Urban and Coastal Water Management through Nature-Based Solutions

Mediterranean urban and coastal areas face intensifying water challenges driven by climate change, urbanization, and ecosystem degradation. This paper explores the potential of Nature-based Solutions (NbS) as integrated, cost-effective, and socially inclusive responses to water-related risks. Drawing on six case studies across the region, it highlights the importance of embedding NbS within policy and planning frameworks, fostering participatory governance, and ensuring long-term sustainability. Findings demonstrate that well-designed NbS can enhance resilience and deliver cumulative co-benefits for communities and ecosystems alike.

Picture 1 : Wetlands © Pexels

1- Water resources vulnerability in the Mediterranean

In the context of climate change, rapid urbanization, and ecosystem degradation, water management in urban and coastal areas faces escalating challenges. Flash floods, water stress, and pollution reveal the growing technical, economic, and environmental limits of conventional planning models.

Around 60-70% of freshwater potential in the Mediterranean basin is located in northern areas, while only about 20%-30% lies in the South (Plan Bleu - RED2020, 2020). If current trends persist, up to 290 million people across the region could face severe water stress by 2050 (Plan Bleu - MED2050, 2025). Figure 1 illustrates short-term projections for 2030 under a pessimistic climate scenario (RCP 8.5). Currently, 220 million people (of which 180 million of them in the South and East Mediterranean) already experience water scarcity, making the region home to 60% of the world's water-poor population. Many countries are under severe[1] to extreme[2] water stress, with consumption nearing or exceeding renewable water availability of natural water tanks. Agriculture alone accounts for over 70% of the total water withdrawals[3] (Plan Bleu - MED2050, 2025), as shown in Chart 1 for most Mediterranean countries - except in parts of the Balkans, France, and Monaco, where municipal and industrial uses dominate.

1 Less than 1,000 m³/capita/year (Plan Bleu - MED2050, 2025).
2 Less than 500 m³/capita/year (Plan Bleu - MED2050, 2025).
3 Total water withdrawals (Km³/year) including sectoral breakdown at national level (agriculture, municipalities, industry) from 2000 to 2022 (Aquastats,2025)

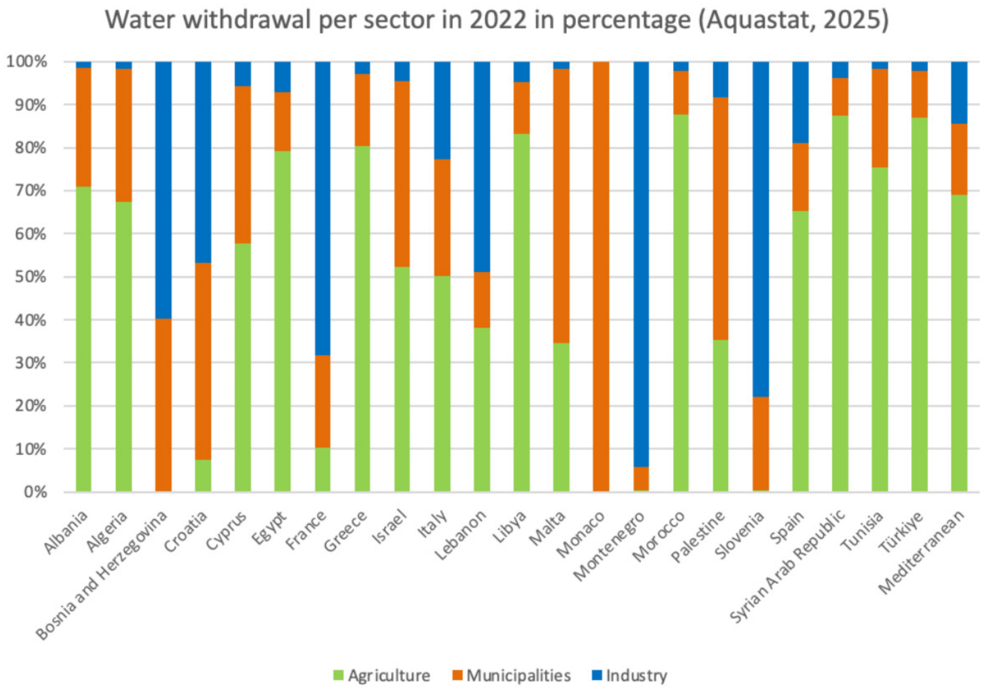

Chart 1: Water Withdrawal per sector in 2022 in percentage.

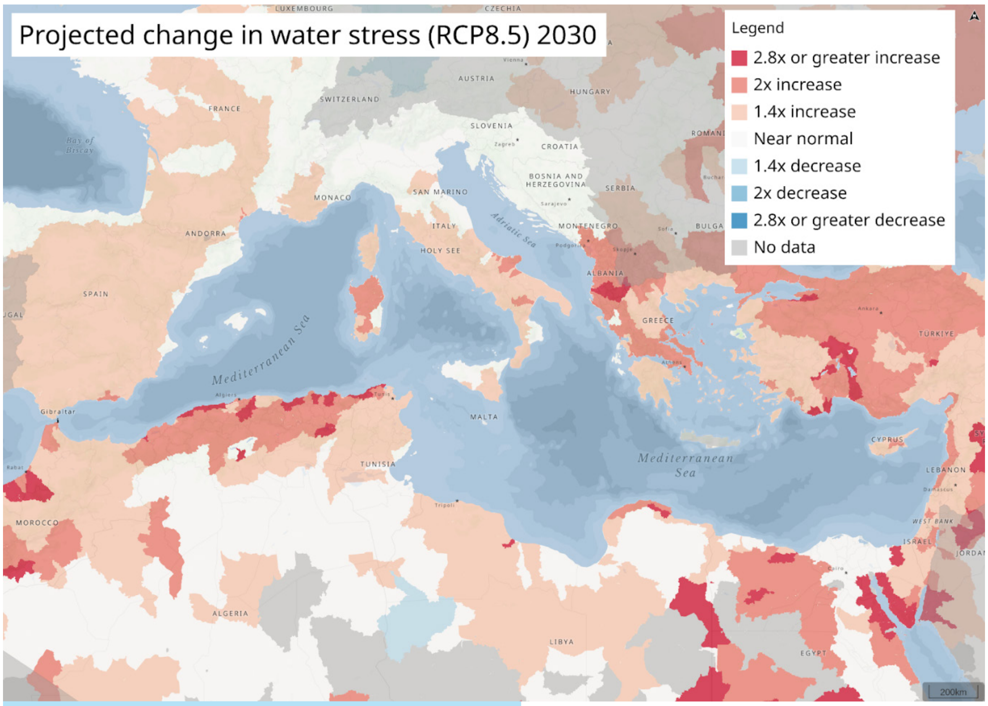

Figure 1: Projected change in water stress (RCP 8.5) 2030 [4]
Source: Plan Bleu Observatory

4 With the goal of producing information for decadal-scale planning, adaptation, and investment, the Aqueduct Water Stress Projections model potential changes in future demand and supply of water over the next 3 decades. Global indicators were developed for water demand (withdrawal and consumptive use), water supply, water stress (the ratio of water withdrawal to supply), and intra-annual (seasonal) variability for the periods centered on 2020, 2030, and 2040 for each of 2 climate scenarios, RCP4.5 (accessible on MapX also) and RCP8.5 (link), and 2 shared socioeconomic pathways, SSP2 and SSP3.

Two paradoxes underpin the water scarcity crisis in the Mediterranean:

The first lies in the coexistence of increasing water demand and declining freshwater availability. Climate projections indicate that for each degree of warming, annual precipitation could drop by 4%, potentially reducing freshwater resources by 10% by 2050 (Plan Bleu - MED2050, 2025). Figure 1 also illustrates that regions are projected to experience a twofold or greater increase in water scarcity by 2030, predominantly in coastal and densely populated urban and peri-urban areas - where demand is already high. To address diminishing water supplies, many countries have invested in unconventional water resources, such as wastewater treatment plants (WWTPs) and desalinisation technologies. However, urban centers - particularly in the rapidly urbanizing southern Mediterranean - continue to face major infrastructure challenges. In numerous cities over 10,000 inhabitants, WWTPs are often still under development. These systems require continuous maintenance, and without adequate support, they can contribute to environmental degradation and the spread of emerging contaminants that threaten ecosystems and public health (Plan Bleu - MED2050, 2025). Desalination, while increasingly adopted to offset freshwater deficits, remains energy-intensive and poses socio-economic and environmental impacts that may undermine its long-term viability and scalability.[5]

The second paradox lies in the simultaneous occurrence of chronic water shortages and acute water surpluses linked to seasonal hydrological extremes (Plan Bleu - MED2050, 2025). Droughts are becoming more frequent and intense, yet are often followed by short, extreme rainfall that overwhelms infrastructure and triggers flash floods. This duality poses complex challenges for water resource management, particularly in urban areas. In response, Mediterranean countries have traditionally relied on grey infrastructure, including dikes, river embankments, and retention basins, to mitigate flood risks. While these solutions have provided critical protection, they may no longer suffice under the increasing unpredictability and intensity of climate-related events.

These patterns are further exacerbated by sea level rise and saltwater intrusion into coastal aquifers, which not only hinder aquifer recharge but also deteriorate water quality through salinization and pollution. As a result, both water security - due to reduced quantity and quality - and urban resilience - due to rising food risks and infrastructure strain - are increasingly threatened. These shared challenges highlight the need for greater regional cooperation and investment in sustainable, environmentally friendly water and sanitation solutions.

In this context, Nature-based Solutions (NbS) emerge as sustainable and integrated responses in regard to conventional grey infrastructure solutions. Based on natural processes, NbS helps - among a whole range of additional benefits (e.g. socio-economic and environmental) - restore ecological functions while addressing concrete water challenges. From restored coastal marshes that buffer erosion, to river corridors designed to contain floods, to urban wetlands that filter and reuse wastewater, these approaches have proven effective - provided they are well-planned, integrated, and socially accepted.

2- Paper Methodology

Based on the IUCN Global Standards for NbS - particularly inclusive governance (Criterion 5), balanced trade-offs (C 6), adaptive management (C 7), and long-term policy integration (C 8) - this publication present a synthesis of six case studies from across the Mediterranean (Morocco, France, Italy, Albania, Egypt, Spain), as presented in Plan Bleu's publication Nature-Based Solutions for Mediterranean Cities (2024). These cases illustrate diverse NbS for urban and coastal water management. Despite varied contexts, all projects share a core approach: restoring or catalyzing natural processes to enhance water resilience and deliver co-benefits for nearby ecosystems, communities, and economies. By examining effective NbS practices and outcomes, this synthesis demonstrates their potential to guide sustainable urban water strategies.

3- Key pillars for making NbS a success : Governance, Planning, and Participation

These three pillars emerged consistently across the six cases studies and are further supported by another Plan Bleu report developed under the GEF MedProgramme SCCF Project, which highlights institutional coordination, long-term planning, and stakeholder engagement as key enablers to effective NbS implementation.[6] The case studies show that NbS are most successful when embedded within operational frameworks that integrate social, institutional, economic, and technical dimension.

5 For further information on désalinisation (link).
6 GEF MedProgramme SCCF Project (link).

Picture 2 : Boukhalef wastewater treatment plant operated by Amendis. © Maquet (2020)

3.1 - Collaborative governance and inclusion:

Effective NbS governance requires coordination across local, regional, and national levels, involving public institutions, private actors, researchers, and civil society to enhance social acceptance. Three case studies have been shown effective for their governance model and active participation of different stakeholders.

In Tangier, the Boukhalef Wastewater Treatment Plant (WWTP) showcases a large-scale NbS contributing to urban water resilience by treating and reusing wastewater in one of Morocco's rainiest regions (Picture 2). Originally commissioned in 2015 with a capacity of 10,700m^3/day, the facility was expanded to 42,700m^3/day in 2020 - saving an estimated 3 million m^3 of water annually. Treated water has been reused for urban green space management. The success of this project can be largely attributed to the effective multi stakeholder governance framework and the allocation of responsibilities among a range of public and private actors. This institutional collaboration ensured long-term operational sustainability along with a cost-recovery pricing support (water supplying at USD 0.27/m^3).

In other parts of the Mediterranean, experiences from the EU-funded Adapto (2017-2021) project in Hyères (France) and the ADAPT pilot project (2019-2024) in Elbasan (Albania) have highlighted how collaborative, multi-level governance combined with meaningful public participation and inclusion is critical to the success of NbS projects.

Understanding local needs and perceptions requires an initial diagnostic phase using surveys, interviews, or focus groups. Where skepticism exists, clear communication helps foster ownership and support. In Hyères for example (Picture 3), the project coordinated by the Conservatoire du Littoral, sought to restore a degraded coastal ecosystem by removing industrial rock defenses and re-establishing natural dune and underwater vegetation (e.g. Posidonia meadows) to fix the seabed and reduce coastal erosion. Successfully, the design was based on a strong and sensitive diagnosis of sites'users (consultation, perceptions of safety, local attachment) where social buy-in was facilitated by participatory tools and community outreach to support social acceptance (post project surveys: 54% of population in favour of implemented actions). Hence, site users identified the most effective communication tools for raising awareness about coastal adaptation to climate change as information panels (43%), municipal communication (22%), and local press (21%). Virtual simulations (10%), and specialized media (7%) were seen as less effective.

Success in the Elbasan project has also been reached through strong educational and outreach initiatives that strengthened local awareness, promotion of alternative livelihoods to reinforce community resilience. The project focuses on reducing erosion and flood risks in the Shkumbini River basin through forest restoration (8.5 ha) and the development of sustainable grazing and livelihoods (e.g., agro-tourism). A participatory approach involving local and national stakeholders, including women and vulnerables groups, shaped the de-

Picture 3 : Hyères Old Salt Mines - Pond and pine forest of l'Anglais. ©Larrey. Adapto. (n.d.).

sign of context-specific NbS and long-term ownership. Socio-economic co-benefits for over 1000 households reinforced community resilience.

3.2 - Planning NbS:

The long-term success of NbS for water and flood management depends on their integration into coherent planning strategies that span across spatial and policy scales. NbS reach their full potential when embedded within broader urban, territorial and watershed management frameworks, supported by diagnostics, spatial coherence, and adaptive management. Their effectiveness is further enhanced when aligned with the objectives of international and regional environmental strategies and frameworks—such as the Sustainable Development Goals, the EU Water Resilience Strategy, the Nature Restoration Regulation, and relevant Mediterranean Action Plan protocols. Multi-level integration not only ensures the durability and performance of NbS, but also promotes policy coherence and collective progress toward shared sustainability goals.

In 2023, a collaboration between the University of Cairo and three foreign universities yielded proposals to address the frequent flooding suffered by the metropolitan area of Alexandria through the strategic deployment of several small-scaled NbS integrated within the city Sustainable Drainage Systems[7] (SUDS) and broader urban land-use frameworks. A detailed hydrological assessment guided the spatial integration of context-specific NbS - including bioretention basins, rain gardens, wetland ponds, and permeable pavements - across diverse urban landscapes. Strengthening urban resilience by embedding NbS into long-term planning and zoning regulations has been key to the success of the project.

In Barcelona, the Llobregat River Park (Picture 4) - launched in 2007 - represents a flagship long-term initiative for river restoration and climate adaptation. The project integrates multiple NbS, including water reuse infrastructures within a strategic water cycle plan, the demolition of a concrete ditch transformed into a vegetated one, bioengineered riverbanks, erosion control measures, and native species reforestation. Key component of the success is the integration of the project into regional planning frameworks, an assiduous ecological monitoring (by LIFE UrbanGreeningPlans initiative), the use of adaptive management based on ecological performance and a very efficient maintenance. Maintenance has been identified as critical to sustained NbS performance (in over 80% of assessed cases).

In Cagliari, Sardinia, the EcoSistema Filtro (ESF) - a constructed wetland established in 2004 within the Molentargius-Saline Nature Reserve (Picture 5) - demonstrates how NbS can support urban redevelopment and conservation goals through a broader land-use strategy to avoid conflicts between users and reduce pressures on environment, but also a long-term operational sustainability through public access limitations and reinforced cooperation between stakeholders. De-

7 Sustainable Drainage systems are urban water management methods that mimic natural hydrology to control runoff, reduce discharge volume, and improve water quality, helping protect natural water bodies.

Picture 4 : Regenerated water use system through canals in the meander of Sant Joan Despí, 2011© Àrea Metropolitana de Barcelona. (n.d.).

Picture 5 : Parco Naturale di Molentargius e saline - Cagliari. ©LeniKovaleva. Sardegna Turismo (2015)

signed to treat wastewater through natural filtration, the ESF contributes to improve environmental and socio-cultural features with a successful management planning.

On the international stage, ambitious wetland restoration initiatives are gaining momentum, exemplified by the EU Horizon 2020 WaterLANDS project.

This initiative, in which Plan Bleu contributed to the development of a Theoretical Governance Framework[8], demonstrated how aligning governance with appropriate funding schemes and coherent policy frameworks are crucial to upscaling wetland restoration as NbS for climate change adaptation, disaster risk reduction and water resilience across Europe.

4- NbS efficiency for water-related challenges

Table 1 compares and illustrates the effectiveness of each NbS to water-related problems. The case studies show varying levels of ecosystem service delivery, from targeted benefits to broader multifunctionality. Some, like in Elbasan, prioritize flood control, while others, like Hyères, combine water purification, decontamination processes and soil improvements. The classification[9] into main, side, or low/no services helps highlight these differences. Overall, the table reflects how NbS can be tailored to local priorities while offering co-benefits.

8 Terrisse, A., Karner, M., Kaufmann, J., & Ernoul, L. (2025). Characterizing governance models for upscaling wetland restoration. Environmental Management, 75(5), 1155–1167.

9 From Plan Bleus' publication Nature-Based Solutions for Mediterranean Cities (2024).

Case studies	Nbs type	Water purification	Flood control	Decontamination processes	Soil improvement and erosion control
Tangier (Morocco)	WWTP capacity	Main objective of service group	Low or no level of service group	Low or no level of service group	Main objective of service group
Hyères (France)	Salt mine restoration	Main objective of service group	Side effect service group	Main objective of service group	Main objective of service group
Elbasan (Albania)	Forest restoration	Side effect service group	Main objective of service group	Side effect service group	Low or no level of service group
Alexandria (Egypt)	Flood risk mitigation through many small-scaled nature-based interventions within a SUDS	Side effect service group	Main objective of service group	Low or no level of service group	Main objective of service group
Barcelona, Llobregat River Park (Spain)	River restoration; climate adaptation	Main objective of service group	Side effect service group	Side effect service group	Main objective of service group
Cagliari (Italy)	Wetland construction and protection	Main objective of service group	Side effect service group	Side effect service group	Main objective of service group

(light green)	Low or no level of service group
(medium green)	Side effect service group
(dark green)	Main objective of service group

Table 1: NbS effectiveness for water-related challenges from the six case studies.
Source: Adapted from Plan Bleu (2024).

5- Nbs co-benefits and cost-effectiveness

NbS for water and flood risk management offer a range of co-benefits that extend well beyond their primary functions. They contribute to improved water quality, enhanced biodiversity, and increased social cohesion by creating healthier and more attractive public spaces with recreational value. A recently published study shows that natural solutions, such as dune restoration, Posidonia oceanica seagrass replanting and beach nourishment, can reduce urban flooding during extreme events by 78% (Marino et al. 2025). In the Pantani della Sicilia Sud-Orientale lagoon case study, researchers simulated future scenarios using advanced hydrodynamic models combined with habitat mapping, confirming once again NbS as effective, scalable, and sustainable tools to protect coasts from climate change.

From an economic perspective, NbS often outperform traditional infrastructure in terms of cost-effectiveness[10] over their lifecycle. Although they may not fully address large-scale challenges - such as those observed in Alexandria - NbS can reduce both capital and operational expenditures while minimizing negative externalities. Their integration with grey infrastructure and enabling policy frameworks is essential for effective flood and water management. Importantly, ecosystem-based adaptation typically requires around 10 years to deliver measurable outcomes, underscoring the value of hybrid strategies that combine NbS with conventional and societal solutions.
These hybrid approaches, which prioritize NbS where feasible, help optimize financial resources, attract green investments and climate finance, and offer sustainable options for both public and private stakeholders. They must be supported by complementary urban planning measures, including building regulations, land-use policies, and integrated development strategies.

Among NbS, ecosystem restoration is particularly cost-effective. For instance, the restoration of coastal salt marshes in Hyères cost €840 000, with €700 000 in maintenance over 30 years - significantly less than traditional coastal defenses (€2.4 million plus €3.1 million in maintenance) (Plan Bleu, 2024). Beyond cost savings, such interventions yield broader economic benefits: they support local tourism, create green jobs, enhance property values, and reduce disaster recovery costs, thereby strengthening community resilience.

10 For more information see Plan Bleu's work on Cost-Benefit Analysis (CBA) and Multi-Criteria-Analysis (MCA) for NbS in the frame of the SCCF Project (link).

6- Conclusion

The six case studies presented here demonstrate that NbS long-term effectiveness and scalability depend on integration into long-term coherent policy and multi-scale planning frameworks, supported by inclusive governance, stakeholder co-creation, continuous monitoring and adaptive management. Cost-effectiveness - particularly in ecosystem restoration - reinforces their viability over conventional solutions while bringing cumulative co-benefits such as biodiversity restoration, flood regulation or water purification. However, NbS are inherently context-specific and require coordinated yet flexible approaches across governance levels.

Unlocking the full potential of NbS requires the mobilization of innovative financing mechanisms, such as blended finance and public-private partnerships. Regional cooperation can facilitate pooled investment and risk-sharing, enhancing the attractiveness of large-scale NbS to institutional investors and development banks. In this regard, Plan Bleu/RAC, part of the UNEP/MAP system, especially through the Mediterranean Strategy for Sustainable Development (MSSD), are playing a key role in advancing research, dialogue, and pilot initiatives to build capacity and mobilize resources across the region.

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Disclaimer

This note analyses Urban and Coastal Water Management through Nature-Based Solutions using data from multiple national and international sources. The results are subject to limitations related to data gaps and uneven spatial and temporal coverage. While standardized methods were applied to enhance consistency and robustness, users should interpret the findings with caution and, where relevant, complement them with additional scientific sources and local expertise

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