Living with Water: toward an amphibious planning paradigm for multi-risk territories

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Historically, climate adaptation responses have focused on large-scale mitigation strategies, often overlooking local needs, knowledge, and perceptions. Traditional planning—rooted in land-based logics and constrained by rigid borders—struggles to address the complexity of risks that are deeply interwoven with water. In Italy, a multi-risk landscape where land and sea interact constantly, challenges such as unsustainable growth often take the form of overbuilt, impermeable coastal zones that disrupt natural water

1. Introduction: why do water cities matter in the light of multi-risk conditions?

In an era marked by accelerating climate change and increasing environmental threats, water cities—as urban regions shaped by rivers, deltas, coasts, and other aquatic systems—are emerging as critical frontiers for spatial planning (Olivadese & Dindo, 2024; Hein, 2020; Granceri et al., 2024, Bradaschi, 2024; Pelling & Blackburn, 2013; Bongarts et. al., 2021). These are not only fragile ecosystems but also complex socio-technical systems where overlapping risks—flooding, pollution, sea level rise, subsidence—converge with infrastructural

cycles; social inequalities are evident in unequal access to safe, resilient public spaces along bodies of water; and intensifying environmental risks—from coastal erosion to flooding—are symptoms of failing to engage with water's dynamic character. Drawing on research from the PNRR-funded MIRACLE project, this contribution calls for adaptive, amphibious strategies that bring local knowledge to the forefront. We propose urban laboratories as platforms for resilience, structured around three steps: (1) multi-risk analysis, (2) participatory and perceptual mapping, and (3) scenario building. By embracing water's fluidity and relational nature, these labs foster inclusive, context-specific adaptation planning for more just and water-sensitive urban futures.

vulnerability and socio-economic inequalities. In this sense, water cities are not only "frontlines" of climate change but also emblematic lenses through which to rethink our relationship with nature, as they bring together environmental, social and governance challenges (Hein, 2021; van Leeuwen et al., 2019).

Their existence unfolds through the interplay between land and water—a liminal, fluctuating condition that challenges traditional binaries and planning paradigms (Fig. 1). These hybrid geographies do not just require resistance to water but invite us to imagine new urban forms, strategies and governance models fundamentally shaped by its presence (Silva et al., 2023, De Martino et. al, 2023).

This contribution embraces water as both diagnostic lens and design agent, highlighting its capacity to make climate change visible and tangible: it rises in floods, disappears in droughts, infiltrates soils, erodes coastlines, and compromises infrastructures (Fig. 2). These manifestations are particularly acute in the Italian context, where recent events—from high tides in Venice to the Emilia-Romagna floods—underscore how urban vulnerability is deeply linked to historical patterns of land use and water governance.

The disconnection between planning practices and hydrological cycles, the impermeabilization of surfaces, and the marginalization of wetlands have exacerbated exposure to cascading risks. As noted by Fabian (2012) and Viganò (2009; 2012), the issue is not just water itself, but the territorial systems that seek to govern it through exclusion and rigidity. In this sense, water becomes a "revealing substance"—an analytical and projective lens through which the cascading nature of multi-risk conditions can be better understood (Fabian, 2012; Vigano, 2009, 2012; Vigano & Secchi, 2009; Gill et al., 2022, Komendantova et al., 2014, 2016).

Venice Lagoon from above in the North of island Burano. Meanders in the saltmarshes of Palude Pagliaga in estuary of river Dese at confluence with Canale Silone (Sile).

Source: Tony Hisgett from Birmingham, UK, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons.
Fig. 1

This calls for a paradigm shift: from risk control to adaptive coexistence; from static zoning to relational design; from centralized governance to multi-actor negotiation. Urban resilience must be reframed not as resistance to change, but as the capacity to live with water in its multiple temporalities and forms. New spatial strategies—restoring wetlands and ecological corridors, integrating blue-green infrastructure, designing floodable public spaces—must be grounded in territorial specificities and community knowledge (Sohn et al., 2018).

This shift also demands a rethinking of scale and governance. From neighbourhood rain gardens to transboundary watershed management, effective responses must be coordinated across ecological, social, and institutional boundaries. Governance becomes a matter of justice: who gets to decide how water is used, stored, diverted, or protected? Whose voices are heard when planning for climate adaptation? As water governance intersects with access, equity, and rights, it reveals underlying power asymmetries and opens space for democratic experimentation and community-led action.

Ultimately, water territories are laboratories of experimentation. They expose the limits of land-centric planning and invite the development of new grammars, tools, and imaginaries. Planning with water is not only a necessity—it is an opportunity to reimagine how we

May 2023, Emilia-Romagna Flood.
The town of Conselice completely submerged by water.

Source: Cesare Barillà, CC BY-SA 4.0
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Fig. 2

design, inhabit, and govern our shared spaces in a changing climate.

This article aims to contribute to the rethinking of spatial planning in water territories by conceptualizing "amphibious risk" as both a diagnostic and design-oriented approach Ran, & Nedovic-Budic, 2016). Through an interdisciplinary lens and grounded in the experience of the MIRACLE (*Multi-risk Integrated Resilience Approach for Coastal Landscapes and Environments*) project (https://storymaps.arcgis.com/stories/f6f607ad8bf14521b3fd34b1a6d6b2d8), this contribution proposes a new approach to multi-risk conditions that embraces the fluid nature of territories and challenges conventional planning paradigms (Krause, 2017, 2022, Linton, 2014).

The structure of the article reflects this ambition. The first section introduces the theoretical grounding of amphibious risk, drawing from environmental humanities, spatial theory, and climate literature. The second part presents the methodological framework and the co-design process developed within the MIRACLE urban laboratories. The third section analyses key outcomes from four case studies in Italy—Verona, Vicenza, Bagnoli and Castellammare di Stabia—highlighting how amphibious thinking can be translated into spatial strategies (Morita, 2016). The conclusion discusses the broader implications of this paradigm shift for spatial planning theory and practice under conditions of accelerating climate uncertainty.

FLUID ENCOUNTERS by Marie Benninghoven, Ramona Buia, Jules Bresson, Lada Leidmane, Tim ter Heide.

Source: The project was developed at the design studio Urban Archipelago at TU Delft between April and June 2023.
The course was coordinated by Carola Hein and Maurice Harteveld.
Teachers: Paolo De Martino, John Hanna, Muamer Tabakovic.
Fig.3

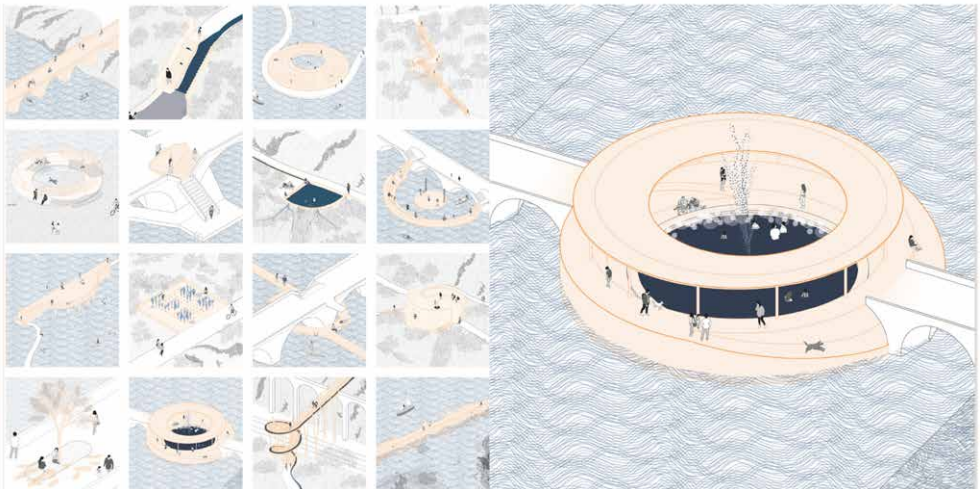
2. Toward a liquid perspective: the amphibious risk

2.1. Limits of Conventional Approaches to Water-Related Risk

Despite the growing attention to water-related risks, conventional approaches continue to treat them as technical issues to be solved through sectoral engineering solutions and rigid planning frameworks. These responses often remain reactive and fragmented, failing to reflect the lived dimensions of risk or the overlapping nature of contemporary hazards. In many cases, strategies such as large-scale flood barriers fail to engage with the everyday realities, experiences, and knowledge of the communities most affected. Moreover, planning processes confined by administrative boundaries are unable to navigate the systemic, interdependent character of water-related threats. Water, however, is a carrier of systemic interdependencies—intertwining physical processes with socio-political, ecological, and infrastructural dynamics. This complexity has sparked a growing critique of static models and siloed assessments, highlighting instead the need for dynamic, integrated frameworks capable of accounting for multiple hazards and evolving vulnerabilities (Gallina et al., 2016; Sperotto et al., 2016; Gill & Malamud, 2014).

2.2. Water as Structuring Force: From Amphibious Territories to Amphibious Risk

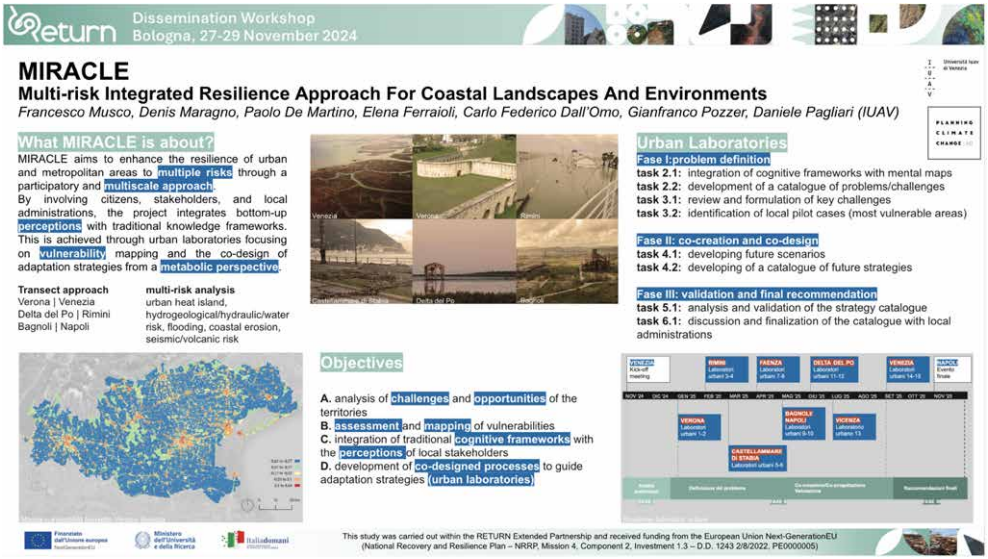
A broad literature now argues for a shift toward more integrated and holistic perspectives—ones that view water not as an external threat but as a structural agent shaping identities, landscapes, and modes of inhabitation. Water is no longer a passive background to urban life; it shapes vulnerabilities, imaginaries, and possibilities. Water cities—and water territories more broadly—are increasingly recognized as complex environments where hydroclimatic processes and socio-political dynamics interlace. This has led to a reconceptualization of urban and territorial space as inherently **amphibious**, situated between land and water, stability and flux. Hydroclimatic threats such as tidal surges, saline intrusion, shoreline retreat, and cumulative flooding intertwine with urbanization patterns, infrastructural fragilities, and social inequality, revealing amphibious conditions as constitutive rather than exceptional. Recent scholarship emphasizes the metabolic, relational, and dynamic nature of these amphibious territories (Morita, 2016). Water acts both as connector and destabilizer, giving rise to **amphibious risk**: a situated condition of coexistence between multiple thresholds—social, ecological, infrastructural—shaped by the fluid entanglement of land and water. Amphibious risk is an ontological condition inherent to coastal and water-based environments, demanding adaptive and negotiated planning responses (Lawyer, 2023; McArdle, 2023; Bailey-Charteris,



2024; Baumeister, 2023; Belland et al., 2025). Framing water as a relational and political medium—not merely a biophysical hazard—requires engaging with wet ontologies and hydro-social imaginaries (Peters & Steinberg, 2019; Roca & Salazar, 2022; Steinberg & Peters, 2015; Franco-Torres et al., 2020). These frameworks reject the land–sea binary and foreground interdependence between bodies, ecologies, and territories. Hydrofeminist perspectives (Neimanis, 2017; Siegel, 2019; Helmreich, 2011) further decenter the human as a sovereign subject, emphasizing relationality, vulnerability, and coexistence—dimensions central to amphibious planning.

2.3. Implications for Adaptation, Governance, and Spatial Imagination

This reconceptualization of water and risk entails a parallel shift in how adaptation is understood (Neil, 2005; Nilubon & Laeni, 2024; Nilubon et al., 2016; Radhakrishnan et al., 2018; Olivadese & Dindo, 2024). Adaptation is reframed not as a technical fix but as a negotiated, anticipatory practice grounded in context-sensitive strategies such as nature-based solutions, green infrastructures, and participatory mapping. Frameworks like Water Sensitive Cities and adaptive pathways advocate for planning as a fluid, co-designed process embedded in local knowledge and resilience capacities. The case of Venice, alongside other coastal contexts, demonstrates how participatory tools—such as bottom-up flood models and collective mapping—can translate adaptation into spatial and institutional practice (Sperotto et al., 2016; Bianchi, 2023). Underlying both risk and adaptation is the fundamental issue of **governance**. Water territories—marked by institutional fragmentation and overlapping competences—become arenas of negotiation over legitimacy, authority, and knowledge. The literature highlights the need for multi-level and multi-actor coordination, the integration of vulnerability assessments into planning tools, and the incorporation of risk management within broader social justice agendas. These challenges are especially acute in dense urban environments, where adaptive capacity is constrained by infrastructural ex-



posure and institutional inertia (Poljansek et al., 2021). They call for new spatial imaginaries–osmotic, filtering, floating–that translate amphibious thinking into design practice, as illustrated in Figure 3. Planning in amphibious conditions thus means designing osmotic, percolating, porous spaces aligned with the rhythms and thresholds of water (Baumeister, 2023; Setiadi et al., 2023). Together, these interdisciplinary insights lay the groundwork for a new paradigm: **planning not in spite of water, but through it**. The amphibious city becomes a site of coexistence, negotiation, and invention–where instability becomes a condition for adaptive, inclusive, and ecologically grounded transformation.

3. Planning through Water: experimental approaches from the MIRACLE project

In order to shift from conceptual framing to situated experimentation, it is essential to explore how planning practices are beginning to engage with water-related risks as structural conditions of urban life. The MIRACLE project, developed within the Italian *PNRR* framework, offers a concrete space for this engagement–where the interplay between environmental vulnerability, territorial transformation, and collective imagination is addressed through co-design and participatory planning and cartography.

Focusing on coastal and multi-risk landscapes in Italy, MIRACLE establishes urban laboratories as sites of experimentation where water is reconceptualized as a territorial agent–a medium through which risks, vulnerabilities, and opportunities become legible and actionable (Fig. 4). Within these labs, technical analysis and local knowledge converge through a three-step process that includes multi-risk analysis, perceptive mapping, and co-design scenarios. Each lab is structured around three phases: a diagnostic phase based on scientific data, a perceptive phase involving participatory mapping, and a design phase dedicated to future scenarios. This structure enables the combination of formal tools with collective narratives.

This three-phase structure reflects a hybrid

Poster presentation project Miracle during the Dissemination Workshop held in Bologna between the 27 and 29 of November 2024.
Fig. 4

and iterative methodology that combines spatial analysis, qualitative foresight techniques, and participatory design practices—in line with the intuitive logics tradition of scenario planning (Wilkinson & Edinow, 2008; Spaniol & Rowland, 2018).

Urban laboratories were facilitated through interactive workshops involving multiple stakeholders, including local administrations, experts, community representatives, and students. Each phase relied on dedicated tools: gis-based risk datasets and thematic maps in the diagnostic phase; paper or digital base maps for participatory annotations in the perceptive phase; and visual synthesis tools (collective drawings, strategic schemes, scenario narratives) in the co-design phase.

Data collection combined semi-structured mapping protocols and informal interviews. Participant inputs were then analyzed through inductive coding, enabling a triangulation of visual, verbal, and spatial datasets—a strategy that ensured consistency across cases while respecting local specificity (Bradfield et al., 2005).

Preliminary findings show that most regional threats have a hydrological component, reinforcing the idea that water is not just one risk among others, but rather a condition that underpins and connects multiple forms of exposure. At the core of this methodology lies a radical rethinking of water—no longer confined to the hydraulic infrastructure or emergency planning domain but understood as a conceptual and operational lens for spatial and metabolic regeneration. Water flows, accumulates, erodes, reveals, and connects; it draws lines of separation and invites crossings. This amphibious lens unlocks a new grammar of urban design, one that accounts for material and social permeability, thresholds of vulnerability, and the fluid boundaries between crisis and care.

The diagnostic phase begins with the triangulation of existing data from regional risk maps, hydrological indicators, and environmental reports. Each urban laboratory begins by constructing a shared framework that integrates these data with spatial analysis tools and local risk assessments. The outputs of this phase include composite maps that identify vulnerable areas based on multi-risk conditions (heat, flooding, subsidence, etc.), and are used to trigger reflection in the subsequent workshop sessions.

However, this is only the starting point: a second, equally crucial phase invites participants—citizens, professionals, educational institutions, decision-makers—to map their own perceptions of risk, translating lived experiences into collective spatial narratives. Far from being banal, perception reflects how communities interpret and interact with their environments—what they value, fear, protect, or contest. Participatory mapping exercises were conducted using paper-based or digital maps, where participants marked spaces of memory, fear, and opportunity, thus enabling the

**Top: multi-risk map showing areas exposed to heat and hydrogeological risks.
Bottom left: perception map developed with local stakeholders, highlighting lived experiences of vulnerability and spatial disconnection.
Bottom right: strategy map outlining proposals for green corridors, risk mitigation, and urban regeneration.**
Fig. 5

production of "perception maps" that complemented the scientific baseline. Mapping these perceptions allows us to visualize the social and cultural layers of water territories, uncovering insights that traditional scientific or technical approaches often overlook.

These mappings do not seek precision, but resonance. They reveal emotions, memories, disruptions, and informal practices that remain invisible in conventional readings. They activate what Kevin Lynch once called "the image of the city", built not from abstract geometry but from affective and symbolic structures.

The final phase of urban laboratories opens a space for co-design future imaginaries, where knowledge and perception are recombined into adaptive strategies. These future scenarios do not offer blueprints, but hypotheses—territorial narratives that explore how to live with overlapping risks through spatial, ecological, and institutional transformations.

Strategic maps were then produced collectively to translate shared priorities into design hypotheses: green corridors, floodable spaces, blue-green infrastructure, governance arrangements. These maps were drawn on large printed bases and digitized after the workshops to allow comparison across cases.

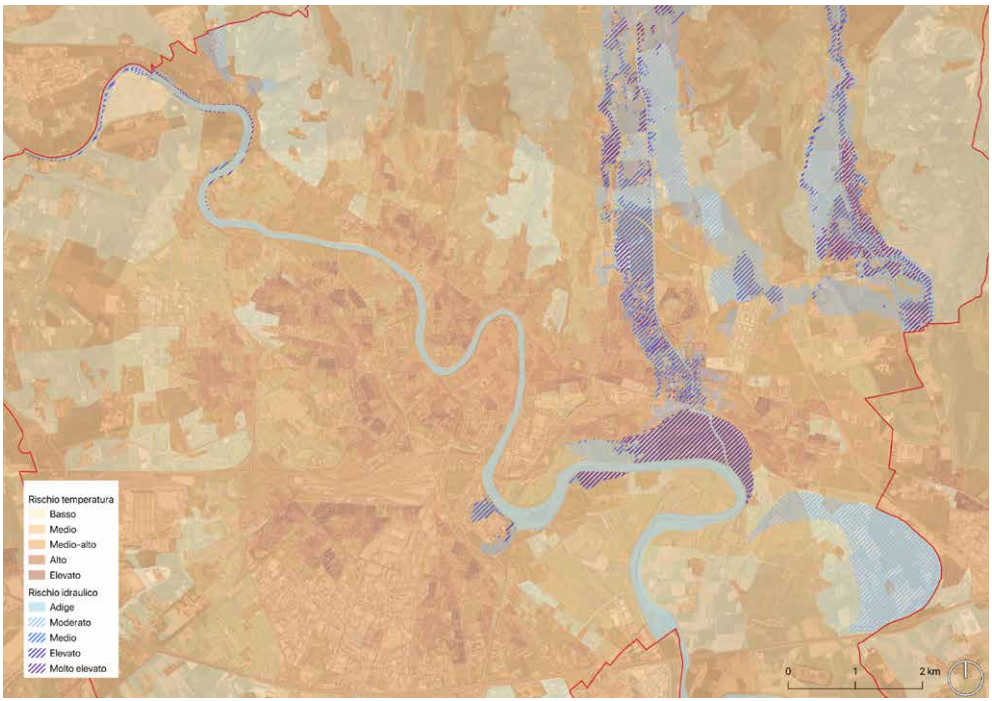
The analysis of outputs from the labs combined qualitative coding of participant feedback, visual analysis of mapped content, and comparison with scientific data. This triangulation method ensured that each case produced insights that were both locally rooted and comparably structured.

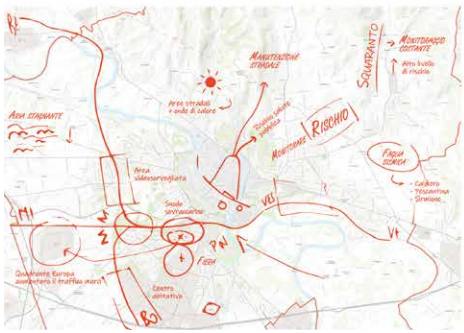
Water, in this framework, becomes not just the object of intervention but the opportunity through which to reconnect fragmented territories, overcome planning enclaves, and cultivate new spatial changes. The MIRACLE project thus positions itself at the crossroads of environmental urgency and planning innovation, advocating for a culture of anticipation grounded in community knowledge and hydrological awareness.

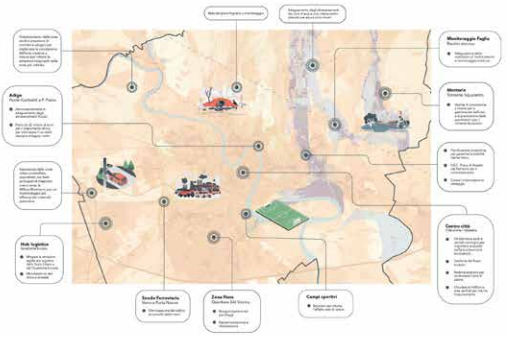
In the following section, four urban laboratories—Verona, Vicenza, Bagnoli, and Castellammare di Stabia—illustrate how this approach unfolds in diverse territorial contexts, each marked by distinct challenges and opportunities. Each urban laboratory offers a distinct lens through which to examine the entanglement of hydro-climatic risks, urban practices, and institutional arrangements. These cases reveal how planning can be reoriented toward more anticipatory, inclusive, and water-sensitive approaches.

3.1. Verona: mapping overlaps, designing with vulnerability

In Verona, the mapping of perceptual and strategic vulnerabilities offered a multi-layered reading of how water and heat-related risks intersect with broader territorial fragilities. The co-design process revealed the Adige River corridor, particularly the areas of Montorio and







the northeastern belt, as highly exposed to hydrogeological threats, including landslides and flooding, calling for organized evacuation plans and long-term mitigation strategies. Through workshops and stakeholder dialogues, a network of vulnerabilities emerged, touching not only environmental but also infrastructural and social dimensions of the city (Fig. 5).

Participants emphasized that Verona's urban fabric is increasingly pressured by urban heat islands, mobility congestion, and the strategic vulnerability of critical infrastructures, such as the southern highway and the congested freight nodes at Scalo Libero and Quadrante Europa. These hubs, while economically strategic, generate pollution, increase land consumption, and amplify existing exposure to climate-related risks. As a result, a cross-scalar analysis was undertaken to identify intervention areas ranging from specific neighbourhoods to broader ecological systems, stressing the need for green infrastructures and ecological corridors that can

Top: multi-risk map illustrating heat and water-related vulnerabilities, especially in peri-urban areas. Bottom left: perception map reflecting concerns over impermeability, infrastructure, and social exposure to climate risks. Bottom right: strategic map proposing integrated nature-based solutions and mobility enhancements for a more resilient cityscape.
Fig. 6

both mitigate environmental pressures and enhance territorial permeability.

From a spatial perspective, the western part of the city revealed chronic air stagnation and pollution accumulation, demanding targeted actions to restore urban ventilation and reduce emissions. At the same time, stakeholders identified the fragmented and insufficiently integrated green areas as a missed opportunity for resilience-building. Enhancing their connectivity would enable them to function as natural pollution buffers and biodiversity habitats, while also contributing to the city's hydraulic safety. Along the riverbanks, areas such as Caldero, Pescantina, and the Isolotto of San Pancrazio emerged as particularly fragile, underscoring the urgency of integrated planning approaches that address both fluvial risks and the city-river relationship.

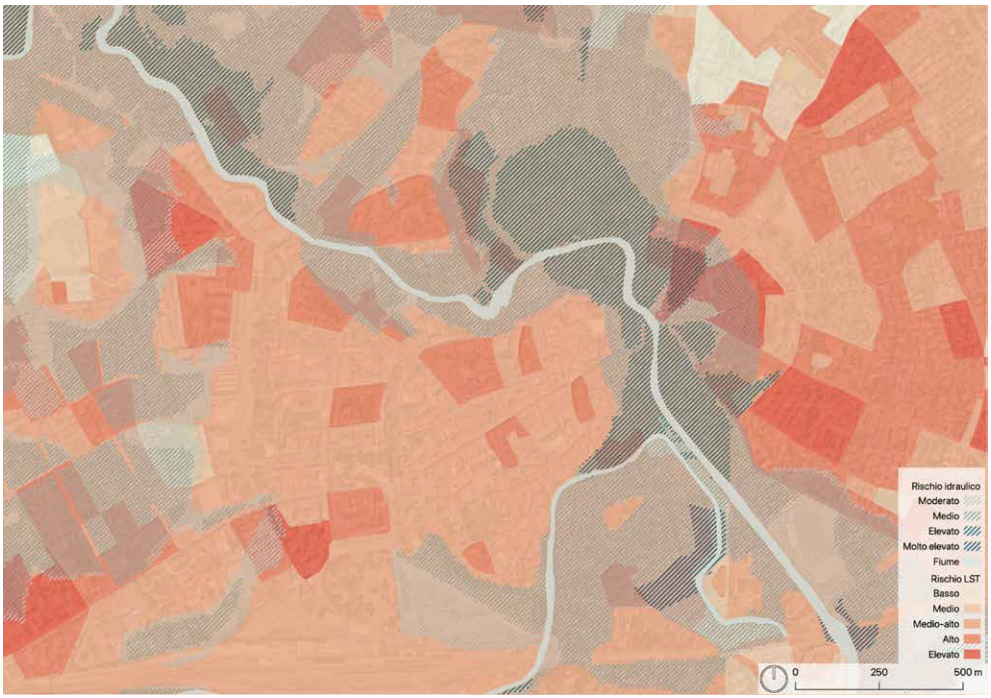
Strategic planning in Verona is beginning to reflect this shift in perspective. A 32 million euros of public investment in water remediation and management has been allocated to improve water retention capacity, optimize irrigation systems, and contain the impact of urban expansion on fragile soils. This shows a growing awareness of the need to reconfigure the water-land relationship, not only to prevent risk but also to reshape territorial strategies. In this sense, water emerges as a structuring element of the urban landscape—an active vector through which vulnerabilities are revealed, and adaptive planning can unfold.

At the same time, the city's rapid residential growth has raised concerns about soil stability, with landscape alterations such as terracing and hill cutting accelerating runoff and erosion. These issues require careful governance to maintain a balance between development and ecological integrity. Equally pressing are mobility and logistics challenges, which demand a systemic redesign of freight flows, stronger rail infrastructure, and more sustainable modes of transport, particularly in areas burdened by the transit of hazardous materials.

Overall, the Verona urban laboratory illustrates how participatory mapping and multi-risk analysis can illuminate the spatial translation of vulnerability, transforming diffuse concerns into territorial knowledge. The process not only mapped risks but also generated visions of transformation—anchored in water as a relational medium—that integrate risk mitigation, ecological restoration, and territorial innovation as core principles for a new planning culture.

3.2. Vicenza: toward an ecological and inclusive regeneration

In *Vicenza*, the urban laboratory highlighted the cumulative nature of environmental, infrastructural, and social vulnerabilities, revealing a complex urban landscape marked by territorial fragmentation and declining ecological performance. A key issue that emerged was the city's impermeability, intensified by the



predominance of car-centric infrastructures, huge industrial and military zones, large parking lots devoid of vegetation, and a network of disconnected public spaces. These conditions not only worsen urban heat island effects, especially in the industrial zones, but also reduce water infiltration, increasing the risk of surface flooding during heavy rainfall events.

Vicenza's natural basin morphology, which limits air circulation, exacerbates pollution accumulation and heat stress, particularly during summer months. Ongoing construction sites for the high-speed rail line (TAV) add another layer of environmental stress, which will contribute to noise, dust, and vibrations, while also posing soil and water contamination risks. The city thus faces a dual exposure to long-term systemic risks and short-term construction impacts, both of which were intensely debated during the laboratory sessions (Fig. 6).

A critical concern voiced by participants was the growing disconnection between urban

development and socio-environmental needs. The expansion of commercial hubs in the outskirts has drained vitality from the historic centre, while large areas of vacant buildings and underused spaces remain inaccessible due to regulatory barriers and institutional inertia. This dynamic contributes to an overall sense of urban dispersal, weakening the potential for collective spaces and social cohesion.

Social tensions are further deepened by gentrification processes that exclude vulnerable populations, alongside the progressive reduction in public transport services—a phenomenon that encourages private car use and undermines sustainable mobility. Although a cycling network is present, it is largely peripheral and used recreationally rather than for everyday commuting. Waterways, once central to the city's spatial logic, remain an untapped potential for sustainable mobility and ecological reconnection.

To counter these trends, the urban laboratory identified a set of integrated spatial and policy responses. First, urban greening emerged as a key priority: the introduction of green roofs, vertical vegetation, and tree-lined corridors was seen as essential to reconnect ecological functions, support biodiversity, and provide climate mitigation benefits. The use of permeable surfaces and innovative CO_2-absorbing materials was proposed as a technical response to surface runoff and heat accumulation. These environmental solutions were linked to a broader urban quality agenda, centred on the reappropriation of spaces for collective and inclusive uses also through temporary uses.

A second set of proposals focused on adaptive reuse and housing pressure. The reactivation of vacant buildings was strongly advocated, not only as an answer to housing demand, but also as a tool to counter speculative development and reduce the city's ecological footprint. This was supported by calls for renovation incentives tied to environmental performance, and fiscal policies to protect small businesses and prevent the displacement of lower-income residents. Avoiding the commodification of the city's real estate was recognized as a core condition for social resilience.

On the mobility front, participants proposed a reorganization of parking systems, prioritizing peripheral park-and-ride structures and disincentivizing car access to the central area. Plans included low-speed zones, pedestrian-first strategies, and the reintegration of waterways as soft mobility corridors, reconnecting fragmented parts of the city and offering climate-adaptive routes. The historic centre, in particular, was framed as a testing ground for mobility innovations capable of combining safety, accessibility, and environmental awareness.

Finally, the discussion pointed to the need for new modes of governance and citizen engagement. Participants emphasized the urgency of breaking institutional silos, promoting collaborative platforms between public author-

ities, civic actors, and private stakeholders. Digital tools, public forums, and participatory mapping were proposed as concrete devices to democratize planning processes and foster transparency. In this context, the protection of Vicenza's UNESCO heritage was reframed not as a constraint, but as a driver of innovative and inclusive environmental planning.

Through its participatory approach, the Vicenza laboratory revealed the layered nature of urban fragility and the need for systemic and place-based responses. The city's future depends on the ability to synchronize ecological regeneration, social equity, and infrastructural transformation, building a shared vision capable of steering Vicenza toward a more liveable and inclusive environment.

3.3. Bagnoli: the politics of risk and regeneration

In Bagnoli, the overlapping of environmental fragility, industrial legacy, and institutional stagnation reveals the full complexity of planning in amphibious territories. Here, bradyseism—a slow and intermittent uplift and subsidence of the ground—is indeed part of the public discourse, yet it is rarely considered in relation to the broader system of interconnected risks. Its implications for seismic safety, infrastructure resilience, and water management are significant, but often treated in isolation rather than as part of a cumulative and interdependent landscape of vulnerability. This natural condition intertwines with a long-standing legacy of contamination, inherited from the ILVA steelworks and other decommissioned industrial sites, which have left behind critical pollutants such as asbestos and heavy metals, requiring ongoing and complex remediation processes.

The participatory mapping and expert interviews revealed not only environmental but also institutional and communicative risks. As emphasized by Daniela Mello (Invitalia), the transformation of Bagnoli is not hindered solely by technical complexity, but by a persistent deficit in public communication and shared vision. Mello pointed to the polarization of public discourse, fuelled by media narratives and political conflict, which has undermined trust and generated a deep sense of distance between communities and institutions. While environmental monitoring systems—such as the installation of real-time air and water quality stations—have improved transparency, many residents still perceive the planning process as opaque or imposed from above. This creates a "democratic risk," in which technical decisions lose legitimacy and trigger opposition, even when well-grounded.

Urban ecologist Antonio Di Gennaro further emphasized the lack of coordination between planning tools, describing the coexistence of multiple, often contradictory plans as a key factor behind delays and dysfunctions. This has resulted in paradoxical situations—such as the dismantling of a previously built park

to comply with updated remediation protocols—reflecting the rigidity of normative approaches and the absence of integrated, adaptive frameworks. Di Gennaro argued for a science-based pragmatism, capable of balancing precautionary principles with timely action, thereby reducing delays and public costs while increasing confidence in the redevelopment process.

Within this landscape, design responses developed through the MIRACLE laboratory focused on three integrated trajectories (Fig. 7). First, ecological connectivity and remediation emerged as a priority. The creation of a new urban forest was envisioned as a keystone intervention to restore ecological continuity, improve air quality, and provide a multifunctional green infrastructure supporting biodiversity, climate adaptation, and human wellbeing. This forest acts as a "green lung" between the sea and the hills, symbolizing a break from industrial toxicity and a step toward regeneration.

Top: multi-risk map displaying areas exposed to heat, hydrogeological, volcanic, and seismic hazards, as well as land and water pollution.
Bottom left: perception map generated through stakeholder engagement, capturing local concerns, spatial imaginaries, and risk awareness.
Bottom right: strategic map outlining key design proposals for ecological remediation, public space regeneration, and infrastructural reconnection.
Fig. 7

Second, coastal and cultural redevelopment was seen as essential for reactivating the waterfront and reconnecting Bagnoli to the wider urban and social fabric of Naples. This involves opening up physical and symbolic access to the coast, currently hindered by barriers, contamination, and institutional ambiguity. The reuse of industrial archaeology as cultural infrastructure—galleries, open-air museums, performance venues—was proposed not only as a heritage valorisation strategy but also as a participatory process, engaging residents in shaping the meanings and uses of new public spaces.

Third, infrastructure and public health were addressed through the revitalization of mobility networks—including tramway and maritime transport—paired with real-time environmental monitoring of pollutants and asbestos residues. This integration of mobility, health, and transparency represents a concrete step toward restoring institutional credibility, reducing risk perception gaps, and enabling informed, inclusive decision-making.

In Bagnoli, planning is not only about building infrastructure or remediating soil—it is about reconstructing trust, navigating between memory and possibility, and reimagining public space as a site of ecological and democratic transformation. The case exemplifies how amphibious risk must be understood not just in physical terms, but as a social and institutional condition, requiring flexible, communicative, and visionary planning tools.

3.4. Castellammare di Stabia: reclaiming the waterscape

In *Castellammare di Stabia*, the MIRACLE urban laboratory unfolded within one of the most hydraulically and environmentally compromised territories in Italy. The Sarno River, long burdened by illegal discharges, industrial effluents, and infrastructural decay, emerged as both a symbol and a material expression of the city's fragility. Decades of uncoordinated urban growth, inadequate sewage systems, and pollution from tanning and industries have left deep marks on the territory, compounded by sediment accumulation, vegetation overgrowth, and persistent flooding risks. Despite past remediation attempts, the incomplete functionality of treatment plants and ongoing water losses underscore a persistent paradox: abundant water resources coexist with infrastructural neglect and environmental injustice. The Laboratory revealed how this layered landscape of risk is not limited to ecology, but intersects with longstanding social vulnerabilities, informal urbanization, and frag-

Top: composite map of multi-risk conditions (heat, hydrogeological, volcanic, and seismic hazards) highlighting the most vulnerable areas.
Bottom left: perception map co-created with local stakeholders, indicating perceived risks, criticalities, and spatial narratives.
Bottom right: strategic vision map identifying key design directions for reconnection, regeneration, and ecological transformation.
Fig. 8

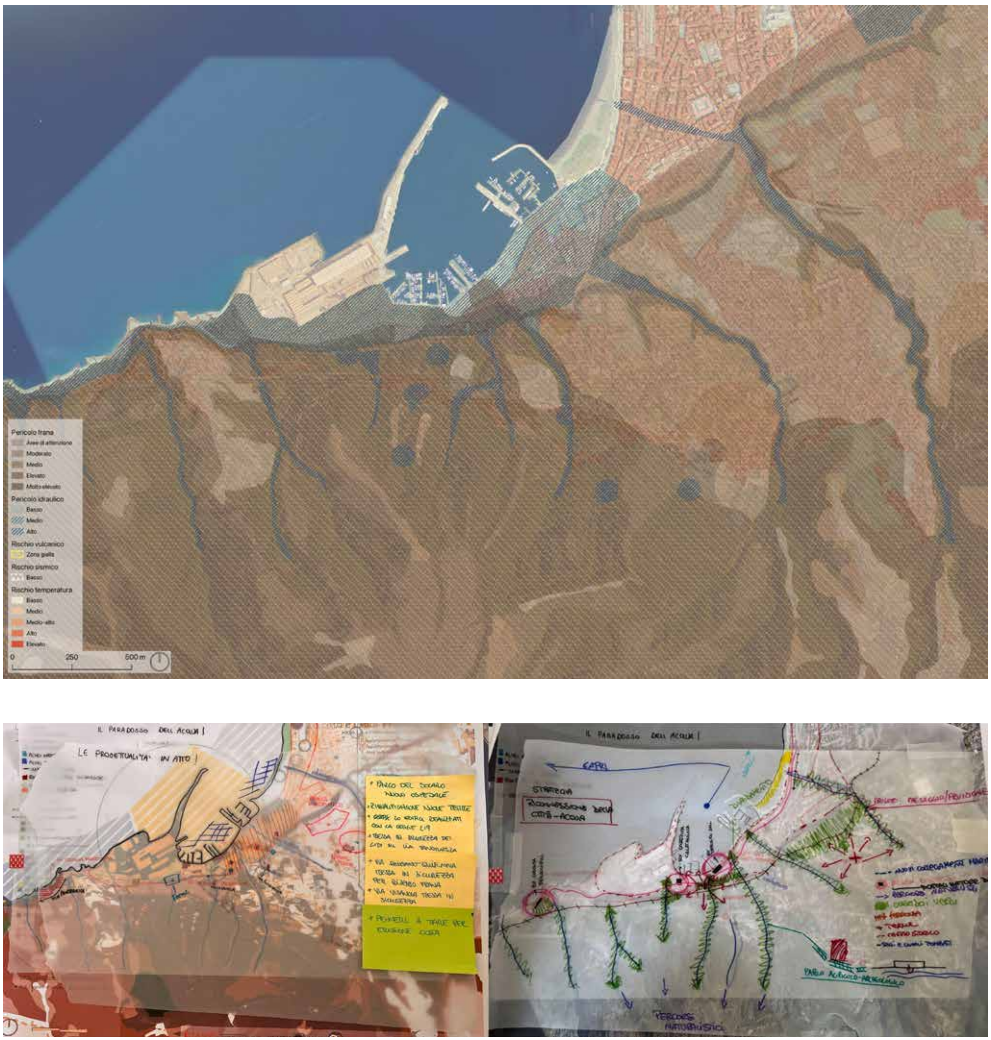
mented planning tools. The presence of natural springs, landslides, and unstable soils—combined with illegal construction and weak enforcement—has produced a condition of chronic precariousness. In some cases, buildings damaged by seismic events could not be rebuilt in situ, forcing relocations to peripheral zones with exceptions to soil protection laws. In this context, the Sarno basin emerges not only as a site of contamination and hazard, but as a potential infrastructure of reconnection—linking ecological restoration to a broader urban regeneration strategy.

Four design trajectories emerged from the participatory process, each grounded in the desire to reorient the city's relationship with water. The first centres on the northern zone of Castellammare, where the creation of a continuous green buffer—a so-called "mirror band"—would parallel existing infrastructure and serve as a connective tissue between the inner city and the coast. This linear space, framed by ecological "green branches" and water-sensitive "blue branches," proposes the transformation of disused industrial areas into new multifunctional districts with cultural, educational, and sports facilities, while also addressing hydraulic vulnerabilities in a phased and integrated manner.

The second trajectory addresses the urban border between Castellammare and Torre Annunziata—an area marked by isolation, infrastructural voids, and spatial fragmentation. Here, the proposal focuses on activating transversal links that reconnect peripheral neighbourhoods to the port and waterfront, softening the exclusivity of luxury marinas through inclusive public functions. A new riverside park at the Sarno's mouth is envisioned as a gathering place and flood mitigation device, reconfiguring the riverbank as both ecological asset and civic commons.

The third trajectory reframes the "paradox of water" as a narrative driver for urban transformation. While Castellammare is rich in water sources—thermal springs, coastal waters, buried canals—this abundance is often hidden or disconnected from everyday urban life. The design vision seeks to reclaim these latent ecologies, unearthing canals, repurposing abandoned buildings, and restoring the coastal threshold as an interface of memory, care, and sustainability. In this perspective, *landscape becomes an infrastructure of repair*, capable of absorbing risk, strengthening social bonds, and reactivating Castellammare's identity as a water city.

The fourth trajectory highlights a socio-cultural dimension, focusing on the reactivation of thermal baths not merely as physical infrastructure, but as spaces of collective memory, identity, and everyday engagement with wa-



ter. Thermal baths are often part of neglected or underused water infrastructures. Their rehabilitation offers an opportunity to reimagine existing assets not only for leisure but also for emergency response, water reuse, or even climate adaptation functions (e.g., passive heating, water storage). Term baths act also as soft-critical infrastructure, which supports the emotional, symbolic, and social fabric that communities rely on in times of uncertainty or stress.

Through these situated imaginaries, the MIRACLE project positions Castellammare di Stabia as a critical testbed for planning through water—where ecological challenges, infrastructural gaps, and collective aspirations converge. Far from offering prescriptive solutions, the process opened up new questions on how to inhabit and govern complexity, embracing water not as a hazard to be controlled but as a generative element in shaping liveable, connected, and resilient urban futures (Fig. 8).

Case Study	Main Risks Identified	Social & Urban Vulnerabilities	Main Participatory Methods Used	Strategic Design Directions	Key Outcomes / Spatial Vision	Role of Water in the Transformation
Verona	Flooding, heatwaves, air pollution, landslides	Critical infrastructure exposure, logistics congestion, urban sprawl, soil instability	Risk perception mapping, stakeholder workshops, cross-scalar dialogues	Green corridors, floodable areas, urban ventilation, ecological restoration	Water as territorial infrastructure for resilience and permeability	Medium to reconnect fragmented ecologies and manage multiple risks
Vicenza	Urban heat, surface flooding, pollution, soil and water contamination (TAV construction)	Car-dependence, urban sprawl, vacant buildings, social exclusion, institutional inertia	Participatory mapping, public forums, co-design charrettes	Urban greening, adaptive reuse, soft mobility, temporary uses	Inclusive and ecological regeneration of fragmented urban fabric	Tool for ecological and social reconnection, especially through waterways
Bagnoli	Bradyseism, contamination (asbestos, heavy metals), institutional and communicative risks	Distrust in institutions, fragmented governance, loss of public legitimacy	Expert interviews, participatory mapping, thematic workshops	Urban forest, cultural reuse, mobility infrastructure, environmental monitoring	Democratic and ecological transformation via integrated planning	Axis for remediation, trust-building, and reactivation of collective space
Castellammare di Stabia	Water pollution (Sarno River), flooding, unstable soils, illegal construction	Informal settlements, infrastructural neglect, socio-spatial fragmentation	Co-design sessions, visual mapping, spatial scenario development	Green-blue infrastructure, riverside park, thermal baths reactivation, unearthing canals	Reclaiming water as connective and symbolic infrastructure	Narrative and material infrastructure of memory, care, and regeneration

3.5. Comparative synthesis: convergences and differences across urban labs

The MIRACLE urban laboratories unfolded in diverse socio-ecological contexts, yet revealed striking commonalities in the way water-related risks intersect with spatial fragilities, infrastructural gaps, and socio-political dynamics. Despite local specificities, all cases pointed to the urgency of reframing water not as a threat to be controlled, but as a relational medium to reconfigure urban logics, mobilize collective agency, and generate situated design strategies.

The table below provides a comparative overview of the four case studies, highlighting the main risks, vulnerabilities, participatory tools, design directions, and spatial imaginaries that emerged throughout the process.

4. Conclusion: towards fluid geographies

This article has argued that planning in water territories requires a conceptual and operational shift—one that recognizes amphibious risk not merely as the sum of hydrological threats, but as a condition of territorial life marked by fluidity, interdependence, and instability. Drawing from environmental humanities, climate theory, and spatial planning literature, the notion of amphibious risk was proposed as both a diagnostic category—to read the complexity of water-related vulnerabilities—and a design-oriented paradigm, capable of gener-

ating new spatial and governance imaginaries. The MIRACLE project embodied this shift through a threefold methodology based on multi-risk mapping, co-design charrettes, and situated experimentation in four urban laboratories. Verona, Vicenza, Bagnoli, and Castellammare di Stabia offered highly diverse socio-ecological contexts, yet all revealed the limits of compartmentalized planning and risk governance. Across these territories, amphibious conditions—material, institutional, and symbolic—emerged not only as sources of fragility, but as opportunities to reframe planning logics, reconnecting ecological processes with spatial justice, public space, and collective agency.

In Verona, the convergence of riverine hazard, heat vulnerability, and logistic congestion called for integrated green corridors and the repositioning of water as territorial infrastructure. Vicenza emphasized the legacy of car-centric development and vacant buildings, suggesting a shift toward permeable, inclusive, and participatory urban regeneration. Bagnoli revealed the entanglement of environmental remediation and democratic legitimacy in a context shaped by bradyseism and industrial decline, pointing to the need for risk governance that is science-based yet socially anchored. Castellammare di Stabia exposed the paradox of water abundance and infrastructural neglect, where polluted riverbanks and buried canals became sites for ecological and civic reactivation. In each case, water was reframed not as a threat to be contained, but as a medium for transformation, linking space, memory, and care.

Beyond site-specific outcomes, MIRACLE proposes a broader culture of anticipation, one that contests the reactive, technocratic approaches often found in spatial planning. By embracing local knowledge, collective imagination, and hydrological awareness, the project fosters an epistemology of resilience rooted in transformation rather than recovery, in coexistence rather than control. Water is thus repositioned as a relational actor, capable of reorienting not only planning practices, but the very geographies of governance.

What emerges is the need for a new planning paradigm attuned to fluid geographies: territories where land and water no longer operate as binary opposites, but as interwoven domains co-constituted by metabolic, social, and political flows. Embracing amphibious risk does not mean resigning to precarity but learning to govern through it—designing for uncertainty, negotiating across disciplines and communities, and cultivating spatial futures grounded in ecological justice. MIRACLE's contribution lies precisely in showing that such a shift is not only necessary, but possible—when planning becomes an imaginative, situated, and collective act.

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