Innovative approaches to address territorial multi-risk: rethinking spatial planning processes in the era of transition

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In a context marked by environmental crises and interdependent vulnerabilities, this article introduces an innovative methodological approach to spatial planning based on the paradigm of multi-risk transition. The L methodology combines a vertical axis, ensuring strategic coherence across governance levels, with a horizontal axis focused on territorial multi-risk diagnosis. Unlike existing planning frameworks that

Introduction

The increasing complexity of territorial transformations—exacerbated by climate change, human pressure on ecosystems, and the intensification of socio-economic vulnerabilities—requires a radical revision of spatial planning approaches. In this context, the emergence of the ecological transition paradigm has marked a significant turning point, reshaping priorities, frameworks, and instruments of public action in the spatial domain. However, despite the proliferation of strategies, plans, and programs aimed at sustainability, a structural gap persists between the systemic vision

often treat multi-risk assessment and governance coherence as separate analytical domains, the L methodology integrates them into a single operational structure. This dual-axis framework enables planners to simultaneously interpret systemic vulnerabilities and align adaptive strategies across scales, thus addressing a critical gap in the current literature on spatial and climate planning. The article primarily explores the latter through an experimental application in the UNESCO MAB Biosphere Reserve of the Po Delta (Veneto Region). By integrating vulnerability and exposure data, the multi-risk assessment is conceived as both a cognitive and operational device to inform place-based visions and strategies. The proposed methodology serves as a transformative tool to rethink spatial planning as an adaptive governance process, capable of bridging scales, actors, and knowledge in complex territorial contexts.

promoted by higher-level strategic frameworks and the capacity of local planning tools to translate such objectives into territorially contextualized operational practices. At the same time, the concept of resilience, although widely adopted in the discourse on climate planning, has often been reduced to a set of technical responses lacking a truly transformative vision, and limited to the management of specific risks. In response to these criticalities, a new paradigm is emerging—that of multi-risk transition—which encourages the interpretation of territorial vulnerabilities not as isolated or sectoral phenomena, but as outcomes of interdependent and systemic processes. This perspective requires a fundamental rethinking of the role of planning, which should no longer be understood solely as a normative or regulatory tool, but as a cognitive and strategic device capable of anticipating challenges, integrating knowledge, and guiding transformations (Pasqui, 2005). This contribution situates itself within this theoretical and operational framework, by proposing a methodological approach to address the complexity of the multi-risk transition through a multiscalar perspective on spatial planning. The proposed methodology—referred to as the "L methodology"—is structured along two interrelated analytical and operational axes: a vertical axis aimed at fostering strategic coherence across governance levels and regulatory tools; and a horizontal axis focused on interpreting territorial specificities through multi-risk diagnosis and the definition of site-specific trajectories for action. While the methodology is conceived

as a coherent and integrated framework, this contribution intentionally focuses on one specific component: the development and use of multi-risk assessment as a diagnostic device within the horizontal axis. The vertical dimension—namely, the analysis of multi-level regulatory and strategic frameworks—was activated in the case study but will not be explored in detail here. Likewise, the full articulation of the visioning phase and the definition of objectives, strategies, and actions will be addressed in future applications. The chosen focus aims instead to highlight the transformative potential of the multi-risk approach, conceived not as a mere technical tool but as a cognitive and projective infrastructure capable of guiding planning choices in contexts of high complexity and uncertainty.

This research builds upon a consolidated body of international studies that have progressively reframed spatial planning as a key instrument for resilience-building (Fleischhauer, 2008; Pelling et al., 2024; Weichselgartner & Kelman, 2015). However, as noted by Panwar, Wilkinson and Pelling (2024), the translation of risk knowledge into planning practice remains limited, revealing persistent disconnections between scientific assessment and policy design. Within this debate, the approach proposed here aligns with recent attempts to address risk through integrated, multi-scalar and cross-sectoral frameworks (Ferreira et al., 2023), contributing to the ongoing redefinition of planning as a transformative governance process, and introducing an original framework that connects diagnosis and strategy in multi-risk planning.

Building on this theoretical background, the research emphasizes the necessity of developing integrated frameworks capable of reconnecting environmental sustainability, social cohesion, and systemic resilience. From this perspective, risk—especially in its multilevel and multidimensional configuration—is no longer conceived as an object to be managed, but rather as an interpretative lens through which to guide territorial visions and strategies. The proposed methodology was tested in the UNESCO MAB Biosphere Reserve of the Po Delta (Veneto Region), selected as an emblematic context for the application of the multi-risk approach. This choice is rooted in the hybrid nature of the area, which combines ecological fragility, socio-economic pressures, and a stratified governance structure, making it particularly suitable for experimenting with the L methodology. The UNESCO MAB area also represents a virtuous example of a supra-local governance framework which, through its management plan, integrates conservation and development objectives, offering a fertile ground for developing a comprehensive territorial diagnosis. As previously stated, this article places specific emphasis on the development of an integrated multi-risk model, which combines the assessment of

intrinsic territorial vulnerability with the exposure of socio-economic and environmental components. This approach not only enables the identification of areas under highest pressure but also supports the construction of a synoptic map of cumulative stressors, functional to the definition of place-based visions and strategies. The multi-risk framework is thus conceived as a strategic and enabling device, capable of supporting informed decisions aligned with systemic priorities and local specificities.

The structure of the article reflects the conceptual and operational articulation of the proposed framework. The methodological section outlines the foundations of the L methodology, with particular focus on its dual-axis logic (vertical and horizontal) and on the construction of the multi-risk assessment as a diagnostic tool. The results section presents the application of the model within the UNESCO MAB Po Delta Reserve, highlighting territorial dynamics emerging from the intersection between vulnerability and exposure, and identifying priority areas for intervention. The discussion explores the main elements of innovation and the potential of the methodology, comparing the proposed approach with the limitations of conventional planning practices. The conclusions reflect on the theoretical and practical contribution of the research, its potential for transferability, and future avenues for development. The article ultimately reaffirms the strategic role of spatial planning in shaping resilient development trajectories in an era of transition and uncertainty.

Ultimately, this research aims to contribute to the scientific and operational debate on the reconfiguration of spatial planning processes by proposing multi-risk as both a cognitive and operational lever to reorient spatial strategies toward more coherent, integrated, and transformative pathways.

Framing the research: from ecological transition to multi-risk transition

The ecological transition has become a central paradigm in contemporary environmental and territorial policy agendas. It reflects a growing awareness that responding to climate change, biodiversity loss, and systemic ecosystem degradation requires a profound reorganization of socio-territorial models (Carrosio, 2019; Magnaghi, 2014). Far from being a purely sectoral or technical matter, this transition entails a comprehensive restructuring of institutions, infrastructures, and spatial practices, in line with long-term principles of sustainability and resilience (Ronchi, 2021).

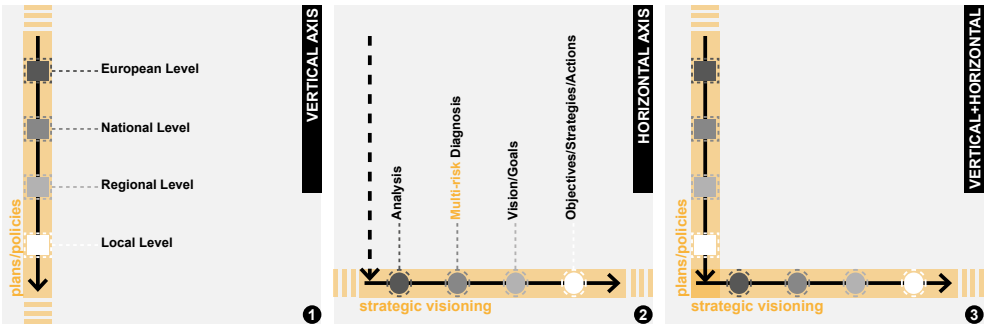
Strategic frameworks such as the *European Green Deal* (2019) play a fundamental role in this regard, promoting a systemic vision built on interconnected objectives: decarbonization, ecosystem protection, sustainable mobility, and the promotion of the circular economy. At the national level, this vision has been adopt-

Graphical representation and methodological construction of the "L" framework.
Source: authors' elaboration.
Fig. 1

ed through the *National Plan for Ecological Transition (PTE),* which outlines eight strategic pillars: climate neutrality, air quality improvement, reduction of land consumption and hydrogeological risk, sustainable water management, biodiversity restoration, protection of marine and coastal environments, sustainable agriculture and bioeconomy, and circular use of resources. These priorities aim to provide a coherent, cross-sectoral framework for guiding territorial transformation. However, policies and planning tools still operate along a silos approach, thereby limiting the transformative potential of the ecological transition. Planning instruments often struggle to address the complexity of territorial vulnerabilities, treating sustainability objectives as ancillary components rather than structural principles of spatial action (Orioli et al., 2023). The risk is that the transition may result in a fragmented set of sectoral interventions disconnected from broader governance and systemic adaptation processes (Giudice et al., 2022).

Similar limitations emerge in the implementation of resilience-oriented strategies. While the concept of resilience has gained a central role in territorial planning—especially in relation to climate risks—it has often been translated into narrowly defined operational measures: adaptation plans, defensive infrastructures, and single-risk interventions (Davoudi et al., 2012; Vale et al., 2014). These approaches tend to separate hazards from their social and territorial contexts, overlooking the interdependencies among systems and the cumulative nature of vulnerabilities (Friend, 2013; Pelling, 2010). International frameworks such as the Sendai Framework for Disaster Risk Reduction (2015–2030) have emphasized the need to move beyond hazard-specific approaches. Rather than treating risks as isolated events, planning should address how climatic, environmental, infrastructural, and socio-economic factors interact and reinforce each other (Ward et al., 2022; Zschau, 2017). Recent reflections on risk governance highlight the inadequacy of mono-risk readings, calling for approaches capable of addressing systemic threats and multidimensional fragilities (Gallina et al., 2020).

Several international frameworks have been developed to operationalize multi-risk assessment and to move beyond single-hazard perspectives. Gallina et al. (2020) proposed a methodology for the integrated assessment of climate-related hazards in coastal areas, based on multi-criteria analysis and GIS. While the model provides a replicable structure for identifying combined risks, it remains largely descriptive and detached from planning practice. Stalhandske et al. (2024) developed a global modelling framework using the CLIMADA platform, capable of analysing compounding and sequential hazards at different temporal and spatial scales. However, its highly quantitative nature and global scope limit its applicability for territorial governance



and local-scale planning. At a conceptual level, Graveline and Germain (2022) contributed to advancing the theoretical understanding of resilience by identifying its multiple dimensions and emphasizing the shift from reactive to transformative approaches, though without providing operational tools to translate this vision into spatial practice.

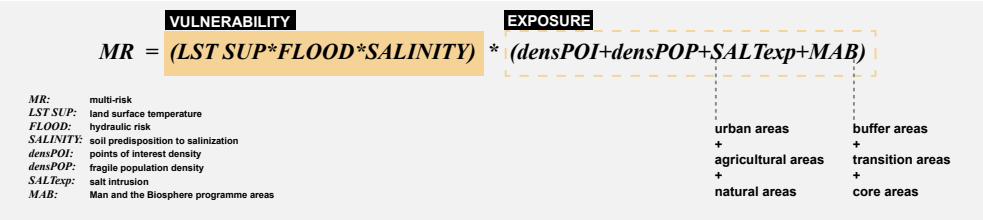
However, despite these advances, the L methodology aims to bridge analytical and territorial dimensions by integrating multi-risk diagnosis with spatial and governance coherence. Unlike purely quantitative or conceptual frameworks, it embeds vulnerability and exposure within a spatially grounded, multi-scalar structure that connects scientific evidence, territorial knowledge, and policy frameworks. This integration between horizontal and vertical axes operationalizes multi-risk assessment as both a diagnostic and strategic device for spatial planning.

Considering these criticalities, this article advances the concept of multi-risk transition as a conceptual and operational advancement over traditional resilience paradigms. In this perspective, risks are no longer conceived as separate technical phenomena to be managed, but rather as complex, interconnected processes that require cohesive, flexible, and context-sensitive responses. This approach encourages a rethinking of planning as an anticipatory tool capable of structuring coherent future trajectories by aligning local decision-making processes with supra-local strategies. The aim is no longer merely to mitigate the impact of isolated emergencies, but to read systemic dysfunctions, structural vulnerabilities, and the transformative potential of territories through the lens of risk—understood as a critical infrastructure of meaning for spatial design (Liao, 2012; Renn, 2017).

Methodology: designing the "L" framework for integrated and multi-risk-informed spatial planning

The methodology proposed in this contribution is conceived as an integrated framework for addressing the complexity of the multi-risk transition within territorial planning processes. It is structured along two interconnected analytical axes—a vertical and a horizontal one—whose intersection forms an "L", highlighting the link between top-down priorities and bottom-up dynamics (Fig. 1).

The vertical axis begins with an analysis of supranational and national regulatory and strategic frameworks, particularly the *European Green Deal* and Italy's *National Plan for Ecological Transition* (*PTE),* as well as key strategies for climate adaptation and resilience, such



as the *National Adaptation Plan to Climate Change (PNACC)* and the *National Strategy for Sustainable Development (SNSvS)*. This top-down trajectory enables the identification of institutional priorities, intervention domains, and critical issues that structure the transition across multiple administrative scales—from national to municipal levels.

Unlike the knowledge framework typically developed within the cognitive phase of a spatial plan, the vertical axis does not serve a descriptive function. Its role is strategic and comparative: by cross-reading supranational, national, regional, and local frameworks, it identifies consistencies, gaps, and overlaps among policy agendas. This process provides a synthetic reference grid that guides the subsequent territorial diagnosis developed along the horizontal axis. In this way, the vertical axis establishes the strategic coherence that orients the multi-risk assessment, ensuring that local analyses and actions remain aligned with broader transition priorities. While the horizontal axis focuses on the analytical reading of territorial vulnerabilities and potentials, the vertical one operates at a meta-level, translating institutional frameworks into strategic guidance for action. This distinction prevents any overlap with the cognitive phase of planning, ensuring complementarity between diagnostic and strategic dimensions.

The translation of general objectives into place-based priorities allows for the construction of an initial framework of alignment between environmental policies, planning tools, and programmatic agendas (Torresan et al., 2020). However, this axis does not merely identify formal objectives; it also reveals gaps, misalignments, and fragmentation across sectors and levels of governance, offering a first orientation for the design of localized strategies. Subsequently, the horizontal axis develops an in-depth reading of the territorial context through a multi-phase process: integrated analysis, territorial diagnosis, shared vision building, and the definition of objectives, strategies, and actions. Within this dimension, the methodology draws on the vision–goals–objectives–strategies–actions (VGOSA) model, which supports backcasting processes for defining desirable future scenarios and designing context-specific interventions (Bryson, 2011; Davoudi, 2017; Kahn, 1962; Simon, 1976).

A core component of the horizontal axis is the development of an advanced territorial diagnosis, based on a multi-risk approach that enables the integrated interpretation of both environmental and socio-economic dimensions of vulnerability. The methodology adopted for defining multi-risk is grounded in two complementary dimensions—intrinsic vulnerability and exposure—identified as crucial for supporting complex decision-making in territorial management (Stalhandske et al., 2024) (Fig. 2). The first addresses intrinsic vulnerability, assessing risks arising from climatic

Graphical representation of the methodology adopted for multi-risk assessment.
Source: authors' elaboration.
Fig. 2

and physico-environmental factors affecting the territory, while the second focuses on exposure, evaluated through the presence and spatial distribution of socio-economic and natural assets potentially subject to impacts. This contribution examines the following exposed elements: built assets, agricultural areas, natural resources, population density, and socio-economic activities.

According to the "*Rapporto Clima in Veneto*" (2024) by the Regional Environmental Protection Agency of Veneto (ARPAV), the mean air temperature in the Veneto region has increased by approximately +0.6 °C per decade since 1993, with higher warming rates in summer and autumn (+0.76 °C and +0.68 °C/decade). The Po Delta and coastal plains are explicitly identified among the areas most exposed to extreme heat, tropical nights, and surface warming phenomena due to low wind ventilation and high evapotranspiration rates. At the same time, hydraulic risk represents a long-standing and increasing concern: the ARPAV analysis confirms that the southern plains and deltaic zones are the least rainy (≈ 650 mm/year). These dynamics, together with projected increases in extreme winter precipitation (+15 – 35 %) and longer dry spells in summer (up to +20 days) under high-emission scenarios (RCP8.5), imply a marked rise in flood and waterlogging frequency. Finally, the salinization of soils emerges as a critical climate-induced process in the coastal and deltaic systems, tightly coupled with the previous two: the combination of increased temperature, reduced summer rainfall, and more frequent extreme hydrological events contributes to the inland progression of the salt wedge and soil salinity, which ARPAV lists among the prioritary adaptation challenges for low-lying coastal areas of the Veneto Region. Considering these regional trends, while other climatic descriptors described from ARPAV (e.g., wind regime, humidity, snow cover, and extreme convective activity) are present but only partially relevant for these territorial contexts, these three variables were prioritized as the most representative for evaluating multi-risk exposure in transitional coastal systems such as the Po Delta.

The heatwave-related risk was calculated through statistical analysis conducted on a collection of Landsat-8 satellite images, used as an indicator of land surface temperature, within the Google Earth Engine environment.

Hydraulic risk was derived from data provided by the *Flood Risk Management Plan* (PGRA), reclassified on a progressive scale highlighting increased hazard levels in proximity to the secondary hydrographic network of the plain. Finally, soil predisposition to salinization was obtained through a progressive classification of data provided by ARPAV.

The second part of the equation refers to the exposure of territorial and socio-economic elements and was defined using four main

indicators: the density of points of interest (densPOI), the density of vulnerable population (densPOP), urban and agricultural areas potentially affected by salt wedge intrusion (SALTexp), and the reserve areas recognized under the UNESCO Man and Biosphere (MAB) Programme (2020). The density of points of interest was obtained from OpenStreetMap data and reflects the concentration of commercial, touristic, cultural, and recreational activities, serving as an indicator of socio-economic exposure. OSM POIs were aggregated by ISTAT 2021 census spatial geometry and normalized by area (POI·km^{-2}) for each single unit. We adopted three fixed thresholds – 0–5 POI·km^{-2} (low), 5–10 POI·km^{-2} (medium), ≥10 POI·km^{-2} (high) – defined through a multi-stage process: (i) exploratory analysis of the indicator distribution identifying two local discontinuities around ~5 and ~10 POI·km^{-2}; (ii) domain calibration with respect to the local functional hierarchy (episodic absence of services in widespread reclamation areas, fractional nuclei with basic facilities, municipal centers with a broader portfolio of functions); (iii) criterion of interpretability and comparability over time/space, preferring stable thresholds to purely data-driven methods (quantiles/Jenks) that vary with the sample. Population density, derived from ISTAT data, is a key parameter for identifying the presence of potentially vulnerable populations (under 15 and over 65 years of age) in the event of extreme climate events. Urban and agricultural areas located below sea level were identified as particularly exposed to salt wedge intrusion, as they are susceptible to salinization, with consequences for agricultural productivity and the economic value of cultivated land. Finally, UNESCO MAB areas represent contexts of high ecological and cultural value, where environmental risks may generate direct impacts on biodiversity, conservation practices, and overall touristic appeal. These areas are structured into three functional zones: "core zone", "buffer zone", and "transition zone". The Core Zones represent strictly protected areas of high importance for biodiversity, subject to stringent restrictions to prevent significant disturbance.

The Buffer Zones serve as protective buffers and allow activities compatible with conservation, such as scientific research, sustainable tourism, and low-impact agriculture. The Transition Zones extend outward and are dedicated to the experimentation of sustainable development strategies, involving local communities, public authorities, and private stakeholders (UNESCO, 2022).

This diagnosis relies on methods and indicators capable of representing the co-occurrence of natural, climatic, and anthropogenic risks, as well as the cumulative pressures affecting communities, infrastructures, and ecosystems. In this way, multi-risk is not conceived as a mere sum of stress factors, but as an interpretative

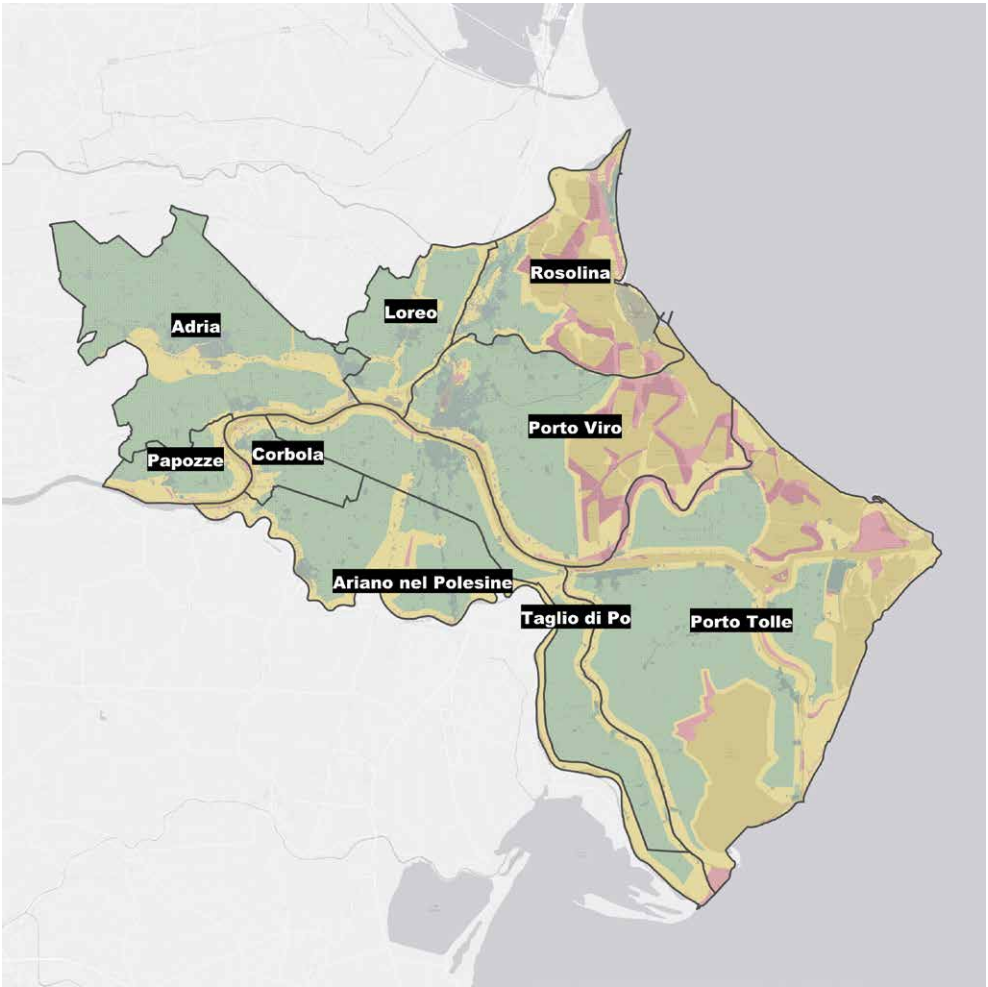
Definition	Risk Equation component	Source	Range Value	Details
Land Surface Temperature over mean value threshold	Vulnerability	Landsat 8	0,25-1	% of anomaly over average LST in summer 2024
Flood Vulnerability Index	Vulnerability	PGRA	0,25-1	Flood vulnerability classes from RSP by PGRA ADBPo
Surface Salinity Class: soil predisposition to salinization	Vulnerability	ARPAV	0,25-1	Salinity class of the surface soil horizon (0–30/50 cm)
Point of Interest Density	Exposure	OpenStreetMap	1-3	OSM amenities + Rural Heritage per square km
Vulnerable Population Density	Exposure	ISTAT	1-3	ISTAT 2021, <15 + >65 years old per square km
Saline Exposed Surfaces Atlas	Exposure	Veneto Region Land Use & Land Cover	1-3	Natural, Urban and Agricultural Land
MAB	Exposure	UNESCO MAB	1-3	Transition, Buffer, Core

Elements used for the calculation of the multi-risk equation and corresponding classification adopted by the authors.
Source: authors' elaboration.
Tab. 1

framework capable of guiding the selection of objectives and the definition of strategies.
The interaction between the two axes—rather than their simple overlap—represents the operational core of the methodology. While the vertical axis identifies the coherence and relevance of systemic needs and the strategic directions emerging from institutional frameworks, the horizontal axis allows these to be translated in relation to local characteristics, vulnerabilities, and resources. Their intersection generates a framework capable of linking strategic priorities with local dynamics and enabling integrated planning processes.

Results: applying the "L" methodology in the Po Delta MAB Area – a multilevel and multi-risk-based reading

The proposed methodology was applied to the UNESCO MAB Po Delta Reserve, selected as a pilot case to verify its operational validity



at a meso-local scale – an intermediate level between municipal planning and regional coordination (Fig. 3). The application focused primarily on the diagnostic phase (horizontal axis) and on the construction of the multi-risk map, while the visioning and strategic components will be developed in subsequent stages. Although this area geographically coincides with the boundaries of the Po Delta Regional Park, it was not interpreted strictly as a protected area, but rather as a biosphere reserve, in line with the UNESCO MAB designation and its associated strategic framework. This choice was not merely cartographic but methodological: the UNESCO MAB Programme provides a governance model capable of combining environmental protection with the promotion of sustainable socio-economic development—a duality that aligns fully with the multi-risk perspective adopted by the methodology. The reference to the UNESCO MAB framework enabled the identification of a supra-local governance structure in which environmental, social, and economic dimensions are institutionally integrated.

Unlike the *Management Plan of the Po Delta*

Administrative subdivision of the Veneto Po Delta overlaid with the zoning of the UNESCO MAB area. Transition areas (green) allow for sustainable human activities; buffer zones (yellow) serve as protective belts for the core zones; core areas (red) are designated for the long-term conservation of biodiversity and ecosystems.
Source: authors' elaboration.
Fig. 3

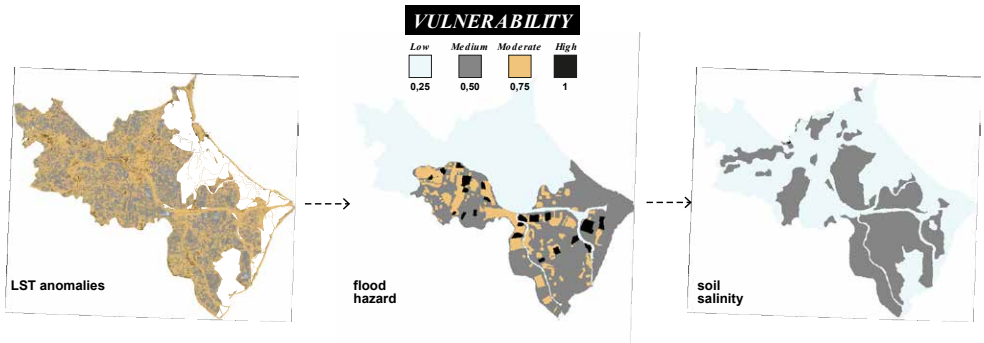
Regional Park, which is primarily focused on conservation and renaturalization, the UNESCO MAB strategic framework offers a broader interpretative lens for territorial transformation processes. This allowed for the selection of a study area that is not only ecologically significant but also characterized by internal inequalities, exposure to multiple risks, and substantial anthropogenic pressures—all elements that define its relevance for multi-risk planning.

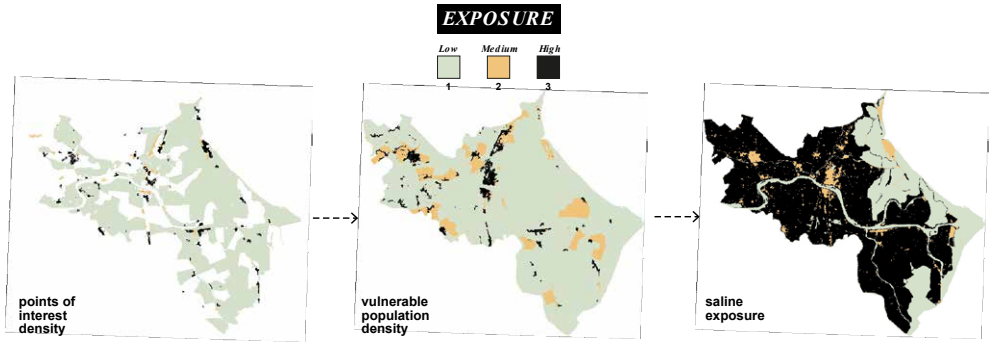
Within this territorial perimeter, the vertical component of the methodology was activated through a multilevel analysis of political and planning frameworks. At the European level, the analysis considered the *European Green Deal* and the *European Strategy for Climate Change Adaptation (SEACC).* At the national level, the analysis examined the *National Plan for Ecological Transition (PTE),* the *National Strategy for Climate Change Adaptation (SNACC)*, and the *National Adaptation Plan to Climate Change (PNACC),* from which cross-cutting priorities emerged concerning decarbonization, biodiversity, circular economy, and hydrogeological risk prevention.

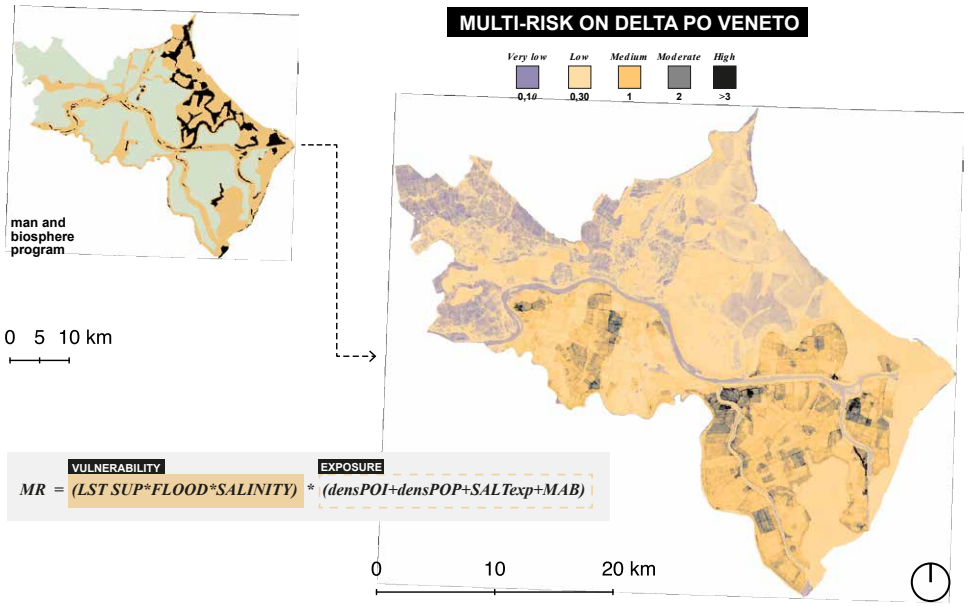
At the regional scale, the analysis included the *Veneto Regional Spatial Coordination Plan (PTCR)* and the *Regional Strategy for Climate Change Adaptation (SRACC).* These instruments revealed the persistence of sectoral approaches and the need for integrated tools capable of mediating between environmental urgencies and socio-economic development objectives. Finally, at the local level, the analysis focused on urban planning instruments (*Piani di Assetto del Territorio* and *Piani degli Interventi*) of the nine municipalities within the UNESCO MAB area: Adria, Ariano nel Polesine, Corbola, Loreo, Papozze, Porto Tolle, Porto Viro, Rosolina, and Taglio di Po.

The analysis revealed a limited capacity of individual municipalities to address interdependent risks, due to both institutional fragmentation and a disconnect between intervention scales and actual territorial dynamics. This finding reinforced the need to refer to the UNESCO MAB strategic plan as a supra-local framework capable of operationalizing the vertical component of the methodology.

The analysis thus enabled the reconstruction of a coherent trajectory of strategic priorities, tracing their evolution across different governance levels and identifying inconsistencies, redundancies, and gaps within the planning system. This output served as the foundation for activating the horizontal component, dedicated to the spatial and systemic articulation of risks and to the construction of a shared vision calibrated to the specificities of the UNESCO MAB reserve territory. The activation of the horizontal component of the methodology took place through an analytical-diagnostic reading of the territory, aimed at building a robust knowledge base from which to derive, in line with the strategic approach of the L meth-







$$MR = \underbrace{(LST\ SUP * FLOOD * SALINITY)}_{\text{VULNERABILITY}} * \underbrace{(densPOI + densPOP + SALTexp + MAB)}_{\text{EXPOSURE}}$$

Multi-risk assessment for the Veneto Po Delta, combining spatial indicators of vulnerability and exposure to climate-related hazards. Vulnerability is assessed through the integration of land surface temperature (LST) anomalies, flood hazard zones, and soil salinity patterns. Exposure is determined by mapping the density of points of interest, the distribution of vulnerable populations, areas affected by saline intrusion, and the extent of the UNESCO MAB Programme. The resulting multi-risk map highlights areas where these factors converge, offering a composite view of zones most at risk from the combined impacts of climate stressors and human presence.

Source: authors' elaboration.
Fig. 4

odology, the future transformative vision and actions. This reading was formalized in an operational model of territorial diagnosis based on the concept of multi-risk, understood not as a sum of isolated hazard factors, but as a multilevel and multidimensional integration of intrinsic territorial vulnerabilities and the socio-economic and environmental exposure to stressors. The weighted combination of these two sections resulted in a synoptic map of territorial multi-risk, useful not only for identifying areas of highest risk concentration, but also for understanding the overlaps and potential interactions among environmental, infrastructural, and settlement components. In this sense, the model functions as an essential diagnostic layer, capable of guiding the subsequent definition of a strategic vision and local actions in line with the priorities that emerged from the vertical framework.

Specifically, the integration between the vulnerability framework and the exposure framework generates a new informational layer. In the area of the UNESCO MAB Po Delta Reserve, the application of a weighted calculation strengthens the policy design framework within the L-methodology process, producing an output that identifies portions of territory organized according to a hierarchy of risk priorities.

As shown in *Fig. 4*, the municipalities of Ca' Tiepolo, Donzella, Polesine Camerini, and Scardovari are among the most exposed. This is due to their agricultural vocation, the significant presence of vulnerable residents (under 15 and over 65 years old), the concentration of socio-economic activities, and specific morphological conditions which, according to the current *Flood Risk Management Plan (PGRA),* make parts of these areas particularly prone to flooding from the secondary hydrographic network of the plain. The territory of the Municipality of Corbola and the agricultural mosaic stretching between Taglio di Po and Ariano nel Polesine also shows simultaneous exposure to multiple forms of vulnerability. On one hand, the area is subject to hydraulic risks, linked to the presence of a complex hydrographic network and reduced soil drainage capacity. On the other hand, it exhibits an increasing predisposition to surface salinization, a phenomenon aggravated by marine intrusion and changes in tidal and groundwater regimes. This stretch of land, characterized by multidimensional fragility, is located near the Buffer Zones of the UNESCO MAB Biosphere Reserve, posing additional challenges for the integrated management and protection of the area's

agricultural and environmental ecosystems. The island of Boccasette represents another strategic area, situated in a highly sensitive environmental context and surrounded by zones belonging to the UNESCO MAB Biosphere Reserve. Although its surface area is smaller than that of other zones mentioned above, Boccasette presents a combination of critical conditions that make it particularly vulnerable. It hosts small settlement clusters exposed to both hydraulic and climatic risks, as well as agricultural surfaces increasingly subject to thermal stress and saline intrusion. The coexistence of these conditions exposes the area to diffuse multi-risk, requiring targeted monitoring and adaptation interventions, particularly considering the area's ecological and landscape value.

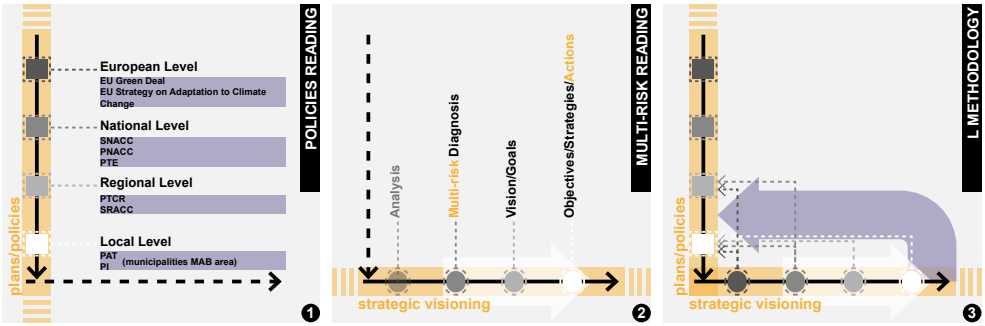
The introduction of the multi-risk dimension within the methodology thus strengthens the coherence between analysis and design, bridging the traditional gap between technical knowledge and strategic decision-making. The diagnostic output does not merely provide a snapshot of risk conditions but rather initiates a transformative process in which the definition of territorial visions, objectives, and strategies can rely on an integrated, multidisciplinary, and territorially targeted knowledge base.

Beyond the specificities of the Po Delta, the results demonstrate the replicable potential of the "L" framework as a diagnostic and decision-support tool for other areas exposed to multi-risk dynamics. However, its current application remains partially limited by the limited availability of localized socioeconomic data and the uneven institutional capacity of municipalities. Future developments could therefore aim to strengthen the integration of social vulnerability indicators and improve the model's operational scalability within regional and national planning systems.

Discussion: rethinking spatial planning through multi-risk – insights, limits and strategic potential of the "L" approach

The application of the L methodology to the UNESCO Po Delta Biosphere Reserve highlights its potential to strengthen spatial planning in contexts marked by interdependent risks and fragmented governance. The framework translates risk analysis into an operational system, enabling the convergence of data, indicators, and governance priorities into coherent spatial decisions. Rather than producing descriptive maps, it operationalizes the transition from diagnosis to the formulation of targeted actions and investment priorities.

In the Po Delta case, the model combined diverse datasets to generate a composite multi-risk map identifying critical sub-areas. This output supported the prioritization of interventions, such as retrofitting drainage infrastructure, mitigating salinity intrusion, and



Graphic representation and application of the L methodology.
Source: authors' elaboration.
Fig. 5

enhancing ecological corridors, thus connecting analytical evidence with planning practice.

A key strength of the methodology lies in its flexible yet structured design. Its analytical backbone remains fixed, while thematic components are adaptable to local contexts: in this study, three primary risks—land surface temperature, flooding, and soil salinization—were analyzed as most relevant, though additional factors such as ecosystem health or drought severity could easily be integrated without compromising conceptual consistency. This modularity makes it applicable across diverse territorial systems, from coastal and deltaic landscapes to inland or mountainous regions, according to specific local stressors.

Although tested within a UNESCO MAB designated area, the methodology's logic extends beyond biosphere reserves. It can be applied to territories governed by other protection regimes, such as national parks, nature reserves, or Natura 2000 sites, by integrating their zoning schemes into the exposure component to represent ecological and cultural values. In areas without formal protection, the model can identify zones that warrant enhanced conservation measures, transforming risk mapping into a design instrument for developing or revising protection frameworks. This projective capacity underscores its strategic rather than procedural nature, positioning it as an enabling tool for adaptive territorial governance (Fig. 5).

For the discipline of spatial planning, this dual analytical and projective capacity is particularly relevant. The methodology bridges data-driven assessment and territorial visioning, reframing planning as an anticipatory practice capable of addressing cumulative vulnerability and uncertainty.

The empirical results confirm that a supra-local governance structure, such as the UNESCO MAB Management Plan, serves as an enabling condition for the methodology's implementation. Nonetheless, the analysis of municipal plans revealed persistent barriers, including fragmented institutions, weak coordination, and limited analytical capacity. The L methodology can therefore function not only as a decision-support system but also as a capacity-building mechanism, strengthening local competences and promoting dialogue across

governance levels.

Despite its potential, the methodology faces practical and epistemic challenges. Its effectiveness depends on data reliability and cross-institutional coordination, both of which are frequently weak or uneven. Moreover, the weighting and normalization of indicators involve interpretative choices that can affect results. Future implementations should therefore adopt sensitivity analyses and participatory validation to improve transparency, robustness, and stakeholder trust.

Even acknowledging these limitations, the L methodology demonstrates strong potential for advancing the integration of multi-risk perspectives into spatial planning. Its clear procedural logic, adaptability, and spatially explicit outputs provide a solid foundation for informed, place-based strategies. Future research should test its transferability across contrasting territorial settings, urban, rural, and peri-urban, and refine indicators linked to ecosystem performance, social vulnerability, and resource management.

Ultimately, the L methodology offers a structured yet flexible pathway for planning under complexity and uncertainty. By operationalizing the concept of multi-risk transition, it shifts planning from reactive adaptation to proactive design, using risk as a catalyst for transformation and as a basis for more coherent, resilient, and adaptive forms of spatial governance.

Conclusions

This contribution presented the development and testing of an integrated methodological framework designed to address territorial complexity in the current phase of transition.

The proposed methodology—articulated along two analytical and conceptual axes, vertical and horizontal—aimed to connect institutional, programmatic, and strategic levels with local dynamics and emerging vulnerabilities, through a systemic reading of risks and ongoing transformations. Within this framework, the concept of multi-risk transition was adopted as both an interpretative and operational key to renew the epistemological and technical foundations of spatial planning.

The most innovative element of the work lies in the adoption of risk not as a sectoral variable to be mitigated, but as a cognitive and design infrastructure forming the basis of a new methodological approach for guiding spatial transformation. Constructing multi-risk as an interpretative matrix made it possible to overcome the hazard-specific and sectoral approach that still characterizes many planning tools, providing instead a composite and integrated reading of the environmental, social, and economic challenges affecting territories. This shift is significant not only from an analytical standpoint, but also for its capacity to offer a solid and coherent basis for medium- to long-term strategic planning. In the case study

of the Po Delta Reserve , the methodology demonstrated how it is possible to reconstruct interscalar coherence and align supra-local agendas with local specificities, even in the presence of strong misalignments across levels of governance and planning. Although tested within this framework, the methodology is conceived as adaptable to different territorial contexts – urban, inland, and mountain areas – where the interplay between environmental pressures and governance fragmentation generates similar multi-risk conditions.

The multilevel analysis confirmed the persistence of fragmentation, redundancy, and gaps that, in practice, hinder the implementation of genuinely integrated transformative strategies. In this sense, the UNESCO MAB context proved to be a useful reference to define an operational perimeter for testing the methodology, offering a regulatory and programmatic framework that integrates both environmental protection and sustainable socio-economic development goals. This approach demonstrated how spatial planning can benefit from supra-local frameworks oriented towards the integration and coherence of different dimensions of transformation. The diagnostic component of the methodology–based on the multi-risk grid–represented a key step, not only as a knowledge base but also as an enabling factor for new decision-making processes. The articulation between intrinsic vulnerability and socio-economic exposure allowed for the identification of the most fragile areas and for reading the overlaps between different stress factors, thus contributing to the construction of an articulated and dynamic representation of the territory. This representation is a fundamental prerequisite for guiding the definition of localized strategic visions, capable of accounting for the specific features of the context and its evolutionary trajectories.

At the same time, it is important to recognize the limits of the proposed approach. The application of the methodology was limited to the diagnostic phase and did not extend to the full definition of visions, objectives, and actions. This limitation does not concern the method itself but reflects the scope of the present work, which aimed primarily to explore the articulation and transformative potential of the multi-risk concept within planning processes. Moreover, the integration between the vertical and horizontal axes – while conceptually defined – still requires further operational development to be effectively implemented within existing institutional and regulatory frameworks. Future experimentation should therefore focus on translating this integration into practice, involving stakeholders, local planning instruments, and decision-making arenas more directly. Despite these limitations, the work has laid a solid foundation for rethinking spatial planning processes in a historical phase marked by profound transformations, widespread uncertainty, and interconnected risks.

Spatial planning is therefore called not only to incorporate new knowledge and data but also to redefine its intervention paradigms, opening to flexible and adaptive tools capable of operating under conditions of systemic complexity. Within this context, the L methodology emerges as a tool capable of reconciling vision and operability, top-down and bottom-up approaches, strategies, plans, and actions. Its articulation allows for the reconstruction of strategic and project coherence across different levels of governance, offering a useful framework for the critical revision of existing tools and the introduction of innovative elements in territorial planning.

Ultimately, this contribution aims to foster debate on how planning can transform to respond to contemporary challenges. The multi-risk transition, understood here as both a reading and action paradigm, allows for the integration of elements often addressed separately, such as environmental sustainability, social cohesion, climate change adaptation, and quality of life in territories. This approach does not intend to propose definitive solutions but to open a working perspective that—through the joint analysis of vulnerability and policy—enables the construction of pathways toward resilient and conscious development. Strengthening the connection between technical knowledge and institutional design remains one of the central challenges for spatial planning. In this direction, the proposed methodology offers a flexible and replicable framework for developing place-based multi-risk strategies, adaptable to diverse territorial contexts. By integrating analytical and governance dimensions, it contributes to the international debate on how planning can evolve as a transformative discipline capable of addressing the complexity of contemporary

References

risks and transitions.

Alves, P. B. R., Djordjević, S., & Javadi, A. A. (2021). An integrated socio-environmental framework for mapping hazard-specific vulnerability and exposure in urban areas. Urban Water Journal, 18(7), 530-543.

ARPAV. (2024). Rapporto 1 – Clima in Veneto: Strategia Regionale di Adattamento ai Cambiamenti Climatici. Dipartimento Regionale per la Sicurezza del Territorio, UO Meteorologia e Climatologia – UO Clima. https://sharing.regione.veneto.it/index.php/s/eQb9XakSnCzZqLd

Autorità di Bacino Distrettuale delle Alpi Orientali. (2021). Piano di Gestione del Rischio Alluvioni (PGRA) – II ciclo 2021–2027. Venezia.

Bryson, J. M. (2011). Strategic planning for public and nonprofit organizations: A guide to strengthening and sustaining organizational achievement. John Wiley & Sons.

Carrosio, G. (2019). I margini al centro: L'Italia delle aree interne tra fragilità e innovazione. Donzelli editore.

Commissione Europea. (2019). European Green Deal. Bruxelles. https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX:52019DC0640

Commissione Europea. (2021). Strategia Europea di Adattamento al Cambiamento Climatico (SEACC). Bruxelles. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

Comune di Adria, Comune di Ariano nel Polesine, Comune di Corbola, Comune di Loreo, Comune di Papozze, Comune di Porto Tolle, Comune di Porto Viro, Comune di Rosolina, Comune di Taglio di Po. (2010–2022). Piani di Assetto del Territorio (PAT) e Piani degli Interventi (PI).

Davoudi, S. (2017). Spatial planning: the promised land or rolled-out neoliberalism?. In The Routledge handbook of planning theory (pp. 15-27). Routledge.

Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., ... & Davoudi, S. (2012). Resilience: a bridging concept or a dead end?"Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a pasture management system in Northern Afghanistan urban resilience: what does it mean in planning practice? Resilience as a useful concept for climate change adaptation? The politics of resilience for planning: a cautionary note: edited by Simin Davoudi and Libby Porter. Planning theory & practice, 13(2), 299-333.

Ferreira, T. M., Moura, S., & Silva, J. A. R. M. (Eds.). (2023). Multi-risk interactions towards resilient and sustainable cities. Springer. https://doi.org/10.1007/978-981-99-0745-8

Fleischhauer, M. (2008). The role of spatial planning in strengthening urban resilience. In Resilience of Cities to Terrorist and other Threats: Learning from 9/11 and further Research Issues (pp. 273-298). Dordrecht: Springer Netherlands.

Friend, R., & Moench, M. (2013). What is the purpose of urban climate resilience? Implications for addressing poverty and vulnerability. Urban Climate, 6, 98-113.

Gallina, V., Torresan, S., Zabeo, A., Critto, A., Glade, T., & Marcomini, A. (2020). A multi-risk methodology for the assessment of climate change impacts in coastal zones. Sustainability, 12(9), 3697. https://doi.org/10.3390/su12093697

Giudice, B., & Voghera, A. (2022). Ripartire dall'urbanistica per la transizione ecologica. In Sofferenze urbane. L'abitare in tempi di crisi (pp. 278–282). Pisa: Edizioni ETS.

Graveline, M. H., & Germain, D. (2022). Disaster risk resilience: conceptual evolution, key issues, and opportunities. *International Journal of Disaster Risk Science*, *13*(3), 330-341.

Kahn, H. (1962). Thinking about the unthinkable. New York: Horizon Press.

Liao, K.H. (2012). A theory on urban resilience to floods—a basis for alternative planning practices. Ecology and society, 17(4).

Magnaghi, A. (2014). La regola e il progetto: un approccio bioregionalista alla pianificazione territoriale (p. 304). Firenze University Press.

Ministero dell'Ambiente e della Tutela del Territorio e del Mare. (2015). Strategia Nazionale di Adattamento ai Cambiamenti climatici (SNACC). https://www.mase.gov.it/portale/documents/d/guest/documento_snac-pdf

Ministero dell'Ambiente e della Sicurezza Energetica. (2022). Strategia Nazionale per lo Sviluppo Sostenibile (SNSvS). Roma. https://www.mase.gov.it/portale/documents/d/guest/snsvs22_aggiornata_completa-pdf

Ministero dell'Ambiente e della Sicurezza Energetica. (2023). Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC). Roma. https://www.mase.gov.it/portale/documents/d/guest/pnacc_documento_di_piano-pdf

Ministero della Transizione Ecologica. (2021). Piano per la Transizione Ecologica (PTE). Roma. https://www.mase.gov.it/portale/documents/d/guest/pte-definitivo-pdf

Orioli, V., & Massari, M. (2023). Praticare l'urbanistica: traiettorie tra innovazione sociale e pianificazione.

Panwar, V., Wilkinson, E., & Pelling, M. (2024). The barriers to uptake of disaster risk management science in urban planning: A political economy analysis. Disasters, 48(4), e12644.

Pasqui, G. (2005). Progetto, governo, società: ripensare le politiche territoriali (Vol. 30). FrancoAngeli.

Pelling, M. (2010). Adaptation to climate change: from resilience to transformation. Routledge.

Pelling, M., Comelli, T., Cordova, M., Kalaycioğlu, S., Menoscal, J., Upadhyaya, R., & Garschagen, M. (2024). Normative future visioning for city resilience and development. Climate and Development, 16(4), 335-348.

Programma UNESCO. (2020). Man and Biosphere (MAB) Programme – Biosphere Reserve Delta del Po. Parigi.

Regione del Veneto. (2021). Piano Territoriale Regionale di Coordinamento (PTRC). Venezia.

Regione del Veneto. (2024). Strategia Regionale di Adattamento ai Cambiamenti Climatici (SRACC). Venezia. https://www.regione.veneto.it/web/ambiente-e-territorio/rapporti-tecnico-scientifici

Renn, O. (2017). Risk governance: coping with uncertainty in a complex world. Routledge.

Ronchi, E. (2021). Le sfide della transizione ecologica. Milano: Edizioni Piemme.

Simon, H. A. (1976). Administrative behavior: A study of decision-making processes in administrative organizations (3rd ed.). New York: Free Press.

Stalhandske, Z., Steinmann, C. B., Meiler, S., Sauer, I. J., Vogt, T., Bresch, D. N., & Kropf, C. M. (2024). Global multi-hazard risk assessment in a changing climate. Scientific Reports, 14(1), 5875.

Torresan, S., Critto, A., Rizzi, J., & Marcomini, A. (2020). Assessment of coastal vulnerability to climate change hazards at regional scale: the case study of the North Adriatic Sea. Sustainability, 13(2), 1334.

Vale, L.J. (2014). The politics of resilient cities: whose resilience and whose city?. Building Research & Information, 42(2), 191-201.

Ward, P. J., Daniell, J., Duncan, M., Dunne, A., Hananel, C., Hochrainer-Stigler, S., ... & De Ruiter, M. C. (2022). Invited perspectives: A research agenda towards disaster risk management pathways in multi-(hazard-) risk assessment. Natural Hazards and Earth System Sciences, 22(4), 1487-1497.

Weichselgartner, J., & Kelman, I. (2015). Geographies of resilience: Challenges and opportunities of a descriptive concept. Progress in human geography, 39(3), 249-267.

Zschau, J. (2017). 2.5 Where are we with multihazards, multi-risks assessment capacities?.