As some authors have pointed out, this entails recognizing non-human beings as legitimate agents (Barry, Suliman, 2023; Scott, 2020), as well as acknowledging the intricate interrelations between various types of flows, both human and non-human (Allievi, Bernardi, Vineis, 2023). At the same time, it is important to recall that connectivity has long been a core principle in landscape ecology and a key guideline for maintaining ecosystem health (Brodie et al., 2025), and, by extension, planetary health (Horton, Lo, 2015; Nishi, Hashimoto, 2022).

Drawing on the concept of mobility justice, Sheller (2018) argues that patterns of mobility, unevenly distributed across social and spatial domains, are shaped by both historical and contemporary power relations. Building on this framework, this paper first examines how the territory of the North Adriatic coast has been reshaped over the centuries, with particular attention to the transformations of the last 150 years. We explore how different processes of modernization have significantly altered both local ecosystems and the anthropic use of the land, as well as the movements of human and non-human actors. This analysis is based on a review of existing literature and the interpretation of historical cartographic sources. In the second part of the paper, we turn to current plans and policies concerning mobility and ecology, focusing on three territorial transects that follow the courses of the Stella, Corno-Aussa, and Natissa rivers. This part of the research is based on a combination of qualitative methods, including interviews with local actors, site visits, and a review of regional and local planning documents. Finally, a third section of the paper explores future possibilities for these territories through the lens of urban design and planning. This exploration is based on a series of projective scenarios developed during a design workshop with PhD students in urbanism and urban planning, who envisioned adaptive and just futures for the region through site-specific proposals. Together, these approaches offer a grounded perspective on how mobility justice can inform spatial and environmental planning in a context marked by multiple, overlapping crises.

(Im)mobility of the North Adriatic Coast

The Italian stretch of the North Adriatic coast is characterized by a flat, sandy landscape interspersed with lagoons, estuaries, and low-lying wetlands. However, this present configuration is a relatively recent outcome of centuries of intertwined natural processes and human interventions (Gelichi, Ferri, Moine, 2017; Fontana, Rocchi, 2021). These transformations took place within what is often referred to as the land-sea interaction (LSI): the interplay of biogeochemical processes and socio-economic dynamics (Kidd, Jones & Jay 2019).

Until the Roman period, the coasts and lagoons remained sparsely populated. Major settlements such as Aquileia and Concordia Sagittaria were established just beyond this marshy fringe, on more stable inland terrain. With the decline of the Roman Empire, infrastructure and settlements were gradually abandoned. Populations progressively migrated toward the coastal and lagoon areas, giving rise to a dispersed archipelago of cities, ports, and rural communities sustained by water-based mobility (Auriemma, Maggi, 2013; Gasparri, Gelichi, 2024). The emergence of Venice as a maritime power during the Middle Ages gave centrality to the lagoon system. The Serenissima Republic embarked on major hydraulic interventions, including extensive river diversions, to protect the Venetian lagoon as a vital strategic and commercial asset. Meanwhile, the northern coastal territories became increasingly marginal, often relegated to extractive uses. These transformations imposed a more rigid territorial configuration, at least within the Venetian lagoon, while maintaining its amphibious character (D'Alpaos, 2010; Dorigo, 1994; Fassetta, 1977).

A radical transformation of the region's spatial and ecological configuration began in the 19th century, driven by a series of interconnected modernization processes. Chief among these were the land reclamation projects, which gained significant momentum following Italian unification. Enabled by mechanized pumping systems and sustained public investment, particularly after the enactment of the Baccarini Law in 1882, vast wetlands were drained and converted into productive farmland. These efforts also led to a notable reduction in malaria, an endemic disease that had long afflicted the region (Novello, 2009; Vallerani, 2008).

Much of the reclaimed land lay below sea level, and its productivity increasingly depended on a complex, energy-intensive drainage system. This process, alongside the expansion of agriculture and urbanization, led to the gradual loss of the region's amphibious ecology, which had included spring-fed wetlands, toward the mountains, coastal lagoons and marshes, toward the coast, and a band of forested areas between them. As a result, the historical fluidity that once characterized the region was progressively and rigidly fixed within an artificially regulated landscape.

This "terrestrialization" of the coastal territory unfolded in parallel with the rise of mechanized mobility. The construction of major railway lines reshaped patterns of access and movement across the region. In the following decades, the mass adoption of the automobile spurred the development of an extensive road infrastructure, gradually supplanting the once-vital network of inland waterways. Improved terrestrial accessibility, combined with the eradication of malaria, laid the ground for the explosion of coastal tourism in the 20th century, particularly in the post-WWII economic boom. The coastline was rapidly transformed into a corridor of leisure urbanization. Former fishing villages and dune landscapes were reimagined as tourist enclaves. Lignano, Bibbione and Caorle, among others, saw exponential growth driven by hotel development, second homes, marinas, and camping villages. What began as scattered, informal initiatives soon became systematized through zoning regulations, public incentives, and private investment. However, this urbanization came at the cost of coastal dynamism. Rigid defense structures were built to protect settlements and infrastructure, effectively freezing the coastline and disrupting its natural sedimentary processes (Battigelli, 2007; Fontolan, Bezzi, Pilon, 2011; Perelli, 2005).

Finally, another process of development reshaped the coast: industrial production and port logistics. The most emblematic case is Porto Marghera, which embodied the modernist vision of coastal industrialization. Further east, the area around the Marano-Grado lagoon saw the rise of Torviscosa, a company town established under Fascism for cellulose production, and the development of Porto Nogaro as a regional logistics hub. These sites introduced new forms of mobility, primarily of goods and labor, but also intensified environmental degradation and social transformation. The fragile ecosystems of the lagoons, already under pressure from land reclamation and tourism, were further compromised by pollution, dredging, and the hardening of waterways for navigation. These historical processes have produced a landscape marked by mobility injustice, in which the expansion of land-based mobility for goods, tourism, and other motorized flows has come at the expense of traditional communities, non-motorized forms of transport, and ecological systems, all of which have become increasingly immobilized. Today, the consequences of this historically embedded immobility are becoming ever more apparent. The coastal territory, rendered artificially static and rigid, is now under growing pressure from climate change, facing threats such as sea-level rise, land subsidence, erosion, salt wedge, and storm surges. A region once defined by fluidity and adaptability has become fragile and exposed.

This requires acknowledging that past development paths have unevenly distributed mobility, access, and environmental risk, privileging extractive flows and economic gain over ecological integrity and collective wellbeing, often provided by welfare spaces and policies. The resulting landscape bears multiple layers of injustice: ecological degradation, infrastructural exclusion, socio-economic marginalization, and the erosion of traditional knowledge and relationships with the land. Rethinking its future demands more than technical adaptation; it calls for a fundamental shift in how mobility is understood and distributed, and for a reframing of territorial planning and design through the lens of spatial justice.

Planning coastal futures: climate and mobility policies across three transects in Friuli Venezia Giulia

The Northern Adriatic coast is currently facing crucial challenges related to climate change, encompassing environmental management and sustainable mobility. While institutional awareness of climate risks is growing and several promising initiatives are emerging, policies and plans at the regional, supra-local, and local levels still struggle to integrate these issues in a coherent and coordinated manner. Their translation into concrete actions is further hindered by administrative fragmentation and ongoing institutional changes, which undermine the capacity of local governments to develop and implement effective policies.

In the case of Friuli Venezia Giulia, these dynamics are particularly evident. Hydraulic planning and management, entrusted to the Eastern Alps River Basin Authority (Autorità di Bacino Distrettuale Alpi Orientali) and the regional land reclamation consortia (Consorti di Bonifica), focus primarily on infrastructure security and efficiency, lacking a systemic approach to climate change. Regional planning consists of a fragmented array of documents, sometimes offering conflicting guidance. Important steps have included the adoption of the FVGreen strategy in 2023, followed by a Regional Strategy for Sustainable Development (Strategia Regionale per lo Sviluppo Sostenibile, SRSvS), and the 2018 approval of a Regional Landscape Plan (Piano Paesaggistico Regionale, PPR), which proposes networks to restore ecological connections, promote sustainable mobility, and enhance cultural heritage. Along these lines, the 2022 Regional Cycling Mobility Plan (Piano Regionale della Mobilità Ciclistica, PREMOCI) focuses on cycling infrastructure and its integration with public and waterborne transport. In contrast, the Regional Infrastructure Plan (Piano Regionale delle Infrastrutture, PRITML, 2011) and the Public Transport Plan (Piano Regionale del Trasporto Pubblico Locale, PRTPL, 2013) promote high-speed mobility, with a strong emphasis on logistics and conventional transport. The region's main urban planning instrument, however, is severely outdated, dating back to 1978, with only partial attempts to update it in recent years (Marchigiani, in press).

At the local level, municipalities in Friuli Venezia Giulia are often small and seldom coordinated by stable supra-local entities. This limits their administrative and planning capacities. The Region has launched initiatives to encourage municipalities to adopt climate action plans, particularly by supporting the drafting of Sustainable Energy and Climate Action Plans (SECAPs or PAESC in Italian). Nonetheless, relatively few municipalities have completed them. Several interesting initiatives have also been launched through European research and territorial cooperation programs, which have enabled experimentation with innovative tools in areas such as integrated coastal and marine zone management, the protection of natural reserves, the valorization of ecosystem services, sustainable tourism, and intermodal water-land mobility. Among these, the Wetland Area Contract for the Marano and Grado Lagoon stands out as a pioneering initiative that brought together local administrations in a collaborative framework to safeguard the lagoon's socio-ecological systems.

To better understand local dynamics of transformation, we carried out an in-depth analysis of three territorial transects along the course of three rivers, extending from their outlets to the sea, passing through the lagoon, and reaching back into the low Friulian plain up to the *risorgive* zone. These transects illuminate emerging challenges linked to climate change, demographic decline, and economic transitions in agriculture, logistics, and tourism. They also reveal how spatial injustices are produced and addressed. Yet, amidst these pressures, some promising local initiatives suggest potential pathways toward more just and sustainable transitions.

The **Stella** River transect navigates a landscape where nature conservation, water governance, and local development intertwine. In its upper reaches between Codroipo and Pcenia, the river retains much of its natural character, flowing through biodiverse wetlands recognized by the European Commission. Since the early 2000s, local governments in Rivignano-Teor have implemented ecological restoration projects, notably the LIFE S.T.A.R. initiative. These efforts enhanced the river corridor's resilience and spurred low-impact tourism: bike paths, canoe access, eco-lodging, and agri-tourism services have flourished. However, downstream, the river enters a rigidly controlled reclamation zone with intensive agriculture and engineered drainage, increasingly vulnerable to climate change. The Foci dello Stella Nature Reserve protects the river mouth, but stronger interventions are needed. In Lignano Sabbiadoro, a major seaside resort, mobility challenges persist due to car dependency and seasonal congestion, despite some green initiatives. This area underscores the urgent need for a new paradigm of mobility justice, one that values ecological integrity, local knowledge, and equitable access to the landscape.

The **Corno** and **Aussa** rivers trace a different path, shaped by industrialization, environmental degradation, and socio-economic decline. In their upper stretches, natural habitats like the Paludi del Corno biotope benefit from conservation projects such as LIFE Friuli Fens. Downstream, however, the rivers become heavily canalized and surrounded by industrial infrastructure. Torviscosa, a legacy of Fascist-era industrial planning, has long been a pollution hotspot. Despite partial closures and its designation as a national contaminated site (Siti di Interesse Nazionale, SIN), remediation remains contested. Porto Nogaro adds complexity: originally a sugar export hub, it

is now a multimodal industrial port. While it sustains employment, it exacerbates congestion, land-use conflicts, and pressure on the lagoon ecosystem.

The **Natissa** transect connects Aquileia and Grado through a corridor of significant archaeological, ecological, and hydrological value. Aquileia has adopted a sustainable planning approach aimed at enhancing and preserving its archaeological heritage while better integrating it into the urban fabric and everyday life. In this context, mobility is treated as a key strategy. Strategic documents, such as the SLOW Aquileia vision, propose rerouting a regional road to create more space for pedestrians and sustainable transport. The Natissa River plays a central role in this strategy, with bank reinforcement projects and the introduction of a public boat service linking Aquileia to Grado, a coastal town situated on an island between the lagoon and the sea. Grado faces serious challenges, ranging from the pressures of mass seasonal tourism to escalating climate risks such as sea-level rise and storm surges. Some measures have been introduced, including Variant No. 34 to the municipal land use plan, which prohibits the construction of underground parking and limits further urban development tied to tourism. Additionally, a recently approved mobility plan promotes sustainable transport and aims to reduce space allocated to private vehicles. However, despite these efforts, the town still lacks a comprehensive and integrated climate adaptation strategy.

In conclusion, while the three transects share overarching challenges, each reveals distinct dynamics: the Stella transect highlights a disconnect between upstream ecological restoration efforts and downstream vulnerabilities linked to mass tourism and industrial agriculture; the Corno-Aussa area exemplifies spatial and environmental injustice shaped by extractive flows and heavy infrastructure; the Natissa corridor demonstrates the potential to integrate cultural heritage, ecological sensitivity, and mobility innovation, while also exposing the limitations of fragmented, small-scale responses to systemic climate threats. Despite these challenges, the research suggests that alternative futures are thinkable and possible. Such futures must be built on a rebalancing of mobility systems, one that values slowness, intermodality, and ecological connectivity alongside speed and efficiency. They must also be grounded in place-based knowledge, empowered by local actors, and attentive to the more-than-human agencies that shape and sustain these landscapes.

Rethinking the North Adriatic through mobility justice: urban design as a tool for adaptive futures

The increasing pressures that affect the North Adriatic lowlands call into question long-standing assumptions about how territories are inhabited, used, and connected. These challenges demand a deeper reconsideration of how spatial justice is conceived and enacted, moving from adaptive transformation to more radical transformative projects (Fedele et al. 2019). The following project-based exploration of the Stella, Corno-Aussa, and Natissa river corridors reflect upon the possibility of an urban and territorial design approach rooted in relational ecologies and integrated mobilities. The projects were built around two main hypotheses. The first is the need to expand sustainable mobility, such as walking, cycling, public transport, and waterborne transit, while increasing intermodality, with the goal of reducing fast mobility, particularly private car use. This draws on Sheller's (2018) interpretation of Illich (1974), who argued that slow mobility is inherently more equitable and sustainable than fast mobility. The second hypothesis is the need to reclaim a more amphibious and adaptive territory, one that gives more space to water and, in doing so, enhances the role of water-based mobility. Such a reconfiguration will not only improve ecological health and connectivity but also increase resilience to the transformations expected under climate change.

The territory along the **Stella** river reveals the essential role of water in sustaining both the ecological life and the cultural memory of this landscape. In recent decades, however, this delicate system has been destabilized and it is further threatened by climate change. The project reimagines the Stella River as an amphibious corridor, capable of absorbing and responding to hydrological fluctuations while supporting new socio-ecological practices. From its springs to its coastal mouth, the Stella becomes an integrated system of ecologies, mobilities, and new circular economies. In the northern stretches, valuable habitats are expanded and connected, reclaiming land from intensive agriculture and restoring the ecological continuity of the river. Toward the mouth, traditional farming is replaced by ecologically adaptive agricultural mosaics, including halophytic cultivation and aquacul-

ture systems, structured to operate within variable water regimes. Mobility, in turn, is reconceptualized as an intermodal, slow, and low-impact network. Cycling infrastructure and intermodal hubs encourage a shift away from car dependency, promoting accessibility while minimizing environmental cost.

The **Corno-Aussa** transect presents a landscape historically shaped by extraction and infrastructural fragmentation, where the pressures of industrial development have left behind damaged ecosystems and marginal communities. Here, the project envisions a phased territorial park aimed at environmental compensation and adaptive climate regeneration. The strategy recognizes the debts owed to both human and non-human communities and proposes spatial repair through ecological restoration and expanded public access. Central to this reimagining is the enhancement of river corridors as vectors of ecological recovery and active mobility. New bicycle and pedestrian paths reconnect fragmented habitats, while soft mobility on land and water is supported by intermodal hubs and equipped landings. This layered infrastructure responds to the needs of local communities, while strengthening ecological connectivity. The final phase of the project envisions the return of amphibious ecosystems and seasonal flooding cycles, thus transforming past damage into future potential.

In the **Natissa** transect the increasing pressure of mass tourism, climate-related risks, and infrastructural congestion demands a new mobility regime capable of mitigating anthropogenic impacts while supporting sustainable livelihoods. In this context, mobility becomes a strategic entry point to imagine and implement an integrated transition. The proposal identifies four amphibious hubs as anchor points in a renewed intermodal network linking buses, bicycles, and ferries. This system would offer a viable alternative to car use, supporting both residents and visitors while alleviating seasonal congestion and pollution. Car traffic in central Grado and Aquileia would be limited to residents, while improved canal networks and a new intermodal node at Cervignano station would enhance regional accessibility. At the same time, the progressive flooding of saline-compromised agricultural areas is proposed to create a new ecological corridor along the Aquileia coast. This would link up with the Anfora canal and surrounding wetland systems, generating ecological value, buffering climate risks, and creating a basis for a new model of sustainable tourism.

Across these three river systems, urban and territorial design serve as tools to operationalize mobility justice, not only by redistributing access to infrastructure and space, but by reconfiguring the relationships among humans, non-humans, water, land, and movement. The goal is not to preserve an existing equilibrium, but to cultivate adaptive, just, and plural futures in a region where stasis is no longer viable.

Conclusions

Viewed through the lens of mobility justice, the North Adriatic emerges as a territory shaped by centuries of profound transformation. Rather than a landscape to be preserved unchanged, it should be understood as a dynamic laboratory for climate resilience, mobility reconfiguration, and ecological renewal, especially in light of the disruptions brought by climate change. Mobility justice serves here as both a diagnostic lens and a generative framework: it reveals how territorial arrangements have produced exclusion and vulnerability, while also opening pathways for spatial practices grounded in care, repair, and cohabitation. Within this perspective, mobility is redefined as a collective resource and a driver of ecological and social regeneration at the territorial scale. The proposed design scenarios outline strategic interventions that redistribute spatial opportunities, prioritizing environmental stewardship and social equity. They emphasize the need to move beyond fragmented or sectoral solutions toward an integrated, multi-scalar approach that weaves together climate adaptation, heritage enhancement, ecological restoration, and infrastructural innovation. The goal is not to preserve an unsustainable status quo, but to embrace transformation, designing for resilience, adaptability, and justice in the face of ongoing change. The scenarios developed along the Stella, Corno-Aussa, and Natissa river corridors are more than speculative proposals; they offer tangible spatial imaginaries and strategic tools for navigating uncertainty and cultivating resilience. By expanding the scope of justice to include more-than-human actors, evolving ecosystems, and historically marginalized places, this approach invites planners, policymakers, and communities to reimagine the North Adriatic not as a fixed coastline to be defended, but as a fluid, amphibious commons.

Importantly, the reflections presented in this text were developed within the framework of a research project funded by the National Recovery and Resilience Plan (PNRR).¹ Our approach interpreted the PNRR's goal of reducing territorial disparities (which brought substantial resources to Italy) through the lens of mobility and access justice. We focused on reducing inequalities not only between north and south, or center and periphery, but also in terms of everyday access to services, infrastructure, housing, and employment. In this view, minimizing mobility injustice in daily practices becomes just as crucial as addressing broader territorial imbalances.

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¹ The project is: Interconnected Nord-Est Innovation Ecosystem, in particular the Research Topic 4 (Land-sea integrated maritime and spatial planning) of the Spoke 8 (Maritime, marine and inland water technologies: toward the digital twin of the Upper Adriatic)

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