



**Politecnico
di Torino**

THESIS REPORT

Waters at the Edge: Forms and Conflicts of Water Urbanism in Albenga

URBAN AND REGIONAL PLANNING



Authors: Nguyen Tuan Khoi (S323482), Pratyay Sanjay Sutar (S322739)

Thesis guide - Prof. Antonio Di Campli, Prof. Alessio Mazzaro (Co tutor).

Date - 17/02/2026

Table of Content

Abstract.....	2-3
Acknowledgement & Acronyms.....	4-5
Chapter 1: Theoretical framework and the Genealogy of Water Urbanism	
1.1 Background.....	8-13
1.2 Research Problem and Questions.....	13-14
1.3 Objectives of the study.....	14-15
1.4 Scope and Limitations.....	15-16
Chapter 2: Literature review and Theoretical frameworks	
2.1 Water Urbanism: Concepts and Global Paradigms.....	19-30
2.2 Case Studies.....	30-34
2.3 Planning Ambiguity and Governance Complexity in Urban Development.....	35-38
Chapter 3: Study area and Research Methodology	
3.1 Study Area Selection and Documentation.....	41-44
3.2 Study Area: Albenga and the Centa River.....	54-57
3.3 Data Sources and Data Collection Methods: Findings.....	57-60
3.4 Analytical Methodology.....	61-64
Chapter 4: Findings and Analysis	
4.1 Regional Catchment Analysis: Terrain and Fluvial Dynamics.....	67-68
4.2 Local Land Use and Settlement Morphology.....	68-71
4.3 Green Spaces and Vegetation Analysis.....	71-73
4.4 Localized Flood Analysis and Vulnerability Scenarios.....	73-83
4.5 Cross-Sectional Analysis of the Albenga Basin.....	83-86
4.6 Chapter Synthesis: The State of Territorial Rupture.....	86-87
Chapter 5: Discussion	
5.1 Interpretation of Key Findings.....	90-91
5.2 Discussion on the Role of Water Impact on Regional Development.....	91-92
5.3 Pros and Cons of Current Planning Practices.....	92-93
5.4 Implications for Sustainable Development.....	93-94
Chapter 6: Proposal	
6.1 Vision and Planning Principle.....	100-113
6.2 Impact of the Proposal.....	113-115
Chapter 7: Conclusion & Bibliography.....	118-126

Abstract

The thesis, entitled "Waters at the Edge: Forms and Conflicts of Water Urbanism in Albenga" examines the severe disconnect between historical urban forms and hydrological systems within the Mediterranean context. Given the global climate emergency particularly the polarization of the hydrological cycle with prolonged droughts interspersed with high-intensity flash floods the study highlights the obsolescence of traditional hard engineering solutions. In Albenga, the historical symbiotic relationship with the Centa River has been disrupted by 20th-century "defensive" planning thinking, transforming the river into a "hydraulic burden" isolated from the heritage core of the "City of Towers" by concrete dikes and intensive greenhouse farming. Applying the theory of Water Urbanism, this study redefines water not as a technical obstacle to be eliminated, but as a "structural framework" for territorial organization. The thesis addresses three fundamental paradoxes: Resistance vs. Resilience, Static vs. Dynamics, and the conflict between water scarcity and abundance. Through the analysis of global precedents of soft engineering and deconcretization, the study establishes a toolkit for a "Mediterranean Water Urbanism" model, emphasizing territorial resilience and landscape-based infrastructure. The proposal offers a strategic planning framework focused on reclaiming social space and improving the quality of Albenga's agro-urban landscape. The main pillars of this vision include a "Detention Green" system acting as a multi-functional ecological filter at key hydrological intersections and a "Walkability" network aimed at eliminating the "barrier effect" of the existing dike system. These interventions are reinforced by a sustainable urban drainage system (SuDS) in the "Piana" agricultural area, transforming greenhouses into rainwater collection points to stabilize the local water cycle. Ultimately, the study confirms that by restoring hydrological-morphological intelligence, Albenga can modernize the City-Water interface, ensuring archaeological preservation, ecological restoration, and promoting socio-economic vitality in the face of future environmental changes.

Keywords: Water Urbanism, Centa River, Socio-Economic-Environment, Hydrological Restoration, Soft Embankment, Sustainable Drainage System (SuDS).

Abstract

Il tesi, intitolato "Acque al limite: forme e conflitti dell'urbanistica dell'acqua ad Albenga", esamina la profonda discrepanza tra le forme urbane storiche e i sistemi idrologici nel contesto mediterraneo. Data l'emergenza climatica globale, in particolare la polarizzazione del ciclo idrologico con prolungate siccità intervallate da alluvioni improvvise di elevata intensità, lo studio evidenzia l'obsolescenza delle tradizionali soluzioni ingegneristiche. Ad Albenga, lo storico rapporto simbiotico con il fiume Centa è stato interrotto dal pensiero urbanistico "difensivo" del XX secolo, trasformando il fiume in un "carico idraulico" isolato dal nucleo storico della "Città delle Torri" da dighe in cemento e coltivazioni intensive in serra. Applicando la teoria dell'urbanistica dell'acqua, questo studio ridefinisce l'acqua non come un ostacolo tecnico da eliminare, ma come un "quadro strutturale" per l'organizzazione territoriale. La tesi affronta tre paradossi fondamentali: Resistenza vs. Resilienza, Staticità vs. Dinamicità e il conflitto tra scarsità e abbondanza d'acqua. Attraverso l'analisi di precedenti globali di ingegneria dolce e decompertizzazione, lo studio definisce un kit di strumenti per un modello di "Urbanistica dell'Acqua Mediterranea", che enfatizza la resilienza territoriale e le infrastrutture basate sul paesaggio. La proposta offre un quadro di pianificazione strategica incentrato sul recupero dello spazio sociale e sul miglioramento della qualità del paesaggio agro-urbano di Albenga. I pilastri principali di questa visione includono un sistema di "Verde di Detenzione" che funge da filtro ecologico multifunzionale in corrispondenza di intersezioni idrologiche chiave e una rete di "Percorribilità" volta a eliminare l'"effetto barriera" del sistema di argini esistente. Questi interventi sono rafforzati da un sistema di drenaggio urbano sostenibile (SuDS) nell'area agricola della "Piana", che trasforma le serre in punti di raccolta dell'acqua piovana per stabilizzare il ciclo idrico locale. In definitiva, lo studio conferma che, ripristinando l'intelligenza idrologico-morfologica, Albenga può modernizzare l'interfaccia Città-Acqua, garantendo la conservazione archeologica, il ripristino ecologico e promuovendo la vitalità socio-economica di fronte ai futuri cambiamenti ambientali.

Parole chiave: urbanistica idrica, fiume Centa, socio-economico-ambientale, ripristino idrologico, argini morbidi, sistema di drenaggio sostenibile (SuDS).

Acknowledgements

The completion of this thesis, "Waters at the Edge: Forms and Conflicts of Water Urbanism in Albenga," marks a significant milestone in our academic journey at Politecnico di Torino. This work would not have been possible without the guidance, support, and encouragement of many individuals and institutions to whom we owe our deepest gratitude. First and foremost, we would like to express our profound appreciation to our supervisor, Prof. Antonio Di Campli, for his invaluable guidance, scholarly insights, and unwavering support throughout this research. His expertise in territorial complexity and his critical perspective on urban and regional planning have been fundamental in shaping the theoretical framework and the strategic vision of this study. We extend our gratitude to the faculty and staff of the Department of Urban and Regional Planning at Politecnico di Torino for providing a stimulating intellectual environment and the necessary resources to conduct this interdisciplinary research. Finally, we dedicate this work to the city of Albenga and its river, with the hope that this research contributes to a more resilient and harmonious future for the relationship between urban life and the natural water cycle.

Acronyms

Urban Planning & Infrastructure

- WU: Water Urbanism
- SuDS: Sustainable Urban Drainage Systems
- WSUD: Water-Sensitive Urban Design
- ABC Waters: Active, Beautiful, Clean Waters
- GI: Green Infrastructure
- BGI: Blue-Green Infrastructure

Hydrology & Environment

- DEM: Digital Elevation Model
- GIS: Geographic Information System
- NbS: Nature-based Solutions
- LID: Low Impact Development

- EIA: Environmental Impact Assessment

Organizations & Frameworks

- SDGs: Sustainable Development Goals
- IPCC: Intergovernmental Panel on Climate Change
- EEA: European Environment Agency
- UN: United Nations
- OECD: Organisation for Economic Co-operation and Development

Local Italian Context

- AdB: Autorità di Bacino
- CdF: Contratto di Fiume
- PUC: Piano Urbanistico Comunale

CHAPTER 1

THEORETICAL FRAMEWORK AND THE GENEALOGY OF WATER URBANISM



1.1. Background

1.1.1. General Background: The Hydrological Imperative

The global landscape is currently defined by a state of Climate Emergency, where traditional urban and territorial management practices are no longer sufficient to mitigate environmental volatility. As global temperatures rise, the Mediterranean region is increasingly subjected to a "polarization" of the hydrological cycle: long periods of severe drought are punctuated by violent, high-intensity rainfall events. These shifts do not exist in isolation but act as catalysts for a series of interconnected territorial problems that directly impact river basins like the Centa (EEA, 2020).

Climate-Induced Territorial Problems such as Intensified River Flooding, Accelerated Soil Erosion, Rising Sea Levels and Coastal Backwater, and Rising Sea Levels and Coastal Backwater. The increase in atmospheric moisture holding capacity leads to "flash flood" events, where the sudden volume of water entering a basin from its mountainous hinterland exceeds the discharge capacity of historical and artificial channels.

Higher runoff velocities, particularly in steep terrains like the areas surrounding Arnasco and Castelbianco, strip the land of its topsoil, increasing the sediment load that eventually settles and blocks river mouths in the lower plains (IPCC, 2022). As the sea level rises, coastal rivers face a "blocking" effect at their outlet; the river water is unable to drain into the sea, causing it to back up and flood urbanized coastal areas a critical threat for cities like Albenga. These natural stressors are amplified by human decisions such as urban sprawl and intensive soil sealing. When floodplains are covered by concrete or greenhouses, the land loses its natural "sponge" capacity, turning seasonal fluctuations into catastrophic disasters.

The convergence of these factors flooding, erosion, and sea-level rise creates a scenario where the "rigid" engineering solutions of the past, such as cement fences and fixed embankments, are becoming obsolete and dangerous. It is within this context of global fragility and local risk that we must introduce Water Urbanism as a necessary paradigm shift for the survival and development of the territory.

The discipline of Water Urbanism emerged as a critical response to the systemic decoupling of urban development from the natural water cycle. Historically, the expansion of the built environment was predicated on the assumption that land could be permanently reclaimed from water through the use of "hard" engineering solutions. This background is rooted in the transition from the 19th-century "Sanitary City," which sought to hide water underground to ensure public health, to the 21st-century "Resilient City," which recognizes water as the primary architect of the territory.

Water Urbanism is founded on the premise that the urban fabric is an integral component of the watershed. A shift in perception defines the background of this field: water is no longer viewed as a "technical object" to be managed by a single department of civil engineering, but as a "territorial project" that requires an interdisciplinary approach. This involves a return to "hydro-morphological" intelligence, where the physical form of the city is designed to accommodate the inherent fluctuations of the hydrological system

The current territorial condition is shaped by a recognized climate emergency in which conventional approaches to urban and landscape management are no longer adequate (IPCC, 2022). Rising global temperatures have intensified the hydrological cycle, particularly in Mediterranean regions, where prolonged drought periods are increasingly interrupted by short, high-intensity precipitation events (EEA, 2020). This "polarization" of hydrological regimes generates cascading territorial risks that directly affect river basins such as the Centa. Increased atmospheric moisture leads to flash flooding, especially in catchments characterized by steep topography, while accelerated runoff contributes to soil erosion and sediment transport from upland areas toward river mouths (IPCC, 2022). In coastal contexts, sea-level rise further compounds flood risk by creating backwater effects that obstruct river discharge into the sea, exposing low-lying urbanized plains, such as Albenga, to recurrent inundation (EEA, 2020). These natural pressures are amplified by anthropogenic transformations, including urban sprawl, intensive soil sealing, and greenhouse agriculture, which significantly reduce the landscape's capacity to absorb and retain water. As a result, rigid engineering solutions inherited from the twentieth century, such as fixed embankments and concrete barriers, are increasingly ineffective and, in some cases, counterproductive. It is within this condition of systemic fragility that Water Urbanism emerges as a necessary

paradigm shift, redefining water not as an adversary to be excluded but as a structuring element of territorial resilience.

1.1.2. Water Urbanism: Foundations and Territorial Impacts

Water Urbanism is defined as an interdisciplinary field of theory and practice where the hydrological cycle serves as the primary driver for territorial organization and urban form. Rather than treating water as a discrete technical constraint, Water Urbanism conceptualizes it as a "structural backbone". As established by scholars such as Kelly Shannon and Bruno De Meulder (2008), it is an approach that transcends the boundaries of traditional civil engineering, using the movement, storage, and filtration of water as the medium through which the landscape is read and the city is designed. It suggests that the urban fabric and the water system are part of a singular, complex socio-ecological metabolism.

The implementation of Water Urbanism principles generates multifaceted impacts across the territorial system. Hydraulic Impact focuses on the reduction of peak discharge and the increase in the "time of concentration" through the restoration of landscape roughness (Ahern, 2011). Ecological Impact which the implementation facilitates the creation of Blue-Green Corridors that support biodiversity and improve the urban microclimate through evapotranspiration.

Social and Aesthetic Impact, the methodology enables the conversion of residual "infrastructure zones" into high-quality public spaces, daylighting hidden watercourses, and reconnecting the citizenry with the natural rhythms of the territory. And last, Economic Impact provide long-term protection of the agricultural sector, particularly vital in contexts like the Albenga plain, by preventing saltwater intrusion and ensuring sustainable groundwater recharge. By repositioning the hydrological cycle at the center of the planning process, Water Urbanism moves beyond mere risk mitigation toward a holistic model of urban-natural integration.

1.1.3. Different Views of Water Urbanism Theory: The Paradoxes

The integration of hydrological systems into the built environment is hindered by three fundamental paradoxes. These contradictions define the current struggle between the "crystallized" urban form of Albenga and the dynamic nature of the Centa River.

a. The Paradox of Resistance vs. Resilience

Traditional urban theory is rooted in the concept of Resistance, where the river is viewed as a hostile entity to be excluded through "Gray Infrastructure" (fixed embankments, cement fences, and culverts). This approach creates a binary condition: the system is either "safe" or "failed." On the other hand, modern Water Urbanism theorizes Resilience through the strategic use of "sacrifice" (Ahern, 2011).

Instead of total exclusion, resilience accepts that water must go somewhere; therefore, certain urban areas such as public parks, plazas, or "abandoned spaces" are designed to flood intentionally.

By "sacrificing" these permeable zones to store water during peak discharge, the pressure is relieved from high-density residential fabric, preventing the catastrophic failure seen in 3-meter flood scenarios (Pahl-Wostl, 2015).

b. The Static-Dynamic Paradox

A fundamental friction exists between the two disciplines: Urbanism is inherently a discipline of static objects (permanent buildings, rigid railway lines, and paved roads), whereas water is a discipline of constant flux. The history of the Centa shows a river that naturally wants to meander and shift its bed, while the city attempts to "freeze" it in a Medieval alignment.

This thesis explores the view that "permanent" urban structures must be designed to accommodate "temporary" hydrological states. This means creating a dual-state urbanism infrastructure that functions as a high-quality public space during dry periods but transforms into a functional drainage or storage element during the "temporary" state of a flash flood (Shannon *et al*, 2008).

c. The Paradox of Scarcity and Abundance

Particularly in Mediterranean climates like Albenga's, planning must manage the contradiction of seasonal extremes. The territory is trapped between the abundance of violent flood peaks and the scarcity of prolonged summer droughts (EEA, 2020).

Current "defensive" infrastructure is designed solely to move "abundant" water to the sea as quickly as possible, which inadvertently exacerbates scarcity by preventing the water from infiltrating the ground.

A Water Urbanism approach resolves this by treating flood peaks as an opportunity for capture and storage. By slowing the water down and restoration of landscape roughness, the system can combat aquifer depletion and saltwater intrusion, ensuring that the water "abundance" of the winter sustains the agricultural sector during the "scarcity" of the summer.

1.1.5. Area Context: The Regional Dynamics of the Albenga Plain

While the theoretical foundations of Water Urbanism are derived from a global body of research and international case studies, their practical applicability must be rigorously tested within specific territorial contexts. In this research, such testing is conducted within the regional setting of the Albenga Plain (Piana di Albenga) in Liguria, a territory that represents a particularly intense intersection between Mediterranean fluvial dynamics and highly specialized agro-urban systems.

The regional framework is defined by the Centa River basin, a relatively short yet hydraulically aggressive catchment that descends rapidly from the Maritime Alps toward the Tyrrhenian Sea. This abrupt transition from mountainous terrain to coastal plain generates a condition of concentrated hydrological energy, with rapid runoff, high sediment loads, and limited spatial capacity for natural dissipation. The Piana di Albenga functions as the terminal alluvial interface of this system, a landscape historically shaped by fluvial deposition that has enabled high agricultural productivity, yet one that remains intrinsically hydro-geologically fragile.

At the same time, the territory is subject to intense anthropogenic pressure. The expansion of greenhouse agriculture, combined with successive phases of urban growth, has significantly reduced soil permeability and disrupted natural infiltration processes. These transformations have altered the hydrological balance of the plain, increasing surface runoff and amplifying the vulnerability of both agricultural and urban systems to extreme rainfall events.

At the regional scale, Albenga thus operates as a critical “hydrological filter” for the entire basin, where fluvial sediment transport, coastal dynamics including storm surges and urban expansion converge. It is precisely within this zone of overlap and conflict that the need for a Water Urbanism approach becomes most evident. Rather than addressing water solely as a technical constraint, the Piana di Albenga demands an integrated strategy capable of reconciling hydraulic safety, agricultural productivity, urban livability, and ecological continuity within a resilient and adaptive territorial framework.

1.2. Research Problem and Questions

In many historical European coastal regions, the tension between modern urban protectionism and natural hydrological systems has increasingly led to a profound disconnection from traditional landscapes. The prevailing model of rigid flood defense characterized by concrete embankments and the artificial redirection of watercourses has often been promoted as the only means to ensure urban safety and regional economic stability. However, existing research and practice in riverine urbanism have historically prioritized hydraulic efficiency and risk mitigation over the socio-cultural and ecological continuity of the city. Little is known about how these technical interventions transform the everyday life, spatial identity, and collective memory of communities whose origins are deeply tied to the water. In the case of Albenga, mainstream engineering frameworks have proven ill-suited to the complex realities of a city whose "City-Water" interface is a fundamental component of its historical and environmental heritage.

Albenga provides a particularly revealing context for this gap. Founded and developed through a symbiotic relationship with the Centa River, the city’s urban morphology was traditionally defined by its proximity to fluvial resources. Yet, following catastrophic flood events and subsequent governmental decisions to divert the river’s flow, this ancestral bond has systematically fractured. The river, once the socio-economic heart of the territory, has been marginalized into a "hidden hydraulic liability," separated from the historical center by high-impact infrastructure and administrative barriers. The socio-spatial implications of this separation for a city of such archaeological and cultural significance remain under-addressed within contemporary urban planning scholarship.

This research addresses this gap by examining how historical flood management and urban expansion have reshaped the relationship between Albenga and its river, and how the Water Urbanism framework can better reconcile safety requirements with ecological and cultural reclamation. The central concern is not merely how to prevent flooding, but how the river can be re-integrated into the urban fabric as a functional and social nucleus. From this perspective, the central research question of this thesis is: How has the historical disconnection from the Centa River affected the economic, social, and environmental conditions of Albenga, and what Water Urbanism strategies can re-establish a resilient, multifunctional link between the city and its water resources?

To investigate this, the thesis expands the inquiry into three specific dimensions that address the multifaceted nature of the urban-river rupture. Environmentally and spatially, the research scrutinizes how the artificial alteration of the river's path has led to localized ecological degradation and a significant loss of permeable landscapes, while evaluating how the current spatial configuration of Albenga's waterfront serves as a physical obstruction that prevents citizens from meaningfully engaging with the fluvial environment. Socially and culturally, the study explores the ways in which the "barrier effect" of rigid embankments has eroded the community's sense of stewardship and historical identity, questioning whether this ongoing separation represents a permanent loss of cultural continuity for the "City of Towers." Finally, from an economic perspective, the inquiry examines how the marginalization of the riverfront and its perception as a hydraulic liability have stifled the potential for experiential tourism and hindered sustainable investment within the fertile agricultural "Piana," which remains disconnected from the city's urban core.

Finally, the study seeks to identify planning and design strategies specifically the Detention Green and Walkability systems capable of mitigating environmental risks while enabling Albenga to adapt, preserve its heritage, and prosper sustainably. The research evaluates how the spatial organization of the city can evolve from a defensive posture to a proactive, water-centric model, ensuring that the Centa River once again serves as the foundational structure for the region's long-term resilience.

1.3. Objectives of the study

The primary objective of this study is to systematically and comprehensively evaluate the multidimensional relationship between the historical urban fabric of Albenga and the

hydrological dynamics of the Centa River, aiming to formulate a strategic planning framework rooted in Water Urbanism. This framework seeks to ensure sustainable development by reconciling the imperative for flood resilience with the preservation of local heritage and the promotion of regional economic vitality. To realize this goal, the study first analyzes the historical and spatial evolution of the urban-river relationship, clarifying the mechanisms of spatial fragmentation caused by past hydraulic engineering and extreme flooding events that have disrupted Albenga's traditional connection to the water. Second, it identifies and evaluates the critical environmental and social impacts of hydrological instability, such as ecological degradation of the riparian corridor and the resulting social detachment from the riverfront, particularly focusing on the vulnerability of the historical center.

Third, the research assesses the economic potential and growth drivers inherent in a water-centric urban model, exploring how the revitalization of the riverfront can serve as a catalyst for shifting Albenga's economic structure from agricultural dependency toward experiential tourism and a service-oriented regional network. Fourth, the study aims to develop a set of planning principles and "Soft Engineering" solutions such as the Detention Green system to harmonize hydraulic infrastructure development with ecological conservation and the stabilization of local community life. Finally, the study puts forth an adaptable and scalable planning framework that may be applied to other Mediterranean coastal cities where historical settlements face comparable urbanization pressures, environmental risks, and spatial inequalities, ensuring that large-scale interventions remain sensitive to local urban morphology and indigenous values.

1.4. Scope and Limitations

The Aim: Applying Water Urbanism to the Context

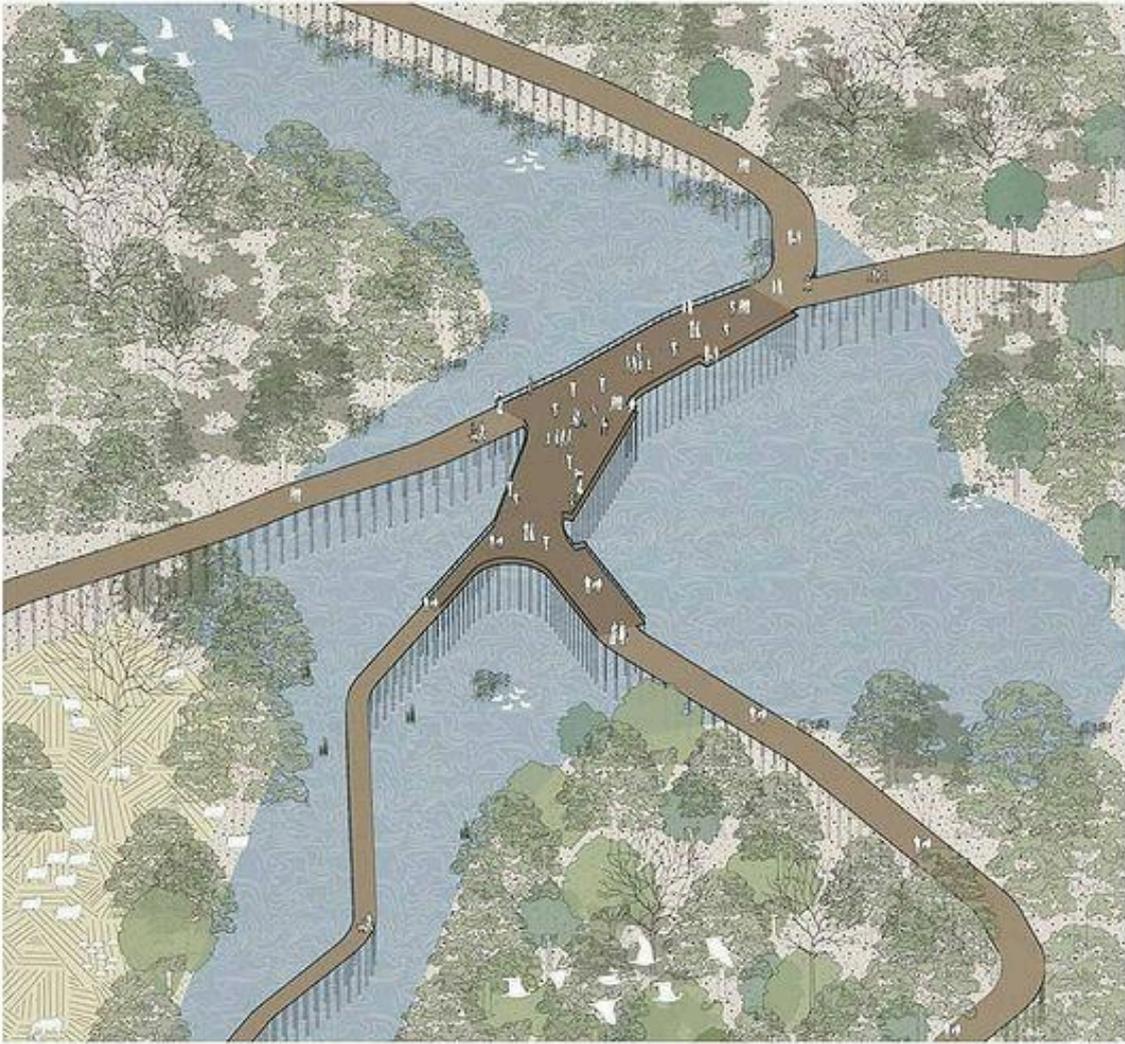
The application of the Water Urbanism framework to Albenga aims to produce a transformative planning model that transcends mere disaster mitigation, focusing instead on the qualitative and social reclamation of the urban-agricultural landscape. To achieve this, the proposal first seeks to restore connectivity by systematically challenging the "barrier effect" of existing embankments through morphological transformations, such as terracing, ramps, and floodable platforms, which allow citizenry to safely access and utilize the fluvial space once again. Furthermore, the project aims to re-conceptualize the river, transforming the

watercourse from a hidden hydraulic liability into a multifunctional linear park that fosters a renewed sense of stewardship and resource awareness by reopening the physical relationship between the urban center and the water's edge.

Simultaneously, the strategy focuses on integrating sustainable infrastructure through the implementation of Sustainable Urban Drainage Systems (SuDS) within the agricultural "Piana," effectively converting greenhouses from runoff-generating surfaces into rainwater-capturing nodes to stabilize the local water cycle and protect the plain's fertility. Finally, the proposal seeks to modernize the "City-Water" interface, leveraging the historical identity of Albenga as the "City of Towers" to create a contemporary waterfront. This modernization process ensures that archaeological heritage is respected while embracing modern hydrological resilience, ultimately positioning the city as a resilient and culturally vibrant Mediterranean hub.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORKS



2.1. Water Urbanism: Concepts and Global Paradigms

2.1.1. Theoretical Underpinnings: The Symbiosis of Water and Form

The conceptual framework of Water Urbanism posits that water is the primary medium through which the urban territory is organized. In contemporary literature, this is increasingly framed as a move away from "Defensive Urbanism" to "Integrated Water Management." The core concept relies on the Hydro-Social Cycle (Swyngedouw, 2009), which acknowledges that the flow of water is inextricably linked to social structures, power dynamics, and urban morphology.

The implementation of Water Urbanism relies on two key technical and conceptual pillars. The first is the notion of landscape as infrastructure, which posits that natural systems, such as floodplains, wetlands, and forests. These perform as essential ecosystem services, including water retention, filtration, and risk mitigation, often with greater adaptability and long-term efficiency than conventional gray infrastructure (Ahern, 2011). The second pillar is Water-Sensitive Urban Design (WSUD), a multidisciplinary planning and design approach that integrates stormwater, groundwater, and wastewater management into the spatial and architectural structure of the city, promoting decentralized, resilient, and context-sensitive solutions (Fletcher *et al.*, 2015).

2.1.2. Water Urbanism and the Sustainable Development Goals (SDGs)

The adoption of Water Urbanism is inherently tied to the global agenda for Sustainable Development. By addressing the intersection of liquid and solid urbanism, this framework contributes to three specific dimensions of sustainability:

Environmental Sustainability (SDG 6 & 13) by restoring natural drainage paths and enhancing soil permeability, Water Urbanism mitigates the "flash flood" risks associated with climate change. It promotes biodiversity by creating aquatic habitats and improves urban microclimates, thereby reducing the carbon footprint of the city through natural cooling (UN, 2015).

From a social standpoint, Water Urbanism advances the goals of SDG 11 (Sustainable Cities and Communities) by counteracting the spatial and cultural

disconnection produced by hard engineering solutions. Rather than isolating rivers behind embankments, this approach emphasizes inclusive design strategies that transform riverbanks and floodplains into accessible, democratic public spaces. Through practices such as the daylighting of buried watercourses, Water Urbanism restores the cultural, recreational, and symbolic value of water landscapes, contributing to collective well-being and place identity (Meyer *et al.*, 2014).

Economically, Water Urbanism aligns with SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production) by promoting blue-green infrastructure as a cost-effective alternative to gray systems over the long term. By reducing flood damage, preventing saltwater intrusion, and safeguarding fertile agricultural soils, these strategies protect the primary productive assets of vulnerable territories and enhance their long-term resilience.

2.1.3. Global Paradigms and Strategic Examples

The literature identifies several "Global Paradigms" that have successfully translated these concepts into large-scale urban transformations. These examples serve as the empirical evidence for the strategies proposed in this thesis:

a. The "Sponge City" Initiative (China)

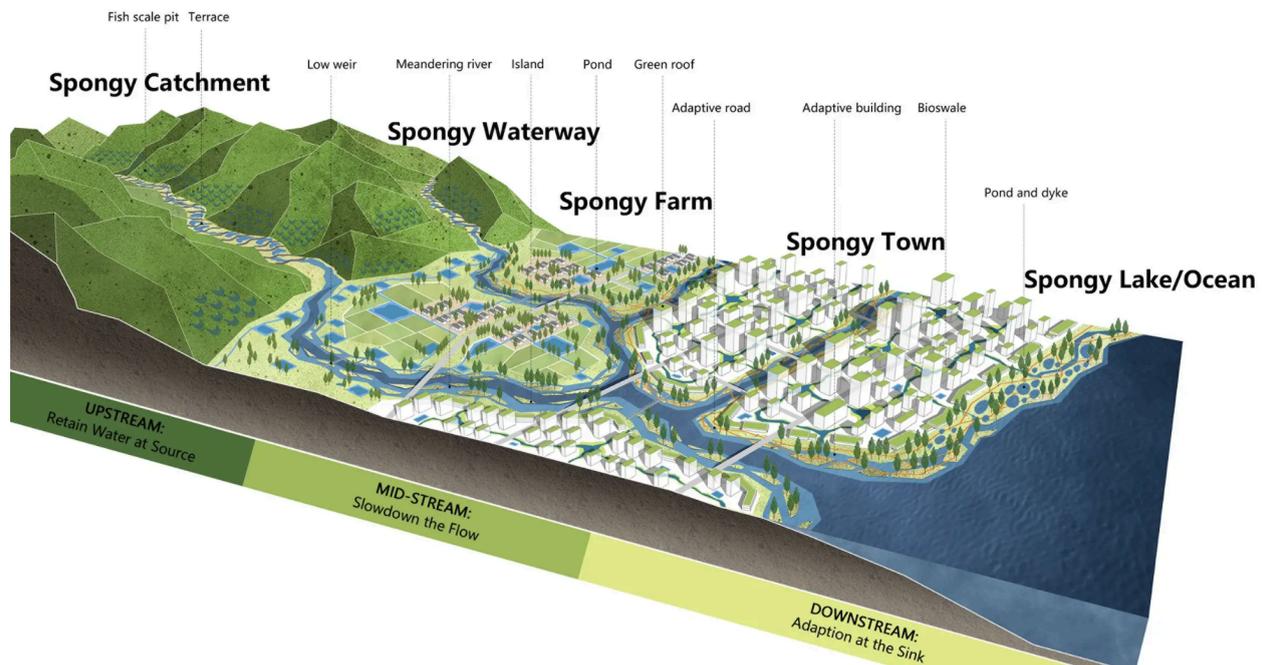


Figure 1 - Image showing schematic representation of the Sponge city concept

(Source: Newsmaker, Kongjian Yu, Architectural Record)

The Sponge City model, championed by Kongjian Yu, is the most comprehensive application of "Negative Planning." In this model, the hydrological "skeleton" is defined first, ensuring that at least 70% of rainwater is captured, reused, or absorbed on-site.

Key Lesson: The transition from "centralized" drainage to "decentralized" infiltration, utilizing "eco-patches" and "green fingers" to manage territorial runoff.

b. "Room for the River" (The Netherlands)

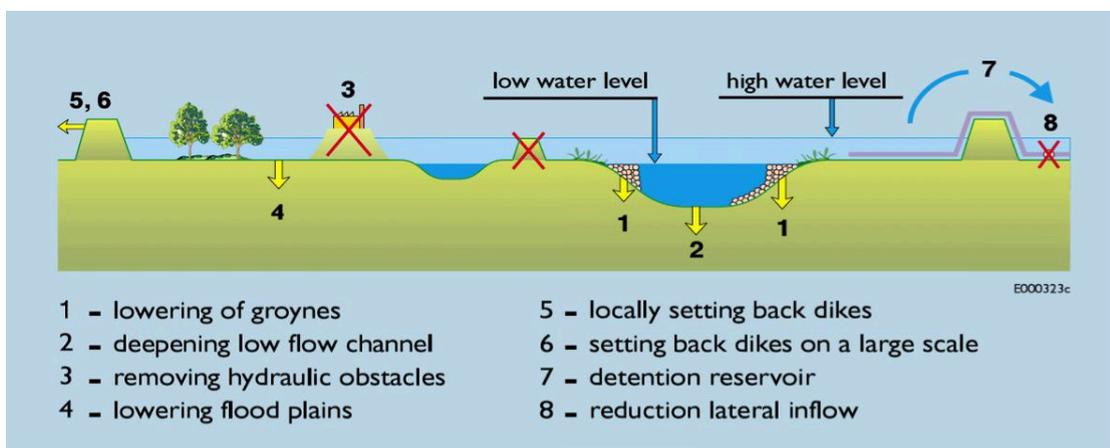


Figure 2 - Schematic representation of the Room for river concept (Source: Room for the river: plenty of possibilities)

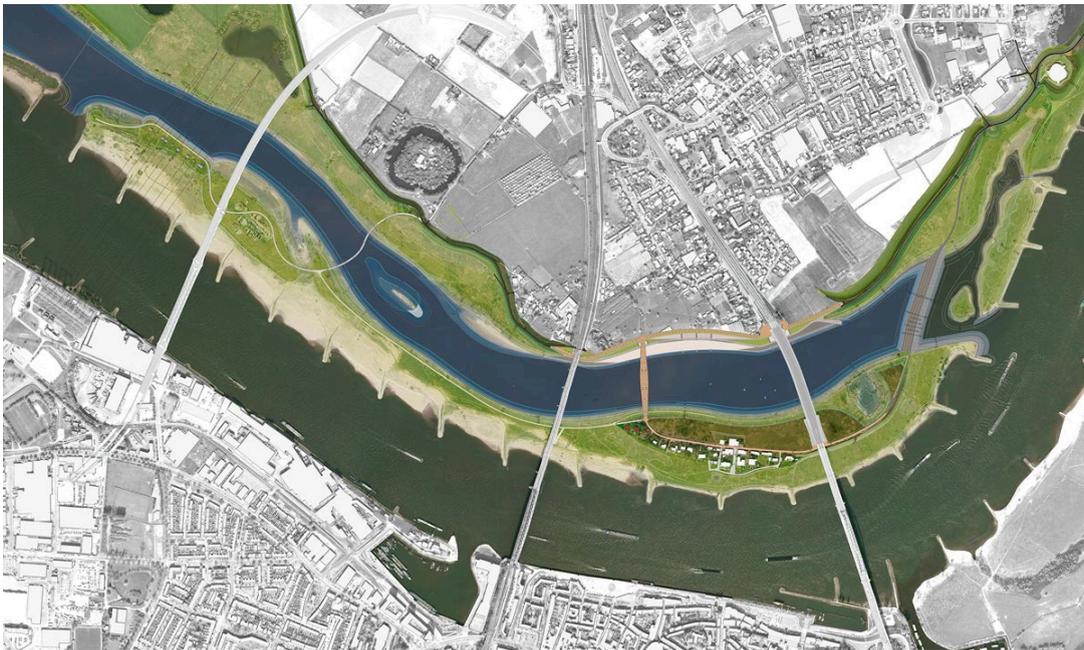


Figure 3 - Master plan of 'The Room for river' (Source:Room for the River, Nijmegen, The Netherlands, H+N+S Landscape Architects)

This national strategy represents a paradigm shift from "fighting the water" to "living with the water." Instead of reinforcing dikes, the Dutch government moved them inland, allowing the river to expand safely into designated floodplains during high-water events.

Key Lesson: The use of "controlled inundation" as a safety mechanism that allows for the coexistence of agricultural production and hydraulic security.

c. The Emscher Park (Germany)



Figure 4 - Aerial view of the Emscher park (Source:Nature and water adventure park "Emscherland", Recklinghausen Tourism)

The restoration of the Emscher River system proves that even highly industrialized and polluted watercourses can be reclaimed. The project utilized a "decentralized" approach to separate clean rainwater from industrial wastewater, restoring the river's ecological function.

Key Lesson: The transformation of "industrial scars" and hydraulic infrastructure into linear parks that serve as regional economic drivers.

To resolve the paradoxes of the Centa River, the research draws upon global strategic examples where the hydrological cycle has been successfully reintegrated into the urban and productive fabric. These cases serve as a "toolkit" of transferable devices that move beyond traditional engineering toward a multi-functional landscape.

- Decementification and River Restoration in Dense Urban Contexts

In high-density areas, the transformation of the riverbed from a technical "barrier" into a public asset requires the removal of rigid infrastructure to restore ecological and social connectivity.

d. Isar-Plan (Munich, Germany)

This project demonstrates the power of renaturalization through widened sections and the introduction of gravel banks, which simultaneously improve flood management and provide public accessibility to the water.



Figure 5 - The Esar plan (Source:isarplan)



Figure 6 - Aerial view of the Esar river proposal (Source: Isar-Plan, Wasserwirtschaftsamt München)

e. Cheonggyecheon (Seoul, South Korea)

The removal of an elevated highway to reopen a buried watercourse serves as a primary example of daylighting. This intervention mitigated the "barrier effect" and improved the urban microclimate through natural cooling.



Figure 7 - Sketch Plan & Section of Bishan - Ang Mo Kio Park (Source: Cheonggyecheon Stream & getting there, Korea To Do)

- "Room for the River" as a Spatial Grammar

Managing the Centa requires more than defensive embankments; it necessitates a set of "spatial devices" that allow the river to expand safely into designed "sacrifice spaces".

f. Yarra River Management (Melbourne, Australia)

This approach treats the river corridor as essential landscape infrastructure, balancing ecological health with urban development through integrated catchment management.



Figure 8 - Image showing the design of Yarra river. (Source: Photo Walk, Karn Bulsuk)

- Agro-Hydraulic Cases: Agricultural Plains and Widespread Drainage

Given that Albenga's greenhouses represent significant impermeable surfaces, precedents that merge productivity with rainwater management are critical.

g. Fens and Polder Landscapes (UK/NL)

These regions manage water levels within vulnerable agricultural areas, treating canals not just as drainage but as productive infrastructure.

h. WSUD in Peri-Urban Catchments (Australia)

The implementation of flood control basins, swales, and rain gardens provides widespread management in fragmented basins similar to the Albenga plain.

SuDS Retrofitting: Projects focusing on transforming large-scale productive roofs (warehouses or greenhouses) into "catchment devices" provide a direct logic for retrofitting Albenga's agricultural fabric.

- River-Sea Interfaces: Coasts, Estuaries, and Backwaters

Albenga's estuary faces specific "backwater" issues where the river and sea collide, necessitating nature-based coastal defenses.

i. Delta Works / Nature-Based Defenses (NL)

While technologically complex, these interventions embody a hybrid logic of soft coastal protection, combining advanced engineering techniques with nature-based solutions. Rather than relying exclusively on rigid structural defenses, such approaches integrate ecological processes such as habitat creation, sediment dynamics, and vegetative stabilization into the management of storm surges and coastal erosion.

j. Dune Restoration and Estuary Projects (UK/FR)

These soft engineering approaches combine public space with flood protection, utilizing natural beach and dune morphology to absorb sea-level rise.

- Blue-Green Infrastructure as Planning Policy

To link theory with the governance issues identified in Albenga, strategic planning must enable multi-functionality through design.

k. Copenhagen Cloudburst Plan (Denmark)

In this framework, streets, plazas, and green areas no longer serve solely recreational, social, or circulatory functions; they operate simultaneously as multifunctional urban infrastructure. Rainwater is captured, temporarily stored, and conveyed through permeable surfaces, vegetated swales, and engineered depressions, creating a network of interconnected hydraulic corridors. This dual-purpose strategy exemplifies a paradigm shift in urban design, where public space becomes both a civic amenity and a resilient mechanism for flood management, reinforcing the broader objectives of Water Urbanism by integrating ecological, social, and technical performance within the city fabric.



Figure 8.2 - Condition in Copenhagen after cloudburst. (Source: Sound of Green, The cloudburst that changed Copenhagen and urban water management)

Copenhagen Cloudburst Plan

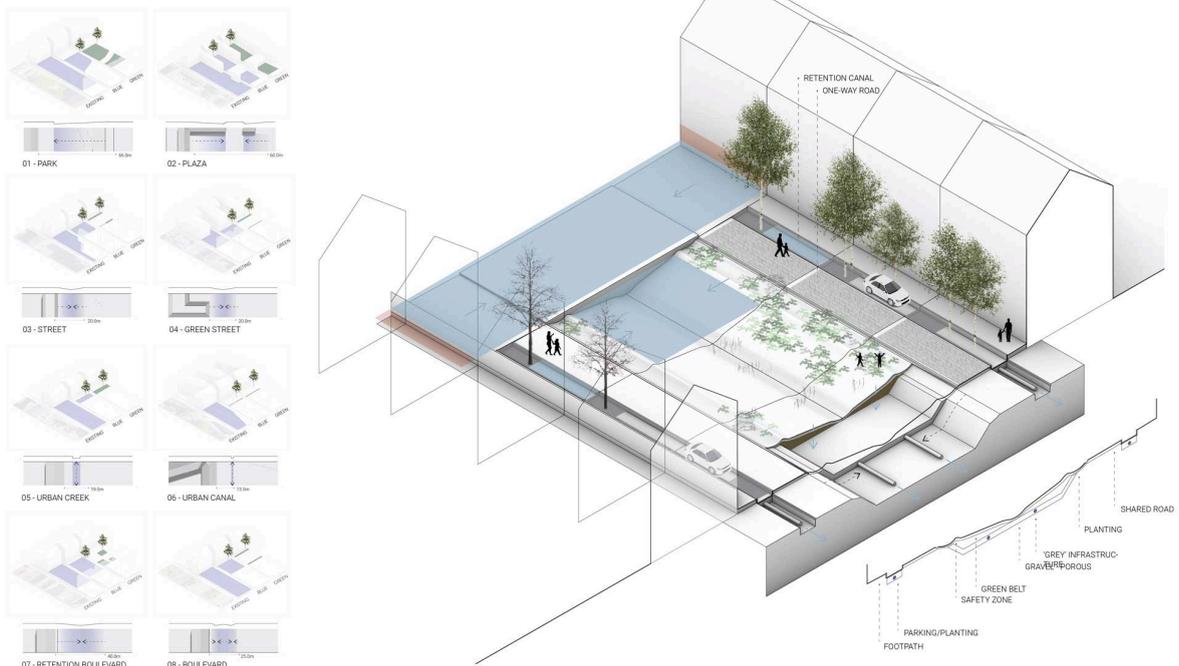


Figure 9 - Schematic representation of the Copenhagen cloudburst plan (Source: Copenhagen Cloudburst Plan, Harvard Graduate School of Design)

1. Rotterdam Water Squares (De Urbanisten, NL)

These squares represent the "Static-Dynamic Paradox" in practice: they function as active sports and social hubs when dry, but transform into temporary water storage basins during heavy rain.



Figure 10 - Aerial view of the Rotterdam water squares (Source: Water square Benthemplein, De Urbanisten.)

2.1.4. Synthesis: Towards a "Mediterranean Water Urbanism."

The literature review indicates that while global case studies of Water Urbanism provide a comprehensive toolkit of design strategies, policy frameworks, and ecological interventions, their direct application to Mediterranean contexts requires careful adaptation. Unlike the relatively steady and predictable river systems of Northern Europe, Mediterranean watercourses are characterized by extreme seasonality, marked by prolonged dry periods interspersed with short, intense rainfall events. These hydrological fluctuations produce a highly dynamic regime, where flow volumes, sediment transport, and flood risk vary dramatically within a single annual cycle.

Consequently, the application of Water Urbanism in the Mediterranean context must emphasize elasticity: the capacity of urban and landscape systems to flexibly contract or expand their functional roles in response to changing hydrological conditions. Under dry conditions, river corridors may function as social and recreational spaces, agricultural zones, or ecological habitats. During periods of high discharge, the same

areas must accommodate temporary water storage, sediment retention, or flood conveyance. This duality necessitates the design of multifunctional, adaptive infrastructure and public spaces that integrate ecological performance with urban utility.

By prioritizing elasticity, Mediterranean Water Urbanism reinterprets the river not as a static hazard to be contained but as an active, operational element of the urban fabric. Such an approach allows cities to maintain continuity in social, economic, and ecological functions while responding dynamically to the unpredictable and highly variable hydrological patterns characteristic of the region.

2.2. Case Study

2.2.1. Buffalo Bayou Park, Houston (USA)

Designer: SWA Group

Role: Resilience Research & Landscape Infrastructure

Buffalo Bayou Park is the primary "Resilience Case Study" cited by SWA Group to demonstrate how public space can function as critical flood infrastructure.

a. Context and Problem

Houston is a "flat" city with a humid subtropical climate, prone to catastrophic flooding. Buffalo Bayou is the city's main drainage artery. Historically, the bayou was channelized and stripped of vegetation, leading to massive erosion and siltation during storm events.

b. Design Strategies: "Designed to Flood."

Instead of establishing robust dike systems, SWA Group's "Soft Engineering" strategy has focused on restructuring the terrain and ecosystem for sustainable hydrological management. By implementing riverbank regrading, the drainage capacity of the channel is significantly increased, while also minimizing flow velocity during flood events. Infrastructure within the park area, including stairs, lighting fixtures, benches, and signage, is engineered to function normally even in complete submersion; the lighting fixtures are treated with specialized waterproofing, and the railings are

designed to withstand impact from floating objects. The effectiveness of this solution is reinforced by the native riverside vegetation, with over 14,000 woody plants and 300,000 flood-tolerant species, acting as a biological filter and natural binding structure that helps stabilize the soil and effectively prevent erosion.

c. Performance and Data (Hurricane Harvey Test)

In terms of practical effectiveness, the project has demonstrated superior operational capabilities through quantitative indicators of resilience and socio-economic impact. During Hurricane Harvey in 2017, although the entire park was submerged under 12 meters (39 feet) of water, the design structure remained intact while traditional gray infrastructure in Houston faced widespread collapse. Economically, this adaptive model saved an estimated \$2.75 million in potential damage costs and acted as a crucial catalyst attracting over \$2 billion in private investment to neighboring urban areas. Furthermore, environmental benefits were optimized through the permeable landscape system, which prevents and treats approximately 84,000 gallons of surface runoff annually, contributing to reduced pressure on the urban drainage system and improved water quality in the area.



Figure 11 - Sketch Plan & Section of Bishan - Ang Mo Kio Park (Source: Atelier Dreiseitl)



Figure 12 - Sketch Plan & Section of Bishan - Ang Mo Kio Park (Source: Atelier Dreiseitl)

2.2.2. Bishan-Ang Mo Kio Park (Singapore)

Designer: Ramboll Studio Dreiseitl

Program: ABC Waters (Active, Beautiful, Clean Waters)

Bishan-Ang Mo Kio is the global gold standard for "De-concretization," transforming a dead drainage canal into a living river.

a. Context and Problem

Built in 1988, the park was bisected by a 2.7 km straight concrete canal. This canal was a safety hazard; during monsoons, water levels rose instantly, trapping people behind fences. Ecologically, the canal was a "dead zone" that provided zero habitat.

b. Design Strategies: "River Naturalization."

The strategy for re-establishing the ecosystem in the area is implemented through a process of surface clearing and topographic restructuring based on the principle of material recycling. De-concretization is carried out by removing and crushing existing concrete slabs, then utilizing this recycled material to create new elevated areas, notably

the "Recycle Hill", a structure that serves both as a high-altitude observation point and an on-site construction waste disposal solution. To stabilize the newly established meandering riverbank system, the project has applied 10 different soil bioengineering techniques, including vegetated gabions, fascines, and geotextiles, marking the first time these technologies have been successfully applied in a tropical climate. In addition, a cleaning biotope system has been systematically integrated, utilizing mechanical filtration layers and specialized aquatic vegetation to treat natural water sources, ensuring ecological standards are met before the water reaches downstream areas.

c. Performance and Data

In terms of operational and practical effectiveness, the transformation of the river to its natural form has expanded the floodplain width from 24 meters to 100 meters, significantly increasing water storage capacity and enhancing the hydrological regulation of the entire park area. The improvement in environmental quality has led to a 30% increase in biodiversity, with the reappearance of rare species such as the smooth-coated otter and the red heron right in the heart of the urban area. In terms of social impact, the project has attracted twice the number of annual visitors, from 3 million to 6 million, affirming the value of public spaces in community engagement. Notably, financial analyses show that the river naturalization method costs 15% less than the budget estimate for rebuilding a traditional concrete canal system, demonstrating the feasibility and economic efficiency of a sustainable green infrastructure model.

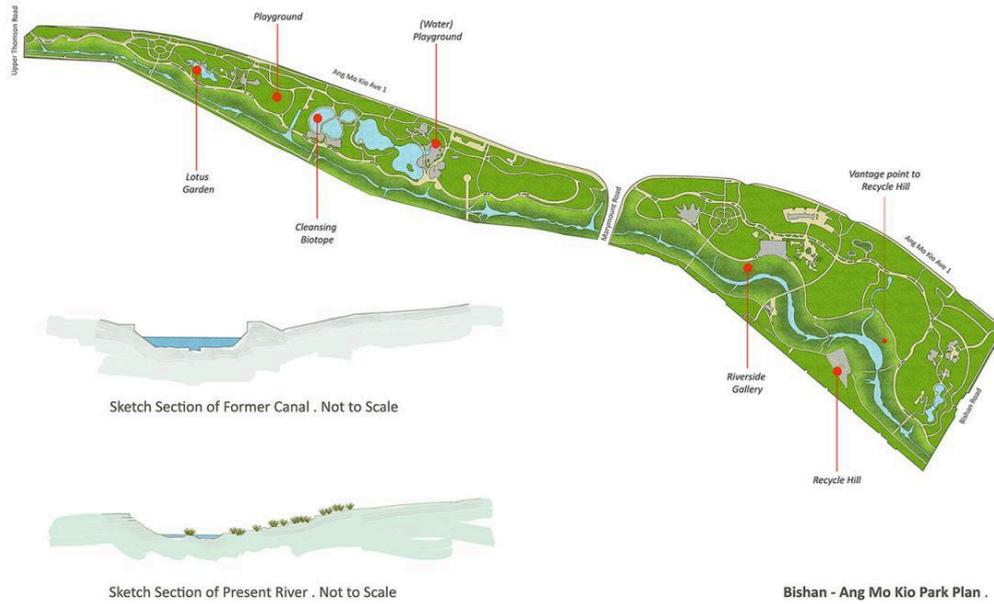


Figure 13- Sketch Plan & Section of Bishan - Ang Mo Kio Park (Source:Atelier Dreiseitl)



Figure 14 - Bishan Park (before), Bishan - Ang Mo Kio Park (after). (Source: Atelier Dreiseitl)

2.3. Planning Ambiguity and Governance Complexity in Urban Development

2.3.1. The "Fragmentation" Problem: Institutional Overlap

A significant obstacle to the practical implementation of Water Urbanism strategies is the fragmentation of jurisdictional authority over fluvial systems. By their very nature, rivers and associated hydrological networks transcend administrative boundaries, yet governance frameworks remain compartmentalized along institutional lines. This thesis identifies a recurring “governance gap,” wherein a single river system is simultaneously managed by multiple entities with often divergent objectives. Hydraulic authorities, such as the *Autorità di Bacino* in the Italian context, prioritize flood control, structural security, and risk mitigation. Municipal planning offices focus predominantly on land use regulation, zoning compliance, and local economic development. Environmental agencies, in contrast, are tasked with safeguarding biodiversity, water quality, and ecological continuity.

The intersection of these overlapping authorities generates a condition of planning ambiguity. For example, proposals that envision multifunctional interventions such as “floodable parks” frequently encounter institutional inertia: they are considered too ecologically oriented for hydraulic engineers, yet too hydraulically sensitive or “wet” for conventional urban planners. Such projects, despite their potential to integrate risk mitigation, ecological restoration, and public amenity, often remain caught in legal and bureaucratic limbo.

This thesis argues that without the establishment of a unified governance framework such as a River Contract (*Contratto di Fiume*) or an equivalent integrated management model Water Urbanism initiatives risk being delayed or abandoned due to institutional friction and jurisdictional fragmentation (OECD, 2015; Magnaghi, 2010). A coordinated, multi-stakeholder governance structure is therefore essential, enabling hydraulic, urban planning, and environmental objectives to be aligned, and providing a procedural and legal foundation for adaptive, landscape-based interventions that reconcile ecological, social, and economic goals along the river corridor.

2.3.2. Legal Ambiguity: Land Use vs. Fluctuating Landscapes

Modern planning law is predominantly predicated on the concept of the “static plot,” wherein each parcel of land is assigned a fixed and permanent function, often codified through zoning regulations and land-use permits. This framework inherently assumes stability and predictability, prioritizing clarity in ownership, liability, and management responsibilities. Water Urbanism, however, challenges this paradigm by introducing the notion of multi-stage or multifunctional land use, in which a single site can assume multiple, seasonally or event-driven roles, for example, functioning as a recreational park during dry periods and as a flood retention basin during periods of high water.

This shift introduces a critical complexity within governance systems: the legal liability associated with public space. If a public park is intentionally designed to flood, questions arise concerning safety protocols, routine maintenance, and insurance responsibilities. Such scenarios highlight the tensions between innovative landscape-based risk management and existing regulatory structures. The ambiguity surrounding “who is accountable when the park floods” often discourages planners and local authorities from implementing adaptive, resilient strategies. Instead, there is a tendency to favor the perceived security of rigid, gray infrastructure such as concrete embankments or floodwalls over the ecological and social benefits of dynamic, multifunctional landscapes (Ahern, 2011; Hooimeijer *et al.*, 2018).

This governance and legal constraint underscores a fundamental challenge for Water Urbanism: the need to develop integrated policy frameworks, liability protocols, and design standards that explicitly accommodate temporally variable land uses. By reconciling regulatory clarity with adaptive landscape functionality, planners can enable sites to operate simultaneously as ecological buffers, social spaces, and hydrological management systems, thereby realizing the full potential of resilient, multifunctional urban landscapes.

2.3.3. The Top-Down vs. Bottom-Up Conflict

The tension between regional safety mandates and local community needs further amplifies the complexity of governance in fluvial urban systems. Top-down mandates issued by regional authorities frequently establish designated “buffer zones” along river corridors, within which new development is strictly prohibited. From a technical

standpoint, these measures are effective in reducing exposure to flood risk and ensuring territorial safety. However, for local communities, such restrictions are often perceived as rigid “land-use freezes” that constrain economic activity, limit opportunities for agricultural expansion, and inhibit the adaptive growth of the urban fabric. This perception can generate socio-political friction, undermining compliance and stakeholder engagement.

Conversely, bottom-up resistance emerges as a result of historical disconnection between the public and the river. The proliferation of hard embankments and other structural flood defenses has physically and socially alienated communities from their watercourses, severing long-standing cultural and functional relationships with the hydrological environment. When contemporary, “porous” strategies such as floodable parks or multifunctional green corridors are proposed, they often encounter skepticism and lack of trust. Local populations, having been excluded from active interaction with the river for generations, may question the safety, effectiveness, and maintenance of adaptive interventions (Swyngedouw, 2009; Watson, 2014).

This dual tension between top-down regulatory imperatives and bottom-up community expectations illustrates a fundamental challenge for Water Urbanism: the design and implementation of interventions must simultaneously satisfy technical safety criteria and cultivate social legitimacy. Addressing this governance paradox requires participatory planning mechanisms, transparent risk communication, and co-designed adaptive strategies that integrate ecological function with cultural and economic values, thereby bridging the gap between engineered security and community-centered resilience.

2.3.4. Toward a "Hydro-Governance" Model

This thesis theorizes that the transition to Water Urbanism requires a new form of Hydro-Governance. This model moves away from "Sectoral Planning" toward "Integrated Territorial Management." The complexity of governance should not be seen as a barrier, but as a design driver. This thesis argues that the "Project" is not just a spatial design, but the creation of a governance framework that can manage the inherent uncertainty of the water system (Pahl-Wostl, 2015).

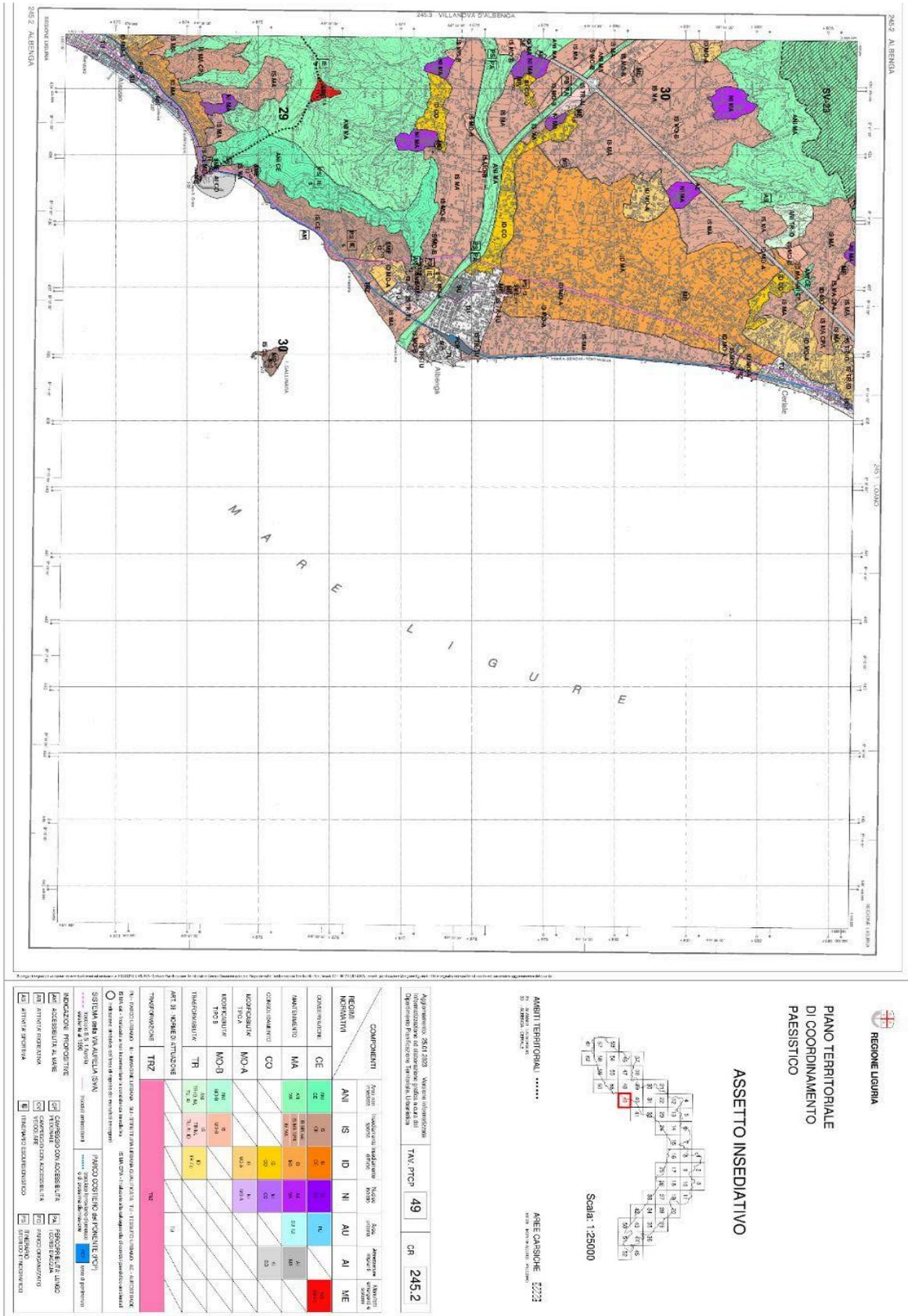


Figure 15 - Piano Territoriale di Coordinamento Paesistico (Source: Il Piano Territoriale di Coordinamento, Provincia di Savona)

CHAPTER 3

STUDY AREA AND RESEARCH METHODOLOGY



3.1. Study Area Selection and Documentation

3.1.1. Rationale for Site Selection: The Albenga Interface

The selection of Albenga as the primary focus of this research is grounded in its status as the largest and most significant alluvial plain in the Liguria region, representing a unique territorial “hinge” between the Maritime Alps and the Tyrrhenian Sea. The Piana di Albenga is characterized by an intensive overlap of diverse land uses, producing a high degree of territorial complexity that encompasses urban, agricultural, infrastructural, and ecological components.

Geomorphologically, the plain occupies a position of primacy within the regional landscape, being the sole coastal plain capable of simultaneously supporting both large-scale agricultural production and consolidated urban systems. This condition is the cumulative outcome of long-term sediment transport processes driven by the Centa River, which over millennia has deposited fertile alluvial materials, forming an expansive, relatively flat surface at the river’s mouth. Consequently, the territory has historically functioned as a strategic interface, where fluvial dynamics, coastal processes, and human settlement converge, shaping both the landscape and socio-economic systems.



Figure 16 - Panoramic view of the Centa river (source - Author)

The strategic importance of the Piana di Albenga is further accentuated by the hydrological dynamics of the Centa River catchment. The plain represents the terminal basin of a relatively short but steep watershed, encompassing the valleys of Arnasco, Castelbianco, and Vendone. These mountainous sub-catchments produce rapid hydrological responses during intense rainfall events, channeling large volumes of runoff toward the low-lying coastal plain. As a result, the Piana di Albenga functions as a critical point of hydraulic accumulation, where upstream geomorphological processes translate directly into localized flood hazards and sediment deposition within both urbanized areas and productive agricultural land.

Within this hydrological and geomorphological context, the Piana di Albenga exhibits a high degree of agro-urban density. Extensive greenhouse infrastructures coexist with a compact historic center and successive phases of modern residential expansion, forming a complex spatial mosaic in which agricultural productivity, urban life, and flood vulnerability are inextricably intertwined. This overlapping of functions amplifies the territory's exposure to hydrological stress while simultaneously raising the socio-economic stakes associated with flood events, particularly given the economic reliance on intensive greenhouse agriculture and the cultural significance of the historic urban core.

Finally, the area is characterized by pronounced infrastructural rigidity, resulting from the juxtaposition of centuries-old urban fabric and twentieth-century hydraulic engineering interventions, particularly hard embankments designed to constrain the Centa River. These rigid structures have progressively severed the morphological and functional continuity between the settlement and its natural hydrological baseline, limiting the capacity of the plain to absorb and dissipate floodwaters naturally. For these reasons, the Piana di Albenga represents an instructive case study for analyzing the physical and conceptual rupture between urban development and fluvial dynamics. It provides an empirical and theoretical foundation for exploring Water Urbanism strategies aimed at re-establishing a more adaptive, ecologically integrated, and socially resilient territorial equilibrium.



Figure 17 - City centre of Albenga (source - Author)

3.1.2. Data Sources and Methods for Study Area Documentation

Environmental and Socio-Economic Data Sources

a. Predictive Tools and Flood Risk Mapping

To evaluate both current and projected conditions of territorial safety, the study incorporates a comprehensive suite of predictive tools and flood risk mapping derived from the most recent planning instruments. The analysis references the latest updates to the Flood Risk Management Plan (PGR) for 2024 and 2025, which delineate Areas of Potential Significant Flood Risk (APSFR) based on historical flood events and hydrological scenarios observed between 2018 and 2024. These APSFR zones highlight areas with heightened susceptibility to both flash floods and gradual inundation, providing a temporal and spatially explicit framework for risk assessment.

Complementing the PGR, the Hydrogeological Setting Plan (PAI) is employed to map geomorphological instability and assess flash flood susceptibility across the Centa River basin. Hazard levels are classified from moderate (P2a) to very high (P4), providing a multi-tiered understanding of the basin's vulnerability in relation to both natural topography and anthropogenic modifications. Additionally, hydraulic modeling outputs produced by the Autorità di Bacino del Distretto dell'Appennino Settentrionale are integrated into the analysis, distinguishing between high-hazard fluvial zones (P3) and coastal flooding domains (P2–P3), thereby offering a granular, science-based perspective on water behavior under extreme events.

The assessment further acknowledges the dynamic character of the regulatory framework, incorporating ongoing legislative updates, such as the 2025 revisions concerning the Varatella stream (DD n. 7840/2025). These adjustments reflect evolving safety standards for adjacent coastal catchments and underscore the necessity of adaptive planning strategies capable of responding to new hydrological data, changing land uses, and emerging environmental pressures. By synthesizing historical flood records, predictive modeling, and regulatory guidance, the study establishes a robust empirical foundation for proactive Water Urbanism interventions, bridging technical risk management with spatial and socio-environmental design considerations.

3.2. Study Area: Albenga and the Centa River

3.2.1. Background Information

Albenga is located within the largest alluvial plain of the Liguria region, a territory largely shaped by the depositional activity of the Centa River throughout the Plio-Quaternary period. This extensive fluvial plain functions as a critical geomorphological and ecological interface, where the hydrological dynamics of the Maritime Alps converge with the Tyrrhenian Sea. The resulting landscape is characterized by exceptionally fertile soils, which have historically supported intensive agricultural activities, yet it remains inherently fragile due to the combination of low-lying topography, high sediment fluxes, and episodic torrential runoff.

Historically, the settlement of Albenga demonstrates a high degree of topographic intelligence, with urban expansion and agricultural systems adapting fluidly to the natural rhythms of the river. Over time, however, this adaptive equilibrium has been supplanted by infrastructural rigidity: contemporary urban fabric is now physically and socially isolated from the riverbanks by continuous embankments and hard engineering defenses. This transformation has disrupted historical patterns of connectivity, eroded riparian ecological functions, and limited the city's capacity to interact with the river as both a productive and social resource.

Albenga's strategic location further amplifies its regional significance. The city functions as a central node within Western Liguria, bridging the Mediterranean coastal corridor with the inland valleys of Arnasco, Castelbianco, and Zuccarello. Its position as a gateway territory has historically facilitated economic exchange, cultural interaction, and transport connectivity, making the city a critical pivot point for both regional development and contemporary interventions aimed at integrating urban resilience with the dynamics of the Centa River basin.

Historical Evolution of Albenga and the Centa River

a. Oppidum Period (Pre-Roman: Around 181 BC)

In its original configuration, the settlement existed as a fortified Gallic-Ligurian stronghold known as an Oppidum, protected by a defensive wall and strategically

placed near the natural river mouth. During this era, the "Old Centa" followed a natural, meandering northern flow that bypassed the urban core to the east before reaching the Tyrrhenian Sea. The primary economy was intrinsically tied to the water through Agricultural Docks, which facilitated the import and export of goods, while the Via Julia Augusta provided the main terrestrial link for regional trade (Figure 16).

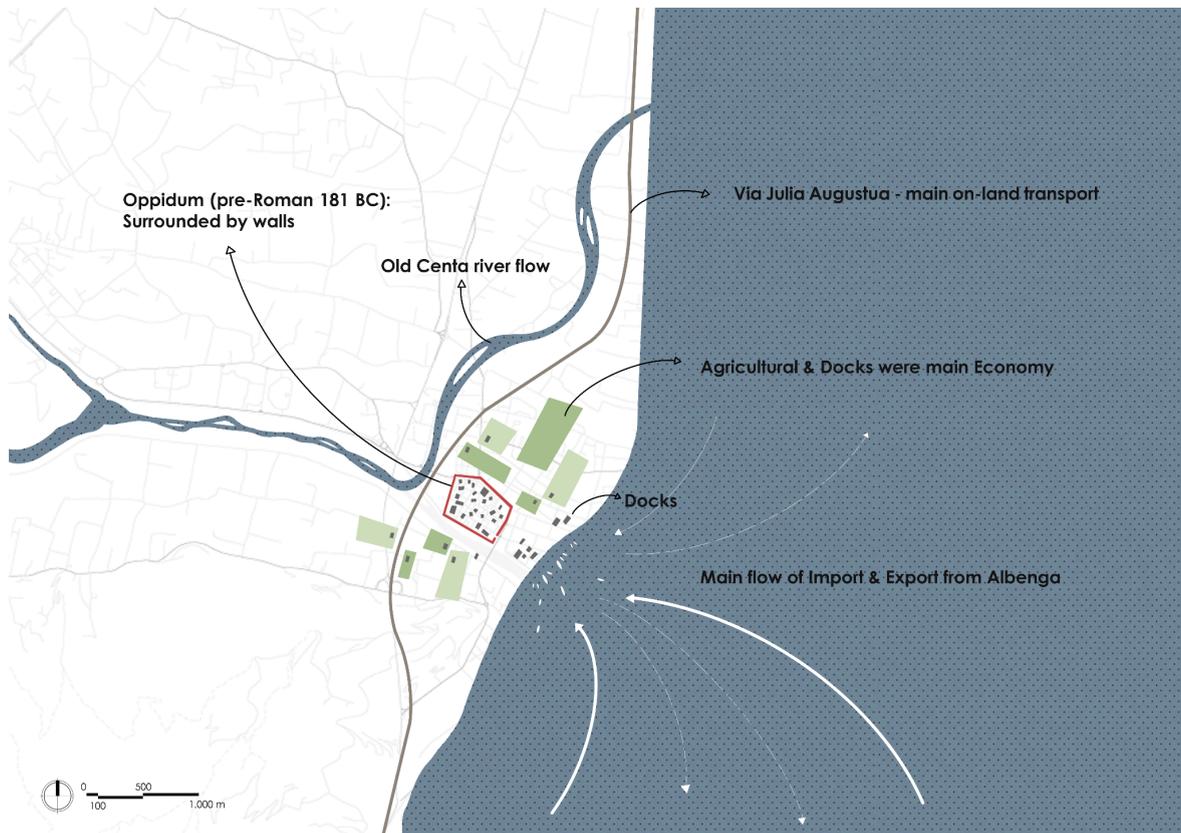


Figure 18 - Plan showing Albenga in the Oppidum period (Source: Authors' analysis and illustration)

b. Municipium Period (Roman Era)

Under Roman rule, the settlement experienced a significant expansion in both administrative and social importance, attaining the status of a *municipium* and benefiting from the introduction of more advanced public services and urban facilities. Among the most significant elements of Roman social infrastructure were the *thermae*, or public baths, strategically located in proximity to the urban core, reflecting both the social centrality of bathing practices and the integration of hydraulic systems into everyday urban life. During this phase, the Centa River remained largely stable in its "Old Centa" configuration, a condition that supported a dock-based economic system

and facilitated the expansion of agricultural activities across the surrounding plain
(Figure 19).

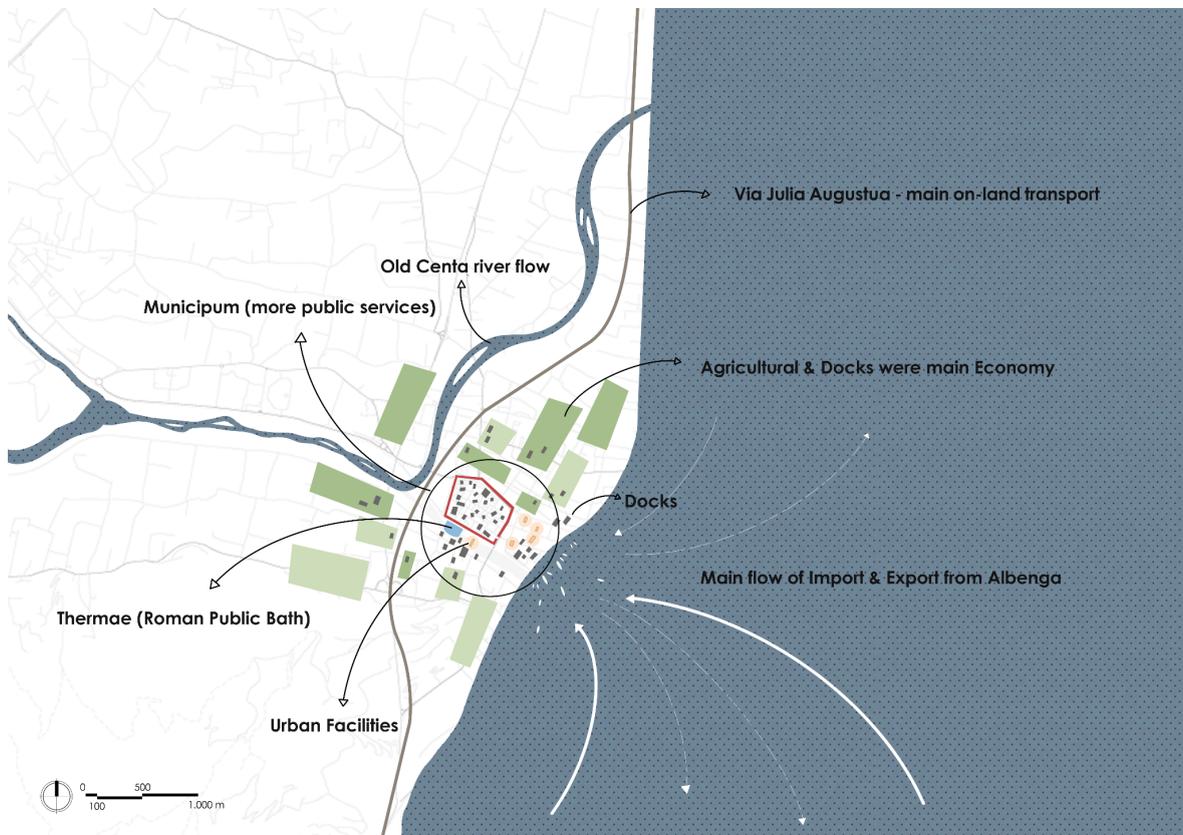


Figure 19 - Plan showing Albenga in the Municipium period (Source: Authors' analysis and illustration)

c. Medieval Period (River Diversion and Expansion)

A profound transformation occurred toward the later Roman period as the economic priorities of the settlement shifted, prompting direct human intervention in the fluvial system. In an effort to expand cultivable land and strengthen the agricultural economy, the inhabitants progressively filled the former riverbed, forcing the Centa into a new course south of the walled city, commonly referred to as the “New Centa.” This artificial diversion had substantial environmental and urban consequences. The new river trajectory proved destructive to existing infrastructure, leading to the loss of the Roman *thermae*, while altered sediment transport patterns caused the coastline to retreat, increasing the distance between the urban center and the shoreline. This episode marks an early and emblematic example of the reciprocal relationship between economic drivers, urban form, and fluvial dynamics, highlighting how interventions

aimed at territorial exploitation simultaneously reshaped the environmental baseline of the settlement (**Figure 20**).

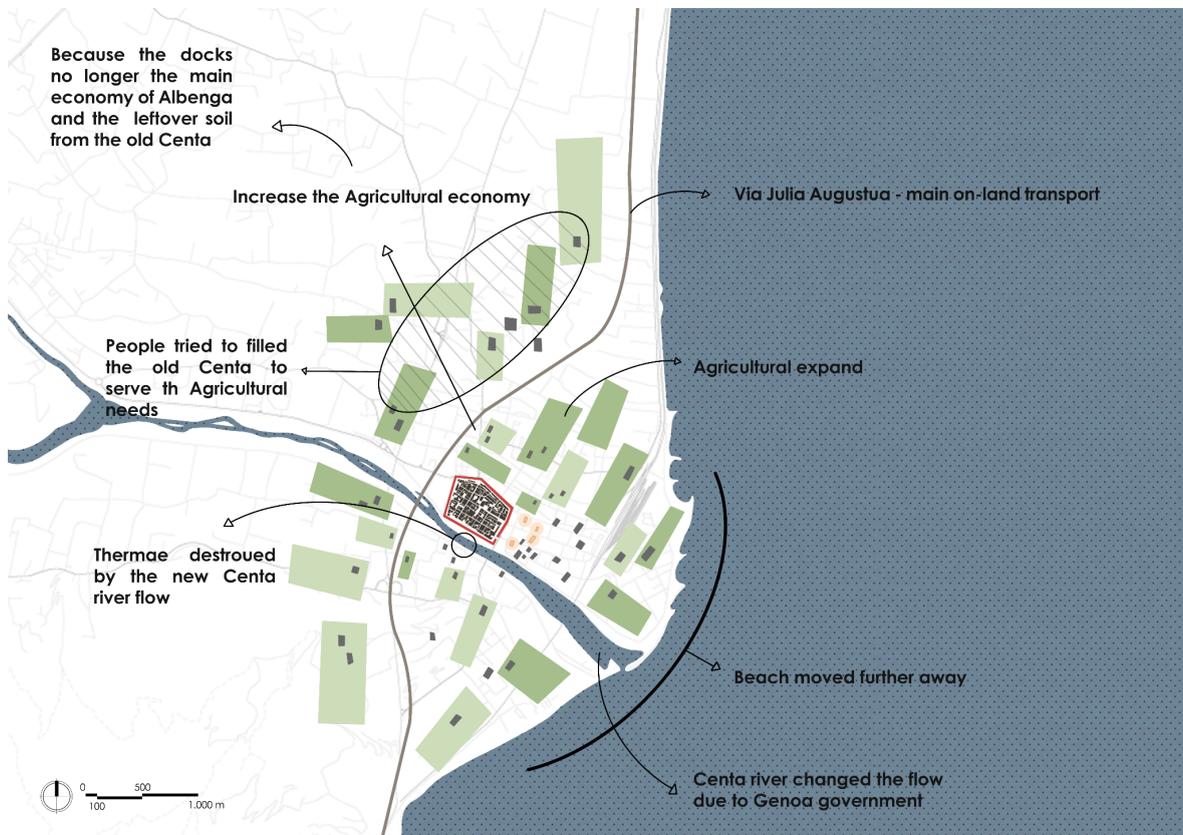


Figure 20 - Plan showing Albenga in the Medieval period (Source: Authors analysis and illustration)

d. Until Now (Modern Era: Fragmentation and Containment)

The modern period is defined by the total containment of the river and the "pushing out" of agricultural and economic activities from the urban core. Infrastructural Barriers to combat the constant threat of inundation caused by the forced river path, cement fences (embankments) were constructed. These barriers physically separate the city from the water. Economic Shift made the river mouth has transitioned from functional docks to a Tourism-based economy. Last, Urban Sprawl transformed the city center and became crowded, urban sprawl pushed agricultural land further away into the plain. This is reflected in the modern PGRA/PAI updates (**Figure 21**)

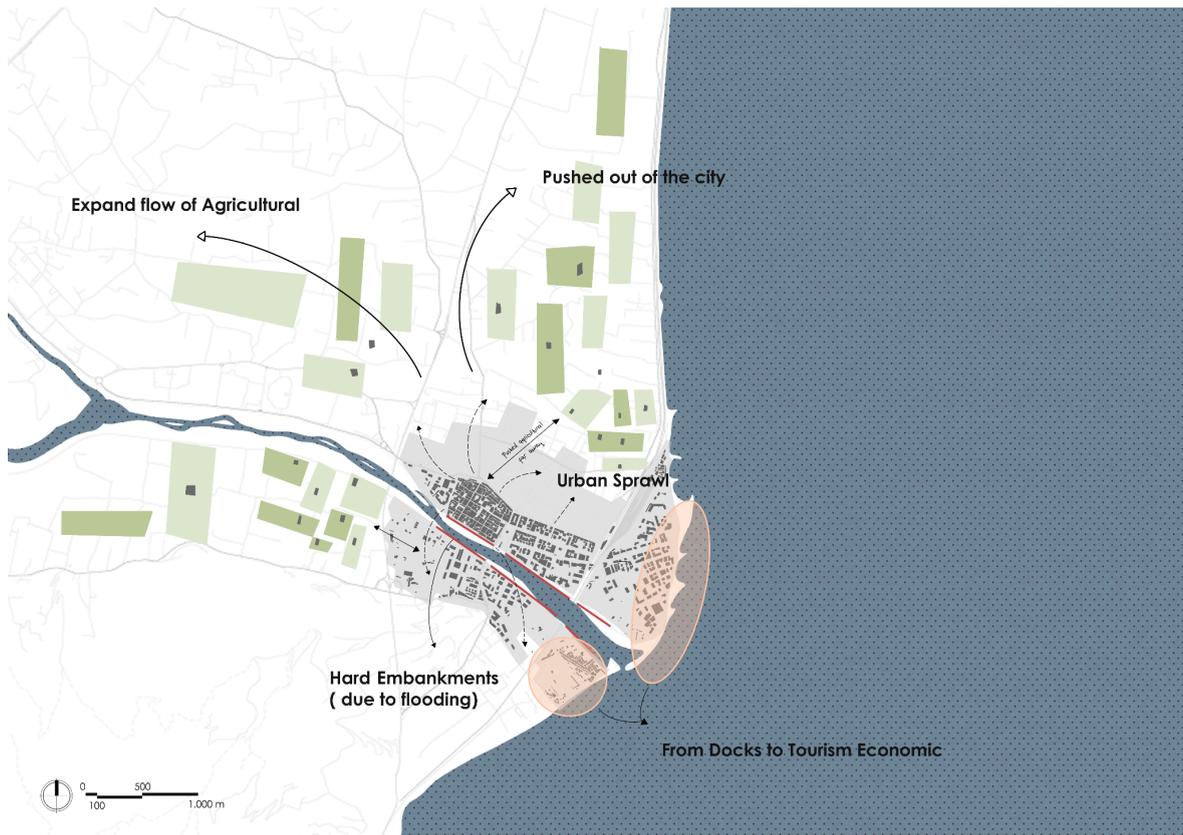


Figure 21 - Plan showing Albenga in present period (Source: Authors' analysis and illustration)

3.2.1. Regional Landscape and Environmental Constraints

The territorial framework of Albenga is governed by the Piano Territoriale di Coordinamento Provinciale (PTCP) of Savona, which establishes a complex network of landscape and environmental protections. The Map of Landscape Constraints identifies areas protected under national legislation (ex Legge 1497/1939), which aim to preserve the aesthetic and cultural integrity of the coastal strip and the river corridors. This is further complemented by the Map of Protected Areas, which classifies the Fiume Centa (Centa River) and the Torrente Arroscia as vital ecological nodes within the provincial "Bormida Natura" and "Alpi Savanesi" groups. These protections signify that the river is legally recognized as a high-value environmental asset, necessitating a "Water Urbanism" approach that balances flood safety with habitat conservation.

3.2.2. Geological Foundation and Hydrogeological Vulnerability

The physical "metabolism" of the Albenga plain is dictated by its Geolithological composition, primarily consisting of Quaternary alluvial deposits (Depositati alluvionali). While these soils provide the high porosity necessary for the region's intensive agricultural productivity, they also indicate a natural susceptibility to rapid saturation and flooding. To mitigate the risks of erosion and landslides in the steep hinterland, the Map of Hydrological Constraints identifies vast sectors of forest land subjected to strict management under the RD 3267/1923 decree. These "hydrogeological filters" are essential for regulating the water flow that eventually reaches the Albenga plain, emphasizing that urban flood management must start with the protection of upstream vegetation.

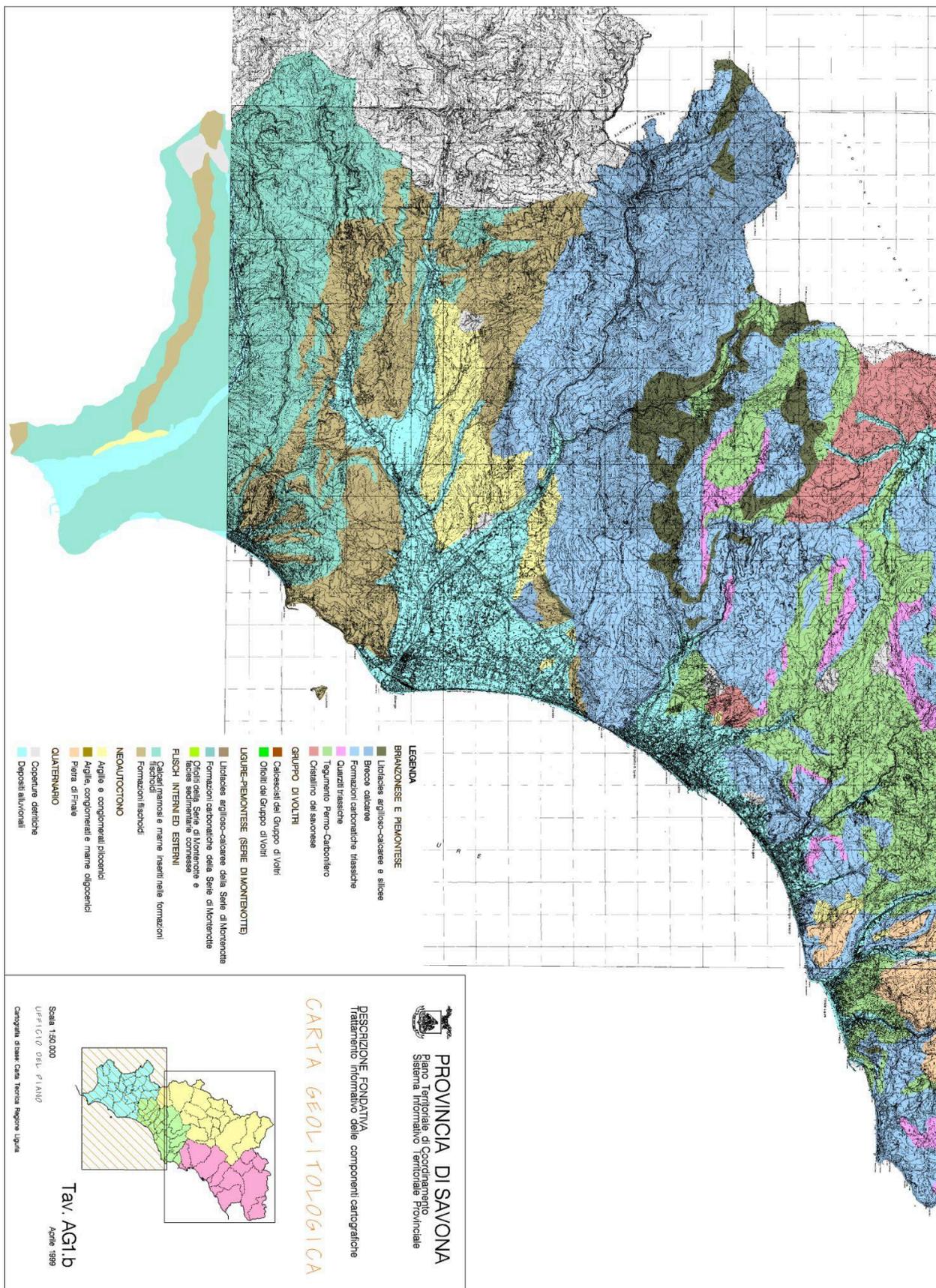


Figure 22 - Geolithological map (Source : Progetti Integrati del PTC, Provincia di Savona)

3.2.3. Historical Evolution and Modern Settlement Morphology

The transition of Albenga from a porous agricultural landscape to a fragmented urban center is documented in the Historical Land Use and Current Settlement plans. The 1853 historical data reveals a territory once dominated by olive groves, vineyards, and pastures, highlighting a legacy of permeability that has been lost to modern industrialization. The Current Settlement Plan illustrates the "Assetto Insediativo Attuale," where the historic core is now surrounded by a discontinuous residential fabric and rigid infrastructural barriers like the railway. This morphological evolution shows how urban sprawl has encroached upon the floodplain, creating a "barrier effect" that severs the city's connection to the river and the sea, complicating modern emergency management and socio-spatial integration.

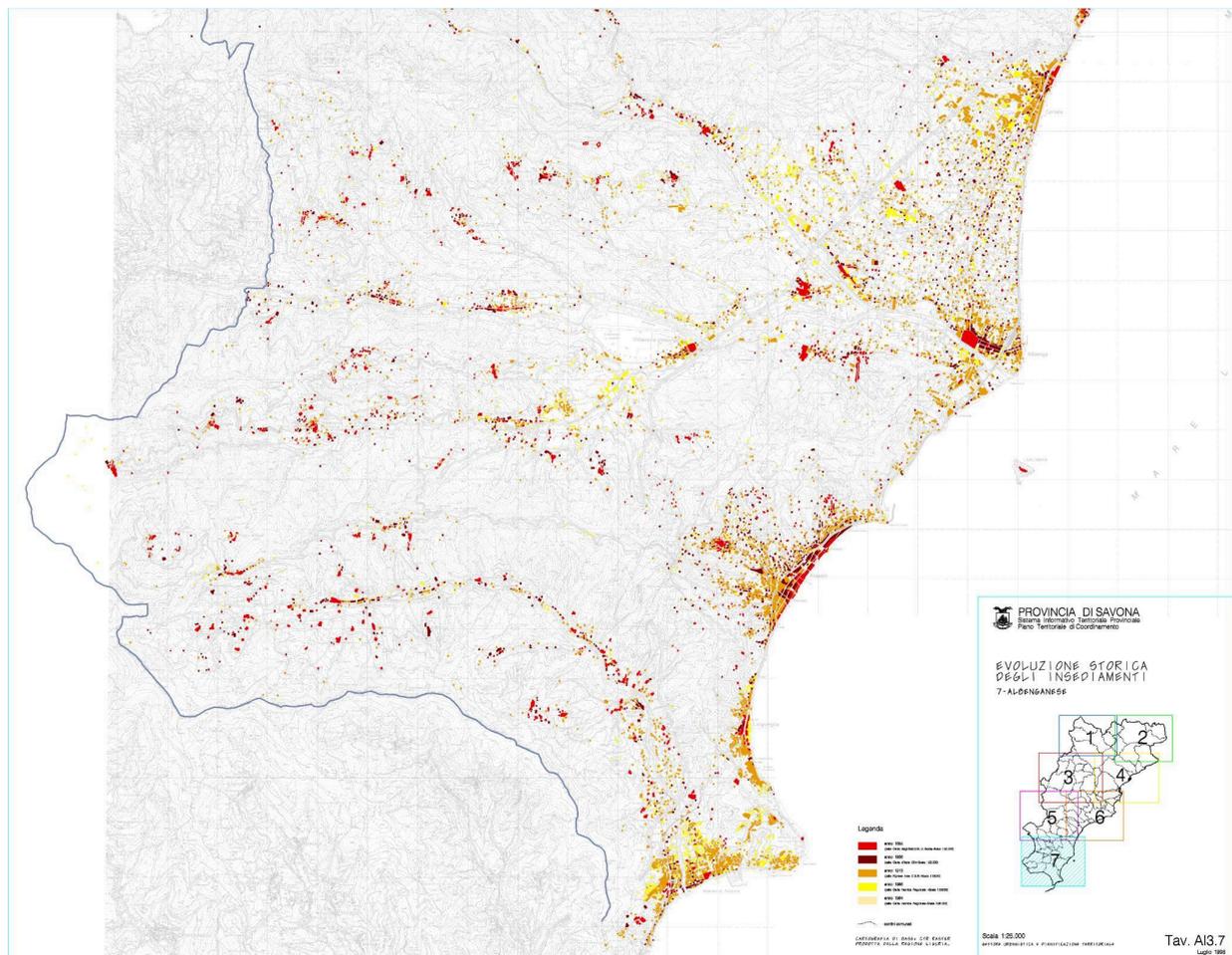


Figure 23 - Historical evolution of settlements (Albenganese) map (Source: Progetti Integrati del PTC, Provincia di Savona)

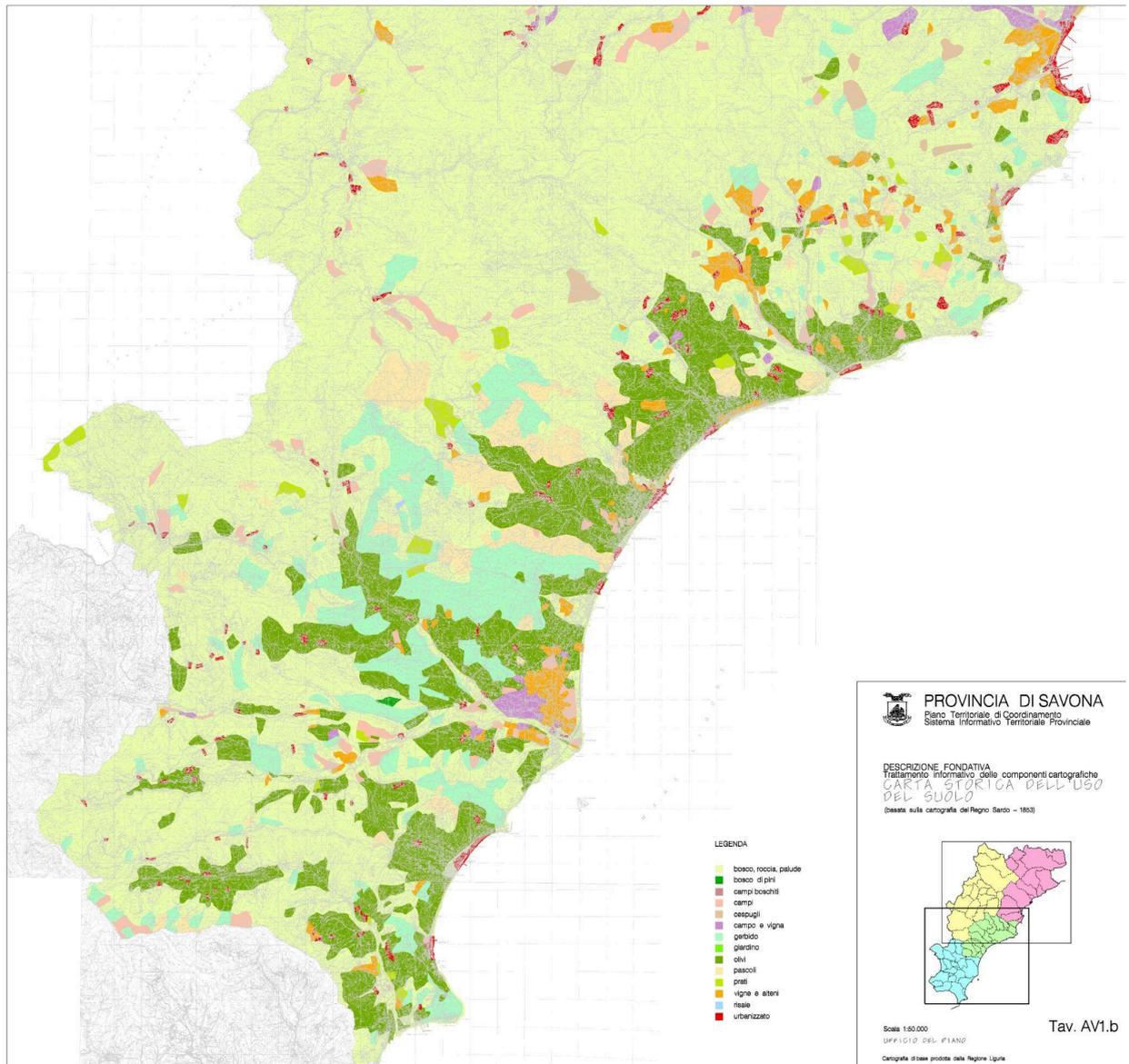


Figure 24 - Historical landuse map (Source: Progetti Integrati del PTC, Provincia di Savona)

3.2.2. Environmental Characteristics: Centa River and Flooding Events

The Centa River is characterized by a "torrential" Mediterranean regime, featuring extreme seasonality that oscillates between periods of prolonged drought and violent flash flood events. Water Quality and Future Flood Forecasts The hydrological behavior of the basin is increasingly influenced by "Mediterraneanization" of the climate, where high-intensity rainfall events result in rapid peak discharges. Future flood forecasts and

current risk assessments, as mapped in the Areas of Potential Significant Flood Risk (APSFRR), indicate that the most significant hazards are concentrated in areas of high soil consumption and at points where natural watercourses have been culverted or remain adjacent to "tombati" sections. Analysis of the Pericolosità da Alluvione data confirms that the fluvial domain exhibits high-level risk (P3) while the coastal interface remains vulnerable to both riverine discharge and maritime surges. The presence of active and inactive quarries in the upstream catchment further complicates water quality through increased sediment transport during these high-velocity events.

Geomorphology and Geology From a geomorphological perspective, the plain is built upon the Sintema del Torrente Centa, which consists of complex alluvial deposits that vary in permeability and stability. The Carta Geolitologica (Sheet 232100) reveals that the subsurface is composed of various stratigraphic units, including the Argille di Ortovero and Plio-Quaternary deposits, which influence the natural drainage capacity and the vulnerability of local aquifers to saltwater intrusion. Further data from the PAI Dissesti Geomorfologici identifies high to very high instability classes (P3 and P4) in the hilly hinterland, specifically around Cisano sul Neva and Amasco, which directly impact the peak flow speeds of the river system as it enters the urbanized plain.

Hydrographic Complexity and Coastal Dynamics Beyond the main riverbed, the hydrographic system is defined by a network of secondary irrigation canals and historical drainage paths known as "beudi." These elements, while partially integrated into the agricultural fabric, often act as catalysts for localized flooding when their capacity is exceeded. Additionally, the seismic-stratigraphic succession of the Plio-Pleistocene layers shows a complex arrangement of marine and continental deposits that define the coastal "shelf," influencing how the river mouth interacts with tidal movements and sediment distribution.

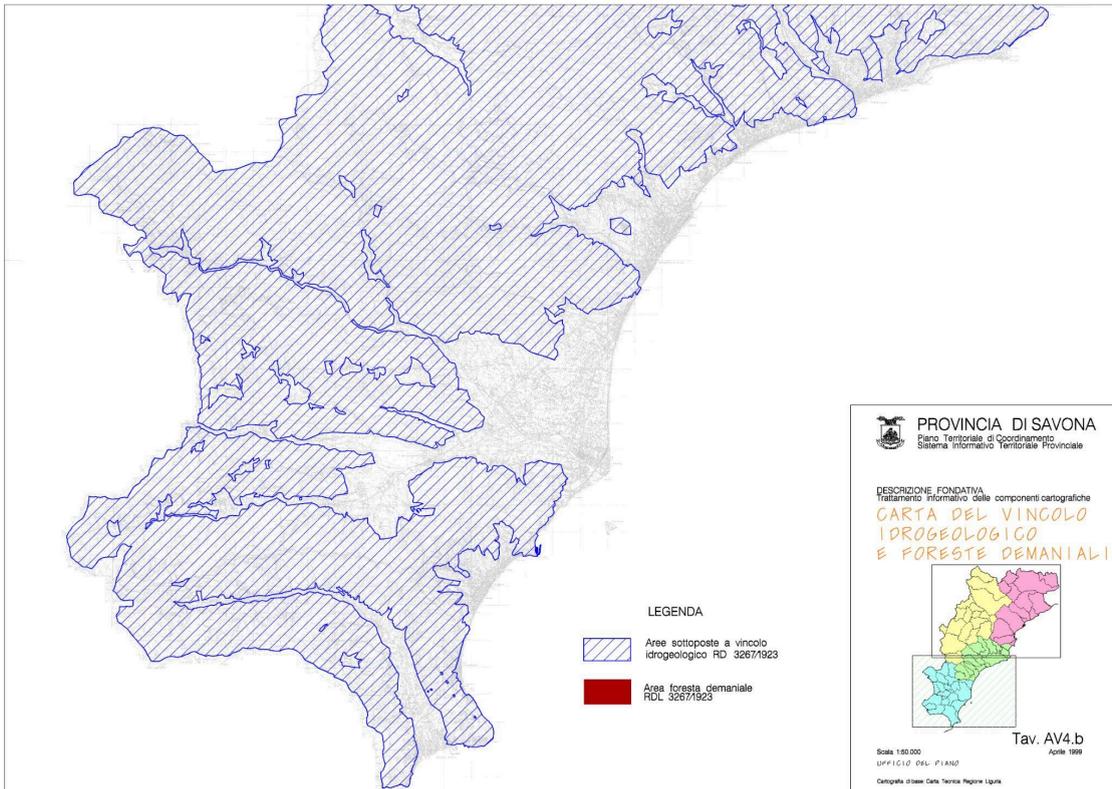


Figure 25 - Map of hydrological constraints and forests (Source: Progetti Integrati del PTC, Provincia di Savona)

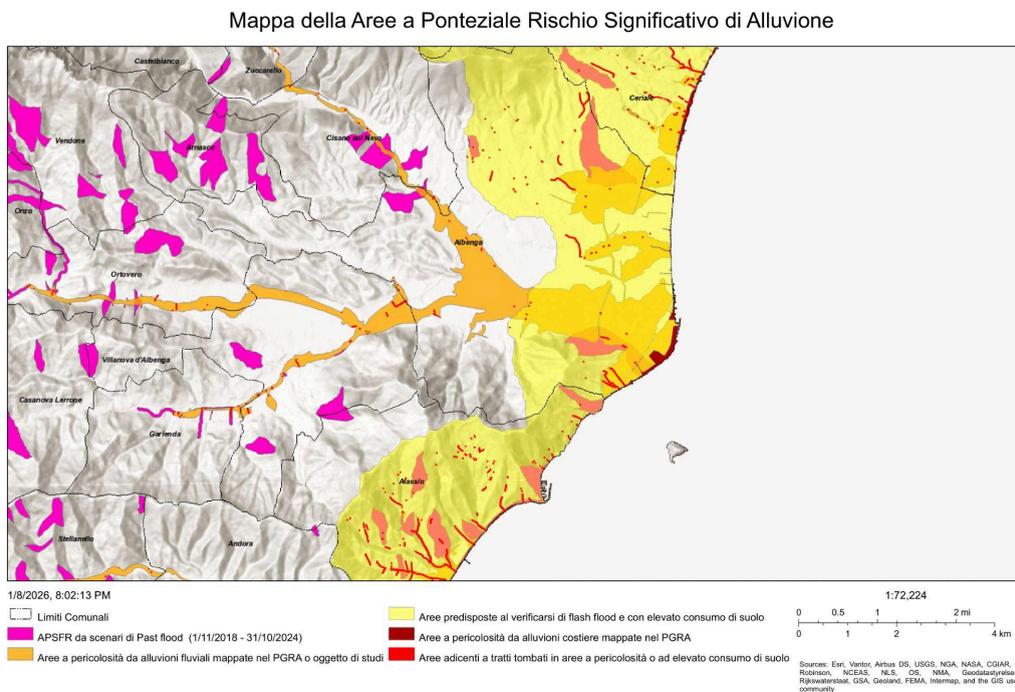


Figure 26 - Map for areas of potential flood risk (Source: Centa Basin Plans, Geoportal Liguria Region)

Mappa della Pericolosità da alluvione

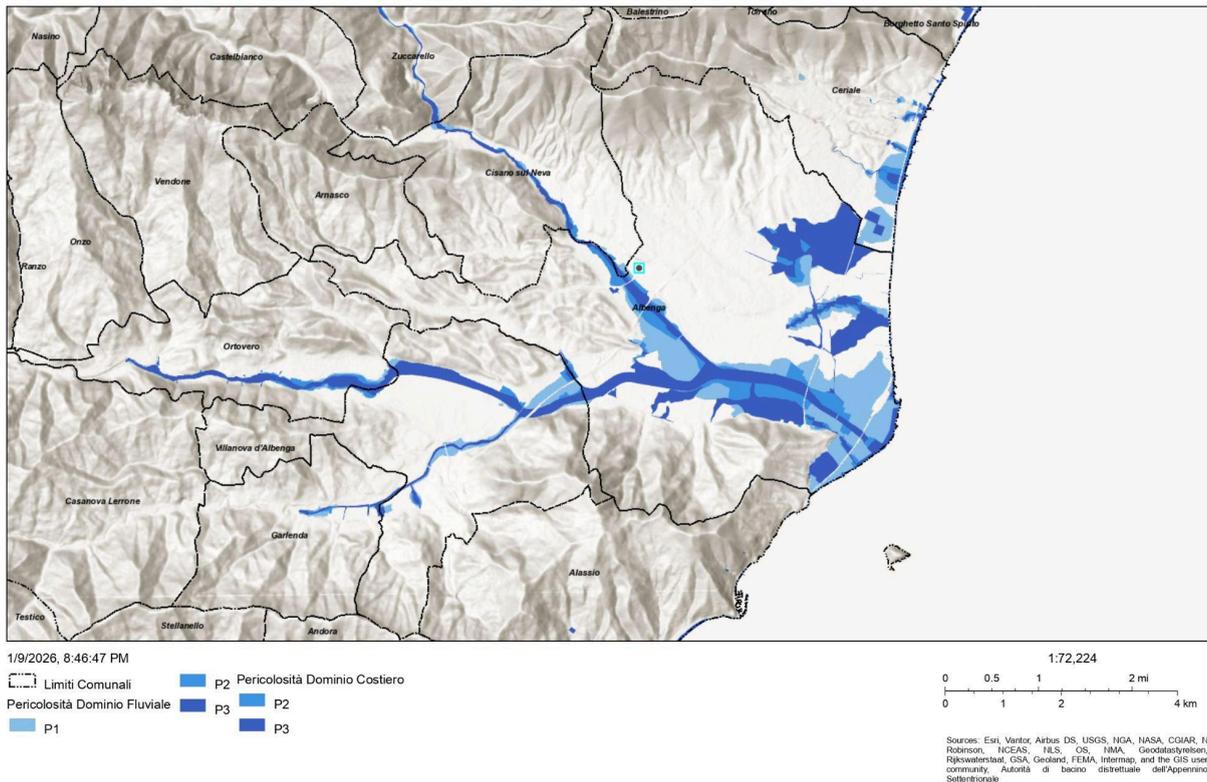


Figure 26.1 - Map of river and coastal flood hazard (Source: Centa Basin Plans , Geoportal Liguria Region)

3.2.4. Socio-Economic Characteristics

The territorial identity of Albenga is intimately connected to its productive landscape, which has undergone a profound transformation from traditional open-field agriculture to a highly specialized, technologically intensive sector.

Economic Structure: The regional economy is dominated by intensive agricultural practices, particularly floriculture and high-value greenhouse cultivation. The Parco Agrotecnologico project, as articulated in the Municipal Urban Plan (PUC), represents the primary regional development strategy, seeking to modernize agricultural production while simultaneously managing the environmental constraints imposed by the low-lying, flood-prone plain. However, the widespread proliferation of impermeable greenhouse coverings has unintentionally exacerbated surface runoff, intensifying the region's exposure to hydrological hazards. This creates a paradoxical economic

vulnerability: the very infrastructures designed to support productivity increase susceptibility to the flood events they are intended to withstand.

Social Activities and the Historical Center: The historical center of Albenga, known as the “City of Towers,” embodies a dense urban core that historically negotiated a functional and cultural relationship with the river. In the contemporary city, however, this connection has been largely severed. Modern urban expansions, combined with defensive embankments, have rendered the riverfront largely “water-alienated,” converting a historically interactive landscape into a marginalized technical zone. Public and cultural activities along the river are constrained by the imperatives of flood protection, preventing the river from functioning as a social and ecological spine.

Within the current planning framework, these river-adjacent zones are identified as critical “fracture points,” where infrastructural rigidity disrupts both environmental functionality and social accessibility. The analysis highlights the urgent need to reconceptualize these areas through integrative strategies that restore ecological continuity, improve public access, and re-establish the river as a central element of the city’s identity. By bridging productive landscapes, historical heritage, and hydrological systems, such interventions offer the potential to reconcile economic vitality with environmental resilience and urban livability.

3.3. Data Sources and Data Collection Methods: Findings

The data collection process for this research involved a multi-scalar synthesis of institutional, technical, and historical records to construct a comprehensive digital model of the Albenga territory. By integrating diverse datasets, the study identifies the physical and regulatory constraints that define the Centa River's current state.

Institutional Planning and Regulatory Data Primary data was collected from the Città di Albenga Municipal Urban Plan (PUC), specifically utilizing the *Descrizione Fondativa* (Foundational Description) to establish the baseline for the town's socio-economic and environmental infrastructure. Technical layers such as the *Assetto idrogeomorfologico* (DFA.1) and the *Carta delle fragilità* (SP.4) provided essential information on local land vulnerability and structural weaknesses. To contextualize these local plans, data were

cross-referenced with the Provincia di Savona Territorial Coordination Plan (PTCP), which offered a supra-municipal view of settlement layouts and regional ecological systems.

Hydrological and Risk Management Data Risk-related data was gathered through the latest updates of the Flood Risk Management Plan (PGR) and the Hydrogeological Setting Plan (PAI). These findings were supplemented by active legislative variations, such as the 2025 updates for the neighboring Varatella basin, which provided a benchmark for evolving regional safety standards. The Mappa della Pericolosità da Alluvione allowed for the classification of the Centa basin into specific hazard zones (P1 to P3), identifying the exact spatial extent of potential fluvial and coastal inundation.

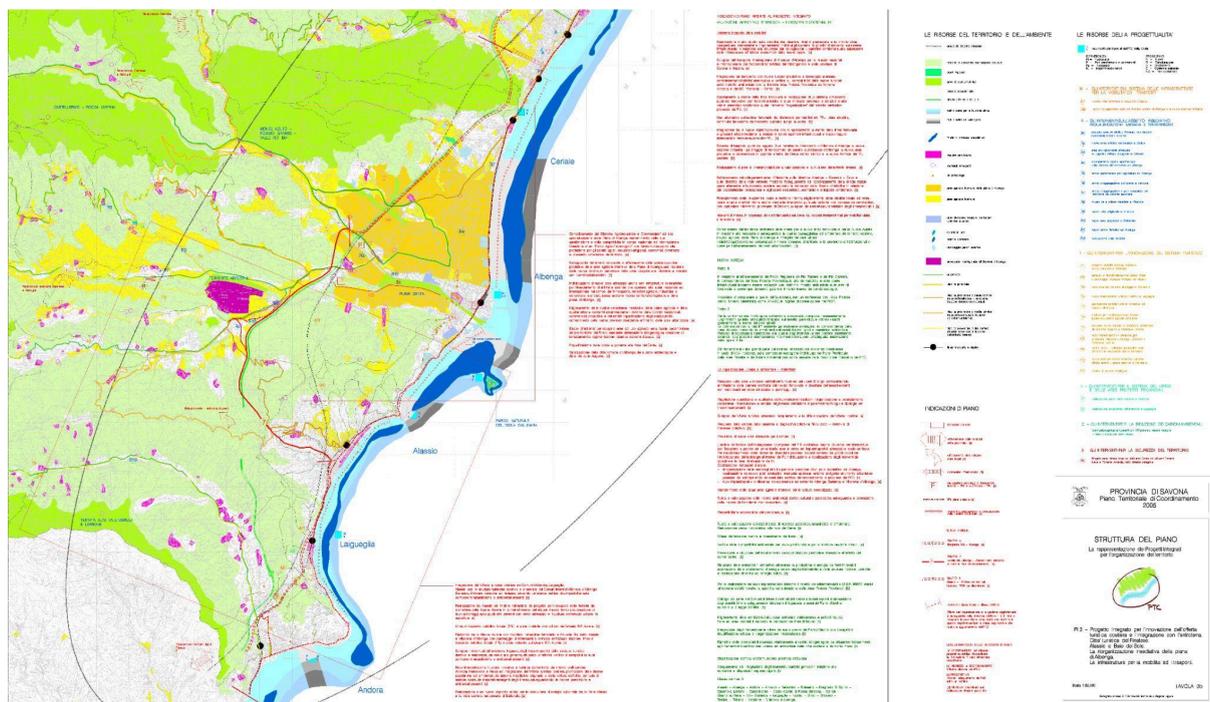


Figure 26.2 - Map of river and coastal flood hazard (Source: Centa Basin Plans , Geoportall Liguria Region)

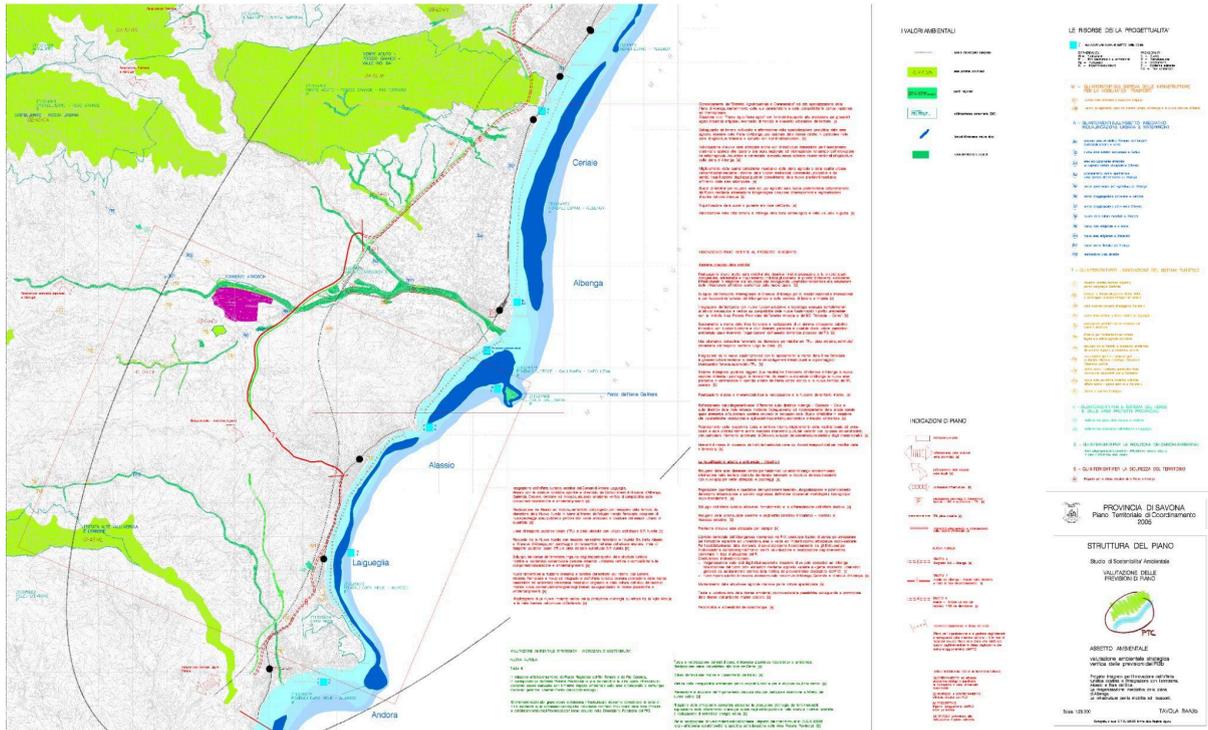


Figure 26.3 - Map of river and coastal flood hazard (Source: Centa Basin Plans , Geoportal Liguria Region)

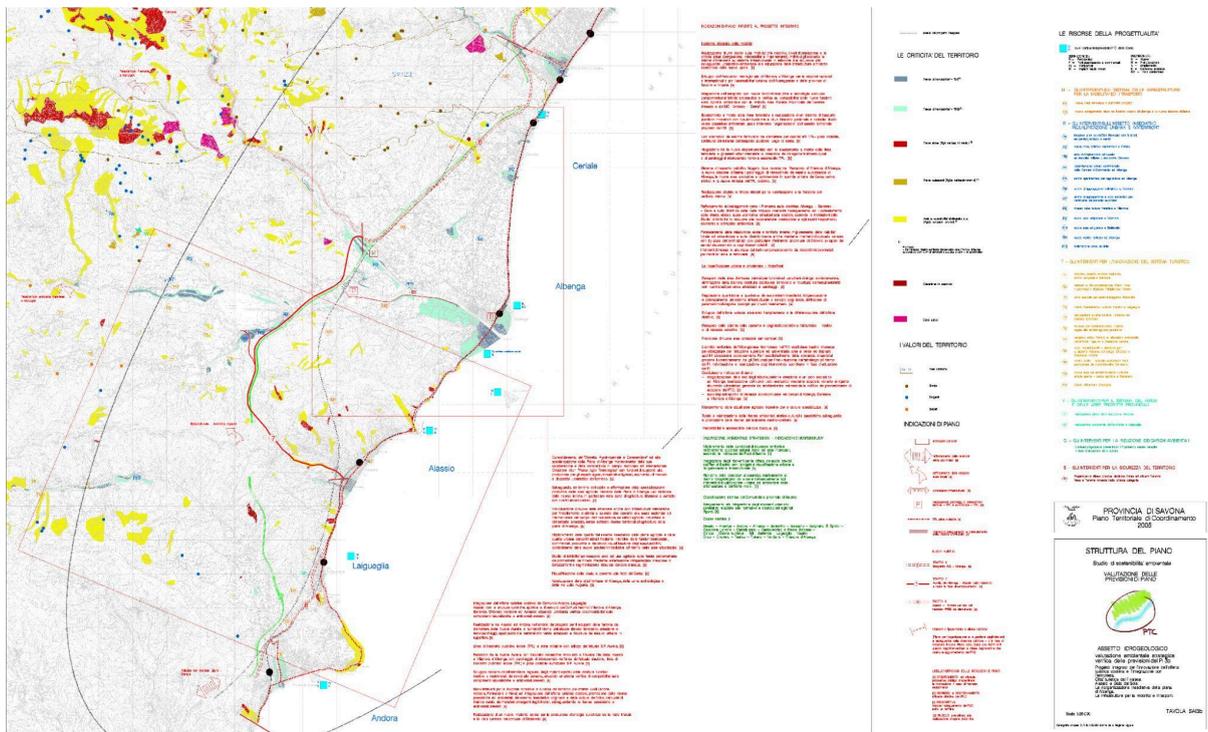


Figure 26.4 - Map of river and coastal flood hazard (Source: Centa Basin Plans , Geoportal Liguria Region)

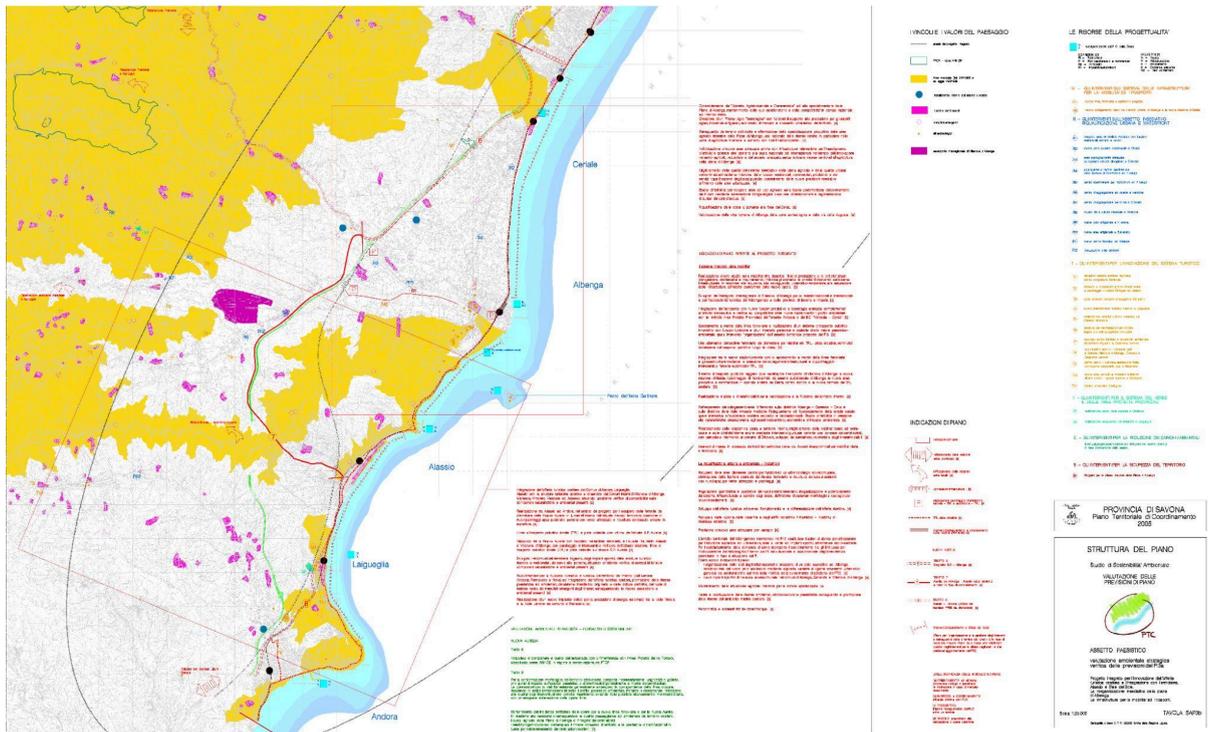


Figure 26.5 - Map of river and coastal flood hazard (Source: Centa Basin Plans , Geoportal Liguria Region)

The physical properties of the soil and the underground stratigraphic layers were documented using the CARG Project (Sheet 245 - Albenga). This geological data provided the technical basis for understanding the "Sponge City" potential of the plain, particularly through the identification of the Sintema del Torrente Centa alluvial deposits. Finally, historical data were collected from the Archivio di Stato di Savona, where 1910 cadastral maps were georeferenced against modern CTR (Regional Technical Maps) to trace the morphological evolution of the riverbed and identify the "lost" hydrological connections resulting from medieval and modern channelization.

The findings from this collection phase reveal a significant disconnect between the historical natural flow of the Centa and the current "crystallized" urban state. The data indicate that while the territory is highly mapped for risk, the management remains reactive, focused on the maintenance of the "hard" barriers documented in the Ambito 17 basin plan variations rather than the restoration of natural hydrological functions.

3.4. Analytical Methodology

The analytical methodology employed in this research follows a multi-layered approach designed to bridge the gap between historical territorial dynamics and modern planning constraints. The objective is to evaluate the transformation of the Centa River basin through a systematic comparison of physical, legal, and environmental data layers.

3.4.1. Multi-Scalar Spatial Analysis

The methodology employs a “zoom-in/zoom-out” analytical approach, conceptualizing the Centa River not as a series of isolated segments but as a singular, integrated metabolic system. At the macro-scale, the study examines the entire watershed, situating the river within its broader geomorphological and tectonic context. Utilizing stratigraphic and tectonic data from the CARG Sheet 245, the analysis explores the kinetic potential of the river system, identifying how alpine runoff, sediment transport, and elevation gradients converge to shape flow dynamics across the transition from mountainous hinterland to coastal plain. This perspective allows for a comprehensive understanding of systemic hydraulic pressures and the spatial logic of water movement at the basin scale.

At the micro-scale, the research focuses on localized “fracture points” where the built environment conflicts with natural hydrological processes. High-resolution municipal datasets (DF.A1.4) enable precise mapping of urban infrastructure such as dense residential blocks, industrial complexes, and culverted sections of the river that disrupt flow continuity or exacerbate flood risk. By integrating these scales, the methodology captures the dynamic interplay between basin-level hydraulic forces and site-specific urban vulnerabilities. This multi-scalar perspective provides a rigorous empirical foundation for Water Urbanism strategies, emphasizing the need to reconcile macro-scale river behaviors with micro-scale interventions that restore connectivity, enhance resilience, and re-establish the river as a functional structural spine within the urban fabric.

3.4.2. Morphological Tracing and Georeferencing

A core component of the methodology is the comparative analysis of historical and contemporary cartography, which enables a multi-temporal understanding of Albenga’s

hydrological and urban transformations. By georeferencing the 1910 cadastral maps held in the State Archives of Savona and overlaying them onto modern Regional Technical Maps (CTR), the study reconstructs the course of the “Old Centa” and its associated floodplain system. This procedure reveals the original spatial configuration of the river, including the location and extent of historical floodplains, minor tributaries, and ephemeral hydrological features that have since been lost or obscured.

Through this cartographic synthesis, the analysis identifies key hydrological elements that historically contributed to the territory’s natural porosity and resilience, such as the Roman Thermae and the historical “beudi” irrigation network. These features illustrate the multi-functional integration of water infrastructure, where hydraulic regulation, agricultural productivity, and urban life coexisted within a dynamic spatial system. By contrasting these historical patterns with the present-day artificial channel and its rigid embankments, the study quantifies the degree of “infrastructural rigidity” imposed by modern channelization. The analysis highlights the consequent loss of territorial permeability and ecological function, providing an empirical baseline for designing Water Urbanism interventions aimed at restoring spatial and hydrological connectivity while reconciling the city’s heritage with adaptive flood management strategies.

3.4.3. Assessing the Transformation of the Centa River Basin

The assessment of territorial transformation is carried out through the systematic overlay of contemporary risk management scenarios, as defined by the Flood Risk Management Plan (PGR) and the Hydrogeological Setting Plan (PAI), with historical morphological data. This comparative approach enables the identification of long-term spatial transformations and their implications for current levels of hydraulic and territorial risk. The methodology is structured around three key indicators. The first concerns permeability loss, quantified by calculating the proportion of the historical floodplain that has been progressively sealed by urban expansion and intensive greenhouse infrastructures, thereby reducing the landscape’s capacity to absorb and regulate floodwaters. The second indicator addresses risk polarization, examining how medieval and modern diversions of the Centa River have concentrated high-hazard zones (P3 and P4) in close proximity to the historic urban core, increasing the exposure of consolidated settlements to extreme flood events (Meyer *et al.*, 2014). The third

indicator focuses on governance fragmentation, analyzing the spatial and institutional overlap between municipal, provincial, and basin district planning authorities in order to identify areas of regulatory discontinuity where planning ambiguity hinders the implementation of integrated water management strategies.

By synthesizing these indicators, the methodology establishes a critical analytical framework for the formulation of Water Urbanism interventions. This framework supports design strategies aimed at re-establishing functional and spatial connectivity between Albenga and the Centa River, while remaining consistent with contemporary legal, institutional, and safety requirements, including those introduced through the most recent regional updates for the 2024–2025 planning cycle.

3.4.4. Morphological Tracing and Synthesis of the Centa River Course

The analytical methodology culminates in the digital reconstruction and synthesis of the Centa River’s morphological evolution, providing empirical evidence of the river’s inherent dynamism in contrast to the city’s static flood defense structures. This approach was executed through a multi-temporal tracing of the river’s course at key temporal intervals, subsequently georeferenced and overlaid onto the contemporary territorial map to produce a comprehensive Synthesis Map of the Centa River Basin. The resulting map functions as both an analytical tool and a design heuristic, revealing the interplay between fluvial processes, sediment transport, and urban form.

By systematically georeferencing riverbed configurations from the years 2010, 2014, 2016, 2018, 2020, and 2024, the study identifies significant temporal shifts in sediment deposition patterns and flow directions within the artificially constrained channel. These changes highlight the persistent hydraulic pressures and areas of sediment accumulation that often conflict with the assumptions embedded within modern flood-control infrastructure. The high-resolution temporal analysis allows for precise identification of recurrently stressed zones, areas susceptible to overflow, and locations where rigid embankments fail to accommodate the river’s natural tendencies.

Despite the extensive network of concrete embankments and “cement fences” constructed during recent planning phases, the river continues to exhibit natural morphological fluctuations within its constrained path. These observations underscore the limitations of purely static, defensive engineering and provide a compelling

rationale for adopting an adaptive, landscape-based approach. The synthesis map thereby bridges historical configurations of the “Old Centa” with contemporary hydraulic and urban conditions, offering a spatially explicit foundation for Water Urbanism strategies that prioritize “room for the river,” ecological restoration, and flexible floodplain management over rigid containment measures (**Figure 26**). In doing so, the methodology not only documents historical transformation but also informs the design of interventions that reconcile urban resilience, heritage preservation, and the dynamic behavior of the river system.



Figure 27 - Synthesis map for the Course of the Centa River over time (Source: Authors analysis and illustration)

CHAPTER 4

FINDINGS AND ANALYSIS



4.1. Regional Catchment Analysis: Terrain and Fluvial Dynamics

The initial phase of the analysis concentrates on the macro-scale hydrological system of the Centa River basin, as depicted in the regional terrain map. This cartographic representation provides a comprehensive overview of the complex topographic configuration that underpins the territory's hydraulic vulnerability, tracing the primary river course alongside its network of seasonal and ephemeral tributaries. By situating the Centa within its broader catchment, the analysis moves beyond a localized urban perspective to examine the systemic processes governing water movement, sediment transport, and flood dynamics throughout the basin.

The Centa River functions as a principal drainage conduit for a diverse inland catchment, receiving high-velocity runoff from steep upland areas through tributaries originating near Arnasco, Castelbianco, and Nasino. Macro-scale mapping and hydraulic assessment reveal critical points where steep mountainous gradients abruptly transition into the flat alluvial plain. These convergence zones are of particular interest for understanding the basin's complex hydrological behaviors, as they concentrate energy, sediments, and discharge volumes that have direct downstream implications.

Confluence Sensitivity: Areas where mountain-derived seasonal streams converge with the main river channel represent hotspots of sediment accumulation and peak discharge. These confluences amplify hydraulic force, increasing the potential for downstream erosion and overflow, particularly during high-intensity rainfall events.

Topographic Bottlenecks: The abrupt transition from the rugged hinterland to Albenga's coastal plain functions as a natural deceleration point, where water energy is transferred rapidly to the urban and agricultural interface. This creates localized pressure points along the river corridor, magnifying vulnerability in low-lying areas and emphasizing the need for site-specific hydraulic interventions.

Seasonal Stream Variability: While many secondary streams remain dry for significant portions of the year, they act as primary conduits for flash flood events. Their episodic flows contribute to rapid peak discharges that, in combination with sediment transport, exacerbate flood risk in downstream settlements and agricultural zones, as confirmed by recent territorial vulnerability studies.

This regional-scale mapping (**Figure 28**) establishes the necessary context for subsequent granular, site-specific analyses. It demonstrates that Albenga’s flood challenges are not isolated phenomena confined to the urban core; rather, they emerge from the integrated morphology and hydrodynamics of the entire Centa River basin. Understanding these systemic interactions is essential for informing adaptive Water Urbanism strategies, which must reconcile upstream hydraulic processes with local urban and ecological design interventions.

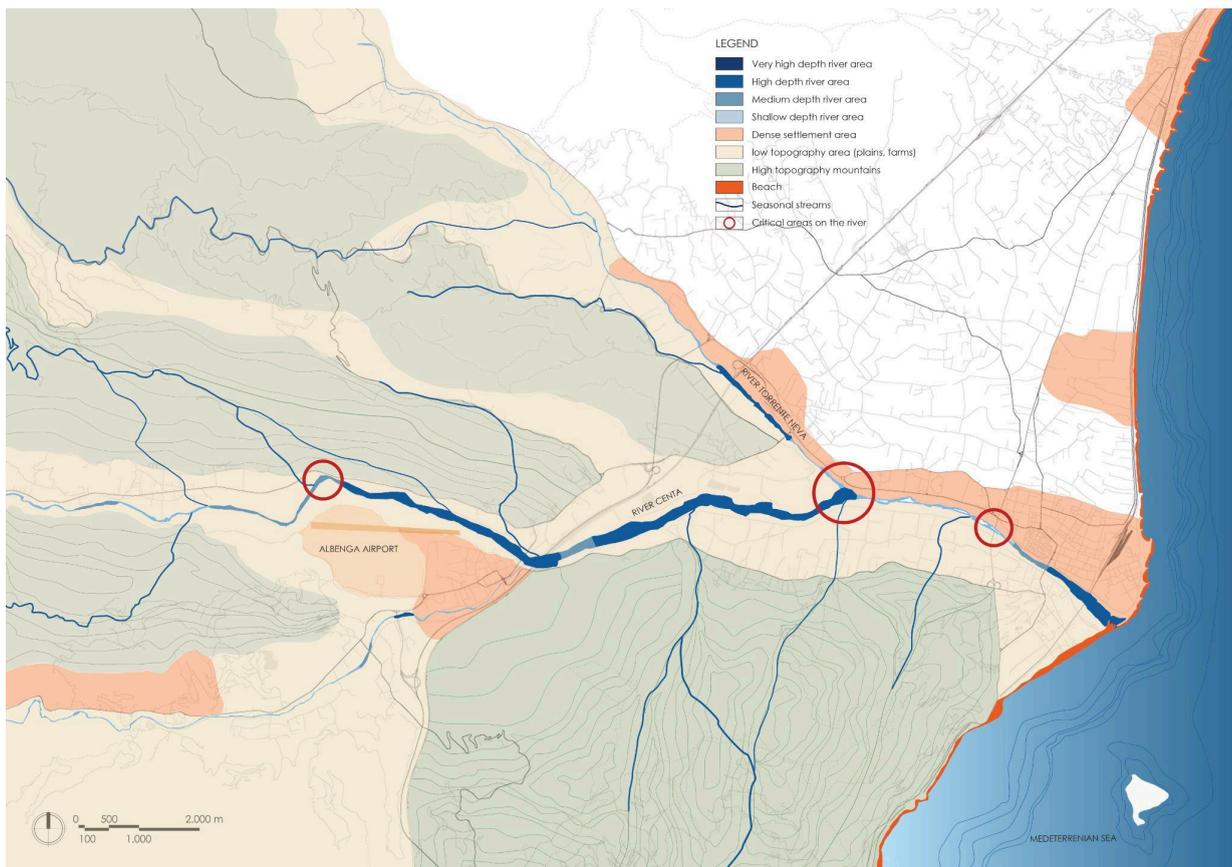


Figure 28 - Regional catchment analysis map (Source: Authors analysis and illustration)

4.2. Local Land Use and Settlement Morphology

The analysis of the Albenga territory’s physical composition reveals an intensive and often conflicting overlap between productive agricultural landscapes and expanding urban settlements. Utilizing the detailed land-use classification, it is possible to categorize the spatial organization of the plain into specific functional zones that define the current ecological and economic metabolism (**Figure 29**).

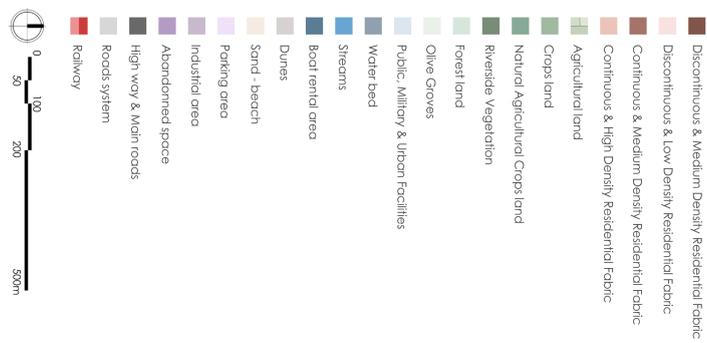
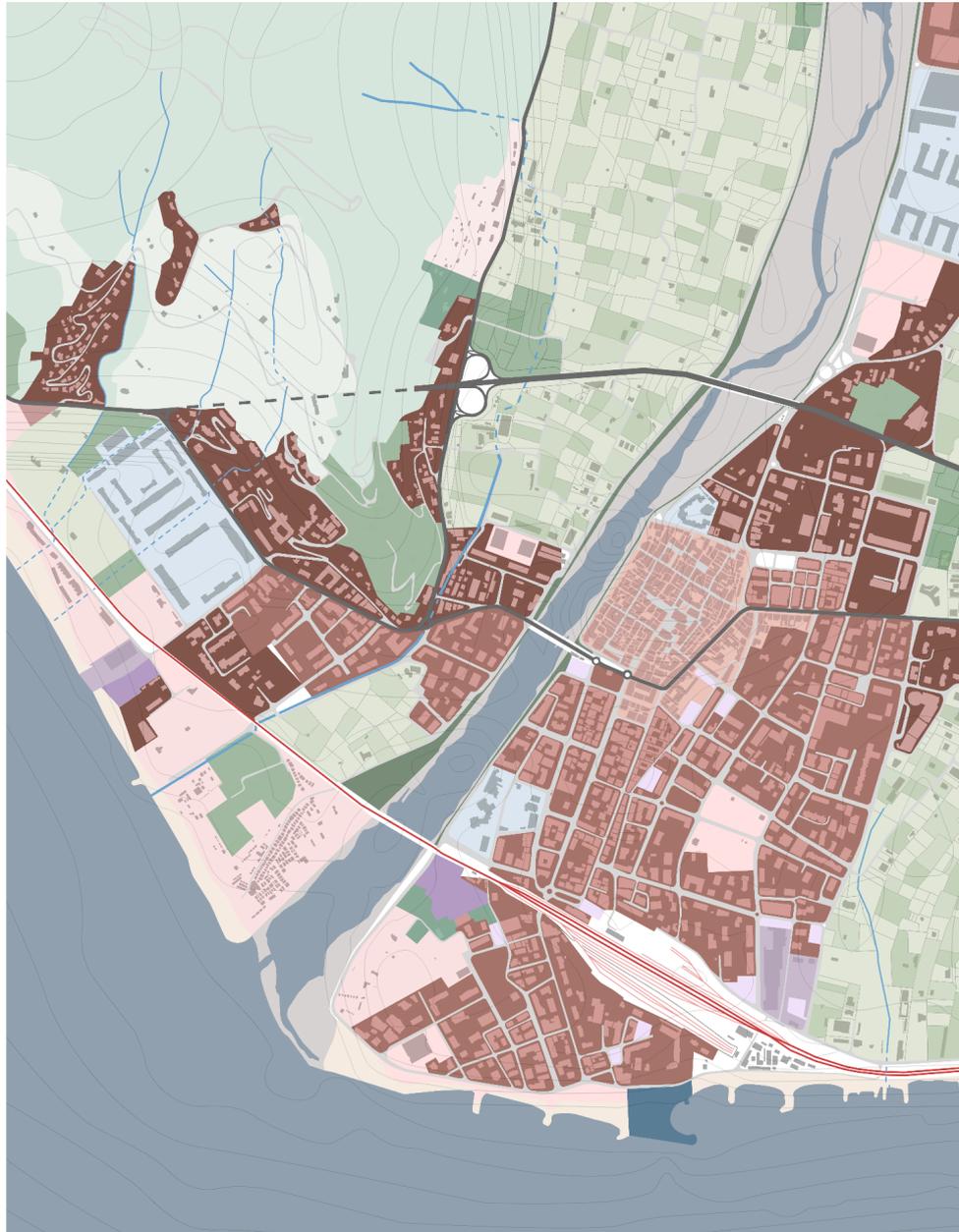


Figure 29 - Landuse map (Source: Authors' illustration based on Geoportal Liguria Region)

Residential Fabric and Density: The urban settlement of Albenga exhibits a heterogeneous residential structure, encompassing a spectrum of typologies that range from high-density, continuous fabric within the historic core to low-density, discontinuous expansions at the periphery. This gradation reflects the historical and ongoing processes of urban sprawl, whereby the city progressively extends into the alluvial plain. The spatial distribution of residential density highlights the differential exposure to hydraulic risk, with peripheral, loosely structured settlements occupying low-lying, flood-prone zones.

Agricultural Dominance: The Albenga plain remains primarily an agricultural landscape, where crop cultivation constitutes the principal economic driver of the territory. Intensive agricultural practices, particularly within natural crop lands and greenhouse systems, involve extensive soil management interventions that interact directly with the hydrological regime of the Centa River. These activities influence infiltration rates, runoff dynamics, and sediment transport, linking land-use intensity with both ecological function and flood vulnerability.

Industrial and Urban Facilities: Large portions of the plain are occupied by industrial complexes, public facilities, military infrastructure, and ancillary urban services. These zones, often associated with highways, arterial roads, and dense circulation networks, generate substantial impermeable surfaces that fragment the landscape and disrupt natural hydrological flows. The resulting spatial discontinuities limit both ecological connectivity and the capacity of the plain to absorb and regulate excess water.

Natural and Riverside Components: Residual natural elements including riverside vegetation, forested areas, and olive groves are scattered throughout the basin, often isolated by the encroachment of urban or industrial development. Mapping indicates that the Centa River's main channel and its secondary streams are frequently severed from surrounding green spaces, diminishing the territory's inherent "sponge" capacity and reducing the effectiveness of riparian buffers for flood mitigation and biodiversity support.

Coastal Interface: The coastline transitions from natural features such as sand beaches and dune systems to heavily managed zones catering to the modern tourism economy, including boat rentals, parking areas, and recreational infrastructure. This transformation has largely supplanted the functional docks and maritime activities that historically structured the land-sea interface, reflecting broader socio-economic shifts that affect spatial and ecological continuity.

Infrastructural Barriers: The territory is further bisected by rigid infrastructure networks, most notably the railway and major highways, which frequently run parallel to the coast. These infrastructural elements, in combination with abandoned or residual spaces, produce physical gaps that impede integrated water management, limit landscape connectivity, and constrain socio-spatial cohesion across the plain.

The synthesis of these land-use layers confirms a pronounced territorial fragmentation. The juxtaposition of dense residential and industrial fabric directly adjacent to the Centa River has necessitated the construction of rigid concrete embankments the “cement fences” of modern flood management which, while serving a protective function, further alienate the city from its fluvial environment. This cumulative analysis underscores the urgent need for integrated, multi-scalar strategies that reconcile urban development, ecological restoration, and adaptive hydrological management in the Albenga plain.

4.3. Green Spaces and Vegetation Analysis

The analysis of the Albenga plain’s green infrastructure reveals a fragmented landscape where natural ecological corridors struggle to coexist with intensive agricultural and urban development. Based on the vegetation mapping (**Figure 29**) and the corresponding land-use categories, the green spaces can be categorized into three primary types that define the territory’s residual ecological potential.

4.3.1. Riverside and Riparian Vegetation

The most critical ecological component within the Albenga plain is the riverside vegetation lining the primary channel of the Centa River. This linear green corridor performs multiple essential functions, including stabilizing riverbanks, attenuating flow velocity during moderate flooding events, and providing habitat connectivity for riparian biodiversity. It serves as a foundational element of the local blue-green network, contributing not only to ecological resilience but also to the spatial legibility and environmental quality of the urban riverfront.

However, spatial analysis and mapping reveal that this vital vegetation is increasingly constrained by the rigid concrete embankments and “cement fences” that define the perimeters of the modern urban core. These structural interventions fragment the linear corridor, interrupting ecological continuity and limiting its capacity to

function as an integrated buffer during hydraulic events. The confinement of riparian vegetation reduces opportunities for natural flood attenuation, diminishes habitat quality, and restricts the corridor's role as a socio-environmental interface between the city and the river. Recognizing these limitations underscores the potential of Water Urbanism strategies, which seek to restore connectivity along the river edge, extend vegetated riparian corridors, and reintegrate the riverfront as a continuous ecological spine capable of simultaneously supporting biodiversity, hydrological regulation, and public amenity.

4.3.2. Forested Areas and Agricultural Buffer Zones

The peripheral hilly areas, particularly around the municipalities of Arnasco and Cisano sul Neva, are characterized by forest land and extensive olive groves. These forested zones serve as the primary "sponge" for the entire basin, absorbing mountainous runoff before it reaches the plain. Within the alluvial plain itself, the natural crops, land, and residual olive groves act as secondary green nodes, though their ecological function is often compromised by the high density of impermeable greenhouse structures.

4.3.3. Ecological Fragmentation and Potential Connectivity

A synthesis of the green spaces mapping reveals that Albenga's urban landscape is heavily fragmented by primary infrastructural elements, notably the railway corridors and major arterial roads, which dissect continuous forested patches and riverside ecological corridors. These infrastructural intrusions create spatial gaps within the green fabric, generating isolated, underutilized, or abandoned parcels that no longer contribute to the ecological or social connectivity of the city. Rather than treating these areas as residual or marginal, this research identifies them as strategic opportunities for targeted "re-greening" interventions.

By re-establishing visual and functional connections between these isolated green patches and the Centa River corridor through measures such as ecological corridors, permeable landscaping, and micro-wetland installations a Water Urbanism strategy can reintegrate the fragmented socio-ecological metabolism of the territory. Such interventions transform technical or infrastructurally constrained zones into multifunctional public green spaces that provide ecological services, enhance recreational accessibility, and foster community interaction. This approach not only

strengthens habitat continuity and biodiversity but also aligns with contemporary paradigms of regenerative urbanism, wherein underutilized urban voids are reimaged as active, resilient, and socially productive elements of the urban ecosystem.

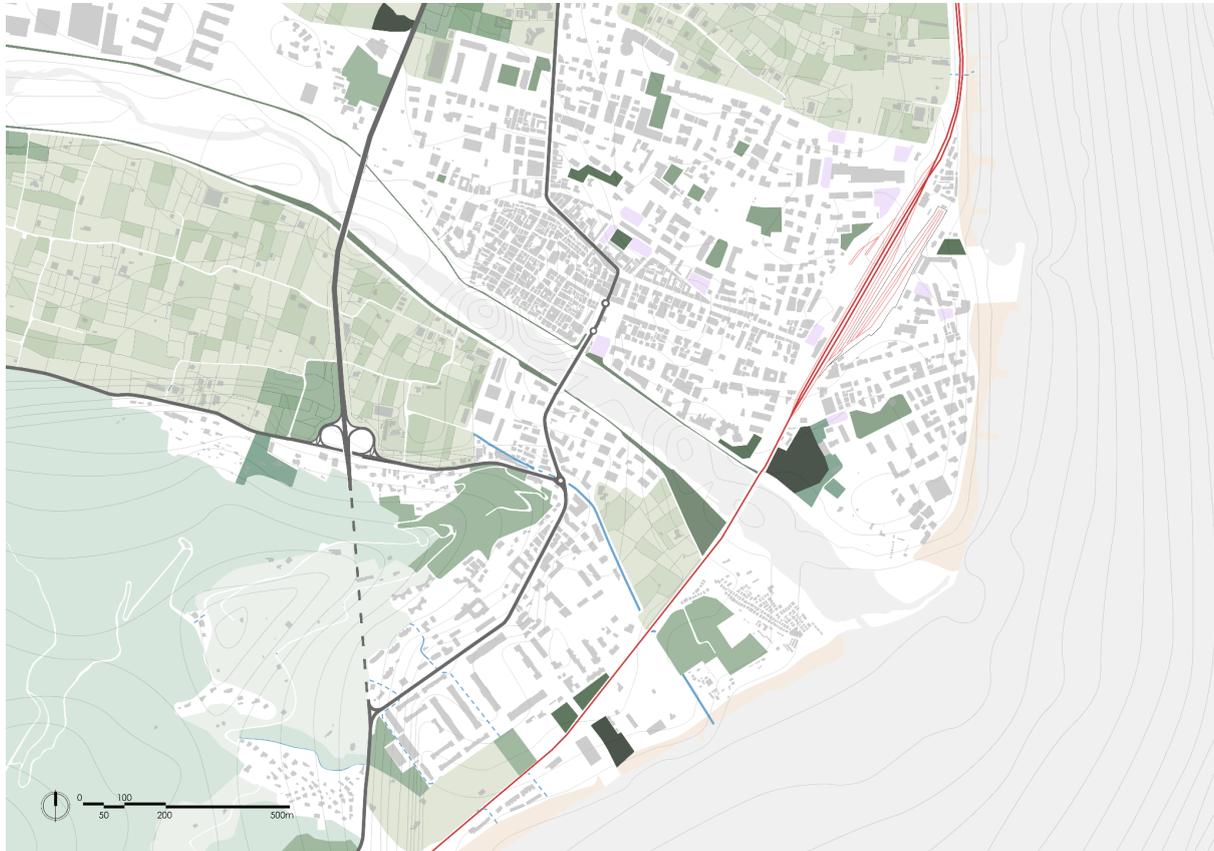


Figure 30 - Map showing the green spaces distribution (Source: Authors illustration based on Geoportal Liguria Region)

4.4. Localized Flood Analysis and Vulnerability Scenarios

The assessment of Albenga's hydrological vulnerability is based on a series of specialized flood maps that illustrate the spatial extent and intensity of potential inundation across the territory. These maps categorize risks into specific hazard classes and provide simulations for varying water depths, allowing for a detailed analysis of the urban and agricultural interface's fragility.

4.4.1. Flood Hazard Classification and Risk Zoning

According to the Mappa della Pericolosità da Alluvione, the Centa River basin is spatially delineated into distinct hazard zones encompassing both fluvial and coastal

domains. Within the fluvial domain, the majority of the plain is characterized by P3 (High Hazard) and P2 (Medium Hazard) designations, which closely follow the alignment of the river's artificialized channel and extend laterally into the adjacent alluvial terraces. These classifications indicate areas where the river's hydraulic energy is concentrated, producing elevated flood velocities and depths that pose significant risk to the urban and agricultural fabric.

The Mappa PAI "Dissesti geomorfologici" further refines this risk analysis by identifying zones of very high hazard (P4) as well as high hazard subtypes (P3a/P3b) in the surrounding hilly hinterland. These steep, geomorphologically unstable slopes contribute to rapid runoff and elevated sediment loads, which are conveyed directly into the Albenga plain during high-intensity precipitation events. This topography-induced funneling effect exacerbates the hydraulic pressure within the artificial river channel, amplifying downstream flood risk.

In addition to these regulatory hazard maps, the research integrates Areas of Potential Significant Flood Risk (APSFR), derived from historical flood data spanning 2018 to 2024. These analyses pinpoint critical zones predisposed to flash floods, particularly where intensive soil consumption primarily due to greenhouse agriculture reduces natural infiltration capacity, or where sections of the river are culverted ("tombati"), restricting the waterway's ability to accommodate peak flows. Collectively, these multi-scalar and multi-temporal datasets reveal the convergence of natural topography, historical engineering interventions, and contemporary land-use pressures, providing a comprehensive understanding of Albenga's flood vulnerability and establishing a robust empirical foundation for adaptive Water Urbanism strategies.

4.4.2. Water Depth Scenarios and Urban Vulnerability

The analysis incorporates depth-specific flood simulations to evaluate the potential impacts of significant inundation events on Albenga's urban and peri-urban fabric. In the 1-meter flood scenario, water levels begin to overtop secondary drainage networks and historical "beudi," small-scale irrigation and drainage channels that have long structured the city's agricultural and hydraulic systems.

The simulation indicates that the initial and most acute impacts are concentrated in low-lying zones, notably within the greenhouse agricultural fields and the peripheral

residential fabric. These areas, historically developed in naturally flood-prone sections of the plain, experience early-stage inundation, highlighting their vulnerability and the limitations of existing minor drainage infrastructures. The scenario illustrates not only the spatial distribution of water during moderate flood events but also the cascading effects on both productive landscapes and secondary urban settlements, underscoring the need for integrated flood management strategies that account for historical hydrological patterns while enhancing adaptive capacity across the urban-rural interface **(Figure 31)**.

The simulation of a more extreme event, as illustrated in the 3-meter flood scenario map **(Figure 32)**, reveals the potential for catastrophic failure of the city's primary defensive embankments. At this magnitude, floodwaters are no longer confined to peripheral zones but penetrate directly into the high-density residential fabric of the historic center, threatening both built heritage and the continuity of everyday urban life. Critical transport infrastructure, including principal roads and railway corridors, is likewise inundated, demonstrating the vulnerability of essential mobility networks and emergency response routes. This scenario underscores the systemic limitations of conventional hard-engineering defenses, highlighting that static embankments are incapable of managing extreme hydraulic events. The findings further reinforce the necessity of a paradigm shift toward integrated and adaptive flood management strategies that combine ecological, spatial, and infrastructural resilience across multiple scales of the urban and territorial system.



Figure 31 - 1m flood scenario (Source: Authors' illustration based on Geoportal Liguria Region)



Figure 32 - 3m flood scenario (Source: Authors' illustration based on Geoportal Liguria Region)

4.4.3. Synthesis of Vulnerability Findings

The overlay of these flood scenarios (**Figures 33 and 34**) onto contemporary land-use maps confirms that Albenga's existing "hard" defense strategy is approaching its technical and functional limits. Analysis of the APSFR mapping highlights a pronounced concentration of hydraulic risk along the interface between the continuous high-density residential fabric and the riverbed. In these zones, the urban form leaves no residual space for the river to naturally expand, effectively constraining its dynamics within a rigidly confined corridor. The results indicate that the extensive system of concrete embankments historically implemented to safeguard the city has paradoxically generated a heightened condition of residual risk. In the event of structural failure or overtopping, these barriers funnel water directly into the urban core, producing immediate and severe inundation with limited capacity for gradual energy dissipation. This finding underscores the inadequacy of conventional containment-based solutions in the face of extreme hydrological events and reinforces the need for adaptive, landscape-integrated strategies that restore flexibility, spatial permeability, and a distributive capacity to the river corridor.

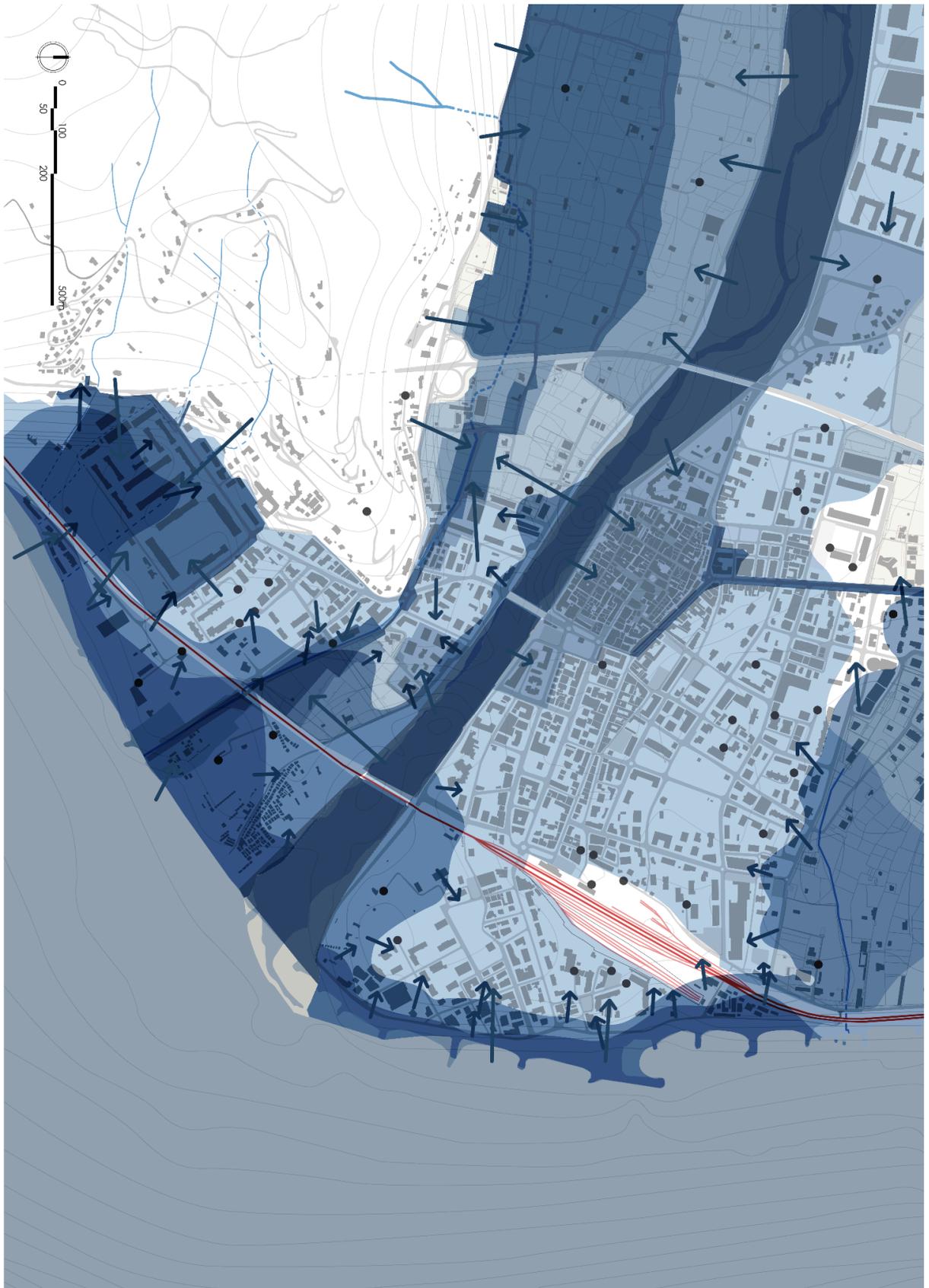


Figure 33 - Synthesis map for the worst-case scenario of flood Area 1 (Source: Authors' analysis and illustration)

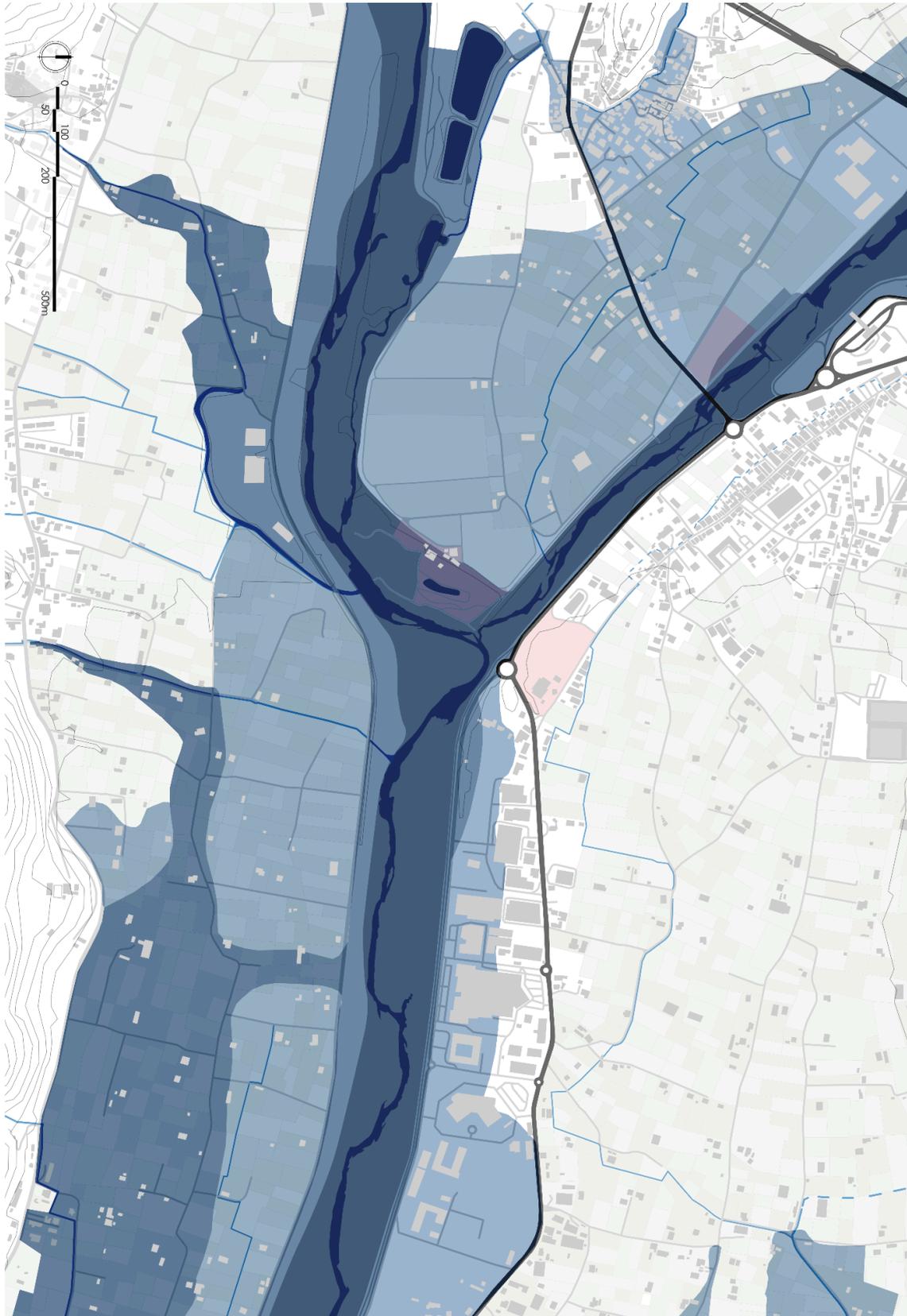


Figure 34 - Synthesis map for the worst-case scenario of flood Area 2 (Source: Authors' analysis and illustration)

4.4.4. Critical Infrastructure and Utilities Analysis

The documentation and analysis of the Albenga territory's utilities and critical infrastructure provide a clear view of the "backbone" that supports the town's socio-economic metabolism. This analysis identifies how major services ranging from energy distribution to sanitation intersect with the river basin and the various land-use zones.

The utility network of the study area is characterized by a high degree of centralization, with primary distribution lines largely aligned with major transportation infrastructures, such as the railway corridor and the Via Aurelia. This configuration generates a technical layer that is deeply embedded within the urban fabric, reinforcing the functional interdependence between mobility systems, productive landscapes, and essential services. While this spatial logic enhances efficiency and accessibility under ordinary conditions, it also concentrates strategic infrastructures along limited corridors, increasing their exposure to systemic disruptions.

Energy and communication networks are structured around high-voltage electrical lines and primary telecommunication conduits that closely follow the main road system. This alignment ensures a continuous supply of power and data to both the consolidated residential core and the energy-intensive greenhouse infrastructures located within the agricultural plain. However, the reliance on linear corridors creates a strong dependency on a limited number of infrastructural axes, reducing redundancy and resilience in the event of localized failures.

Water supply and sanitation systems are managed through an extensive underground network responsible for the distribution of potable water and the collection of wastewater. This network intersects the Centa River at multiple points, which constitute critical technical vulnerabilities. During extreme flood events, these crossings are particularly exposed to structural damage, service interruptions, and potential contamination, highlighting the fragility of subsurface infrastructures in hydraulically dynamic environments.

Public and urban facilities, including administrative buildings and emergency services, are predominantly concentrated within the high-density residential fabric. Spatial analysis reveals that many of these strategic functions are located within zones

classified as medium to high flood hazard (P2/P3). This overlap significantly complicates emergency management and disaster response strategies, as the very services required during extreme events are themselves exposed to risk, underscoring the need for a more integrated alignment between infrastructural planning, risk mitigation, and territorial safety (**Figure 35**).



Figure 35 - Map showing critical infrastructure and utilities (Source: Authors' analysis and illustration).

The synthesis of the utilities map with the 3m flood scenario reveals a significant threat to the town's operational continuity. During such high-intensity events, the failure of a single node, such as a pumping station or a primary electrical substation located in the floodplain, can lead to a systemic collapse of services across both the urban and agricultural domains. Furthermore, the historical beudi irrigation system, while marginalized in modern planning, remains a latent utility that can inadvertently distribute floodwaters deeper into the crop land.

By mapping these technical layers, the research highlights that a "Water Urbanism" approach must go beyond surface-level landscape interventions. It necessitates a "smart" integration of utilities that can withstand or adapt to the hydrological cycles of the Centa basin, ensuring that the public and urban facilities remain functional even during peak discharge periods.

4.5. Cross-Sectional Analysis of the Albenga Basin

The topographical sections provide a critical vertical reading of the territory, illustrating the extreme altitude drop from the alpine hinterland to the coastal shelf and the resulting hydraulic pressure exerted on the urban fabric. These drawings allow for an understanding of the basin as a tiered system of ecological and settlement zones.

The sectional analysis of the Centa River basin reveals a clear altimetric and functional differentiation of the territory, highlighting the progressive transformation from mountainous catchment areas to the coastal urban landscape. At elevations exceeding 150 m above sea level, the upper sections are characterized by steep gradients and dense forest cover, which function as the primary hydrological catchment of the basin. This mountainous high-terrain area represents the source of hydraulic kinetic energy, where seasonal streams originate and rapidly convey runoff downstream, particularly during intense rainfall events.

Descending toward elevations between approximately 10 m and 50 m, the sections illustrate a transitional piedmont zone marked by gentler slopes, fragmented agricultural land, and small, dispersed settlements. This intermediate landscape operates as a buffer between the high-energy mountain environment and the intensively urbanized plain. Its mixed rural–residential character plays a crucial role in moderating runoff dynamics, although increasing land-use pressure risks undermining this regulatory function.

The central portion of the section cuts through the Centa River itself, revealing a markedly incised fluvial trench in which the riverbed lies significantly below the surrounding terrain. This depressed and channelized configuration emphasizes the critical risk associated with rigid hydraulic embankments. The presence of “cement fences” confines the river within a narrow corridor, creating a condition in which any structural failure would trigger a rapid, gravity-driven inundation of adjacent urban areas, with limited possibilities for natural drainage or controlled recession of floodwaters.

Adjacent to this fluvial trench, the sections depict the urban and historic interface of Albenga, where the dense fabric of the “City of Towers” is positioned in immediate proximity to the river’s artificial course. This spatial arrangement confirms historical reconstructions from both the Roman municipium and medieval periods, during which the settlement maintained a direct functional and symbolic relationship with the water. The proximity, while historically advantageous, now constitutes a condition of heightened exposure to hydraulic risk.

Beyond the historic core, the section extends across the new settlement areas developed on the flat alluvial plain. This portion of the profile highlights the continuity of urban expansion across low-lying terrain before terminating at sea level (0.00 m). The minimal vertical margin between the urban ground plane and the coastline underscores the cumulative vulnerability of the area to both fluvial flooding and coastal storm surges, particularly under scenarios of sea-level rise and increased storm intensity (**Figure 36**).

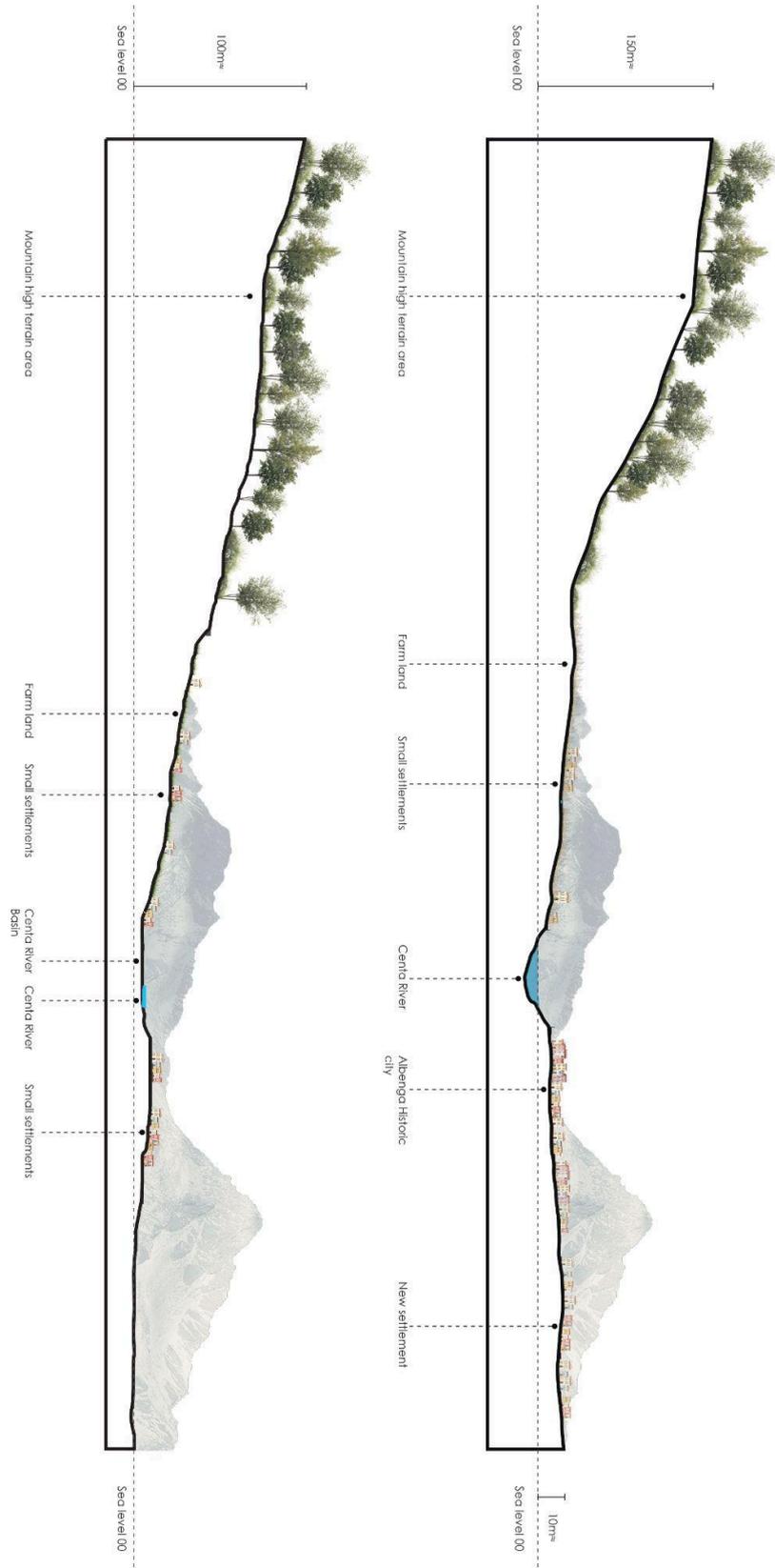


Figure 36 - Technical sections at critical points of the Centa river landscape (Source: Authors' analysis and illustration).

These sections (**Figure 36**) underscore the characterization of the Albenga plain as a fundamentally “receiving” landscape, where geomorphological and infrastructural conditions converge to amplify hydraulic risk. The pronounced verticality of the surrounding mountainous terrain channels high-velocity runoff toward the low-lying plain, while the rigidity of the existing urban embankments further constrains and accelerates the flow. This combination produces a pronounced funneling effect, leaving the historic city devoid of any inherent topographical buffer to attenuate peak discharge events. Consequently, the plain functions less as a distributive landscape capable of modulating water energy and more as a concentrated receptor of hydrological pressure, reinforcing the imperative for interventions that integrate the river into the urban fabric and restore a more resilient, adaptive relationship between Albenga and its primary watercourse.

4.6. Chapter Synthesis: The State of Territorial Rupture

The findings and analyses presented in this chapter confirm that Albenga’s current territorial condition is characterized by a profound physical and functional disconnection from its primary hydrological driver, the Centa River. Through the synthesis of multi-scalar data ranging from regional mountain-to-sea geomorphological structures to fine-grain networks of utilities, vegetation, and land use the analysis reveals a systemic vulnerability embedded within the basin’s spatial configuration. Rather than emerging from isolated failures, this condition reflects the cumulative effects of historical interventions, regulatory inertia, and contemporary patterns of territorial occupation.

At the regional scale, the topographic configuration of the Centa basin produces a pronounced hydraulic funneling effect. Cross-sectional analyses and large-scale river mapping clearly demonstrate how high-velocity runoff originating in the mountainous hinterland is rapidly conveyed toward the coastal plain, where it is abruptly compressed into a rigid and highly artificialized urban channel. This spatial constriction intensifies hydraulic pressure precisely at the point where the river intersects with the historic city, significantly amplifying flood risk under extreme rainfall conditions.

Historical tracing further confirms that this vulnerability is deeply rooted in legacy decisions dating back to the medieval period. The diversion of the river from its original northern course the “Old Centa” and the subsequent infilling of its natural floodplain to expand agricultural land fundamentally altered the drainage logic of the plain. While this

intervention generated short-term economic benefits, it permanently reduced the territory's capacity to absorb, dissipate, and adapt to fluctuating water volumes. Contemporary flood risk patterns thus emerge as a direct spatial consequence of this irreversible transformation.

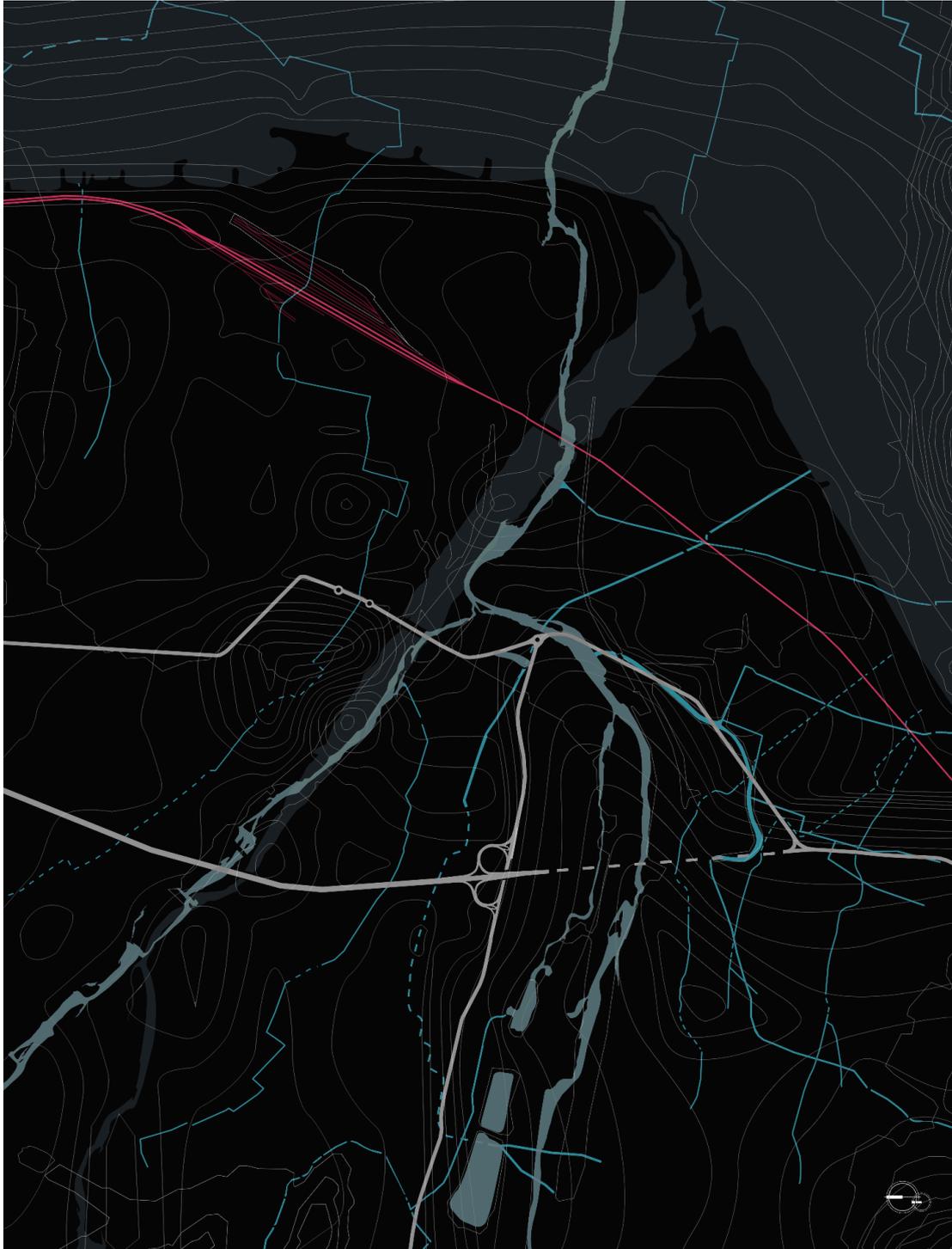
At the urban scale, the “Until Now” analysis reveals that existing safety infrastructures have reached a critical threshold. The extensive system of concrete embankments and floodwalls commonly referred to as “cement fences” now functions less as an adaptive defense and more as a rigid barrier. These structures physically and perceptually sever the city from its river while simultaneously concentrating high-hazard zones (P3–P4) in close proximity to residential areas and essential urban utilities. In doing so, they exacerbate residual risk and increase the potential severity of failure.

From an ecological perspective, vegetation mapping and land-use analysis expose a highly fragmented landscape. The expansion of intensive greenhouse agriculture and dispersed urbanization has progressively displaced natural riparian buffers, floodable fields, and wetlands. What remains are isolated green patches with limited permeability and minimal “sponge” capacity, insufficient to perform meaningful hydrological or ecological regulation at the basin scale.

Finally, the simulation of 1-meter and 3-meter flood scenarios demonstrates the structural inadequacy of reactive, hard-engineering solutions in addressing the increasingly intense and unpredictable Mediterranean torrential regime that characterizes the Centa basin. These findings underscore the necessity of a paradigm shift in territorial management. This diagnostic framework thus provides the empirical and conceptual foundation for the subsequent chapter, which advances a Water Urbanism proposal. In this approach, the river is no longer treated as a threat to be contained, but is reimagined as a structural spine capable of organizing space, enhancing resilience, and reintegrating Albenga into a cohesive and adaptive hydrological landscape.

CHAPTER 5

DISCUSSION



5.1. Interpretation of Key Findings

The synthesis of historical cartographic reconstruction and contemporary spatial analysis demonstrates that Albenga's present condition of hydraulic vulnerability is not the result of recent failures, but rather the outcome of long-term path dependency rooted in "crystallized" decisions made centuries ago. In particular, the medieval diversion of the Centa River from its northern course commonly referred to as the "Old Centa" to the current southern channel represented a strategic intervention aimed at short-term economic gain through the reclamation of fertile agricultural land. While effective within the historical context of agrarian expansion, this intervention fundamentally altered the hydrological logic of the plain.

The redirection of the river disrupted a previously porous and meandering fluvial system that had functioned as a distributed metabolic network, capable of dissipating energy, accommodating seasonal flooding, and sustaining ecological balance. In its place, a rigid and linearized riverbed was imposed, concentrating flow and accelerating water velocity within a confined corridor. Contemporary flood risk mapping reveals that this transformation has produced high-risk hydraulic conditions (P3–P4) that are now directly adjacent to the historic urban core, placing Albenga's medieval towers and heritage fabric in a condition of chronic exposure.

The "Until Now" analytical mapping further illustrates how modern urban expansion and the intensification of greenhouse-based agricultural infrastructure have progressively eroded the territory's residual capacity to absorb and regulate water. These developments have effectively displaced the landscape's natural defensive systems such as floodplains, wetlands, and secondary channels pushing them beyond the urban perimeter. As a result, the city has become almost entirely reliant on continuous concrete embankments as its primary form of protection.

This dependence on hard engineering infrastructures generates a deceptive perception of safety, while in reality amplifying residual risk by eliminating spatial redundancy and adaptive capacity within the hydrological system. In this condition, failure becomes catastrophic rather than incremental. The analysis underscores the necessity of reinterpreting historical hydraulic decisions not as immutable constraints, but as reversible or adaptable

conditions. Only by reactivating the latent spatial logic of the plain through strategies aligned with Water Urbanism and landscape-based adaptation can Albenga begin to transition from a rigid, risk-intensive system toward a more resilient and metabolically balanced territorial structure.

5.2. Discussion on the Role of Water Impact on Regional Development

Water has historically functioned as both the primary structuring force and a critical limiting factor in the territorial development of the Albenga plain. From its earliest phases of urban formation, the presence of the “Old Centa” river and its associated agricultural docks positioned Albenga as a strategic Mediterranean hub within regional and trans-regional trade networks. The river not only facilitated the movement of goods and people but also structured patterns of settlement, production, and exchange, embedding hydrological dynamics directly into the spatial and economic organization of the territory.

In contemporary conditions, the Centa River continues to operate as the structural backbone of the regional economy, albeit in a transformed manner. Its alluvial processes have generated fertile soils that underpin the intensive greenhouse-based agricultural system characteristic of the Albenga plain. This form of production, while highly efficient and economically significant, remains intrinsically dependent on the hydrological regime of the river basin. Water, therefore, persists as a fundamental productive resource, shaping land-use patterns and sustaining regional competitiveness within agricultural markets.

Despite this productive role, water is increasingly perceived primarily through the lens of risk and hazard management. Regional-scale analysis highlights how the geomorphological configuration of the basin characterized by a mountainous hinterland converging toward a narrow coastal plain produces a pronounced “funnel effect.” During extreme rainfall events, high-velocity runoff is rapidly conveyed from the uplands toward the low-lying plain, transforming Albenga into a receiving landscape for concentrated hydraulic pressure. This topographic condition imposes significant constraints on urban expansion and infrastructural development, as the plain must continuously absorb, regulate, and dissipate excess water flows.

Within this context, the integration of water into spatial planning and territorial design emerges not as a purely aesthetic or environmental ambition, but as a structural necessity for

the long-term economic and spatial viability of the region. Treating water solely as a threat to be controlled through defensive measures overlooks its foundational role in shaping both historical and contemporary development patterns. Instead, a regional strategy grounded in Water Urbanism must recognize water as a dynamic territorial agent one that simultaneously supports production, structures landscapes, and demands adaptive spatial responses. Only through such an integrated perspective can Albenga reconcile hydraulic risk management with the preservation of its economic base and the sustainable transformation of its territorial system.

5.3. Pros and Cons of Current Planning Practices

An evaluation of the existing regulatory framework specifically the Municipal Urban Plan (PUC), the Flood Risk Management Plan (PGR), and the Hydrogeological Setting Plan (PAI) reveals a pronounced structural disconnect between instruments of risk assessment and the practices of urban and landscape design. On a technical level, these planning tools provide highly detailed cartographic representations of flood hazard conditions, classifying territory according to graduated risk levels (P1–P4) and delineating precise regulatory boundaries. From a risk prevention perspective, this regulatory apparatus has proven effective in limiting further uncontrolled urbanization within areas exposed to high hydraulic vulnerability, thereby reducing potential damage to people, property, and critical infrastructure.

However, despite the analytical precision of these instruments, the dominant planning approach remains largely reactive and defensive in nature. Flood risk management is predominantly addressed through rigid structural interventions, most notably continuous embankments and reinforced concrete barriers that function as linear containment devices. While such measures can be technically effective in reducing short-term flood risk, they operate through a logic of separation rather than adaptation. As a result, they generate a physical and perceptual disconnection between the urban fabric and the riverfront, transforming riparian zones into marginal, mono-functional technical corridors. This approach significantly constrains opportunities for ecological restoration, landscape enhancement, and public access to water, ultimately undermining the river's potential role as an active component of urban life.

This condition produces what can be defined as a form of “planning ambiguity,” rooted in a rigid zoning paradigm that assigns land to fixed and mutually exclusive functional

categories—such as intensive agricultural areas, residential zones, or strictly protected spaces—without adequately accounting for the inherently dynamic and cyclical behavior of hydrological systems. Water is treated as an external risk factor rather than as a constitutive element of territorial structure. Consequently, this static regulatory framework reinforces institutional and sectoral fragmentation, as responsibilities for water management, urban development, and environmental protection are distributed across separate governance scales with limited integration.

The absence of a unified territorial vision prevents the landscape from being understood and managed as a single hydrological metabolism, in which flows of water, energy, and ecological processes interact with urban form over time. This disjunction significantly limits the capacity of current planning instruments to support integrated and adaptive strategies consistent with the principles of Water Urbanism. Overcoming this limitation requires a shift from zoning-based control toward process-oriented planning, where risk management, spatial design, and ecological performance are integrated within a flexible and multiscale governance framework capable of responding to climatic uncertainty and long-term environmental change.

5.4. Implications for Sustainable Development

To achieve long-term sustainability, Albenga must move beyond a paradigm of hydraulic containment toward a model informed by Water Urbanism, in which the hydrological cycle is integrated into the spatial and infrastructural logic of the city (Shannon *et al.*, 2008; Wong *et al.*, 2009). The findings of this analysis indicate that sustainable development in this context requires interventions that re-establish functional and ecological continuity between the urban structure and the Centa River, shifting from defensive flood control toward adaptive and resilient territorial systems.

First, restoring porosity at multiple scales is essential. This entails replacing impermeable surfaces and underutilized or residual spaces with interconnected blue-green corridors capable of increasing soil permeability, extending the time of concentration, and reducing peak discharge during extreme rainfall events (Ahern, 2011). Such corridors simultaneously perform hydraulic, ecological, and social functions by supporting biodiversity, improving urban microclimates through evapotranspiration, and providing multifunctional public spaces that can temporarily store floodwater without structural failure.

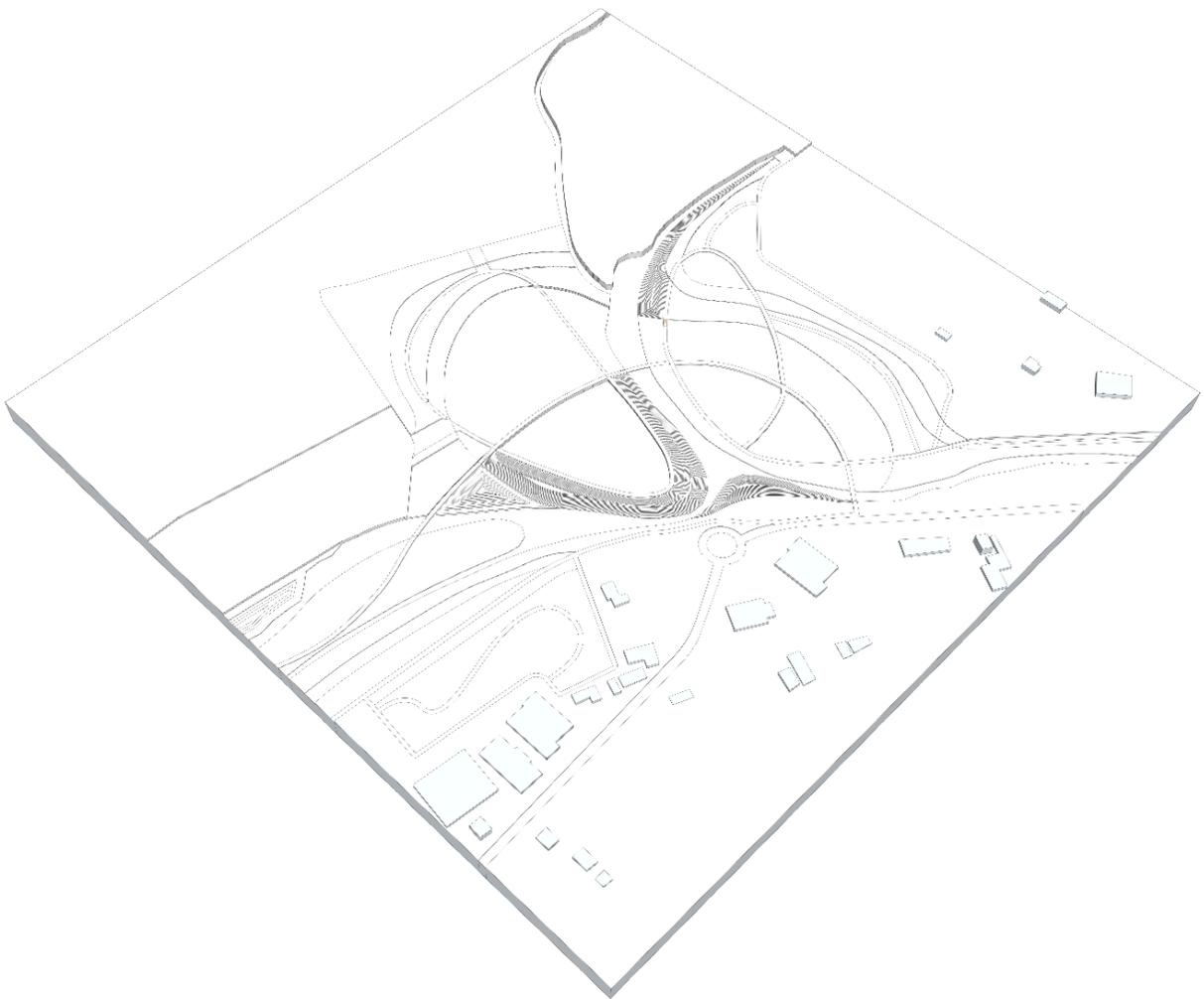
Second, the principle of Room for the River should guide the reconfiguration of the riverfront and adjacent floodplain territories. This approach represents a strategic shift away from rigid embankments toward stepped river profiles, widened floodplains, and floodable public parks designed to safely accommodate 1-meter and 3-meter flood scenarios (Rijke *et al.*, 2012). By allowing controlled inundation in designated areas, hydraulic energy is dissipated spatially rather than resisted structurally, reducing systemic risk while preserving essential urban functions (Meyer *et al.*, 2014). This logic aligns with contemporary European flood-risk policy, which promotes integrated and spatially adaptive flood management over purely defensive solutions.

Third, infrastructural integration must be reconceived to enhance systemic resilience under variable hydrological conditions. Critical utility networks, such as energy distribution, potable water supply, and wastewater systems, should be designed or retrofitted to be resilient, relocatable, or submersible, ensuring continuity of service during controlled flooding events (Pahl-Wostl, 2015). This approach recognizes infrastructure not as a static technical layer but as part of a broader socio-ecological system that must remain operational under conditions of uncertainty and climate stress.

Taken together, these strategies would transform the Centa River from a technical liability into a high-quality public and ecological asset, re-establishing the historical socio-spatial relationship between the city and water that has been progressively severed by twentieth-century hydraulic engineering. In this framework, flood risk management becomes a territorial project, where safety, urban quality, and ecological performance are addressed simultaneously through spatial design rather than separation (Shannon *et al.*, 2008).

CHAPTER 6

PROPOSAL



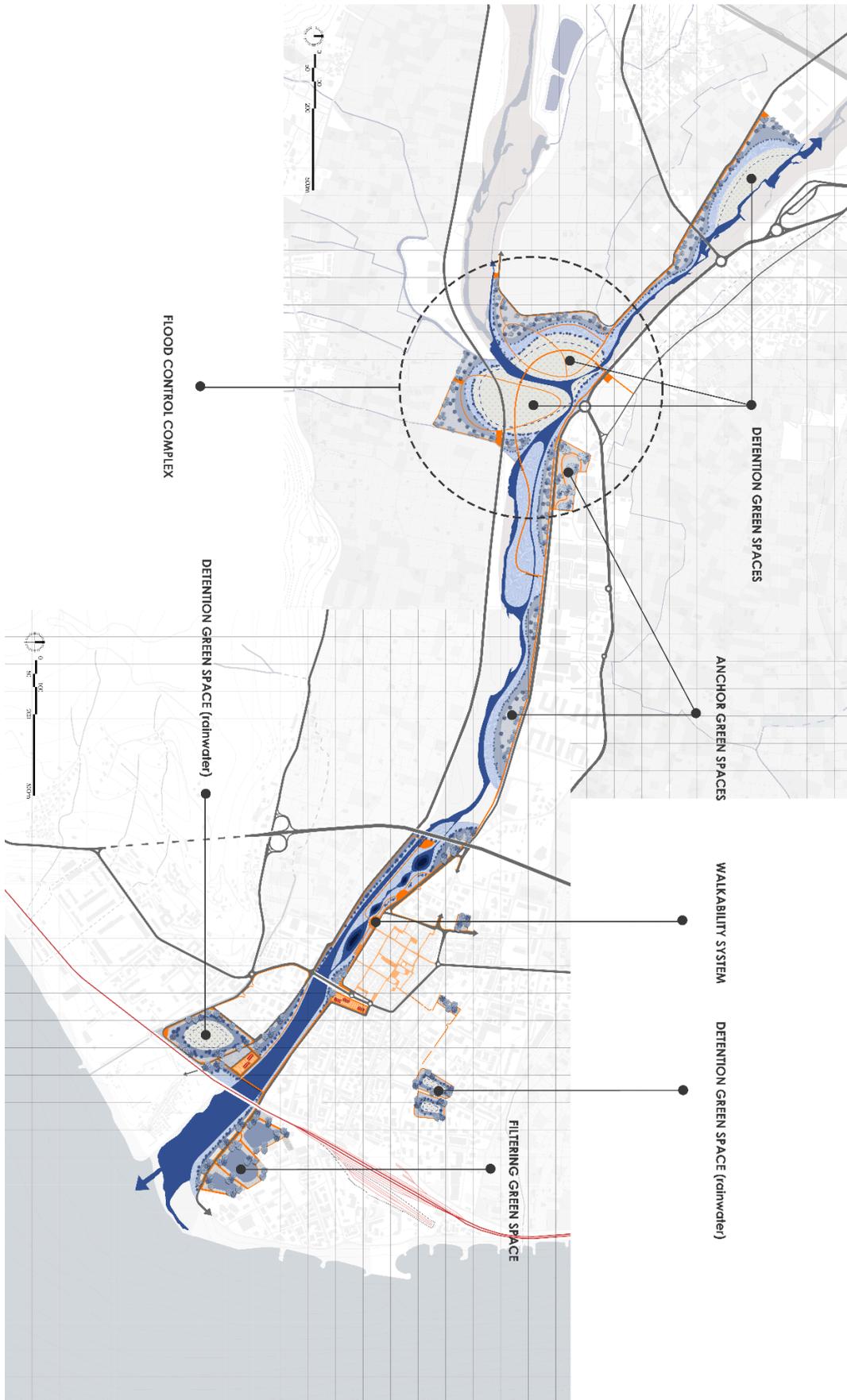


Figure 37 - Proposal Master Plan (Source: Authors' illustration)

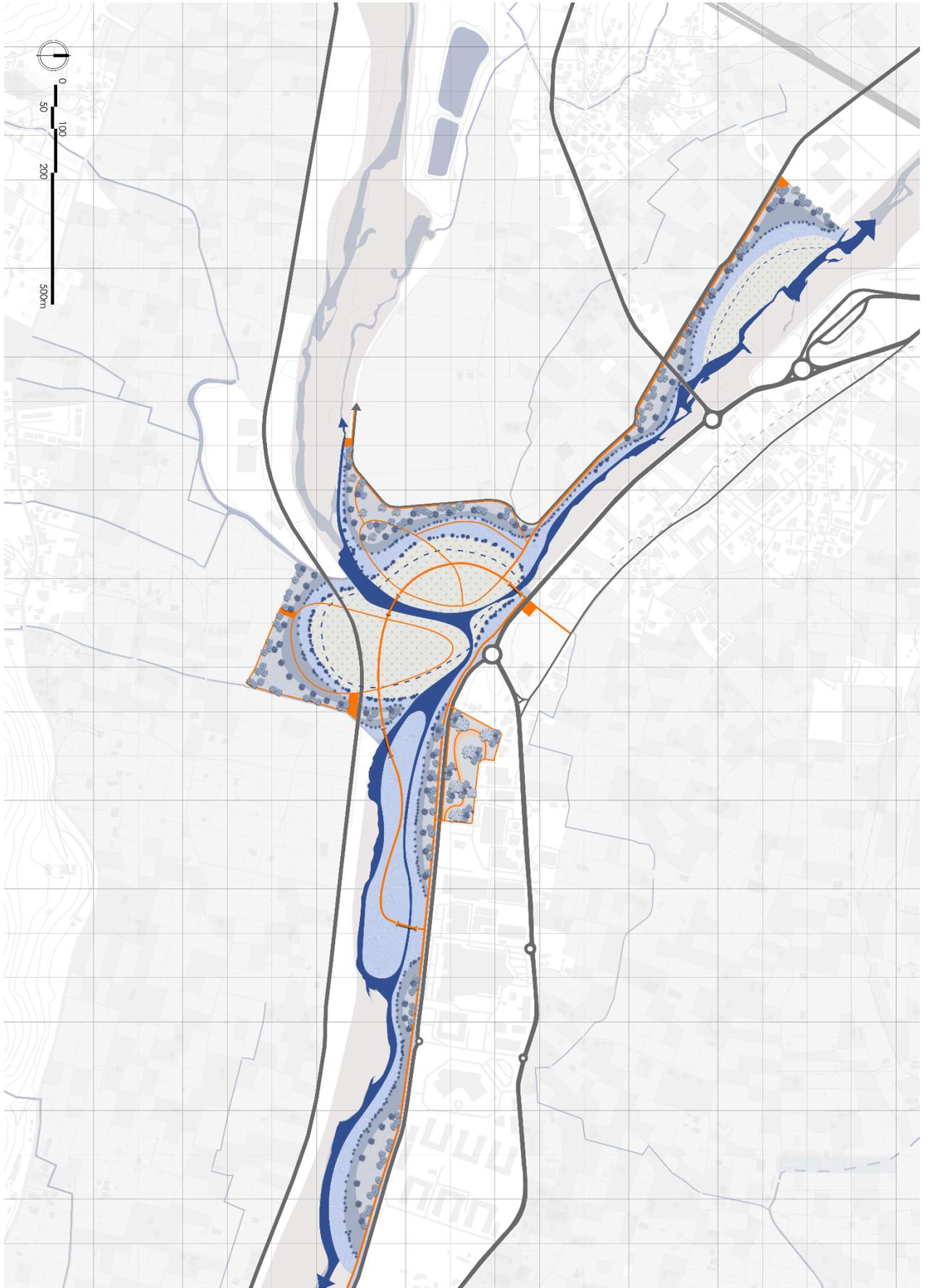


Figure 38 - Proposal Master Plan Area 2 (Source: Authors' illustration)

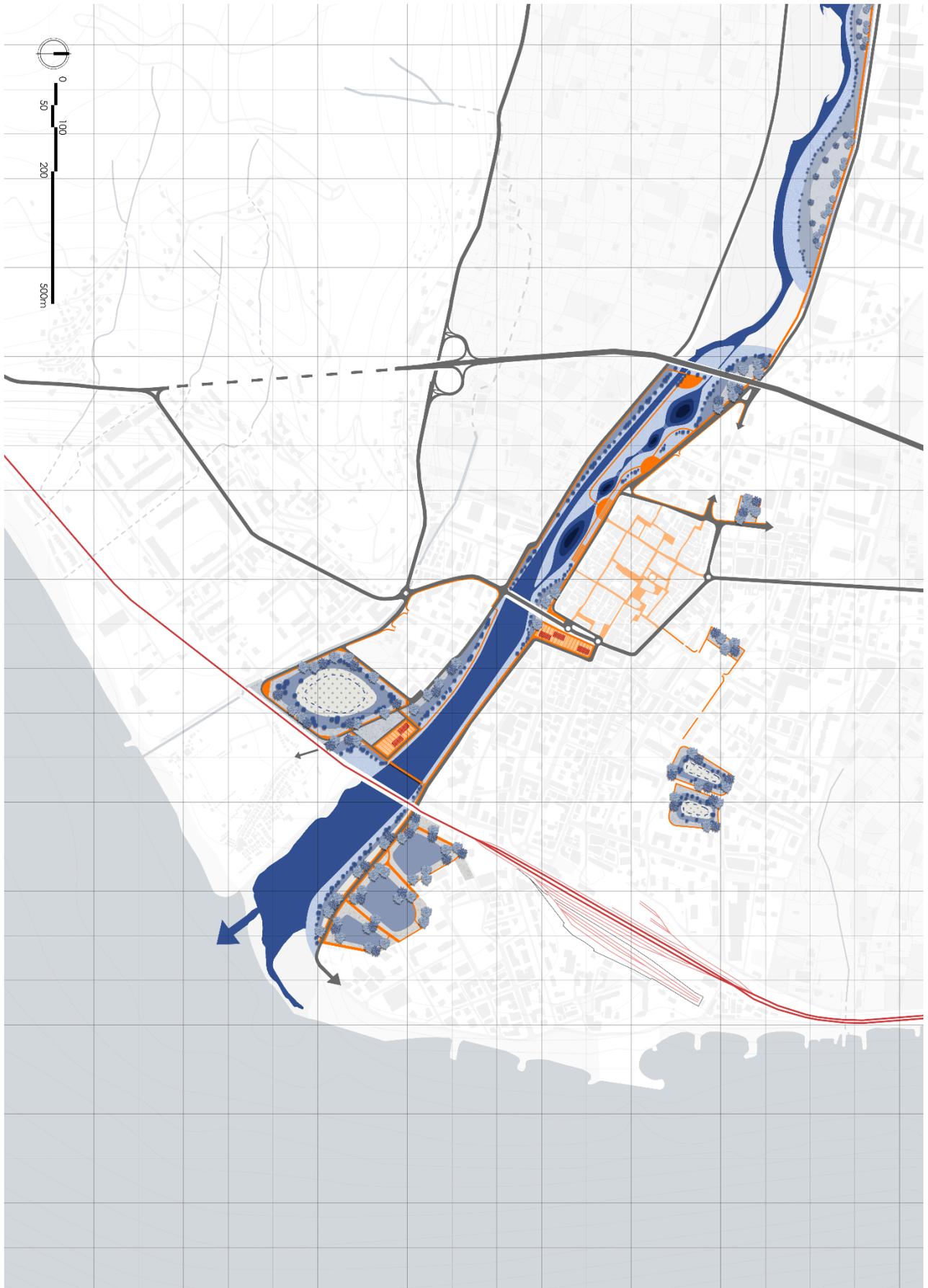


Figure 39 - Proposal Master Plan Area 1 (Source: Authors' illustration)

6.1 Vision and Planning Principle

6.1.1 Vision and Overall Strategy

This proposal defines a strategic planning framework aimed at redefining the relationship between Albenga's urban morphology and the regional hydrological system through the lens of a Water Urbanism model. At its core, the framework addresses the long-standing spatial and functional disconnection between the city and the Centa River basin, a condition largely produced by historically rigid engineering interventions focused on flow control, coupled with recurring extreme flood events. These approaches, while effective in terms of short-term risk management, have progressively disrupted the organic relationship between urban development and water systems. In contrast to traditional engineering paradigms that conceptualize water as a threat to be contained or diverted, this proposal reframes water as a structuring element of urban space and as an operational infrastructure capable of supporting ecological regeneration and economic revitalization.

The proposed vision marks a clear transition from a static, defense-oriented model toward a flexible and adaptive urban system in which built form and open space are designed to respond dynamically to fluctuating hydrological conditions. Rather than reinforcing impermeable barriers, the strategy prioritizes green infrastructure, permeable surfaces, and floodable landscapes as primary spatial tools. These interventions re-establish physical and functional continuity between the historic urban core and the riverfront, allowing water processes to become visible, accessible, and integrated into everyday urban life. By embedding flood risk mitigation directly into land-use planning and urban programming, the proposal enables the creation of mixed-use environments that generate synergistic social, ecological, and economic value while enhancing the overall quality of the urban landscape.

From a structural perspective, the hydrological network is reinterpreted as a foundational framework for regulating microclimatic conditions and strengthening Albenga's resilience in the face of climate change. Existing dikes, canals, and drainage infrastructures are redesigned as multifunctional landscape systems that simultaneously perform hydraulic functions and operate as ecological corridors. These linear green structures facilitate the restoration of local biodiversity, improve environmental

connectivity, and contribute to the mitigation of urban heat and surface runoff. In parallel, a slow-mobility network is developed along the water axes, reinforcing social connectivity and promoting alternative modes of movement that reduce dependence on conventional transport infrastructures, which have historically contributed to spatial fragmentation.

Within the broader context of Albenga's ongoing economic transition from traditional agricultural production toward a service-oriented, experiential, and knowledge-based economy, the redefinition of water's role within the urban system becomes a critical and timely challenge. The proposal asserts that spatial transformation must proceed in a balanced and context-sensitive manner, safeguarding the city's historical and landscape heritage while simultaneously enhancing its competitiveness within the regional planning framework. Ultimately, the project envisions Albenga as a resilient and sustainable urban system in which economic activities, public spaces, and hydrological processes are integrated into a dynamic equilibrium. This approach establishes a robust foundation for long-term development, enabling the city to adapt effectively to future environmental uncertainties and evolving socio-economic conditions.

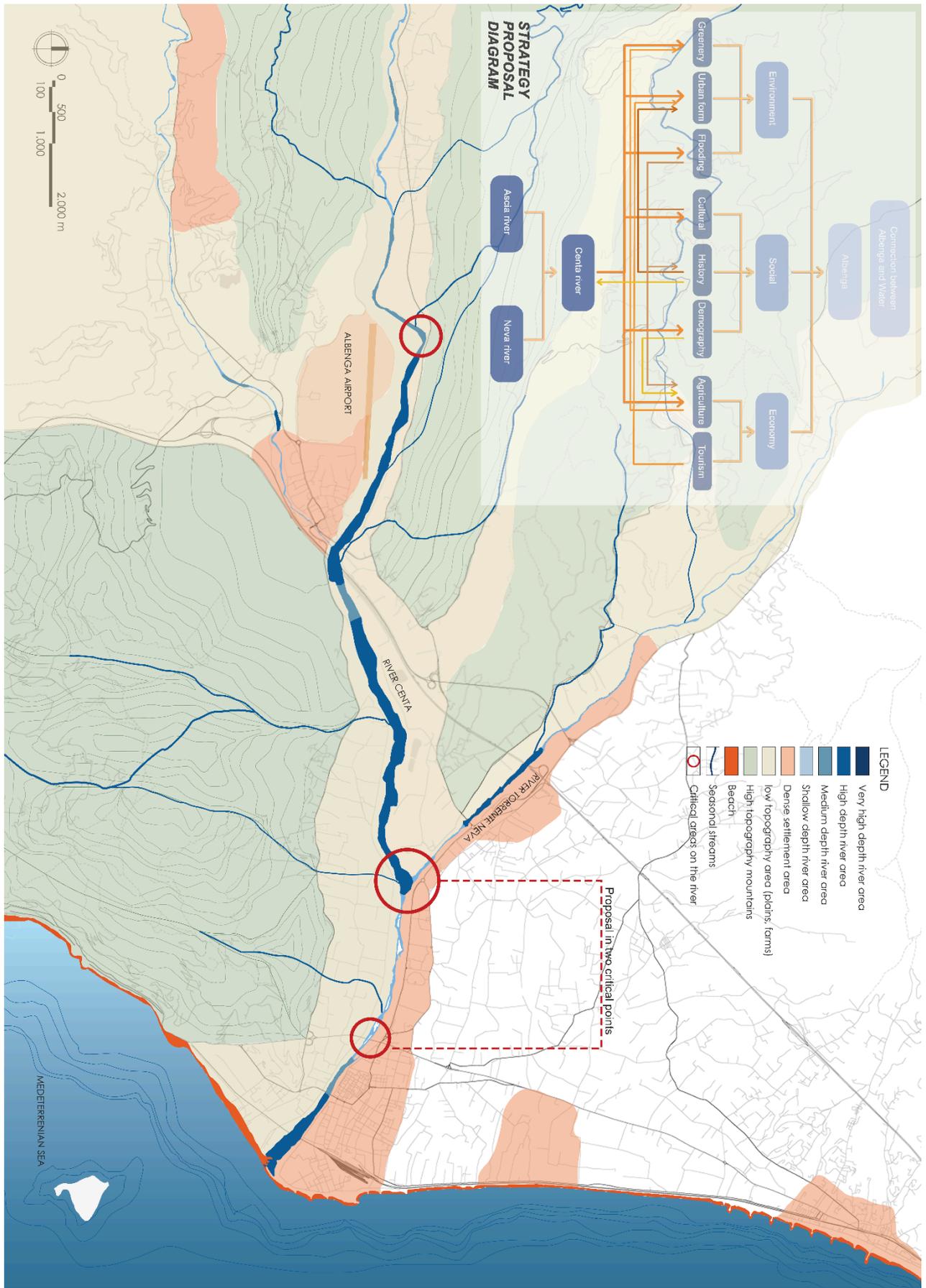


Figure 40 - Proposal diagram (Source: Authors' illustration).

6.1.2 Key strategies

a. Detention Green

The Detention Green design strategy was conceived as an integrated landscape hydrological framework aimed at establishing a natural and adaptive filtration system within two strategically significant zones of the Centa River basin. These zones function as a primary hydrological buffer that intercepts, regulates, and moderates water flow before it reaches the highly vulnerable historical core of Albenga. Rather than addressing flood risk solely through conventional engineering solutions, the strategy adopts an ecosystem-based approach that enhances water detention capacity, promotes infiltration, and reduces peak discharge during extreme hydrological events, thereby strengthening the overall resilience of the river system.

Structurally, the system is articulated through three principal design components, with the most prominent being a large-scale water storage and detention complex located at the confluence of the three main streams. This nodal condition is deliberately leveraged as a critical spatial and functional hinge within the river corridor. While its primary role is to temporarily retain excess water and stabilize hydraulic performance during flood events, the complex is simultaneously conceived as a multifunctional green infrastructure. Its spatial configuration supports ecological continuity, landscape permeability, and recreational accessibility, transforming what would traditionally be a mono-functional flood control facility into an active and publicly accessible urban landscape.

By embedding public spaces, recreational facilities, and slow-mobility networks within the hydrological infrastructure, the Detention Green system extends beyond its technical mandate to assume a socio-spatial role within the broader urban structure. The river corridor thus becomes a catalyst for everyday social interaction, community-oriented activities, and environmental awareness. Furthermore, due to its strategic location along major access routes to Albenga, the detention landscape is envisioned as a threshold space and an urban gateway, capable of intercepting tourist flows and stimulating economic exchanges linked to cultural, ecological, and leisure-based activities.

At a conceptual level, this strategy seeks to redefine the conventional understanding of “defensive infrastructure” by shifting from a paradigm of separation and control toward one of integration and value generation. Hydrologically sensitive areas are no longer treated as residual or restricted zones but are reconceptualized as productive landscapes that mediate between natural systems and urban development. Through this approach, Detention Green spaces establish spatial continuity between ecological networks and the existing built fabric, fostering a hybrid condition where environmental performance and urban vitality coexist.

The long-term implications of this strategy extend beyond flood mitigation. By reducing hydrological risk in the historic center, it safeguards cultural heritage while simultaneously creating the preconditions for new forms of sustainable economic activity, including eco-tourism, landscape-based services, and community-driven initiatives. By strategically activating key hydrological intersections, Albenga is able to reconcile the demands of water safety with aspirations for dynamic and resilient urban growth. In doing so, the river is repositioned not as a constraint to development, but as a structural and symbolic driver of the city’s future transformation.

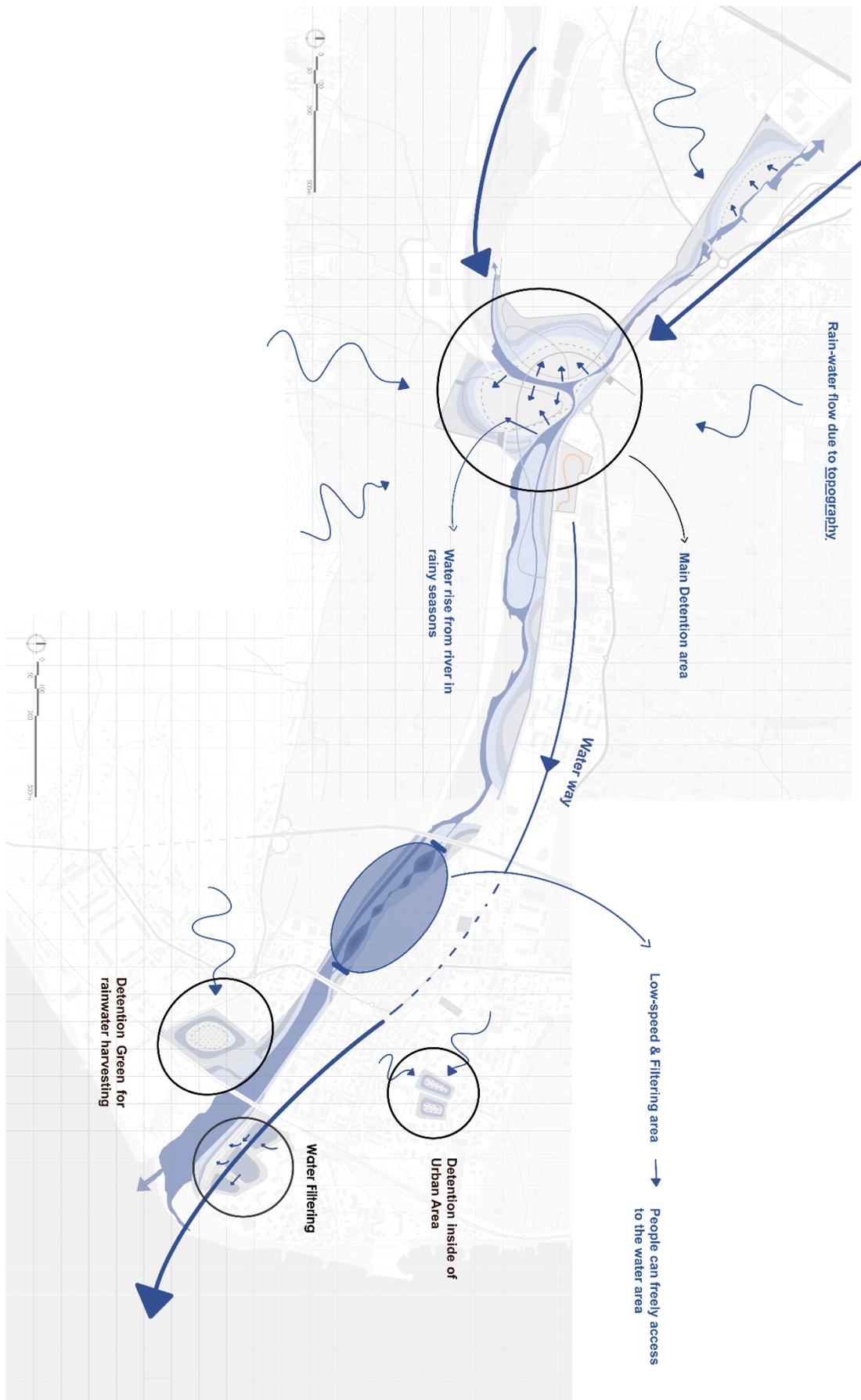


Figure 41 - Proposal Water system (Source: Authors' illustration).

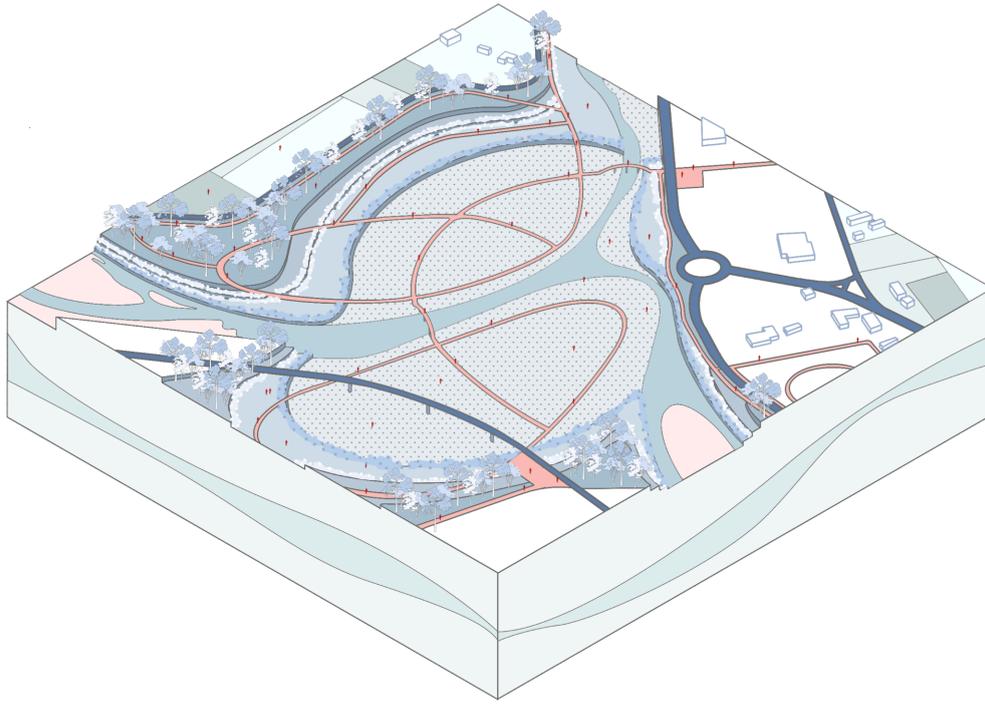


Figure 42.1 - Proposal Water system Axonometric - Detention Green Complex (Source: Authors' illustration).

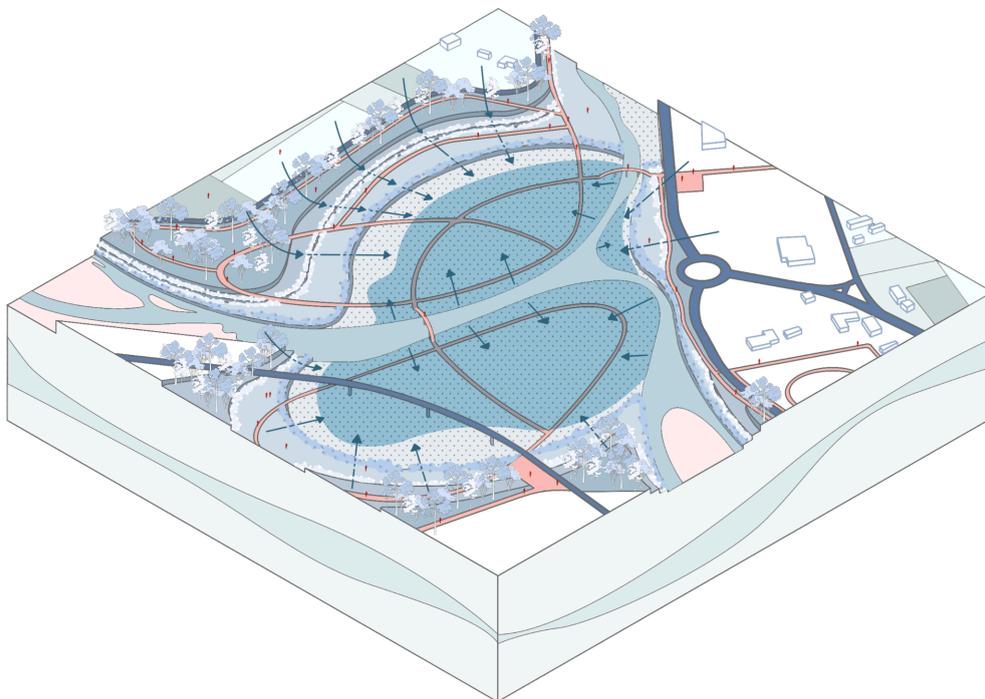


Figure 42.2 - Proposal Water system Axonometric - Detention Green Complex with flood scenario (Source: Authors' illustration).

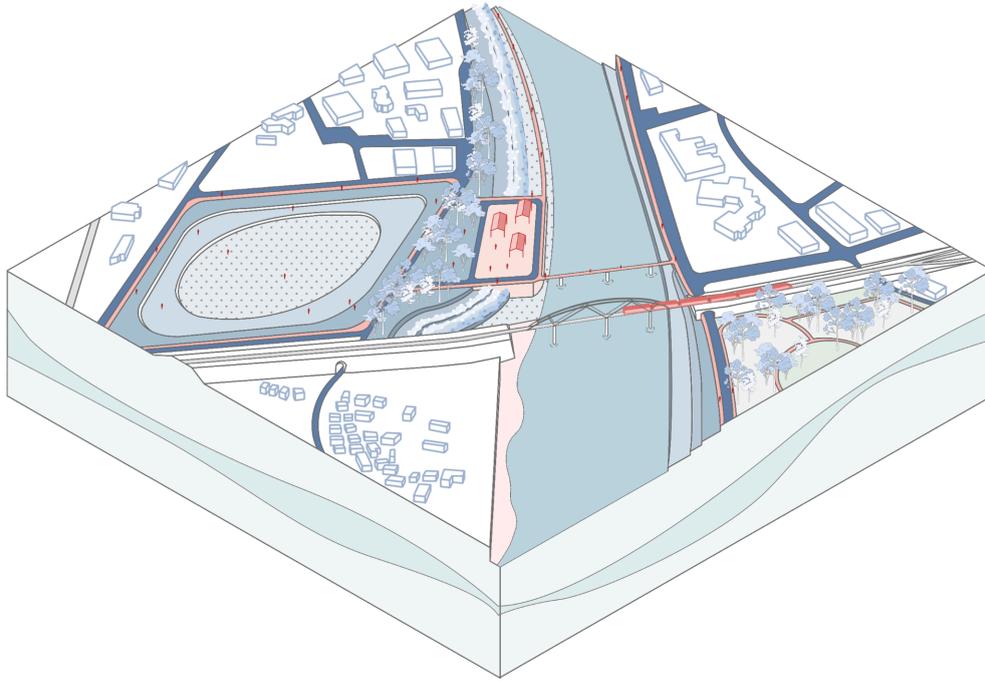


Figure 42.3 - Proposal Water system Axonometric - Detention Green for Rainwater harvesting (Source: Authors' illustration).

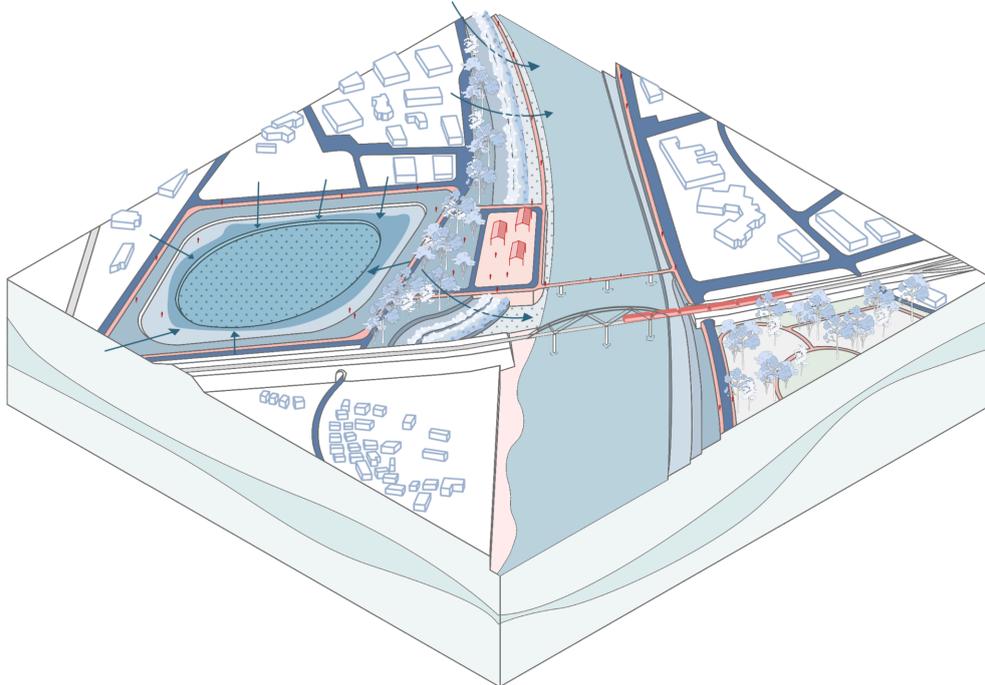


Figure 42.4 - Proposal Water system Axonometric - Detention Green for Rainwater harvesting with flood scenario (Source: Authors' illustration).

b. Walkability systems

The Walkability System is conceptualized as a strategic urban framework designed to address the spatial and functional fragmentation that characterizes Albenga's contemporary urban structure. This fragmentation has emerged as a cumulative consequence of repeated historical flood events and the implementation of rigid defensive infrastructures, which while effective in mitigating hydraulic risk have introduced both physical and perceptual barriers between distinct urban sectors. In response, the Walkability System seeks not only to re-establish disrupted physical connections but also to reconfigure the river corridor as a continuous, multifunctional spatial armature capable of supporting pedestrian movement, social interaction, and everyday urban life.

Rather than relegating the riverside to a marginal or residual space, the strategy reconceives it as a linear zone of activity structured around slow mobility. Pedestrian and non-motorized networks are prioritized to foster a direct, experiential relationship between inhabitants and the hydrological landscape. Walking paths, promenades, and leisure-oriented routes are carefully designed to accommodate diverse rhythms of movement, transforming circulation infrastructure into socially and environmentally active public space. In this paradigm, mobility transcends its conventional functional role, emerging instead as a spatial and social experience that encourages environmental awareness, public engagement, and collective stewardship of the riverfront.

A fundamental component of the Walkability System is its ability to establish continuous and legible connections between the key nodes of the Detention Green framework. Pedestrian routes are strategically integrated into water detention, filtration, and storage infrastructures, allowing hydraulic, ecological, and recreational functions to coexist seamlessly. This integration positions the walkability network as connective tissue linking restored ecological areas, reinforcing landscape continuity, and contributing to the formation of a coherent urban ecosystem along the Centa River corridor.

By interlinking water detention complexes with surrounding green infrastructures, the system substantially enhances accessibility for both residents and visitors, enabling fluid movement across areas that were previously disconnected or difficult to navigate. This connectivity not only facilitates circulation but also promotes a continuous spatial experience, allowing pedestrians to traverse a network that integrates ecological, recreational, and hydrological functions. Simultaneously, the uninterrupted pedestrian routes support a gradual spatial transition between the dense historic core and newer development zones, softening abrupt urban boundaries and fostering a more coherent and integrated urban morphology.

Over the long term, these interventions contribute to the redefinition of Albenga's urban identity, wherein the Centa River is reframed from a perceived barrier into a structuring backbone that organizes movement, social interaction, and economic activity within a resilient and multifunctional green infrastructure system. This approach illustrates the strategic potential of walkability as an instrument of socio-ecological integration, positioning pedestrian mobility at the intersection of urban design, environmental stewardship, and Water Urbanism. By embedding circulation within ecological and hydrological networks, the framework simultaneously advances resilience, environmental connectivity, and the social activation of public space, demonstrating how mobility-driven interventions can shape sustainable, adaptive, and experientially rich urban landscapes.

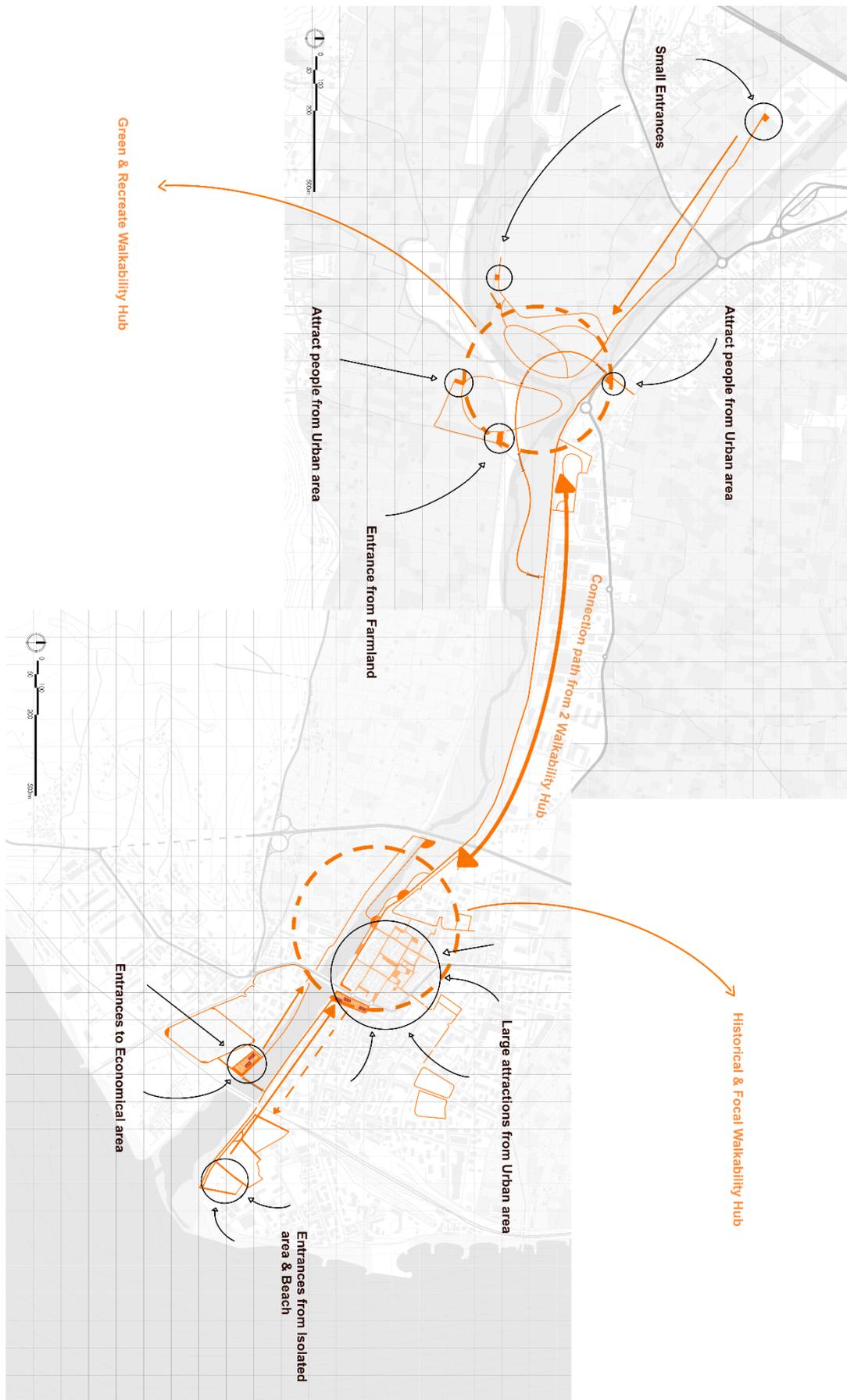


Figure 43 - Proposal Walkability system (Source: Authors' illustration).

c. Slow-flow water area

The diversion design implemented in the area adjacent to Albenga's historic center is conceived as a targeted micro-intervention of high strategic relevance within the broader water urbanism framework. Although limited in spatial scale, this intervention plays a critical role in re-establishing the functional and perceptual relationship between the consolidated urban fabric and the hydrological system of the Centa River. Through an active diversion mechanism, a controlled portion of the river flow is redirected into a system of four interconnected detention ponds, carefully positioned at the interface between the dense network of historic alleyways and the linear riverside corridor.

The spatial configuration of the four detention ponds is designed to operate simultaneously as a hydraulic, ecological, and urban device. From a hydrological perspective, the ponds function to decelerate flow velocity, reduce peak discharge, and enhance thermal regulation through increased water surface exposure. In parallel, their layered structure supports biological filtration processes, enabling sediment capture and pollutant reduction before water is gradually reintroduced into the river system. This localized hydraulic control significantly reduces the risk of storm surges and surface flooding in the historic center, thereby establishing a resilient buffer zone that protects the long-established urban fabric without resorting to rigid defensive barriers.

Beyond its technical function, the detention pond system plays a key socio-spatial and aesthetic role, acting as an urban interface that enables renewed interaction with the river in a controlled and environmentally enhanced setting. By replacing rigid embankments with a permeable transitional landscape based on natural filtration, the design improves water quality while reinforcing spatial continuity and accessibility along the riverfront.

By integrating hydrological infrastructure with public space design, the intervention enhances the experiential quality of the historic river edge while providing a safe and flexible setting for cultural, recreational, and everyday activities. In doing so, it reinforces Albenga's identity as a "river city" and illustrates how targeted, site-specific interventions can support long-term urban resilience and adaptive responses to environmental change.

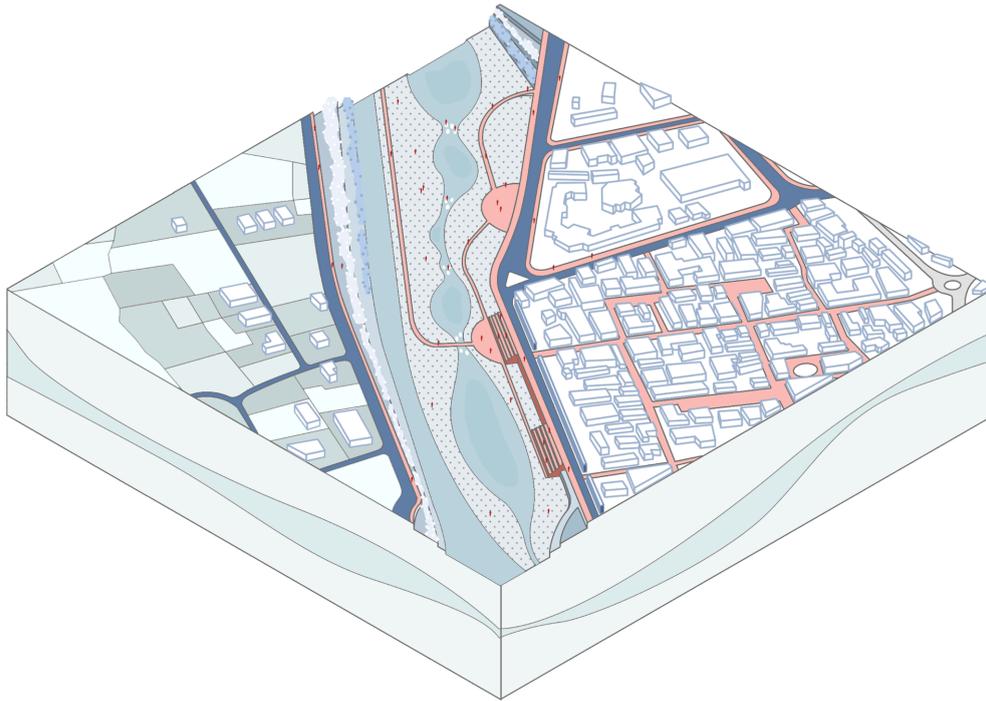


Figure 44.1 - Proposal Water system Axonometric - Slow flow water area (Source: Authors' illustration).

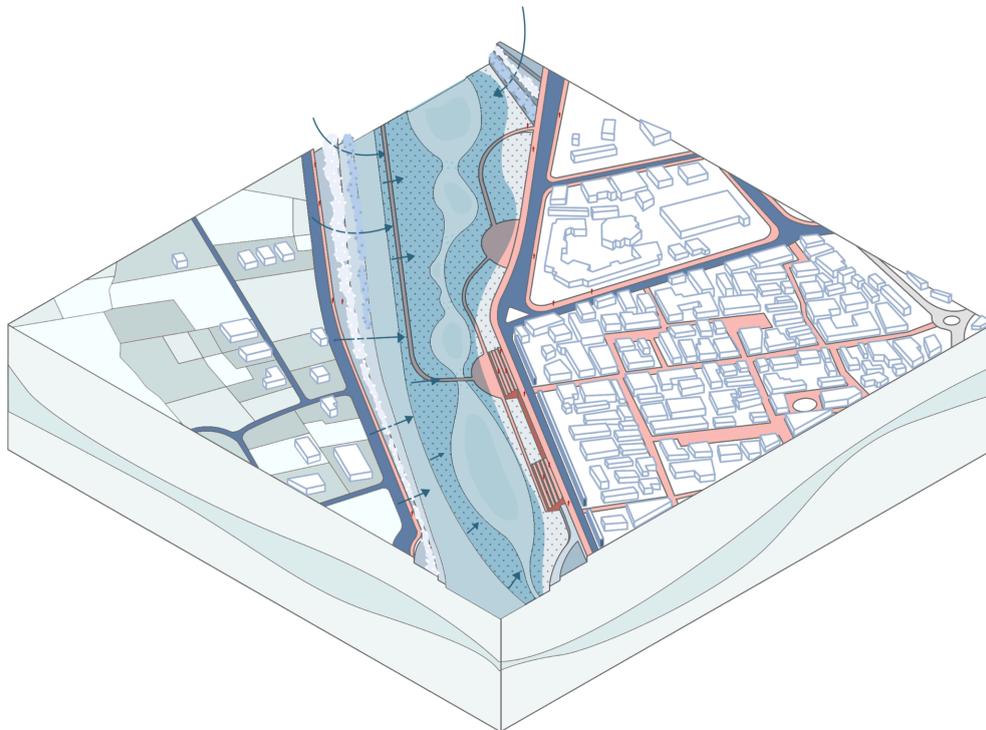


Figure 44.2 - Proposal Water system Axonometric - Slow flow water area with flood scenario (Source: Authors' illustration).

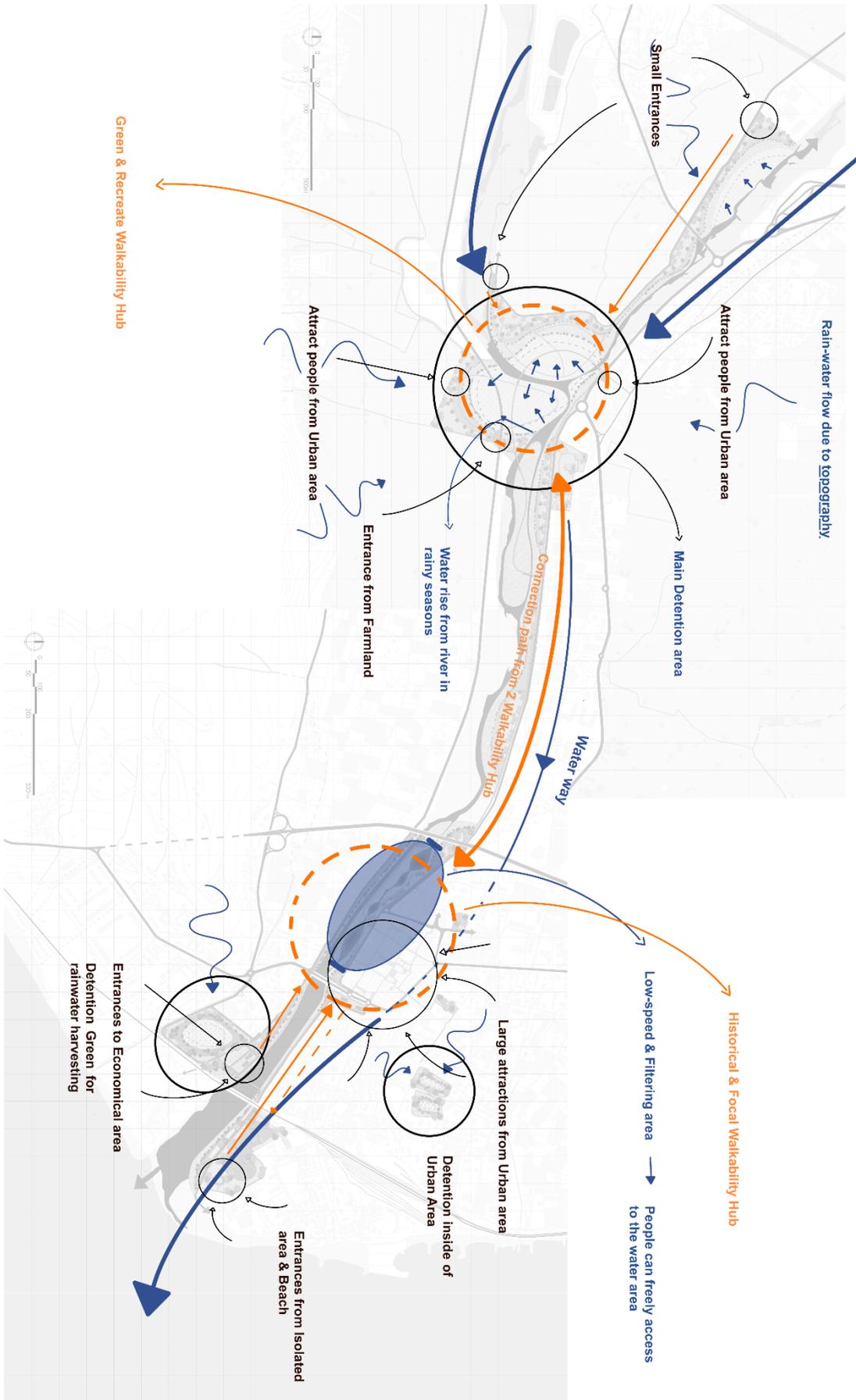


Figure 45 - Proposal system summarize (Source: Authors' illustration).

6.2 Impact of the Proposal

The implementation of the Water Urbanism strategy in conjunction with the Detention Green system in Albenga extends far beyond the scope of conventional infrastructural upgrading, establishing instead a comprehensive model for urban regeneration with interrelated ecological, economic, and social impacts. By strategically expanding the functional floodplain and introducing a calibrated diversion system in proximity to the historic center, the proposal significantly enhances the Centa River's capacity for water storage, flow regulation, and hydraulic moderation. The systematic replacement of rigid gray infrastructure with detention ponds, floodable landscapes, and permeable surfaces enables a substantial reduction in flow velocity and peak discharge, thereby alleviating hydraulic stress on the fragile historic urban fabric during extreme climatic events.

This enhanced hydrological performance is further reinforced through the introduction of cleansing biotopes at key nodal points within the river system. These biotopes operate as natural filtration mechanisms, improving water quality while supporting sediment retention and pollutant reduction. In doing so, they facilitate the gradual restoration of native ecosystems and promote urban biodiversity, contributing to the re-establishment of ecological continuity along the river corridor. The integration of these nature-based solutions positions hydrological resilience not as an isolated technical objective, but as a foundational driver of broader environmental regeneration.

In parallel, the transformation of hydrologically sensitive areas into multifunctional "green complexes" acts as a catalyst for Albenga's long-term economic restructuring. By enhancing landscape quality and environmental performance, the project enables a strategic shift away from reliance on traditional agricultural production toward a diversified economy grounded in services, experiential tourism, and knowledge-based activities. Detention nodes particularly those located at key urban thresholds and access points are redefined from defensive infrastructures into active economic and social hubs. Their visibility and accessibility foster new forms of commercial exchange and attract private investment, reinforcing the river corridor as a productive urban asset.

Complementing this economic transformation is the establishment of a coherent walkability network and a series of accessible river interfaces that address the historic separation between the city and its water system. By prioritizing non-motorized mobility and

continuous public spaces along the river, the proposal encourages daily social interaction and strengthens the relationship between residents and the hydrological landscape. The resulting clean, safe, and accessible riverside environment supports cultural activities and recreational use, reinforcing Albenga's identity as a "river city" in which historical heritage and contemporary urban life coexist in a mutually reinforcing manner.

From a governance and implementation perspective, the proposal ensures long-term fiscal and environmental sustainability through a strategic shift toward soft engineering and nature-based solutions. Compared to conventional hard infrastructures, green systems offer significantly reduced maintenance and operational costs while maintaining high adaptive capacity. The use of recycled materials and advanced soil bioengineering techniques further optimizes public investment, creating a flexible and resilient framework capable of responding to uncertain future environmental conditions. Through the holistic integration of ecological resilience, economic development, and social regeneration, the project positions Albenga as a robust, adaptable, and sustainable urban system, capable of addressing contemporary climate challenges while supporting long-term territorial competitiveness

CHAPTER 7

CONCLUSION



This work has examined Albenga starting from a simple observation. The city and its river no longer recognize each other. The Centa has been progressively transformed into a technical object, separated from everyday life and from the forms of settlement that historically depended on it. Planning instruments, hydraulic infrastructures, and land-use decisions have contributed to fixing this separation, turning water into a problem to be managed and space into a surface to be defended.

The analysis has shown how this condition is the result of accumulated choices rather than of a single error. Defensive strategies adopted over time have stabilized the river's course and reduced its spatial presence, but at the same time they have produced rigidity. Risk has not disappeared. It has been displaced and concentrated. The city has become more fragile precisely because it has attempted to make itself immobile in a context defined by variability.

The concept of Water Urbanism has been used in this research as a lens through which to reinterpret this situation. It has allowed the Centa to be read again as a structuring element of the territory, capable of organizing spaces, uses, and relationships. This reading does not propose a return to a pre-modern condition, nor does it deny the need for safety. It suggests instead that safety can be pursued through spatial articulation and through the design of relationships between water, land, and settlement.

The project framework developed for Albenga is based on this assumption. The Detention Green system introduces spaces where water can slow down, expand, and infiltrate, becoming part of the landscape of the plain. The reconfiguration of the riverfront and the walkability network reopens access to the water and reconnects fragments of the city that have long remained separated. The integration of distributed drainage strategies within the agricultural fabric assigns an active role to productive land, acknowledging its capacity to participate in the regulation of the local water cycle.

These proposals share a common principle. Space is no longer assigned a single, permanent function. Instead, it is designed to accommodate change. Floodable areas, adaptable public spaces, and hybrid agricultural infrastructures are understood as ordinary components of the urban structure. Temporality becomes a design parameter, not an exception. In this sense, the project does not add new elements to the territory. It reorganizes existing ones, making their latent capacities visible and operative.

The implications for planning are significant. Municipal plans are asked to confront the limits of rigid zoning and to recognize forms of land use that vary over time. Supra-municipal and landscape plans are required to engage more directly with transformation, rather than acting only as instruments of protection. Above all, the separation between hydraulic management and spatial planning emerges as increasingly untenable. Water crosses administrative boundaries and disciplinary fields, and planning must acknowledge this condition.

Albenga is not an isolated case. Many Mediterranean coastal plains present similar combinations of intensive agriculture, sealed surfaces, infrastructural barriers, and increasing hydrological instability. In this context, Albenga can be read as a revealing situation. It shows how climate-related risks intersect with long-standing spatial structures and planning cultures. It also shows that alternative trajectories are possible, provided that water is considered part of the project of the territory.

This research suggests that working with water means working on the form of the city and on the meaning of planning itself. It requires attention to slow processes, to ordinary spaces, and to relationships that are often taken for granted. The river, once confined to the margins, becomes again a shared reference. Not as a symbol, but as a concrete framework within which a more adaptive and careful way of inhabiting the territory can take shape.

7.1 Contributions to Urban Planning Theory and Practice

Theoretically, this study advances a “Water-based Urbanism” framework as a strategic alternative to the historically entrenched, concrete-centric flood defense models applied in Albenga. Rather than conceptualizing the Centa River as a hazard to be segregated from the urban fabric, the proposed framework repositions the hydrological system as an active, operational infrastructure capable of structuring urban morphology, guiding land-use patterns, and shaping spatial experiences. This approach extends the discourse on Regenerative Urbanism by integrating three interrelated layers: hydraulic restoration of the river corridor, preservation and enhancement of the historical urban core, and the creation of multifunctional ecological nodes along the waterfront. By doing so, the framework expands the notion of

urban resilience beyond the mere mitigation of natural hazards, encompassing the socio-economic reactivation of the riverfront as a core urban asset.

Methodologically, the study introduces a hybrid qualitative-quantitative analytical framework that bridges historical cartographic reconstruction with contemporary hydraulic simulation. This approach enables a multi-scalar understanding of the interactions between urban form, hydrological dynamics, and ecological processes. The framework demonstrates potential for standardization as a transferable tool for other Mediterranean coastal cities confronting similar challenges, where the juxtaposition of heritage structures and dynamic river systems produces spatial and functional fragmentation.

A second theoretical contribution is the operationalization of “Hydrological Connectivity” as a lens for urban social restructuring. By interpreting the river as a living interface rather than a boundary, the proposal illustrates how micro-scale interventions—such as the four-pond diversion system—can act as socio-spatial mediators. This conceptualization reconceptualizes high-risk ecological zones not as isolated or obstructive spaces, but as active nodes that foster interaction, cultural engagement, and community cohesion. It thus advances transitional planning theory, presenting water as a primary connector of urban experience rather than as a source of disruption or exclusion.

In practical terms, the proposal advocates for the use of soft engineering and soil bioengineering techniques as the principal tools of intervention, in contrast to traditional hard gray infrastructure. Strategies such as slope regrading, infiltration basins, and cleansing biotopes offer scalable, ecologically sensitive, and cost-effective methods for flood attenuation, water purification, and biodiversity enhancement. Complementing these environmental measures, the integration of walkability networks provides a proactive form of social infrastructure, reconnecting residents with the river and repairing historical spatial ruptures within the urban fabric.

Overall, the research produces a dual contribution. Conceptually, it advances the theoretical discourse on regenerative and water-based urbanism by demonstrating how hydrological systems can operate as structural, social, and ecological connectors. Practically, it delivers a flexible, implementable toolkit for sustainable riverfront development that balances heritage preservation, urban resilience, and socio-environmental functionality. In this

way, Albenga becomes both a case study and a model for coastal cities seeking to harmonize historic urban identity with adaptive water-sensitive design interventions.

7.2 Limitations of the Study

The study focuses on critical strategic nodes, such as the confluence of the three flows and the historical center's edge, to analyze micro-interventions. However, this creates a "Scale Gap," as the proposal may not fully encompass the broader regional spillover effects of the Centa River's upper catchment area. Without a comprehensive hydrological model of the entire watershed, the long-term impacts of extreme sediment transport or regional agricultural runoff on the proposed "cleansing biotopes" may be underestimated.

Furthermore, the data-specific nature of hydraulic modeling remains a limitation. Because climate change induces increasingly unpredictable weather patterns in the Mediterranean, the flood level indicators used in this study are based on current historical data. This makes the design time-specific; future research would require continuous updates of hydrological simulations to maintain the accuracy of the proposed detention capacities.

A key limitation also lies in the lack of a "Pilot Project" phase. In Mediterranean urbanism, new spatial models involving water access often face resistance due to entrenched safety regulations and local habits. The success of the "Detention Green" nodes depends heavily on urban governance and the coordination between environmental agencies and heritage preservation boards. Since this study exists outside the current administrative legal framework of Albenga, the feasibility of transitioning from a strategic vision to a synchronized legal action plan remains a significant challenge.

7.3 Suggestions for Future Research

A crucial next step is the development of Regional-Scale Hydraulic Simulations to verify the long-term effectiveness of the proposed ecological nodes under various 50-year and 100-year flood scenarios. Integrating GIS-based land-use models would allow researchers to assess how the "Water Urbanism" strategy impacts property values, tourism flows, and local investment trends over time.

Another research direction involves exploring the Socio-Hydrological Livelihood Transformation. Further studies could investigate how the reactivation of the riverfront

changes the economic habits of Albenga's residents, shifting from land-locked commerce to water-oriented services. Measuring the "Social Return on Investment" (SROI) of the walkability and green system will help quantify the proposal's success in terms of public health and communal well-being.

Finally, future research should focus on Institutionalizing the "Water Urbanism" Model. This includes developing a legal and management framework that allows for "community-led" maintenance of the green complexes. Comparative studies between Albenga and other Italian river-cities could help generalize the "Adaptive Buffer" concept, assessing its potential for scaling up in various European contexts where historical urbanism must be reconciled with aggressive climate adaptation.

BIBLIOGRAPHY

1. Ahern, J. (2011). *From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world*. Landscape and Urban Planning
2. European Environment Agency, *Climate change impacts and adaptation in Europe-2020*
3. Fletcher, T. D., et al. (2015). *SUDS, LID, BMPs and WSUD*. Urban Water Journal
4. Hooimeijer, F., & Maring, L. (2018). *Water urbanism in the Netherlands*. Delft University of Technology.
5. IPCC, *Sixth Assessment Report – Impacts, Adaptation and Vulnerability- 2022*
6. Magnaghi, A. (2010). *Il progetto locale*. Bollati Boringhieri.
7. Meyer, H., & Nijhuis, S. (2014). *Delta Urbanism*.
8. Moss, T. (2004). *The governance of land use in river basins*. Land Use Policy.
9. OECD (2015). *Water Resources Governance in Cities*.
10. Pahl-Wostl, C. (2015). *Water Governance in the Face of Global Change*. Springer.
11. Rijke, J., et al. (2012). *Room for the River: Delivering integrated river basin management in the Netherlands*
12. Shannon, K., & De Meulder, B. (2008). *Water Urbanism*.
13. Swyngedouw, E. (2009). *The political economy and political ecology of the hydro-social cycle*. Journal of Contemporary Water Research & Education.
14. UN (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*.
15. Watson, V. (2014). *Co-production and collaboration in planning*. Planning Theory & Practice.
16. *Wong & Brown (2009)*. The water sensitive city Places emphasis on integrating water cycle thinking into urban form

2. Permeability Loss and Floodplain Sealing

(Urban sprawl + greenhouse infrastructure)

Conceptual foundation

Your permeability analysis is consistent with **landscape-as-infrastructure**, **ecosystem services**, and **nature-based solutions** literature.

Key resources

European Commission – Nature-Based Solutions for Flood Risk Management

Supports measuring soil sealing and floodplain loss as indicators of increased flood risk.

 <https://op.europa.eu/en/publication-detail/-/publication/>

EEA – Land take and soil sealing in Europe

Provides the methodological basis for calculating loss of permeable surfaces.

 <https://www.eea.europa.eu/en/analysis/indicators/land-take>

Ahern (2011) – Safe-to-fail landscapes

Establishes permeability and floodplain occupation as critical variables in resilient planning.

 <https://www.sciencedirect.com/science/article/pii/S0169204611000573>

3. Risk Polarization Near Historic Centers

(P3–P4 zones adjacent to consolidated urban fabric)

Conceptual foundation

This directly relates to **urban flood vulnerability theory**, where historical river corrections increase risk concentration rather than reducing it.

Key resources

OECD – Water Governance in Cities

Discusses how historical river training concentrates risk in dense urban cores.

 <https://www.oecd.org/water/governance/water-governance-in-cities.htm>

Swyngedouw (2009) – Hydro-social cycle

Provides the theoretical basis for linking river modification, urban form, and risk redistribution.

 <https://www.tandfonline.com/doi/abs/10.1080/07900620903050991>

IPCC AR6 (2022)

Recognizes flood risk amplification in historic urban centers due to past engineering decisions.

 <https://www.ipcc.ch/report/ar6/wg2/>

4. Governance Fragmentation and Planning Ambiguity

(Municipal vs Basin vs Regional tools)

Conceptual foundation

Your governance analysis is solidly rooted in **multi-level water governance** and **integrated territorial management** theory.

Key resources

Pahl-Wostl (2015) – *Water Governance in the Face of Global Change*

Core reference for analyzing institutional overlap and governance gaps.

 <https://link.springer.com/book/10.1007/978-3-319-21855-7>

Healey (2007) – *Urban Complexity and Spatial Strategies*

Provides the theoretical basis for identifying “planning ambiguity.”



<https://www.routledge.com/Urban-Complexity-and-Spatial-Strategies/Healey/p/book/9780415358980>

OECD – Multi-level governance of water

Explicitly addresses conflicts between municipal, regional, and basin authorities.

 <https://www.oecd.org/water/governance/>