

Spatial Planning and Metropolitan Governance to face Flood risk in the new Climate Change context: A comparison between Eurodelta Megaregion and Valencia metropolitan area

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Abstract

Resilience has become a topic of increasing importance, gaining presence in debates on spatial planning. It refers to the capacity to resist, to maintain vital functions and identity, but also the capacity to go forward, to learn, to build back better, to become more efficient and more functional in face of risks or shocks like flooding, which is being experienced in Europe with greater frequency and more impact. From this definition, this paper focuses on two cases of flood risk management at metropolitan level -Eurodelta Megaregion in The Netherlands and the Metropolitan Area of Valencia in Spain- with the aim to show learned lessons and to identify and propose recommendations regarding innovative and more effective planning procedures and frameworks to improve the resilience-related governance across scales, sectors and actors at metropolitan level.

Keywords: Resilience management; Flood risk; Climate-resilient spatial planning; Metropolitan governance.

Introduction

Resilience has become a topic of increasing importance due to the succession of more frequent crisis phenomena and the emergence of future uncertainties, gaining presence in debates on urban and regional policy and planning (Davoudi, 2012; Tasan-Kok et al., 2013; Greiving, 2018; Marom & Shlomo, 2024). According to Pascariu et al. (2022), 'resilience' is not just the capacity to resist, to maintain vital functions and identity, but also the capacity to go forward, to learn, to build back better, to become more efficient and more functional in face of risks or shocks. This resilience is not only innate or given, but can also be trained, for which policies, plans and programs, with the participation of epistemic communities and communities of practice, with a leading role for citizens who become familiar with risk and its management in each living space.

The management of resilience is related thus to a mix of techniques (planning tools) and patterns of governance (stakeholder management) in face of two main types of risks or changes, namely: abrupt "shocks" that disrupt everyday life for a limited period of time (e.g., an earthquake or a pandemic); and enduring "stresses" or crises that put systems under constant pressure (e.g., climate change or aged infrastructures), leading to overloads

that can severely restrict sustainable development in the long term (Coaffee et al., 2018). Among these risks, flooding is being experienced in European countries with greater frequency and more impact. This can be due to different reasons such as climate change; deficiencies in infrastructure and its management and maintenance; the complexity of stakeholder roles and responsibilities; a lack of clarity and willingness to accept responsibility; and a lack of understanding flood risk (Local Government Association¹). However, risks can be estimated, and the impacts can be significantly mitigated, so response and recovery can be more effective and efficient. In this vein, resilience highlights the need to be prepared to anticipate, react and adapt to changes, especially to those that could produce critical impacts on a territory. As a result, the scale of places, their governance and spatial planning become a crucial issue for managing resilience. Spatial planning at metropolitan level is thus an important basis to make steps forward to an appropriate metropolitan governance in soft spaces but also in formally constituted metropolitan areas. That is asking for collaborative approaches to address complex challenges, re-defining governance and planning practices beyond traditional administrative boundaries.

To identify and propose recommendations regarding innovative and more effective planning procedures and frameworks to improve the interplay across scales, sectors and actors, this paper focuses on two cases of flood risk management at metropolitan level in Europe, namely: the Eurodelta Megaregion (Netherlands) and the Metropolitan Area of Valencia (Spain). Both, The Netherlands (in past 2010 decade) and the Valencia region (more recently in past October 2024 but with a long history of centuries on this matter), have heavily suffered the effects of floods due to extraordinary rainfalls intensified by the climate change, causing very important damages at personal, economic, facilities and infrastructure levels. Both are also cases of informal metropolitan areas, where natural events are asking for governance beyond formal borders.

So, the objective of this paper is to highlight the need to strength a territorial culture and to develop institutional capacity to respond in a coordinated manner to these phenomena at metropolitan scale. By shifting the focus toward the changing roles of planners and citizens, the emergence of frameworks of interinstitutional cooperation beyond administrative borders, and of new types of solutions and adaptation measures (e.g., nature-based solutions), the paper sets the basis to spark a dialogue on innovative approaches to resilience.

The paper is structured as follows: in the next section we introduce the case of Eurodelta Megaregion, providing a general description of the area, the main water-related threats and challenges, and of the different measures adopted regarding flooding. The second section provides the same analysis focusing on the case of the Metropolitan Area of Valencia. A comparison of both cases is conducted in section 3 according to the analytical framework proposed, searching for similarities and differences among cases. Finally, the paper ends with a set of recommendations and final conclusions regarding the interplay between spatial planning and metropolitan governance to face flood risk in a new climate change context.

1. The case of Eurodelta Megaregion (the Netherlands)

Eurodelta is a densely urbanised megaregion with approximately 45 million inhabitants, also known as the “Rhine-Scheldt Delta”. It is a transnational² and a polycentric region spanning parts of the Netherlands, Belgium (Flanders), and Germany (North Rhine-Westphalia), home to major port cities like Rotterdam and Antwerp, acting as a crucial gateway to the continent (Gerretsen et al., 2017). It is shaped by a shared historical background and the socio-economic philosophy referred to as the “Rhineland model” (Braun, 2020). So, strategically embedded within the Trans-European Transport Network (TEN-T), the Eurodelta functions as a key node in the global flow of goods, services, and knowledge. In addition, it positions itself as an innovative, sustainable, and inclusive delta-region, aiming to lead in climate-resilient infrastructure development while improving the quality of life for its

1 See: <https://www.local.gov.uk/topics/severe-weather/flooding/flood-and-coastal-erosion-risk-management/flood-risk-and-flood-risk>

2 Other transnational megaregions in Europe, such as the Øresund region (Malmö and Copenhagen), the Euregio Maas-Rhine, and the Danube Region, offer comparable cases where cross-border integration presents both challenges and opportunities for collaborative spatial governance.

population (SURE, 2020).

However, within the Eurodelta, there is no single, formal metropolitan region encompassing the entire megaregion. Instead, metropolitan governance operates at multiple scales. It functions as a polycentric network of cities with shared challenges, intensive interactions, and strategic cooperation, rather than as a unified administrative entity (ASSET, 2025; METREX SURE Expert Group, 2019; SURE, 2020). They promote cooperation models capable of managing interdependencies, coordinating cross-border policies, and facilitating effective spatial planning in areas with fluid, overlapping jurisdictions (ESPON Project³). Nonetheless, the Eurodelta's potential remains constrained by political fragmentation. Realising its advantages requires a shift toward flexible governance beyond traditional borders and institutional inertia.

1.1. Climate and governance-related challenges at metropolitan scale

Eurodelta is characterised by its low-lying river basins of the Rhine, Meuse, and Scheldt, and its low-lying deltaic landscape through its direct connection to the North Sea. Its strategic location and economic importance have historically driven significant spatial development, often at the expense of natural flood retention areas. This particularly confronts an urgent imperative for climate-resilient spatial planning (METREX SURE Expert Group, 2019). This unique geographical setting, while historically a source of prosperity due to fertile lands and navigable waterways, also presents inherent vulnerabilities, particularly to flooding. Eurodelta's complex administrative fragmentation, socio-economic and cultural values as well as environmental fabric requires a highly integrated and cooperative approach to spatial planning and governance, especially in the face of escalating climate change impacts (Deltametropool⁴).



Figure 1. Water Network in the Eurodelta

Source: Vereniging Deltametropool, Provincie Gelderland, & Provincie Zuid-Holland. (2017).

³ See: <https://www.espon.eu/projects/territorial-governance-non-standard-geographies-nostageo> and <https://www.espon.eu/priorities/thematic-action-plans/governance-of-new-geographies>

⁴ See: <https://deltametropool.nl/projecten/a-economic-strong-just-and-climate-proof-eurodelta/>

The Eurodelta region has a long and often dramatic history of confronting the threat of flooding, a challenge that has been significantly exacerbated by climate change. Historically, the primary concern stemmed from storm surges from the North Sea and high river discharges. Major flood events throughout history, such as the devastating 1953 North Sea flood in the Netherlands, have profoundly shaped the region's approach towards water management. This event, which caused widespread destruction and loss of life, served as a catalyst for the development of ambitious, large-scale engineering projects like the Delta Works⁵, aiming to provide a robust physical defence against the sea.

In climate terms, beyond the immediate threat of flooding, the region grapples with a complex array of climate-induced challenges. Salinisation, the increasing salt content in soil and water, poses a growing problem in low-lying areas, threatening agricultural productivity. Concurrently, increasing drought conditions in higher-lying parts of the Eurodelta impact agriculture and business activities. Land subsidence, the gradual sinking of land, further exacerbates these issues, causing damage to foundations and infrastructure. The increasing frequency of extreme weather events and erratic river discharge patterns introduce new layers of complexity, intensifying the pressure on existing systems (RLI⁶). These environmental shifts are not isolated; they create spatial conflicts, notably between agriculture and nature, as adaptation strategies often require changes in landscape structure and management that lead to competition for land (Blom-Zandstra et al., 2009). The region also faces the challenge of developing new residential areas that are energy-efficient and resilient to drought, heat, and heavy rainfall, alongside integrating renewable energy infrastructure without compromising existing landscapes or public acceptance (Nabielek et al., 2023).

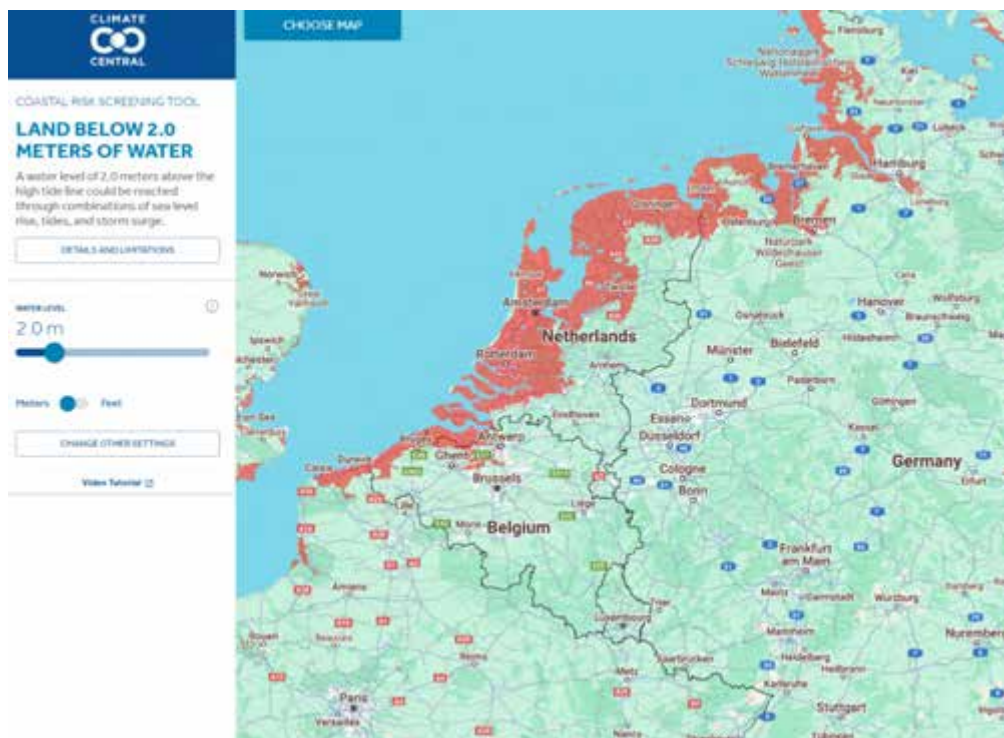


Figure 2. Coastal risks of Eurodelta with 2.0 m sea level rise

Source: Climate Central. (n.d.). Coastal Risk Screening Tool: Land projected to be below annual flood level in 2050. Retrieved May 22, 2025, from <https://coastal.climatecentral.org/map/>

The Eurodelta's aspiration to become a sustainable and globally competitive megaregion is persistently chal-

5 See: Rijkswaterstaat. (n.d.). De Deltawerken. Available at: <https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/waterkeringen/deltawerken> [Accessed: 29 May 2025].

6 see: <https://www.rli.nl/sites/default/files/Rli%202024-02%20Klimaatadaptatie%20ENG%20def%20interactief.pdf>

lenged by fragmentation across administrative, sectoral, value-based, and spatial planning dimensions. These divisions obstruct coordinated spatial development and weaken the region's capacity to address shared challenges effectively. Administratively, the Eurodelta spans multiple national jurisdictions, including the Netherlands, Belgium, Germany, and northern France. Each of these territories is governed by distinct legal systems and planning traditions. This institutional diversity hampers policy alignment and reinforces siloed decision-making. Although the European Union promotes a more integrated spatial planning approach, the rigidity of national frameworks and the protection of institutional interests often inhibit genuine cross-border collaboration (ESPON, 2025a; ISOCARP, 2025).

Sectoral fragmentation is equally pronounced. Despite a dense and advanced infrastructure network, the region suffers from disjointed mobility systems and policy mismatches, particularly in transport and energy. These inefficiencies undermine EU climate objectives, as spatial demands from energy transition and circular economy initiatives increasingly compete for limited land (ESPON, 2025b; Blom-Zandstra et al., 2009). Value-based fragmentation further complicates the planning landscape. Divergent stakeholder interests, such as those between private capital and public equity, create tensions in the implementation of shared sustainability goals (Deltametropool, 2022; Mikaelsson & Lager, 2024). Spatial planning and governance fragmentation is also driven by divergent planning systems, regulatory tools, and institutional capacities. The lack of a unified vision or binding cross-border frameworks results in policy misalignment and inconsistent implementation across borders. This hinders coordinated responses to transnational challenges like urbanisation, climate adaptation, and infrastructure modernisation. So, moving forward, flexible but formalised governance mechanisms are essential to foster coherence, enable joint action, and realise the Eurodelta's long-term spatial potential.

Furthermore, the challenges are compounded by interconnected socio-ecological factors. The transition to a circular built environment, for example, demands physical space for new infrastructure such as circular construction hubs and material storage. This adds to existing spatial pressures from climate adaptation and energy transition (INTERREG Europe, 2025⁷). These interdependencies mean that addressing one issue in isolation often creates new conflicts or intensifies others. Success in climate adaptation is therefore inseparable from managing broader societal transitions. Non-climate drivers such as population growth, demographic ageing, and rising inequality further amplify climate vulnerabilities, with at-risk groups disproportionately exposed to heat and other hazards (Ministry of Infrastructure and Water Management, 2023).

Finally, the ongoing housing expansion and energy transition, while vital, can increase exposure to climate risks if not coordinated through integrated spatial planning (Ministry of Infrastructure and Water Management, 2023). Addressing these challenges requires a holistic approach that accounts for trade-offs and co-benefits, moving beyond fragmented planning. The core obstacle is not a lack of recognition or vision, but the limited political and institutional capacity to implement integrated strategies amid competing economic interests and entrenched land-use practices. This necessitates stronger regulatory tools and a cultural shift across authorities, businesses, and the public to prioritise water and soil systems as foundational planning principles (Jaap de Graeff, Agterberg, et al., 2024).

1.2. Climate-resilient spatial planning and governance practices

Deltametropolis Association was established in 1996 as a collaborative initiative by the four mayors responsible for spatial planning in Amsterdam, Rotterdam, The Hague, and Utrecht, collectively known as the Randstad. Its objective was to develop a spatial strategy aimed at transforming the Randstad into an urban complex of international significance: a European Delta Metropolis. Conceived as an informal collaboration, the association operates as a non-profit, non-governmental, and member-based organisation. The concept of spatial planning in the context of Deltametropolis extends beyond its physical dimensions, it represents an ideal and a mode of thinking. It emphasises a focused and reflective approach to metropolitan development, driven by long-term societal interests. This includes addressing pressing contemporary challenges such as the energy transition, urbanisation, and climate adaptation.

7 See: <https://www.eurometrex.org/new-interreg-europe-project-announced-for-a-eurodelta-spatial-strategy/>

The Dutch Delta Programme was officially launched in 2010 as a long-term national strategy to protect the Netherlands from the growing risks of climate change, including sea-level rise, river flooding, and periods of drought. The programme was initiated following the recommendations of the second Delta Committee, which was established in 2007 in response to increasing scientific evidence of climate-related threats to the country's low-lying and densely populated regions (REF⁸). Since the beginning of the Delta Programme, the indication towards cross-border coastal water management started getting some attention. Since 2015, with the Paris Climate Agreement, Deltametropolis Association, together with METREX and some urban metropolitan regions of the Netherlands, Germany, Belgium, initiated the conversations and possibilities to work together voluntarily on the cross-border Eurodelta scale and named it Strategic Urban Region of Eurodelta (SURE) Network.



Figure 3. Strategic Urban Region of Eurodelta (SURE) Network

Source: Braun, C. (Ed.). (2020, October). Eurodelta - SURE: Strategic Urban Region Eurodelta - Roadmap. METREX, City of The Hague, City of Amsterdam, and Province of South Holland. <https://deltametropool.nl/publicaties/roadmap-eurodelta-sure-2020/>

The Dutch Delta Programme highlights the critical role of spatial adaptation in ensuring that the Netherlands becomes climate-proof and water-resilient by 2050. It promotes coordinated action among municipalities, water boards, provinces, and the national government to address water-related challenges such as flooding, drought, heat stress, and waterlogging. Spatial planning in the Netherlands has long been deeply intertwined with water management. Historic land reclamation and polder development required a highly coordinated approach to land use, resulting in a planning tradition that integrates flood risk assessment and water infrastructure from the outset. Within the Eurodelta, water governance operates through a multi-level structure involving national, regional, and local authorities.

8 See: <https://english.deltaprogramma.nl>

The Dutch Water Boards -Waterschappen- are a distinctive example of functional governance. With autonomous taxing authority and direct responsibility for managing dikes, water levels, and water quality, they have cultivated a strong territorial culture of water awareness and shared responsibility. Comparable regional and local bodies exist in Flanders and North Rhine-Westphalia, though typically within broader provincial or state governance frameworks. While differing in institutional autonomy, these entities collectively reflect a commitment to integrated and locally rooted water management across the Eurodelta. Bringing together the many separate authorities and governments, as well as the citizens in the diverse Eurodelta region, can be quite difficult. However, everyone shares common ground due to similar water-related challenges like flood risks.

a) Professional approach and community engagement

Building on the existing formal governance structures and exploring with new informal ways of working, the Eurodelta also relies on “soft spaces”—flexible, non-statutory zones of collaboration that transcend administrative boundaries. These spaces enable actors to address shared challenges, such as flood risk or climate adaptation, where rigid jurisdictions fall short. The Strategic Urban Region Eurodelta (SURE) network exemplifies this approach. It serves as a collaborative platform for urban and spatial planning professionals, facilitating cross-border dialogue and coordination. SURE promotes a vision of a borderless, sustainable megaregion by aligning efforts across mobility, spatial development, climate adaptation, and the circular economy, advancing integrated solutions beyond institutional silos.

In recent years, resilience planning in the Eurodelta has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. Rather than relying solely on defensive infrastructure, the region is moving toward integrated, adaptive strategies that combine spatial planning, ecological restoration, and stakeholder collaboration. This shift reflects a growing recognition that border regions require flexible, cross-jurisdictional solutions tailored to their layered governance contexts (Maila, 2025). The following initiatives and instruments illustrate this transition, showcasing a range of experimental and institutional efforts aimed at enhancing climate resilience, spatial quality, and cross-border cooperation across the Eurodelta in the field of flood risk management.

For instance, the International Commission for the Protection of the Rhine (ICPR⁹) has been a long-standing initiative facilitating cooperation among Rhine-bordering countries to manage water quality and flood risks. This framework has significantly improved the river's ecological status. Still, climate change and increased industrial activities present new challenges, requiring adaptive management strategies. The ICPR could evolve further by strengthening data sharing, harmonizing regulations, and enhancing stakeholder participation to effectively address contemporary water management issues.

Another example is the NEB Bauhaus of the Seas Sails – Delta Grenspark Groot Saeftinghe project. This New European Bauhaus initiative explores innovative approaches to coastal and estuarine development by integrating nature, culture, and community engagement. The Delta pilot at Grenspark Groot Saeftinghe acts as a testing ground for adaptive strategies that balance ecological restoration with economic activities and connect global perspectives with local needs. The project actively engages local communities, who share knowledge passed down through generations of living with water and brings in practitioners and policymakers to discuss future trends and scenarios for the delta. Young planners, designers, and architects then develop new scenarios, which are presented back to the communities to foster understanding of their future involvement in delta decisions. While this project fosters interdisciplinary collaboration, its long-term success hinges on sustained stakeholder engagement and the ability to scale its solutions, with the complexities of cross-border governance and spatial planning still needing to be addressed.

b) Risk management and interinstitutional cooperation

Given the numerous administrative boundaries, a multi-level collaboration framework is crucial for developing

9 See: International Commission for the Protection of the Rhine (ICPR). (n.d.). Home. Retrieved from <https://www.iksr.org/en/>

and implementing cohesive strategies. We can see strong examples of this in action with initiatives like the Benelux Union and the EGTC Linieland van Hulst en Waas. The Benelux Union, encompassing Belgium, the Netherlands, and Luxembourg, has a rich history of intergovernmental cooperation spanning over 75 years, often serving as a blueprint for broader European integration. It provides a vital platform for collaborating on shared challenges such as climate change, energy transition, and mobility, leading to policy harmonization and joint projects. However, the Union's effectiveness can sometimes be hampered by differing national interests and administrative complexities. Enhancing its capacity to implement and monitor cross-border initiatives would undoubtedly strengthen its role in fostering regional integration and resilience.

Similarly, the EGTC Linieland van Hulst en Waas demonstrates the practical application of European Groupings of Territorial Cooperation (EGTCs). EGTCs offer a legal framework that empowers regional and local authorities to undertake joint projects. This particular EGTC, situated along the Dutch-Belgian border, is a prime example of how such a framework can facilitate concrete cross-border collaboration within the Eurodelta, working towards a shared spatial strategy and partnership. It focuses on improving spatial quality, preserving cultural heritage, and enhancing housing and liveability in the historically and ecologically significant Linieland region. To fully realize the potential of this pioneering cooperation model, strengthening institutional mandates and ensuring stable financial support are critical.

c) Solutions and adaptation measures

The solutions of water management in the era of climate change require a shift in thinking, robust adaptation measures, moving beyond traditional approaches to embrace more dynamic and ecologically integrated strategies. A prime example of such a paradigm shift is the Netherlands' "Room for the River" program. This initiative redefines flood management by actively creating space for rivers to safely overflow during periods of high water, thereby significantly reducing flood risks. This program moved beyond solely defensive measures to strategically allocate more space for rivers, linking water safety directly to spatial quality, social issues, and broader economic and ecological improvements. Room for the River approach embodies the long-standing Dutch tradition of "making work with work," seizing opportunities presented by the interventions to achieve multiple benefits. However, adapting and replicating this model in other parts of the Eurodelta demands careful consideration of local contexts and existing governance structures.

One major challenge is the difficulty in scaling localized successes to a megaregional level. Furthermore, there is a consistent need for more integrated spatial planning that fully incorporates climate change adaptation. Current planning often remains siloed within national or even sub-national boundaries, leading to fragmented efforts that may not effectively address transboundary water management issues and adaptive decision-making and governance. The harmonization of legal and regulatory frameworks across borders remains a slow process, which can impede the implementation of comprehensive adaptation measures.

2. The case of Valencia metropolitan area (Spain)

The metropolitan area of Valencia is a functional system made up of 44 municipalities with a population of 1.635.239 inhabitants in 2024, that could be enlarged in a second crown up to 66 municipalities and 1.8 inhabitants (Valencia Metropolitan Spatial Plan). The recent catastrophic flooding experienced on October 29, 2024, affected the south part of the metropolitan area, which is called "Horta Sud" county -comarca-. The "Horta Sud" is made up of 20 Valencian municipalities¹⁰ and has a long-standing organizational and cultural history in the region. It is the second most populated county, with 454,668 inhabitants, and the most industrialized of the Valencian region.

It worths noting that traditionally there have been some tensions between the municipalities and the city of Valencia regarding the expansion of power of the capital city over time (Fundació Horta Sud). Only in the period 2015-2023 was a more cooperative approach attempted between the capital city and its surrounding municipal-

¹⁰ The 20 municipalities are the following: Alaquàs, Albal, Alcàsser, Aldaia, Alfafar, Benetússer, Beniparrell, Catarroja, Lloc Nou de la Corona, Manises, Massanassa, Mislata, Paiporta, Picanya, Picassent, Quart de Poblet, Sedaví, Silla, Torrent and Xirivella.

ities. Moreover, the general feeling is of a certain failure in terms of metropolitan governance, largely due to the absence of coordination and cooperation mechanisms between administrations and departments in the area (Romero et al., 2023). This is the context to be considered when assessing the consequences and the responses to the recent flooding in the “Horta Sud” within the metropolitan area of Valencia.

2.1. Climate and governance-related challenges at metropolitan scale

The recent flooding had an enormous impact at different levels, namely: emotional (loss of homes and a sense of vulnerability and helplessness), social (228 deaths), economic (between 0.1 and 0.2% of Spanish GDP in the fourth quarter of 2024, according with the Valencian Institute of Economic Research –IVIE), and environmental (landscape disorder and the spread of industrial and urban waste into the natural environment).



Figure 4. Areas affected by the flooding of October 29, 2024 in Valencia and surroundings

Source: Valencian Cartographic Institute.

The natural origin (physical conditions) that caused floods is well known. So is the disorderly way in which the territory has been occupied in a metropolitan space that has been configured around Valencia, connecting the surrounding cities and towns, all of them within a unique agricultural landscape (Farinós Dasí, 2021).

In climate terms, the floods of October 29th coincided with extraordinary rainfall associated with the frequent high-altitude cut-off low -DANA- conditions, typical of autumn in the Valencian Region. However, this time the rainfall was of an unknown nature and intensity, not in terms of total rainfall (there have been higher ones in the past) but rather in terms of the intensity of the rainfall in one hour (184.6 l/m²/h in the municipality of Turís, total 700 mm of rainfall this day). This intense rainfall in one place and within the short span of just one hour was due to a completely extraordinary atmospheric situation: quasi-stationary convective trains were generated, allowing low pressure systems to reactivate without moving, remaining in the same location, vertically above places where these highs accumulated. These depression systems are associated with climate change and the progressive warming of the Mediterranean (>3°C), which provides energy and humidity to the air masses coming from the Sahara that cross the sea. When they touch land and collide with the first mountain ranges near the coast,

they rise and precipitate, potentially reaching altitudes of 5,500 meters with the high-altitude cut-off low, which triggers their ascent and the precipitation of all water vapor they have accumulated on their journey.

These meteorological conditions combine with coastal geomorphology characterized by the presence of broad alluvial plains that rapidly transition to interspersed wetlands. This area has been intensively exploited for agriculture and transformed into residential, industrial, infrastructure, and tourism uses. This has profoundly transformed the natural drainage system, which, in a layered form, sought its outlet to the sea, using the Albufera lake as a natural drainage area south of the city of Valencia.

However, the floods of October 29th were not due to the rainfall – in many, not a single drop was recorded— but rather to the intense flooding in the pre-coastal mountain ranges. In these extreme events, small rivers, ravines, and dry riverbeds with steep gradients abruptly channel the intense runoff. The high-water speeds (up to 15 km/h) leave very little time for the lower course of the river populations to react to these sudden and ephemeral floods. All of this poses a clear natural threat to the city and the metropolitan area.

This threat has been exacerbated in recent decades by increased exposure due to massive urban and infrastructure growth between 1966 and 2007, which has been carried out in a poorly organized and environmentally integrated manner. These land development processes also include the development of a new artificial channel in the final course of the Turia River, as it comes in the metropolitan area, diverting it away from the city, as reaction to the floods suffered by Valencia in 1957 (Figure 5).



Figure 5. Valencia and its County Urban Master Plan (1966)

Source: <https://www.upv.es/contenidos/CAMUNISO/info/U0684629.pdf>

Thus, from a hydraulic perspective, the problem shifted to the towns south of this artificial channel; the same areas where most of the new industrial and infrastructure developments are concentrated (westward, toward Madrid, and southward, toward Alicante), according to the Valencia urban master plan approved in 1966. Since then, and even before, there have been a series of urban, territorial, hydrological, and emergency planning instruments that have attempted to give coherence to these growths by integrating flood risk into the equation. However, despite the unsuccessful attempt at the Metropolitan Coordination Standards (1988), neither their ap-

plication nor the practical results have been as necessary, as discussed below.

2.2. Climate-resilient spatial planning and governance practices

The establishment of economic activities is taking shape as a fragmented set of facilities, with significant conurbations along the main road infrastructure and access routes to towns, without supra-municipal coordination or shared structures, and with a strong component of tertiary and service-industrial activity alongside productive companies. In many cases, these areas are constrained by infrastructure or other urban development projects. Moreover, the buildings in these areas did not develop typologies designed to withstand the risks of flooding, both materially and humanly. The increase in artificialized land in all municipalities, including those prone to flooding, has exacerbated the effects of the recent DANA.

The consequences of the floods arise thus in a context of a lack of a supra-municipal coordination body for environmental and urban planning, a situation that leads to the need for a comprehensive planning model between Valencia and the region. Some of the issues that have emerged regarding the management of resilience and the spatial planning approach are presented below:

a) Professional approach and community engagement

The disaster has sparked intense debate and reaction among citizens, the media, and among experts, technicians, and professionals (see the interprofessional manifesto led by FUNDICOT¹¹). Proposals and courses of action have begun to be discussed and put forward by these stakeholders, which can be classified into three stages: before a flood (prevention); during the flood (response, related to the established warning systems and planned management and evacuation plans); and post-disaster recovery (reconstruction and rebuilding). In this third stage, it is important to promote adequate communication and understanding among the population of the risks they face, and to promote a so called "territorial culture" to strengthen both the awareness and the relationship between the population and its territory in functional terms, as well as between professionals and decision-makers (last responsible of applied measures).

Before the flood, the work of professionals should be related to the improvement of meteorological and hydrological information systems; while during the flood, and in relation to emergency plans, the work of planning professionals must contribute to a better integration between territorial and urban planning and civil protection. Finally, in the post-recovery period, the work of professionals is clearly related to the development and selection of alternative courses of action. Reality shows that this is much more important in the former than in the latter, where political criteria prevail. This has been the case of the two expert committees organized separately by the Valencian regional government (outsourcing their work to consulting firms, about which little is known today) and the Spanish government after the disaster. In this second case, on May 29, seven months after the floods, the Ministry of Ecological Transition presented its "Plan to Improve Flood Resilience in the Affected Territory" at the Polytechnic University of Valencia. However, the presence of political representatives was predominant during the event compared to the presence of experts, which was reduced to the final roundtable. Moreover, this program includes various types of actions in flood-prone areas of the Júcar-Turia river system, but most of them infrastructure-related and involving public hydraulic works funded by the national government (for an estimated value of €470 million) to minimize the impact of future flooding.

b) Risk management tools and interinstitutional cooperation

Prevention and adaptation aim to anticipate and avoid or reduce impacts. Prevention is more efficient than recovery and mitigation. It is therefore a matter of planning; and of implementing what is planned. This requires a) an appropriate regulatory and instrumental framework (clear definition of tasks, resources and responsibilities); b) political and administrative will and leadership; c) a society and citizens aware of risks and sensitive to the problem; and d) patterns of repeated interaction between actors and smooth channels of communication. Regulating land use according to flood risk is key, integrating urban and hydraulic variables into territorial and

11 See: <https://www.fundicot.org/wp-content/uploads/2024/12/MANIFIESTO-Interprofesional-INUNDACIONES-OCTUBRE-2024-revisado-diciembre-1.pdf>

hydrological planning documents. To achieve this, collaboration between the three administrations affected is essential: water, land, and civil protection.

Spatial planning is particularly relevant as it goes beyond the strict scope of hydrological planning for potentially floodable areas, encompassing broader areas with important functions of water capture, retention, and use (crops, forested areas, artificial areas, etc.). Once the catastrophic process begins, it is the systems, structures, protocols, and decision-making within Civil Protection that must take action to protect the potentially affected population and assets, in close collaboration with the population at risk. Therefore, it is important that territorial and urban planning identify and regulate evacuation corridors and refuge areas for displaced persons, which must be included in Civil Protection emergency plans.

In the case of the Valencia metropolitan area, although there is no metropolitan spatial plan (now under development), there are urban master plans for all the municipalities within the area, and a flood risk prevention sectoral spatial plan (Plan de Acción Territorial de carácter sectorial sobre prevención del Riesgo de Inundación en la Comunitat Valenciana -PATRICOVA-) at the regional level, approved by the Valencian Government in 2015 (updating its first version from 2003). There is also a Flood Risk Management Plan -PGRI- at national level (from 2016), for which the Spanish Ministry of Ecological Transition is responsible through the Júcar Hydrographic Confederation, which developed it. The PGRI, as well as the obligation to prepare a risk map to define the Areas of Significant Potential Flood Risk (ARPSI), have their origin in the Directive 2007/60/EC of the European Parliament and of the Council, of 23 October 2007, on the assessment and management of flood risks, which was transposed into Spanish legislation by Royal Decree 903/2010, of 9 July, on the assessment and management of flood risks.

The PGRI is led by the water authority of the Government of Spain, but are developed with the participation of national, regional, and local institutions and territorial authorities, and include several public consultation and participation procedures. In the case of Valencia, the PGRI of the Júcar River (which includes the Turia river) is aligned to all the instruments: PATRICOVA (which incorporates its own mapping of areas classified as at risk of flooding in the Valencia Autonomous Region), the Civil Protection Master Plan of the Valencian Region government, and, at the municipal level, the urban master plans.

At the Spanish level, the 2016 Regulation on the Management of Public Hydraulic Domains -RDPH- incorporates limitations on land uses in flood zones. It also established that all Spanish Autonomous Communities (namely, the regional level of government) must adapt their land use and urban planning laws to the new flood regulations, for which a Technical Guide was prepared by the Ministry. To this end, they had to modify and adapt territorial and municipal planning that planned future urban developments in flood zones or preferential flow zones (defined, respectively, by Articles 14 and 9.2 of the RDPH). In the Valencian case, the former were delimited when the Júcar PGRI defined the aforementioned ARPSI; for the latter, Article 9 bis prohibits building on them on rural land (with some exceptions, which ultimately becomes their Achilles' heel in terms of compliance).

However, coordination between administrations and the adjustment of different instruments did not occur in a region like Valencia, which has had real estate development and tourism as two important pillars of its economy. This is also because, according to the PATRICOVA, risk maps must be done at the municipal level, although its Article 11.4 also opens the possibility, on a secondary basis, of a supra-municipal level.

c) Solutions and adaptation measures

Integrated flood risk management should focus on sustainable water management and measures that strengthen the resilience of nature and society to extreme weather events. However, traditional public works are often the most popular demands immediately after a disaster strikes. They are often effective in the short term, but less so in the medium and long term; they are more expensive than other types of measures and can create a false sense of security among the population.

These demands for mitigation public works at the territorial level (because at the urban level, mitigation actions and the protection of buildings and people are beyond dispute) focus on the construction of dikes and dams,

maintaining the functionality and/or increasing the capacity of existing riverbeds and channels (increasing the space for water in some of the upper or middle sections of the channels), and refurbishing linear transport infrastructure that can act as a barrier and worsen the effects of flooding. In this sense, the new channel of the Turia River has proven efficient in the task for which it was designed, and it protected the city on its right (northern) bank, but its southern wall acted as a dike for overflowing flows from adjacent basins on the left bank (such as the Pozolet-Saletta ravine system), worsening the situation in these areas. Nor can the Poyo Ravine, where intensive work is being done to restore and artificially condition the riverbed (in contrast to its ecological restoration), guarantee sufficient capacity to handle peak runoffs of more than 2,228,904 m³/s.

This leads us to the need to combine Nature-Based Solutions with other more adaptation-focused measures within a metropolitan Green Infrastructure (Muñoz and Doménech, 2011) through coordinated action at the supra-municipal level, of a metropolitan nature and under the hydrological criteria of the river basin authority, in combination with subregional spatial plans (Farinós Dasí et al., 2024). Some of these Nature-Based Solutions suitable for the case of Valencia are:

- Expanding the floodplain, returning (regenerating) more of the riverbed.
- Managing water with vegetation that facilitates infiltration processes: regenerating riparian forests and river headwaters, thus reducing flow and surface runoff speed.
- Controlling erosion and achieving healthy soils through terraced cultivation systems and “temporary” ground-covers, planting fast-growing plants (legumes or grasses) and then incorporating them as organic matter.
- Reserving areas as floodplains in case of emergency: river parks in the city and in built-up areas, flooding productive agricultural spaces in case of emergency (as has traditionally happened in the Valencian orchard within the current metropolitan area of the city), establishing appropriate compensation mechanisms.
- Become fluffy the soil, allowing water retention and infiltration into the subsoil, combining this with water storage facilities on the surface or in the subsoil of the floodplain (reservoirs that can be used in times of scarcity).

3. Results

The comparison of Eurodelta region and the Metropolitan Area of Valencia on climate-resilience and flood risk management reveals several similarities and differences at the same time. In order to systematically assess the measures regarding resilience management (focus on flood risk) and spatial planning at metropolitan level, we have conducted a comparative analysis based on the following dimensions: a) Professional approach and community engagement; b) Risk management tools and interinstitutional cooperation; and c) Solutions and adaptation measures. The aim is to learn about governance and planning practices beyond traditional administrative boundaries (metropolitan scale) to face flooding.

a) Professional approach and community engagement

This dimension addresses the role of practitioners and citizens to face flood risk at metropolitan scale. It is worth noting here that the use and management of land to face flooding often implies limiting business activities, infrastructures developments as well as has impact on agricultural activities, and this introducing new layers of complexity. In Valencia, the engagement of the community and practitioners is heavily growing, but still lacking strong influence on final decisions, since the recovery process remains highly politicized (based more on politics than in appropriate policies in the right time). On the contrary, in the Dutch case the adoption of New European Bauhaus initiatives implies an innovative approach to coastal and estuarine development by integrating nature, culture, and community engagement. The Delta pilot at Grenspark Groot Saeftinghe also acts as a testing ground for adaptive strategies that balance ecological restoration with economic activities and connect global perspectives with local needs. Here, local communities share their knowledge achieved through generations regarding living with water and brings in practitioners and policymakers to discuss future trends and scenarios for the

delta.

These initiatives exemplify how knowledge sharing between experts and local communities can lead to stronger, more trusted land and water management plans. However, despite these positive efforts, scaling successful local projects into consistent, joined-up strategies between levels and sectors; e.g. across the entire Eurodelta megaregion remains a significant hurdle.

b) Risk management tools and interinstitutional cooperation

This dimension focuses on the existence of planning tools and partnerships beyond institutional borders to manage resilience and flood risk. Effective risk management and coordinated action across multiple levels of governance are essential for addressing the complex, interconnected challenges, especially those related to water. However, both territories experience fragmentation across administrative, sectoral, value-based, and spatial planning dimensions. On the one hand, the Eurodelta face distinct legal systems and planning traditions from different countries. On the other, the case of Valencia, even if it is circumscribed to one single country, also presents high complexity and institutional resistances because of the very competitive political and territorial dynamics between the different levels of government concerned and reluctance towards the power of the city of Valencia on the part of the metropolitan municipalities when designing and implement policy solutions. As well as between hydrological and spatial planning, respectively in hands, of the Spanish national and Valencian regional governments. This institutional diversity hampers policy alignment and reinforces siloed decision-making; despite the normative, legal and instrumental framework is very clearly established in the Spanish case. So, main challenge, in this case, are not structural conditions of governance, but procedural ones (governance practices, both institutional coordination and cooperation, but also bottom-up from increasing public participation).

Nonetheless, in the case of Eurodelta resilience planning has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. The Strategic Urban Region Eurodelta (SURE) network exemplifies this approach, promoting a vision of a borderless, sustainable megaregion by aligning efforts across mobility, spatial development, climate adaptation, and the circular economy, advancing integrated solutions beyond institutional silos. Besides, the creation of the Deltametropolis Association (1996) provides basis for informal collaboration to address pressing contemporary challenges. This is also the case of the Dutch Delta Programme (2010), that promotes coordinated action among municipalities, water boards, provinces, and the national government to address water-related challenges such as flooding, drought, heat stress, and waterlogging.

At formal level, both the Benelux Union and the EGTC Linieland van Hulst en Waas initiatives demonstrates the practical application of European Groupings of Territorial Cooperation (EGTCs), which offer a legal framework that empowers regional and local authorities to undertake joint projects. Both (formal and informal) initiatives are examples of institutional efforts to bring together the many separate authorities and governments and competing public-private interests to make them sharing to some extent common ground due to similar water-related challenges. On the contrary, coordination between administrations and the adjustment of different planning instruments do not occur in Valencia, which has had real estate development and tourism as two important pillars of its economy, ahead of environmental issues.

c) Solutions and adaptation measures

This dimension focuses on the type of interventions or solutions adopted to prevent, react and recover from flooding at metropolitan scale. Due to their great vulnerability to flood risk, both have adopted adaptation measures that have required great investments and additional land for essential infrastructure, including dyke reinforcement, river expansion, and water storage facilities. However, in recent years, resilience planning in the Eurodelta has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. Rather than relying solely on defensive infrastructure, the region is moving toward integrated, adaptive strategies that combine spatial planning, ecological restoration, and stakeholder collaboration.

In this vein, a prime example of such a paradigm shift is the Netherlands' "Room for the River" program, which redefines flood management by actively creating space for rivers to safely overflow during periods of high water, thereby significantly reducing flood risks. This program moved beyond solely defensive measures to strategically allocate more space for rivers, linking water safety directly to spatial quality, social issues, and broader economic and ecological improvements. Valencia, one step behind, also is moving in this direction, despite today, being so present the catastrophic effects of floods in citizens' memory, the approach to flood risk management is more focused on traditional public works (business as usual, also from an economic model point of view). This type of measures is predominant compared to nature-based solutions to face flooding.

Conclusions

The objective of this paper has been to highlight the need to strength a territorial culture and to develop institutional capacity to respond in a coordinated manner to these phenomena at metropolitan scale. By shifting the focus toward the changing roles of planners and citizens, the emergence of frameworks of interinstitutional cooperation beyond administrative borders, and of new types of solutions and adaptation measures (e.g., nature-based solutions), the paper sets the basis to spark a dialogue on innovative approaches to resilience. Hence, the lessons learned from the cases lead us to elaborate a series of recommendations that are summarised below.

Drawing insights from the case of the Eurodelta and the Dutch Delta model, the following recommendations are put forth for climate-resilient spatial planning in this transnational megaregion:

- A core ambition must be to profoundly integrate water and soil systems as guiding principles for all spatial development. This means placing natural systems at the very heart of land-use decision-making, especially given the Eurodelta's inherent vulnerability to sea-level rise, flooding, and subsidence.
- To overcome "spatial lock-in" is critical to implement robust planning frameworks, clear regulatory tools, and targeted financial instruments that genuinely support adaptive land use. Areas currently designated for housing, logistics, or industry, even with existing development pipelines, must be re-evaluated for climate adaptation to enhance long-term resilience. Incentives, such as compensation for converting vulnerable land to nature-based solutions, can help align long-term resilience goals with economic pressures. Stronger policy support is essential to ensure water and soil systems decisively shape land allocation and development.

The role of spatial planners and citizens within the Eurodelta must fundamentally evolve. They are no longer merely technicians or inhabitants but must become coalition builders, navigators between institutions, and facilitators of multi-stakeholder dialogues. Their capacity to work across administrative and sectoral boundaries, aligning policies and maintaining momentum in long-term planning processes, is paramount (Maila, 2025). Furthermore, social equity must become central to spatial planning. Climate adaptation measures must actively address inequality, ensuring that vulnerable populations are not disproportionately exposed to risks like extreme heat or flooding. Planners need to integrate social analysis and values into their work, guaranteeing that adaptation strategies benefit all communities, particularly those with the least capacity to act independently.

In this evolving landscape, Research by Design (RbD) is increasingly a valuable method for addressing complex spatial challenges. Throughout the Eurodelta, this approach enables planners and stakeholders to explore future scenarios through creative design processes, combining technical, social, and spatial perspectives to imagine alternative land uses and policy solutions. The full potential of RbD, however, will only be realized when supported by institutions capable of translating its innovative ideas into formal decision-making.

Finally, planning within the Eurodelta must explicitly reflect the interconnected and cross-border nature of its challenges. As an integrated system of rivers, transport networks, and economic flows that extend across national lines, planning must be grounded in functional realities rather than rigid administrative boundaries

(Allmendinger & Naughton, 2010). Effective megaregional planning therefore demands long-term coordination, shared political will, and planning frameworks that operate across jurisdictions. “Planning without borders” is not merely necessary but increasingly urgent for building resilience at the scale where impacts are most deeply felt.

In the case of Valencia, the flood shock has sparked a broad public debate among scientific experts, the media, citizens, administrations, decision-makers, and private sector stakeholders about what lessons can be learned from what happened on October 29, 2024. Firstly, having regulations and rules in place to ensure adequate risk management, the following are recommended:

- Improved understanding of natural processes, this mean to give priority to meteorological alerts; have real-time information on the hydrological status of riverbeds during periods of extraordinary rainfall; adopt an updated flood hazard and risk mapping adapted to the new context of Climate Change, which considers future scenarios and is coordinated (better a single system) among the various responsible administrations, paying special attention to metropolitan areas due to the impact of flooding on them; and launch environmental and risk education campaigns.
- Coherence between spatial planning and risk management: controlling land-use changes in accordance with water regulations in a systemic approach, especially for the population and critical infrastructure, which are increasingly located in metropolitan areas. It makes no sense to delimit risk areas at the municipal level when runoff flow behaviour is completely inconsistent and exceeds the boundaries of each city.
- Establish as a priority responsibility of any government the proper coordination of the administrations involved in hydrological, spatial planning and risk management.
- Flood risk management requires effective governance approaches: it is not just a technical matter of building flood defences and developing flood warning systems. This means the need to consider not only political sensitivity, but to maintain open channels of communication between political decision-makers, technical staff, and subject matter experts.

Finally, political scientists identify other reasons for the failure of current democratic systems to adequately respond to the climate crisis, namely:

- The capacity of democratic decision-making to consider the medium and long term.
- Power issues and the influence of well rooted interests on political decisions.
- The extent to which citizens' views and values are considered in democratic decision-making.

As Driessen et al. (2016) point out, social and institutional factors often create strong barriers to the successful implementation of risk management systems.

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