Reclaiming the Sea: Cagliari's Waterfront Renaissance

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Abstract. The relationship between coastal cities and their sea has historically been marked by profound infrastructural divides. In Cagliari, Via Roma roadway has represented a physical and visual barrier between the historic urban fabric and the port for decades. This paper analyzes the regeneration process of the Cagliari waterfront, placing it in dialogue with major international best practices (including San Francisco, Genoa, Marseille, and Oslo) to evaluate its methodological validity. Through a comparative approach, the study examines the spatial redevelopment strategies adopted in the new Masterplan. The analysis focuses on the transformation of the Via Roma roadway axis, the pedestrianization of port areas, and the integration of the new surface light metro system (LRS). Particular attention is given to transport solutions: the introduction of unconventional circular loops ("dog-bone" roundabouts) and the regularization of road sections demonstrate how road declassification does not cause urban paralysis but optimizes unbalanced flows, provided there is strong synergy with the external metro network (SS554 and Asse Mediano). The study concludes that the Cagliari project is not merely an architectural redesign, but rather a profound social and urban redevelopment. The new waterfront aims to be a model of climate resilience and sustainable mobility for Mediterranean urban planning, restoring maritime space to the community.

Keywords: Urban regeneration · Waterfront · Intermodal and sustainable transport · New infrastructural layouts · Cagliari

1 Introduction

Coastal cities often face a profound spatial and functional paradox: water, a fundamental element and the very reason for their existence, is frequently inaccessible and separated from urban life [1].

Urban coastlines, monopolized by massive port, road, and logistics infrastructure, act as impermeable fences, creating a clear physical and visual division between the urban fabric and the maritime landscape.

Contemporary urban planning has developed a new sensitivity toward these areas, giving rise to the global phenomenon of the "waterfront renaissance." This cultural and design movement aims to reclaim, redevelop, and redesign the coastline, transforming

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it from a logistical barrier into a vibrant social hub. In this vision, the sea is seen not only as an economic resource, but as a "common good," a stage for community and a foundation for quality of life and urban identity [2].

Cagliari, the capital of Sardinia and a profoundly Mediterranean city, fits into this context of global regeneration thanks to its unique morphology, where sea, lagoons, and hills intertwine in a complex ecosystem [3, 4].

The city currently suffers from a pronounced "separation syndrome": its main waterfront, dominated by the majestic facades of Via Roma, serves primarily as a vehicular transit hub. Port fences and heavy traffic impede natural pedestrian access, but Cagliari is now at the center of ambitious redevelopment projects aimed at healing this rift. Key questions guiding this analysis include: can a road conceived as an "invisible wall" between city and water become the cornerstone of their reconnection? Is it really possible to eliminate heavy traffic from a monumental waterfront without paralyzing urban mobility, but rather making it more fluid and green? How can urban greenery and modern rail infrastructure coexist with the rigid identity of a port city? What practical lessons can Cagliari draw from leading international models? To address these questions and fully grasp the potential of Cagliari's challenge, we must look beyond local borders to the recurring dynamics of coastal regeneration around the world.

This comparative study explores various intervention philosophies, as illustrated in Fig. 1.:



Fig. 1. Representation of interventions worldwide, author's elaboration

- Removal of infrastructural barriers in San Francisco (The Embarcadero) [5];
- Reconnection of historic center and sea in Genoa (Porto Antico) [6];
- Radical pedestrianization in Marseille (Vieux-Port) [7–9];
- Linear park in Thessaloniki (Nea Paralia) [10];
- Multifunctional regeneration in Auckland (Quay Street and Wynyard Quarter);
- Flow management in Oslo (Dronning Eufemias gate);
- Intermodal hubs and rail focus in Nice and Bordeaux [11].

Through this journey, we show that reclaiming the sea is not just architectural restyling but an unrepeatable opportunity to redefine the city's social, cultural, and economic future: can Cagliari thus become an example for the Mediterranean basin?The original contribution of this paper is threefold: (i) it systematically applies a multi-criteria comparative framework to evaluate Cagliari's Masterplan against seven international waterfront cases, making the selection criteria explicit and transferable; (ii) it provides a technical engineering assessment of unconventional road geometries (dog-bone roundabouts) in a Mediterranean port context, grounded in established capacity models (HCM, LWR); and (iii) it advances the discourse on "traffic evaporation" for Southern European coastal cities where quantitative simulation data remain scarce. Together, these contributions position the paper not merely as a case study narrative, but as a replicable analytical template for waterfront regeneration in comparable urban settings.

2 Methodological Framework: Reference Models, Analysis, and Best Practices

To assess the scope and methodological validity of Cagliari's intervention, it is essential to analyze how other coastal cities have resolved conflicts between ports, traffic, and public space. The following comparative analysis ranges from pioneering urban planning interventions to bold infrastructure demolitions, highlighting lessons applicable to Via Roma and Cagliari's historic port.The cases were selected according to four explicit criteria: (1) presence of a physical infrastructural barrier between the urban fabric and the waterfront (analogous to Cagliari's Via Roma); (2) adoption of documented traffic-reduction or road-declassification strategies; (3) integration of public transport and intermodal solutions; and (4) contextual relevance for Mediterranean or Southern European coastal cities. This structured selection allows the analysis to move beyond anecdotal benchmarking toward a replicable comparative methodology, drawing transferable principles rather than merely illustrative precedents.

2.1 Mixed Use and Port Identity (Genoa and Auckland)

An analysis of major waterfront urban regeneration projects highlights key strategies for reconnecting former port areas to the urban fabric. Genoa's Porto Antico, designed by Renzo Piano for Expo '92, as illustrated in Fig. 2, pioneered the redevelopment of industrial archaeological sites, such as the Cotton Stores, for their complete reintegration into city life. Its success relies on the seamless integration of culture, leisure, and commerce in mixed-use areas, ensuring year-round vitality and preventing seasonal decay or the "cathedrals in the desert" effect. Internationally, Auckland's Wynyard Quarter exemplifies how infrastructure for large-scale sailing events can integrate with everyday urban life, merging the advanced maritime economy (superyachts and America's Cup bases) with plazas and open spaces [1, 2, 6].

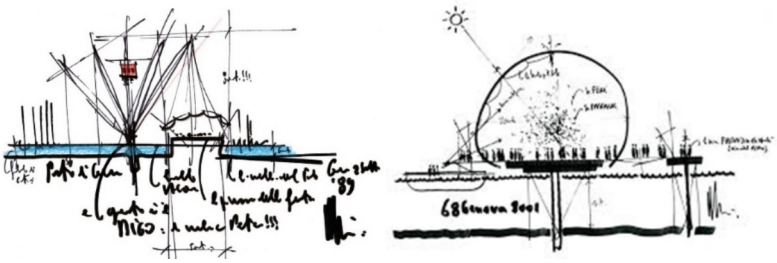


Fig. 2. Renzo Piano's early sketches for the Genoa Old Harbour project.[12]

2.2 Public Space and Landscape Filters (Marseille and Thessaloniki)

For spatial reconfiguration, Marseille's Vieux-Port (Fig. 3a and Fig. 3b) offers a successful "subtractive" model: continuous pedestrianization with mineral materials and luminous landmarks (such as Norman Foster's Ombrière) restore monumental dignity without obstructing the view, while degraded streets utilize large roundabouts. For longer stretches of coastline, Thessaloniki's Nea Paralia provides the ideal reference: its green ribbon of "themed rooms" serves as the perfect landscape and acoustic buffer between heavy traffic and the promenades along the seafront [7–9].



(a) (b)

Fig. 3. (a) Foster's Ombrière [13]; (b) Marseille port Masterplan [7]

2.3 Infrastructure and "Traffic Evaporation" (San Francisco, Nice, Oslo, Bordeaux)

The main challenge for any port area is managing transport infrastructure. The demolition of the Embarcadero Freeway in San Francisco has empirically demonstrated "traffic evaporation": reducing lanes does not cause gridlock ("Carmageddon"), but rather a modal redistribution. This principle guides European leaders: Oslo manages surface traffic (Dronning Eufemias gate) with strict low-speed sections; Bordeaux (Fig. 4) has reclaimed the banks of the Garonne by demolishing old logistics volumes ("creating space") and integrating trams; Nice has addressed high traffic density with intermodal hubs (Pôles d'échanges) [14–17].



Fig. 4. Bordeaux Quais [18]

3 Case Study and Discussion: From the Past, Through the Present, to the New Redevelopment Vision

3.1 History and Identity: A Millenary Bond Between City and Sea

Cagliari's urban history is inseparable from its sea and harbor. From Phoenician and Roman origins in ancient Karales, a key Mediterranean crossroads, the medieval Pisan era birthed the Lappola (now Marina) district for port workers, regulated by the 1318 Breve Kallaretani. Aragonese expansion in the 1300s planned the Marina as an economic engine with rectilinear axes parallel to the coast, evolving from Lappola to Marina. Spanish military needs erected coastal walls like the Porta del Molo, severing habitation from docks for centuries. [19–22].

The 19th-century urban transformation began in 1866 with the abolition of the city's fortress status. This led to the demolition of the city walls (illustrated in Fig. 5. Before and after the intervention) and the subsequent development of Via Roma's porticoed palaces. Conceived as a "bourgeois salon," this area served as a monumental gateway for those arriving by sea (Fig. 6. and 7.). However, the 20th century brought the devastation of II World War, followed by postwar logistical isolation, the installation of physical barriers, and mass motorization, which collectively transformed Via Roma into a high-speed traffic artery. Understanding this historical evolution is essential for current interventions aimed at healing this 20th-century "fracture" and reconnecting Cagliari to its waterfront [13, 23].



Fig. 5. Historical photos of Via Roma before current facade, [24]



Fig. 6. Central walkway with porticos, [24]



Fig. 7. Via Roma central walkway, [24]

The 20th century, however, brought new and profound divides. The devastation of World War II bombings (in 1943, the entire port area was razed to the ground) and the subsequent reconstruction favored a purely logistical approach. In the postwar period, the port was isolated by rigid fences, while Via Roma came under pressure from mass motorization, transforming into a barrier of fast and heavy traffic. The current identity of the waterfront is born of this dichotomy: on one hand, the monumental welcome of the porticos; on the other, the fragmentation caused by road arteries. Understanding this complex genesis is today fundamental for analyzing current urban interventions, whose primary purpose is precisely to heal the "20th-century fracture" and reconnect Cagliari to its sea. Until recently, the seafront was fragmented, with Via Roma hosting up to six vehicle lanes, fracturing historic porticos from inhospitable port docks. Convergence between Cagliari Municipality and Port System Authority (AdSP) sparked urban revision. Stefano Boeri Architetti and MATE Soc. Coop's Masterplan transforms Via Roma into a "Linear Forest," shrinking car lanes for pedestrians and active mobility while greening for climate resilience (heat islands, ecological continuity). Funded for intermodal center and transport overhaul, it improves urbanism and architecture but falls short on full mobility resolution [25–28].

AdSP's Historic Port opening shifts heavy cargo to Porto Canale, dedicating Via Roma docks to cruises and yachting, creating a continuous coastal park from Molo Dogana to Su Siccu, Molentargius Natural Park, and Sant'Elia ensuring visual permeability and cultural programming. [29].

3.2 Via Roma Redevelopment Project: Integration and Mobility

As depicted in the Fig. 8 and Fig. 9, the proposed intervention aims to integrate linear park walkways, ARST surface light metro, and AdSP historic port/waterfront works, with traffic planning as cohesive glue. [29, 30].



Fig. 8. Traffic project in context of other works, author's elaboration

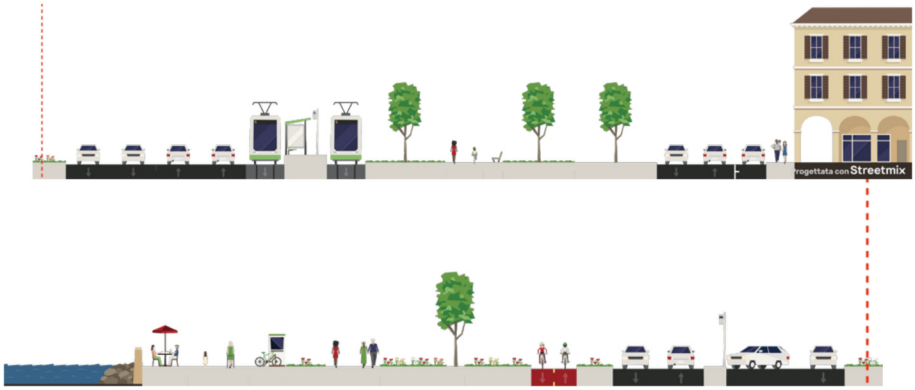


Fig. 9. Section A-A representation of portico-facing area project, author's elaboration

3.3 Via Roma Configuration (Portico Side and Central Strip)

A new central pedestrian-green axis (horizontal forest) emerges as illustrated in Fig. 10. Portico-side carriageway shrinks from 4 to 2 lanes (widening to 4 at Viale Diaz), with linear park bays for high-priority Local Public Transport (TPL) lines (M, 1, 5) shifting them portico-side for frequency and coverage [25, 26].



Fig. 10. Interventions with linear park [16]

3.4 Light Metro System

The new rail line links Piazza Matteotti to Piazza Repubblica, connecting center, Policlinico, Settimo San Pietro, and future Sestu/Poetto via Piazzale Cis/Bonaria hub. It optimizes TPL by backtracking lines 29/30/QEX/PF/PQ to Piazzale Cis, reducing Viale Diaz-Matteotti overlaps; creates dual intermodals at Matteotti and Repubblica extremes linked by tram/urban lines. Extra-urban ARST/private lines terminate at Matteotti west, SS554 east as "metro ring," absorbing users via metro—functional gomma-ferro transfer under ARST.

Transport efficiency is guaranteed by the capacity and frequency of the railway, rationalizing loads and reducing congestion and noise. Tariff integration (geographic zones via third party like City Metro) ensures seamless interchanges [29, 30].

3.5 Lungomare New York 11 Settembre (Seaside)

The reprofiling of the seaside road section is the cornerstone for ensuring vehicular fluidity:

- The road layout is upgraded from a nominal four-lane configuration, currently restricted to an effective capacity of 1.5 lanes per direction due to spatial constraints, to four fully operational lanes, each with a constant width of 3.50 m (two lanes per direction). According to the principles of the Highway Capacity Manual, geometric regularization restores the lane's ideal saturation flow (S0), bringing the width correction factor (fw) to unity. Even assuming preservation of current peak-hour traffic volumes, this simple widening and rationalization of lanes prevents capacity collapse. It eliminates dangerous overtaking attempts and lateral frictions, thereby nullifying the formation of shockwaves typical of the Lighthill-Whitham-Richards model that cause the deleterious stop-and-go. [31]
- The elimination of complex signalized nodes is entrusted to 2 classic roundabouts and 3 unconventional circular loops, including two "dog-bone" roundabouts and one "cuspide" as seen in Fig. 11, 12 and 13. From an engineering standpoint, the dog-bone roundabout offers decisive advantages on a linear axis [32, 33].



Fig. 11. Render of unconventional loop near Molo Dogana, authors' elaboration

3.6 Managing Unbalanced Flows and Geometric Benefits

Unconventional circular loops, including dog-bone roundabouts, represent an ideal engineering solution for managing intersections with heavily unbalanced traffic flows. Unlike standard circular configurations, their elongated and centrally "pinched" geometry allows alignment of the main axis with the highest traffic volume direction. This shape naturally favors the dominant traffic flow: vehicles on the main artery benefit from a more linear and fluid path along the long parallel sides of the infrastructure, reducing steering maneuvers and maximizing throughput. Conversely, flows from secondary roads enter through the two rounded ends (the "spectacles" or "lenses" of the spectacles). In these sections, the tighter curve radii force drivers to slow significantly to negotiate the curve and yield, creating a clear physical hierarchy that optimizes the overall efficiency of the intersection, allowing high volumes to flow smoothly without small influxes causing congestion [31–35].

The elongated geometry thus follows the primary desire line (La Playa-Colombo axis), imposing minimal deflection on the main traffic stream, which maintains a continuous regime of constant and harmonized speed (speed harmonization at around 30–40 km/h).



Fig. 12. Plan of proposed Matteotti dog-bone roundabout, authors' elaboration



Fig. 13. Plan of proposed Deffenu dog-bone roundabout, authors' elaboration

3.7 Impact on Road Safety

Regarding safety, dog-bone roundabouts offer significant structural benefits, although they present specific design challenges. Similar to traditional roundabouts (as shown in the render in Fig. 14.), they drastically reduce conflict points by eliminating orthogonal crossings; however, their primary advantage lies in the elongated central island. This physical barrier (the "bridge" of the eyeglasses) sharply separates opposing traffic streams on the main artery over an extended stretch, effectively preventing risky left turns or reckless overtakes. However, infrastructure safety depends on proper speed calibration. Since the main axis path is much straighter than in a classic roundabout, drivers risk not slowing sufficiently. So, design must include adequate entry deflection curves to force fast vehicles to reduce speed near zones where secondary flows enter or cross.

Compared to 32 conflict points at a signalized intersection, the dog-bone configuration reduces them to a maximum of 12, physically eliminating the possibility of high-energy frontal or perpendicular impacts [36].

A robust international evidence base supports the safety case for unconventional roundabout geometries. Retting et al. [37] and Persaud et al. [38]demonstrated, using empirical Bayes methods on 24 U.S. intersections, reductions of 38% in total crashes, 76% in injury crashes, and approximately 90% in fatal and incapacitating crashes following conversion from signal and stop-sign control to modern roundabouts. These findings are consistent with non-U.S. evidence: Elvik [39] meta-analysed 28 European and international studies and found reductions of 30–50% in injury accidents and 50–70% in fatalities when intersections are converted to roundabouts. The most comprehensive synthesis to date, a meta-analysis of 44 studies by Elvik [40], confirmed approximately 65% reductions in fatal crashes and 40% in injury crashes, with results described as robust across different modelling approaches. More recently, Wang and Cicchino [41] documented that double-teardrop roundabouts, haring the same elongated, centrally narrowed geometry as the dog-bone configurations proposed here, an 84% reduction in injury crashes was observed at high-traffic intersections in Carmel, Indiana, with an overall crash reduction of nearly two-thirds. Overall, this dataset strongly supports the safety projections for the dog-bone junctions on Via Roma, regardless of the intersection-level microsimulation.



Fig. 14. City center entry roundabout render, authors' elaboration

The dog-bone roundabouts facilitate smooth U-turns, supporting Via Roma's distributive role without penalizing axial flow.

With Port Authority works and seafront parking removal, fragmented crossings between port and porticos become unnecessary as seen in Fig. 15. Pedestrian flows reconfigure longitudinally along three axes (porticos, central linear park, port walkway). Transverse crossings will unify and become continuous, eliminating the current "zigzag" path forcing uncertain intermediate stops between bus lanes and park. Rationalization yields 3 strategic crossings in 500 m (one every ~ 160 m), offering safe, defined paths that reduce collision risks and irregular behaviors from discontinuous routes.



Fig. 15. Overall waterfront vision render

Combining roundabouts, pedestrianization fronting Municipio and Viale Cristoforo Colombo, and sea-side parking reduction, with doubled structured stalls at the station (FS), efficiently manages nodes. These zeros out parasitic traffic from vehicles traversing the axis solely for parking searches, U-turns, or port-related exits.

3.8 Flow Analysis and the Strategic Role of the Metropolitano Scale (SS554 and Asse Mediano)

The decisions to downgrade the Via Roma section are firmly supported by empirical data, as illustrated in Fig. 16, from the knowledge framework of the Municipality of Cagliari's Sustainable Urban Mobility Plan (PUMS). Origin/Destination (O/D) surveys in the area (Riva di Ponente/Via Roma axis) clearly reveal the historic improper role of the seafront as a "bypass": about 7% of trips involve traffic with origins and destinations external to the municipality.

As much as 30% consists of pure transit traffic (internal-external or vice versa), with no real destination in the city center.

Thus, an estimated 35% to 40% of current traffic is naturally divertible to alternative routes. The Via Roma intervention thus triggers the well-known phenomenon of traffic evaporation, discouraging parasite transit. However, for this flow reassignment to materialize without penalizing the macroscopic system, it is an indispensable condition to commence construction and complete the SS554 enhancement works. The latter must fully assume the role of "metropolitan ring road." Similarly, vital is securing critical points on the Asse Mediano; any bottlenecks, accidents, or slowdowns on the outer ring would cause an immediate rebound of vehicle volumes to the waterfront axis, nullifying part of the decongesting benefits. The synergy between rail prioritization ("cura del ferro" via MetroCA), resizing the "window on the sea" (Via Roma), and strengthening external tangent rings represents the only equation ensuring transport and urban success for the sector [29]. The metropolitan-scale flow redistribution estimates presented in this section, including the 35–40% divertible traffic share and the modal reassignment scenarios conditional on SS554 completion, are supported by macroscopic traffic simulations contained in the municipal PUMS, which model alternative network scenarios with and without the outer ring road works. This provides a robust quantitative foundation for the traffic evaporation argument at the urban and metropolitan scale. It should be acknowledged, however, that intersection-level performance, specifically, capacity, delays, and safety outcomes, of the proposed dog-bone and cusp roundabouts have not been validated through dedicated microsimulation. The lack of intersection-specific modeling is a recognized limitation; future research should address this gap by applying microsimulation tools (e.g., VISSIM) to individual nodes, enabling rigorous verification of the expected geometric benefits and providing a more robust evidence base for detailed design decisions.

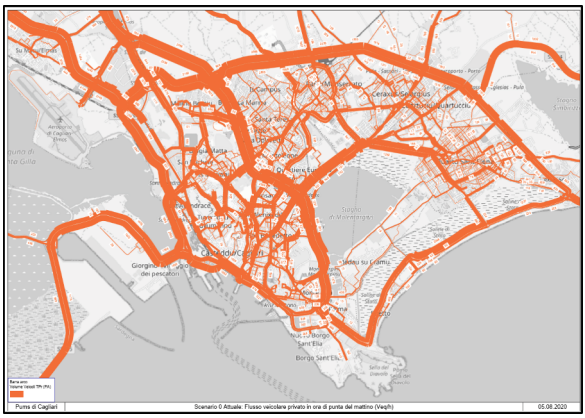


Fig. 16. Peak private vehicle flows [29]

4 Conclusions and Future Vision: The New Mediterranean Waterfront Paradigm

The regeneration process of Cagliari's waterfront, set within the broader context of global urban dynamics, now allows us to draw objective conclusions and outline a clear vision for the city's future. At the outset of this analysis, several fundamental questions arose regarding the real chances of success of such a radical intervention. By comparing it with leading international models and conducting a technical analysis of the project, we are now able to provide precise answers.

Can a roadway artery transform from an "invisible wall" to a cornerstone of reconnection? The answer is yes. As demonstrated by San Francisco's Ferry Building and Oslo's Dronning Eufemias gate, downgrading heavy infrastructure does not result in loss for the city but in its rediscovery. The "Linear Forest" project on Via Roma does not merely narrow the carriageway but fundamentally changes the nature of the space: from a mere vehicular transit area to a "continuous coastal park." The street no longer separates the city from the sea but becomes the physical and perceptual hinge uniting the historic Marina district to the port docks.

Is it possible to remove heavy traffic without paralyzing urban mobility? International experience confirms the principle of traffic evaporation. Fear of paralysis (the so-called "Carmageddon") is systematically disproven when reducing space for private cars is paired with smart public transport enhancement and node redesign. Nice's tram/bus intermodal hubs and Bordeaux's fluid Quais validate Cagliari's design choices. Rationalizing lanes to 3.50 m, inserting the surface light metro (with desirable tariff integration), and adopting 5 strategic roundabouts ("dog-bone" and "cuspide") will ensure elimination of bottlenecks and parasite traffic, making mobility smoother, more predictable, and ecological.

How can urban greening and modern infrastructure coexist with historic identity? Respect for identity does not mean stagnation. Marseille's example, with its mineral pedestrianization and Norman Foster's iconic Ombrière, teaches us that minimalism and

the insertion of "light" contemporary elements can enhance, rather than diminish, historic monumentality. In Cagliari, urban greening and rail infrastructure are designed not to obstruct visual perspectives: on the contrary, reducing cars at street level will restore to citizens and visitors the uninterrupted scenic backdrop of the Palazzo Civico and 19th-century porticos.

What practical lessons does Cagliari draw from international models?

The Sardinian capital is demonstrating that it has absorbed European and global best practices:

- From Genoa and Auckland, it inherits the importance of mixed-use functionality and the role of major events (like sailing competitions) to avoid the "cathedral in the desert" effect and ensure 24/7 economic vitality.
- From Thessaloniki, it adopts the landscape approach: Nea Paralia's sequence of themed gardens is the perfect conceptual model for managing long coastal stretches toward Su Siccu and Molentargius Park.
- From Marseille and Bordeaux, it learns the art of "making space," removing old port volumes to restore open views over the Golfo degli Angeli.

4.1 Future Vision

Cagliari's reclamation of the sea represents far more than architectural restyling: it is an act of identity reappropriation. By removing heavy traffic and opening the historic port to pedestrian use, the city positions itself as a new reference point for Mediterranean urban planning. The new waterfront will be more than just a promenade: it will be a resilient urban ecosystem capable of mitigating climate change, fostering sociality, and revitalizing the economy tied to tourism and maritime innovation. Cagliari has finally stopped viewing its sea from a car window and can now fully live it again. From a sustainability perspective, the reduction of private vehicle lanes combined with the introduction of a light metro and active mobility infrastructure directly supports the goals of Sustainable Urban Mobility Plans (SUMP/PUMS), lowering CO2 emissions, reducing urban heat island effects through the linear green corridor, and improving ecological connectivity between the port, Molentargius Natural Park, and the Su Siccu waterfront. From a safety perspective, the replacement of signalized intersections with engineered roundabout geometries (including dog-bone configurations) reduces conflict points from 32 to a maximum of 12, while speed harmonization at 30–40 km/h and the elimination of unregulated pedestrian crossings substantially lower the risk of high-severity collisions. These outcomes collectively advance the planning and design of the examined areas along two of the most critical dimensions of contemporary urban quality: environmental resilience and road safety. Future quantitative validation through microsimulation and post-implementation monitoring will be essential to confirm and refine these projected benefits.

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