OCEAN IMPACT INITIATIVE

Coastal Cities Review

Hong Kong, China

ONE OCEAN Foundation

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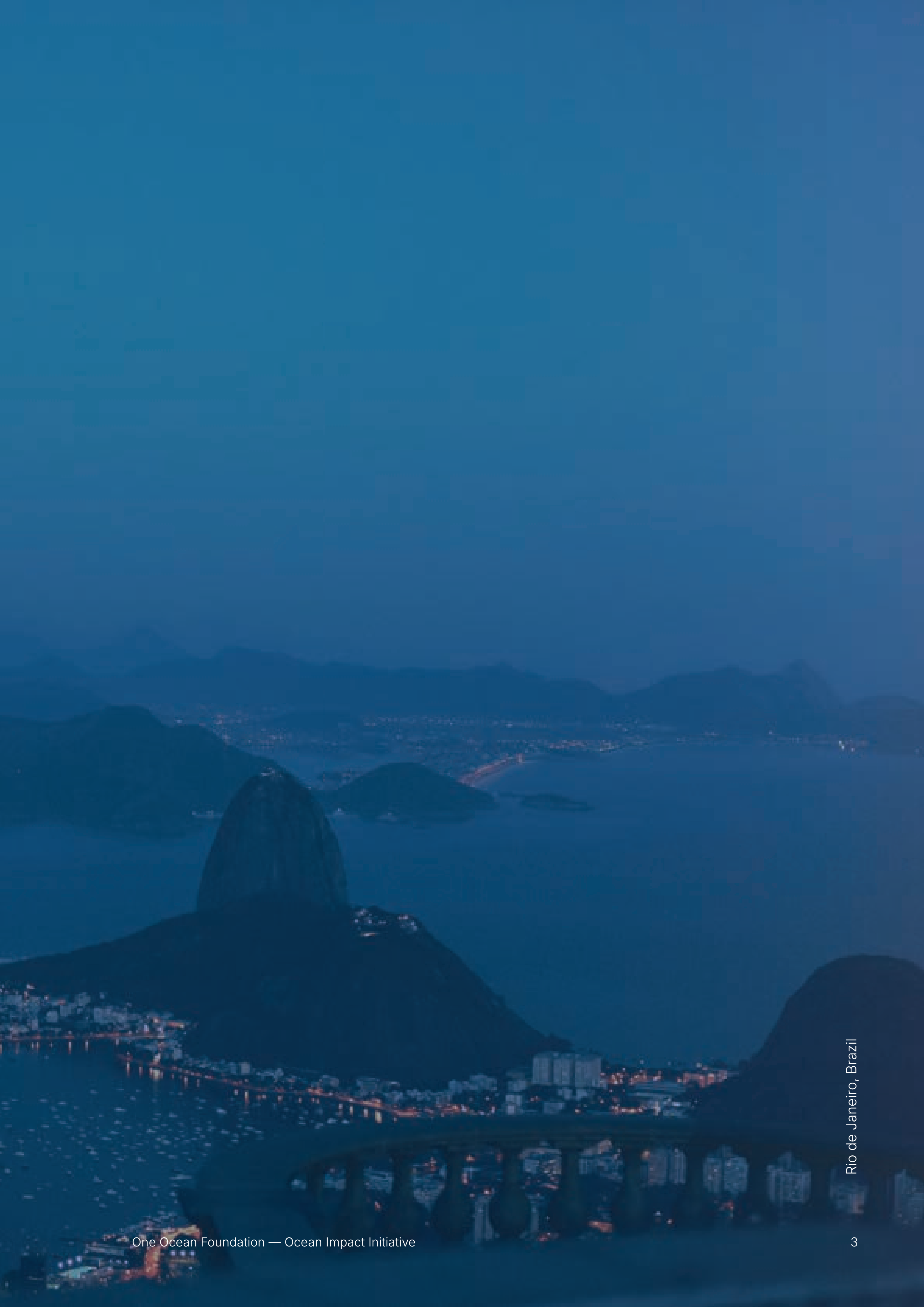

Rio de Janeiro, Brazil

About One Ocean Foundation

This research has been carried out by One Ocean Foundation as part of its Ocean Impact Initiative project.

At the Foundation, we believe that protecting the ocean goes beyond mitigating existing damage — it involves addressing the root causes of the issue. Our approach extends conservation efforts: we actively collaborate with businesses and policymakers to drive systemic change, ensuring a sustainable future for marine ecosystems. The One Ocean Foundation is dedicated to promoting a nature-positive economy that balances resource use with the urgent need to protect and restore marine ecosystems and their biodiversity.

The distinctive feature of the One Ocean Foundation is that every project we undertake is rooted in science and designed to create measurable, long-term impact. Our initiatives are carried out under the guidance of our international scientific committee and through continuous collaboration with cutting-edge research centres and universities. Through collaboration with companies, we help them understand and reduce their environmental footprint while fostering policies that safeguard the ocean.

For information please contact the One Ocean Foundation at:
secretariat@1ocean.org
Tel: +39 02796145
Via Gesù 10, Milan - Italy

To see the latest One Ocean Foundation contents please visit:
www.1ocean.org

About the Ocean Impact Initiative

The Ocean Impact Initiative (formerly known as Ocean Disclosure Initiative) is part of the multi-year research "Business for Ocean Sustainability" promoted by the One Ocean Foundation (OOF) in collaboration with SDA Bocconi School of Management Sustainability Lab, McKinsey & Company and CSIC (Consejo Superior de Investigaciones Científicas) and aims to build knowledge about the relationship between business activities and the ocean.

The project commenced in 2019 with the goal of investigating the role of companies in addressing ocean challenges, focusing on the pressures on marine ecosystems, the level of awareness within the business community and the main responses (technological and organisational) implemented.

The Ocean Impact Initiative aims to provide a science-based framework and methodology with the objective of supporting businesses from all industries in taking action on ocean-related issues, promoting prevention and/or mitigation responses, and favouring disclosure and reporting.

In collaboration with

SDA Bocconi School of Management Sustainability Lab — McKinsey & Company — CSIC Consejo Superior de Investigaciones Científicas

Hvar Island, Croatia

Introduction to coastal cities

Coastal cities stand at the critical intersection between human activity and the ocean, shaping and being shaped by the complex dynamics of climate, environment, and economic development.

As global urbanisation accelerates, cities now host most of the world's population,[1] and a significant share of this growth is concentrated along coastlines, with 16 of 23 megacities around the world located in the coastal zone.[2]

Coastal cities are urban areas situated along the world's ocean, seas, and major estuaries, often within broader coastal regions — the transitional zones between land and water, including large inland lakes where applicable.[3]

These regions are highly dynamic, with diverse forms and functions, and cannot be strictly defined by fixed spatial boundaries. Instead, they are continuously shaped and reshaped by tides, currents, natural processes, and human activities.

Coastal regions have long served as major population centres, drawing people with their access to natural resources, strategic trade routes, and the economic dynamism of the blue economy, encompassing fisheries, ports, tourism, and maritime industries.

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1. Intergovernmental Panel on Climate Change (IPCC).(2022). Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

2. Barmelgy, I. M. E., & Rasheed, S. E. A. (2016). Sustainable Coastal Cities between Theory and Practice (Case Study: Egyptian Coastal Cities). Journal of Sustainable Development, 9(4), 216. https://doi.org/10.5539/jsd.v9n4p216

3. Food and Agriculture Organisation of the United Nations (FAO). (1998). FAO GUIDELINES Integrated coastal area management and agriculture, forestry and fisheries. https://www.fao.org/4/w8440e/w8440e02.htm

Today, 2.15 billion people live in near-coastal zones,[4] and 896 million people inhabit low-elevation coastal zones worldwide.[5] As urbanisation accelerates, coastal cities are experiencing rapid and uneven population growth. Approximately 70% of the world's largest megacities (>10 million people) are within 60 km of the coast, contributing to 50% of the world's GDP.[6] This concentration of people and infrastructure along coastlines reinforces the role of coastal cities as vital hubs of global commerce and innovation, but also heightens their exposure to climate-driven hazards and ecological pressures.

Approximately 70% of the world's largest megacities are within 60 km of the coast

Understanding the diversity of coastal cities is essential for this report, as it helps identify how different types of settlements face distinct risks, challenges, and opportunities for adaptation. Coastal cities vary widely in their characteristics and development patterns.

To capture this diversity, Intergovernmental Panel on Climate Change (IPCC) classifies them into a set of archetypes, according to geomorphological characteristics, urban growth, economic resources and inequalities.

From a geomorphological perspective, three broad categories are identified: open coasts (coastlines composed of sediments without river mouths), estuaries (a wetland receiving sediment from both fluvial and marine sources and affected by tide, wave and river processes) and deltas (a wetland where fluvial sediment is supplied and deposited more rapidly than it can be redistributed by basin processes such as waves and tides).[7] Many coastal settlements combine features of more than one of these typologies.

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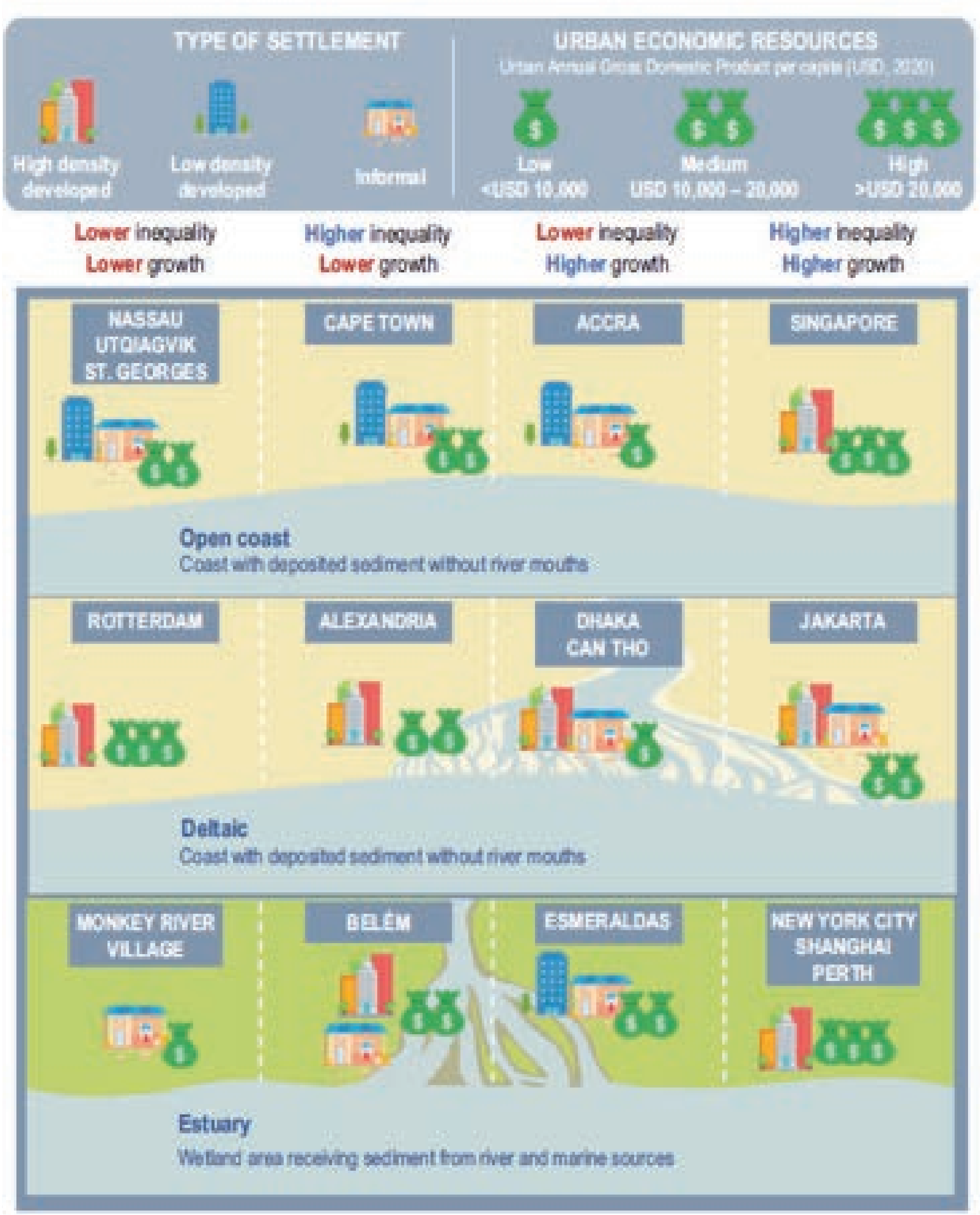
4. Reimann, L., Vafeidis, A. T., & Honsel, L. E. (2023). Population development as a driver of coastal risk: Current trends and future pathways. Cambridge Prisms Coastal Futures, 1. https://doi.org/10.1017/cft.2023.3

5. Intergovernmental Panel on Climate Change (IPCC).(2022). Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

6. Xiang, Z., Li, Y., & Zhang, Z. (2024). Global conservation priorities of coastal habitats towards extreme sea level rise risks. Journal of Cleaner Production, 473, 143455. https://doi.org/10.1016/j.jclepro.2024.143455

7. Intergovernmental Panel on Climate Change (IPCC). (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

Figure 1: Archetypes of the coastal cities



Source: IPCC (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

Furthermore, cities can also begin to be differentiated by their rates of urban expansion and degrees of inequality, typically assessed through indicators such as population growth, the spatial extent of urban development, Gini coefficient (which measures income or wealth inequality), and urban–rural poverty rates.

Nowadays, coastal cities face some of the most severe consequences of climate change. Sea-level rise, extreme weather events, storm surges, flooding, and erosion threaten lives, livelihoods, and critical infrastructure. These climate impacts interact with existing socio-economic vulnerabilities — such as inequality, informal settlements, and inadequate basic services — creating complex, compounding risks.

Cities are both victims of climate change and among its greatest contributors. They are disproportionately exposed to climate impacts while simultaneously generating a significant share of global greenhouse gas emissions and other environmental pressures.[8] Although cities differ greatly in size, socio-economic composition, governance, exposure to external shocks, and adaptive capacity, their ageing or vulnerable infrastructure — including water supply, waste management, transportation, energy, and food systems — remains a persistent challenge,[9] often leading to mismanagement with direct impacts on natural ecosystems.

Rapid urban growth further intensifies demand for resources, increases waste production, and expands impervious surfaces, leading to pollution, habitat loss, and altered land–sea interactions. Runoff, untreated wastewater, and poorly planned development degrade vital coastal ecosystems such as wetlands, estuaries,

8. UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/wcr/

9. Kapucu, N., Ge, Y., Rott, E., & Isgandar, H. (2024). Urban resilience: Multidimensional perspectives, challenges and prospects for future research. Urban Governance, 4(3), 162-179. https://doi.org/10.1016/j.ugj.2024.09.003

coral reefs, and mangroves, which provide essential services including storm protection, water filtration, carbon sequestration, and biodiversity support. Today, only 15% of the world's coastlines remain in a natural state,[10] highlighting the profound scale of human-induced transformation and the urgent need for sustainable urban planning.

Only 15% of the world's coastlines remain in a natural state

Yet coastal cities are not only sites of environmental vulnerability and impacts; they are also centres of innovation with the potential to drive transformative solutions. When effectively governed, they can become leaders in sustainable development, low-carbon urban transitions, and ocean stewardship.

Their density, connectivity, and resource concentration make cities uniquely suited for implementing adaptation and mitigation programs that deliver multiple co-benefits — reducing poverty, generating employment, improving service provision, and enhancing overall quality of life.[11]

This report examines the multifaceted relationship between coastal cities and the ocean, assessing the pressures cities exert on marine systems, the risks they face from climate and environmental change, and the opportunities for resilience offered by nature-based solutions, improved governance, and sustainable urban planning.

As coastal populations and economies continue to expand, understanding and managing these interactions will be essential for building cities that are not only prosperous and inclusive but also ecologically responsible, climate-resilient, and low contributors to climate change.

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10. Ocean Decade. (2025). Ocean science in action: Building a sustainable future for coastal cities. https://oceandecade.org/news/ocean-science-in-action-building-a-sustainable-future-for-coastal-cities/

11. UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/wcr/

Venice, Italy

Vulnerability of coastal cities to climate change

Coastal cities sit at the frontline of climate change,[12] facing a unique combination of physical hazards, socio-economic pressures, and ecological vulnerabilities. As global temperatures rise and environmental degradation accelerates, these coastal urban areas are becoming hotspots of climate-related risk.[13]

Coastal cities are simultaneously economic engines and disaster-prone zones, exposed to extreme weather, sea-level rise, and ecosystem decline. According to the IPCC report, by 2050, many coastal cities will face severe disruptions to ecosystems and human livelihoods.[14] These climate change vulnerabilities are amplified where inequality, informal settlements, and inadequate infrastructure intersect with rapid urban growth and deteriorating natural buffers.[15]

Coastal cities are simultaneously economic engines and disaster-prone zones, exposed to extreme weather and sea-level rise

Sea-level rise represents one of the most severe threats to coastal settlements. Driven by melting polar ice and thermal expansion of seawater, global sea levels continue to rise at accelerating rates.[16]

12. Intergovernmental Panel on Climate Change (IPCC). (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

13. Wannewitz, M., Ajibade, I., Mach, K. J., Magnan, A., Petzold, J., Reckien, D., Ulibarri, N., Agopian, A., Chalastani, V. I., Hawxwell, T., Huynh, L. T. M., Kirchhoff, C. J., Miller, R., Musah-Surugu, J. I., Alverio, G. N., Nielsen, M., Nunbogu, A. M., Pentz, B., Reimuth, A., . . . Garschagen, M. (2024). Progress and gaps in climate change adaptation in coastal cities across the globe. Nature Cities, 1(9), 610–619. https://doi.org/10.1038/s44284-024-00106-9

14. Intergovernmental Panel on Climate Change (IPCC). (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

15. Wannewitz, M., Ajibade, I., Mach, K. J., Magnan, A., Petzold, J., Reckien, D., Ulibarri, N., Agopian, A., Chalastani, V. I., Hawxwell, T., Huynh, L. T. M., Kirchhoff, C. J., Miller, R., Musah-Surugu, J. I., Alverio, G. N., Nielsen, M., Nunbogu, A. M., Pentz, B., Reimuth, A., . . . Garschagen, M. (2024). Progress and gaps in climate change adaptation in coastal cities across the globe. Nature Cities, 1(9), 610–619. https://doi.org/10.1038/s44284-024-00106-9

16. Intergovernmental Panel on Climate Change (IPCC). (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryVolume.pdf

Even modest increases can inundate low-lying districts, damage transportation networks, compromise utilities, and put human lives at risk.[17] By 2040, more than 2,000 coastal cities will lie in low-elevation coastal zones under 5 metres above sea level — growing to 2,620 cities under the 10-meter threshold — placing 1.4 billion people at heightened risk of permanent or episodic flooding.[18] Many of these cities still lack multi-hazard early warning systems.

Coastal communities worldwide, across all continents — cities such as Jakarta, Lagos, Houston, Rotterdam, and Venice — are already facing subsidence, recurrent flooding, and in severe cases the possibility of full submergence by the end of the century unless adaptive measures are rapidly implemented.[19]

In addition, climate change and sea-level rise also drive saltwater intrusion, contaminating groundwater aquifers and river systems that cities depend on for drinking water, agriculture, and industrial uses.[20] This compounds water scarcity in already stressed regions and forces cities to invest in costly alternatives such as desalination, groundwater recharge systems, or expanded water-treatment infrastructure. The scale of the threat is global and rapidly expanding. According to NASA's Jet Propulsion Laboratory, 77% of the world's coastal watersheds could experience significant saltwater intrusion by 2100, with some regions already showing saltwater movement more than a kilometre inland due to rising seas and decreased groundwater recharge under warmer, drier conditions.[21]

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17. David, C. G., Kremer, J., Ashwini, M., Kloft, H., & Goseberg, N. (2025). Digital fabrication of Hybrid Nature-based Solutions as new opportunity for coastal climate change adaptation. Cambridge Prisms Coastal Futures, 3, e24. https://doi.org/10.1017/cft.2025.10014 **18.** UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/sites/default/files/2024/11/wcr_2024_-_executive_summary.pdf

19. World Economic Forum. (2019). These 11 sinking cities could disappear by 2100. https://www.weforum.org/stories/2019/09/11-sinking-cities-that-could-soon-be-underwater/

20. Ray, R. L., & Tikuye, B. G. (2025). Impact of climate change on surface water resources. In Environmental sciences. https://doi.org/10.5772/intechopen.1011407

21. NASA Jet Propulsion Laboratory. (2024). Projections of Saltwater Intrusion in Coastal Watersheds by 2100. https://www.jpl.nasa.gov/images/pia26491-projections-of-saltwater-intrusion-in-coastal-watersheds-by-2100/

Furthermore, coastal cities are increasingly affected by hurricanes, typhoons, cyclones, heavy precipitation, and extreme storms, all intensified by warmer sea-surface temperatures and changing atmospheric patterns. These events trigger destructive coastal and pluvial flooding, cause damage to homes and critical services, prolonged service disruptions, and evacuation challenges, and economic shocks to tourism, fisheries, and port operations.

Urban hardscapes — dominated by concrete, asphalt, and impermeable surfaces — magnify flood impacts by preventing infiltration and overwhelming drainage systems. For example, in Odense, Denmark, a 1% increase in impervious cover is projected to expand flood-prone areas by more than 10%.[22]

Future projections indicate that under high-emission scenarios (RCP8.5), coastal flooding could endanger up to USD 14.2 trillion in assets — nearly 20% of global GDP — making coastal resilience a global economic priority.[23]

22. UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/wcr/

23. Xiang, Z., Li, Y., & Zhang, Z. (2024). Global conservation priorities of coastal habitats towards extreme sea level rise risks. Journal of Cleaner Production, 473, 143455. https://doi.org/10.1016/j.jclepro.2024.143455

Hong Kong, China

Pressures exerted by coastal cities on marine ecosystems

At the same time, coastal cities have a profound influence on the health of the ocean because they concentrate people, infrastructure, and different economic activities directly at the land–sea interface. Their rapid growth increases pressures such as wastewater discharge, solid-waste leakage, stormwater runoff, light and noise pollution, and habitat conversion. Coastal development — ports, tourism facilities, and reclaimed land — alters shorelines and degrades key ecosystems like mangroves, seagrass meadows, coral reefs, and wetlands, which weakens natural coastal protection and reduces biodiversity. At the same time, heavy maritime traffic adds underwater noise and emissions that disturb marine species and contribute to broader ocean stress. Taken together, these impacts make coastal cities major drivers of ocean degradation, but also key actors with the potential to implement sustainable planning and innovation to protect marine environments.

HABITAT AND BIODIVERSITY LOSS

Coastal cities drive extensive habitat loss and biodiversity decline through land reclamation, tourism development, and physical alteration of shorelines. Large-scale land-reclamation projects — commonly used to expand ports, airports, and coastal real estate — directly bury ecologically important marine habitats such as seagrass beds, tidal flats, and coral reefs, while disrupting the natural sediment flows that sustain beaches and estuaries.

Land reclamation for coastal development and infrastructure expansion can drive habitat and biodiversity loss

Commercial ports and marinas, in particular, exert one of the greatest ecological footprints on surrounding seascapes. Their construction often relies heavily on reclamation, and once operational, they concentrate human activity, reduce water circulation, and create heavily modified water bodies (HMWB) where ecological processes are significantly altered. The removal of sediments and hardening of coastlines also interrupts natural sediment transport, contributing to erosion or accretion in adjacent areas, which can affect nearby beaches, wetlands, and estuaries.[24]

The expansion of coastal urban infrastructure significantly contributes to habitat degradation in coastal cities. The construction of roads, residential areas, promenades, marinas, jetties, and artificial waterfronts often requires clearing natural coastal vegetation and reshaping shorelines.

These interventions alter hydrographic conditions, resuspend sediments, increase turbidity, and accelerate coastal erosion. In addition, tourism-driven infrastructure — such as seawalls, boardwalks, and breakwaters — interrupts natural sand transport, producing sediment imbalance and shoreline retreat.[25] Globally, 24% of the world's sandy beaches are already eroding, with poorly planned coastal development and inadequate shoreline management among the key contributing factors.[26] These hard structures disrupt natural sand transport, leading to sediment imbalance, shoreline retreat, and increased vulnerability to storms.

Globally, 24% of sandy beaches are eroding due to inadequate shoreline management

Some of the most severe consequences from construction activities for coastal cities' infrastructure arise from the widespread loss of wetlands, mangroves, tidal flats, and natural beaches, which are often cleared for development despite being biodiversity hotspots and among the most productive ecosystems on Earth.

24. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Ports and warehousing industry review. https://cdn.1ocean.org/6613b6f5a338c00c9aadcd38_ODI_20_Ports_20and_20_Warehouses_20_Industry_20_Review_e73e1f0efa.pdf

25. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Coastal and marine tourism industry review. https://cdn.1ocean.org/66a2005ee6de9abbaa0a67b6_2024_07_19_20_V2_20_Coastal_20and_20_Marine_20_Tourism_compressed_8064ab3a7a.pdf

26. Luijendijk, A., Hagenaars, G., Ranasinghe, R., Baart, F., Donchyts, G., & Aarninkhof, S. (2018). The state of the world's beaches. Scientific Reports, 8(1), 6641. https://doi.org/10.1038/s41598-018-24630-6

Coastal and ocean sprawl fragments once-continuous habitat mosaics, disrupting ecological connectivity vital for species survival. Urban expansion, dredging, and sand mining further intensify erosion; in some regions, shorelines retreat by several metres each year once natural sediment flows are altered. As gentle sublittoral slopes and tidal flats disappear, essential spawning, nursery, feeding, and refuge areas for fish and invertebrates are lost, reducing fisheries' carrying capacity.[27]

The degradation of these habitats undermines the stability of seagrass meadows and coastal dunes, increases flood risks, and threatens the long-term durability of coastal infrastructure — ultimately compromising both marine biodiversity and the sustainability of coastal cities themselves.

27. Aguilera, M. A., Tapia, J., Gallardo, C., Núñez, P., & Varas-Belemmi, K. (2020). Loss of coastal ecosystem spatial connectivity and services by urbanization: Natural-to-urban integration for bay management. Journal of Environmental Management, 276, 111297. https://doi.org/10.1016/j.jenvman.2020.111297

GOOD PRACTICES

Coastal cities can mitigate habitat loss and biodiversity decline by shifting toward nature-based, ecosystem-aligned development practices and stronger coastal-zone regulation. One of the effective strategies is protecting and restoring natural buffers such as mangroves, seagrass meadows, wetlands, dunes, and tidal flats.[28] These ecosystems stabilise shorelines, maintain sediment flows, support fisheries nurseries, and reduce erosion far more sustainably than hard infrastructure. Cities can replace or complement seawalls and breakwaters with "living shorelines" — solutions that use oyster reefs, mangrove belts, or salt marshes to absorb wave energy while preserving habitat.[29]

Coastal cities can protect and restore natural buffers such as mangroves, seagrass meadows, wetlands and dunes

Sustainable port and marina planning can reduce ecological footprints by minimising land reclamation, improving water circulation within basins, and integrating sediment-management plans to maintain natural transport processes.[30] In tourism development, construction can be avoided on dunes and wetlands, and use elevated, low-impact structures instead of shoreline-hardening.

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28. Laino, E., & Iglesias, G. (2025). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

29. Xu, X., O'Sullivan, J., Abolfathi, S., Keenahan, J., Pearson, J., & Salauddin, M. (2025). Advances in understanding the challenges and opportunities of hybrid sea defence approaches for coastal resilience. Environmental Challenges, 19, 101130. https://doi.org/10.1016/j.envc.2025.101130

30. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Ports and warehousing industry review. https://cdn.1ocean.org/6613b6f5a338c00c9aadcd38_ODI_20_Ports_20and_20_Warehouses_20_Industry_20_Review_e73e1f0efa.pdf

CASE STUDY

***Tampa Bay in Florida**, US, is widely regarded as one of the successful examples of large-scale coastal ecosystem restoration in an urban setting. The bay suffered from severe environmental degradation due to rapid urbanisation, wastewater discharges, and nutrient pollution, which led to the collapse of seagrass habitats. In response, local authorities, scientists, and stakeholders formed a coordinated partnership to restore water quality and coastal ecosystems through a science-based, long-term management strategy.*

A key focus of this effort has been the restoration of seagrass meadows, which are critical for stabilising sediments, improving water clarity, and providing nursery habitats for fish, shellfish, and other marine species. As a result, seagrass coverage in Tampa Bay has more than doubled since its lowest point. Alongside this, oyster reef restoration projects have been implemented to further enhance water quality and shoreline protection.[31] *Oyster reefs act as natural biofilters, removing excess nutrients and suspended particles, while also forming physical barriers that reduce wave energy and limit coastal erosion.*

Importantly, these restoration efforts are closely tied to living shoreline initiatives, where natural habitats are used instead of hard infrastructure to protect the coast.[32] *In Tampa Bay, restored seagrass beds and oyster reefs work together with mangroves and salt marshes to create a multi-layered defence system. This approach not only enhances resilience to storms and sea-level rise but also supports biodiversity, including commercially important fish species and protected wildlife such as manatees and wading birds.*

31. Tampa Bay Watch. (2026). Oyster reef. https://www.tampabaywatch.org/our-programs/restoration/oyster-reefs

32. Tampa Bay Watch. (2026). Living Shorelines. https://www.tampabaywatch.org/our-programs/restoration/living-shorelines

GHG EMISSIONS

Coastal cities can contribute to global greenhouse gas (GHG) emissions due to their dense populations, concentrated industries, energy-intensive infrastructure, and busy transport networks. Overall, cities consume 75% of the world's energy and generate around 50-60% of global GHG emissions,[33] with coastal megacities such as Shanghai, New York City, and Mumbai standing out due to their size and economic activity. These emissions arise from energy consumption, building operations, transport, and waste processing. Rapid coastal urbanisation over recent decades has further amplified the emission levels.[34]

Cities consume 75% of the world's energy and generate around 50–60% of global GHG emissions

Ports and logistics hubs play an especially critical role in raising GHG emissions in coastal zones. They rely on a wide range of vessels, vehicles, equipment, and facilities (including warehousing processes) that emit pollutants mainly through the burning of fuels.[35] Global shipping, which typically uses heavy fuel oil, is a major source of CO_2, methane, and nitrous oxide. Additionally, many refineries, petrochemical plants, and manufacturing districts are located along coastlines to facilitate access to international trade routes, further increasing emissions in these regions.[36]

The release of GHGs accelerates global warming and directly harms marine ecosystems. As the ocean absorbs excess atmospheric heat and carbon dioxide, seawater warms and acidifies, leading to widespread coral bleaching and loss of biodiversity.

33. UN Habitat. (2026). Urban Energy. https://unhabitat.org/topic/urban-energy

34. Yu, Q., Li, S., & Chen, N. (2024). Urbanization and greenhouse gas emissions from municipal wastewater in coastal provinces of China: Spatiotemporal patterns, driving factors, and mitigation strategies. Environmental Research, 259, 119398. https://doi.org/10.1016/j.envres.2024.119398

35. United States Environmental Protection (EPA). (2025). Ports Primer: 7.1 Environmental Impacts. https://www.epa.gov/ports-initiative/ports-primer-71-environmental-impacts

36. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Ports and warehousing industry review. https://www.1ocean.org/news/ports-warehousing-industry-review-its-impact-on-the-ocean-and-possible-solutions

GOOD PRACTICES

Coastal cities can reduce GHG emissions by adopting an integrated set of good practices that target their most carbon-intensive sectors. Transitioning to renewable and distributed energy systems — such as rooftop solar, offshore wind, and district cooling — can dramatically cut reliance on fossil-fuel-based electricity, while energy-efficient building codes ensure that new developments use low-carbon materials, passive cooling, and smart energy management. Improving public transportation, electrifying bus and port fleets,[37] and expanding safe walking and cycling networks can reduce emissions from road traffic. In port areas, implementing shore-side electricity (cold ironing), electrifying cargo handling equipment, and optimising vessel traffic management can significantly reduce emissions from ships and terminal operations.[38]

Electrifying public transportation and port fleets can help reduce GHG emissions

Coastal cities can also protect and restore blue-carbon ecosystems — mangroves, seagrasses, and tidal marshes — which naturally sequester carbon while providing climate resilience. Finally, modernising waste systems through recycling, composting, waste-to-energy technologies, and methane capture at landfills can sharply reduce emissions from the waste sector.

37. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Ports and warehousing industry review. https://www.1ocean.org/news/ports-warehousing-industry-review-its-impact-on-the-ocean-and-possible-solutions

38. Ibidem

CASE STUDY

Cascais, *a coastal city in Portugal, is advancing its emissions-reduction goals through a strong commitment to renewable energy and innovative planning tools. As part of the EU Mission for Climate-Neutral and Smart Cities, Cascais is preparing a comprehensive roadmap to reach climate neutrality by 2050, with decentralised renewable energy at the core of its strategy.*

The city has mapped its potential for rooftop solar PV, coastal wind generation, and even wave-energy systems, making full use of its coastal geography to diversify its clean-energy supply. To support evidence-based decision-making, Cascais is also using an innovative Decision Support Tool (DST), developed to help municipalities design effective climate-neutrality pathways. The DST's modelling shows that under a High-Development scenario, total final energy demand could fall by 7.2% by 2050 compared to 2019, largely due to strong energy-efficiency measures aligned with the principle of "Energy Efficiency First". Combined with increased electrification, the introduction of hydrogen in the transport sector, and the widespread integration of renewable energy across buildings and public spaces, Cascais could cut its greenhouse gas emissions by as much as 82% by 2050 — demonstrating how coastal cities can lead the transition toward sustainable, climate-resilient urban futures.[39]

39. Aelenei, L., Viana, S., Simões, T., Amorim, F., Simões, S. G., Barbosa, J., Justino, P., Gonçalves, H., Dinis, J., & Fernandes, G. (2025). Towards climate adaptation: a case study of a Coastal City in Portugal. Building and Environment, 283, 113366. https://doi.org/10.1016/j.buildenv.2025.113366

INTRODUCTION OF CONTAMINANTS AND EUTROPHICATION

Coastal cities are major gateways through which contaminants enter marine ecosystems, largely because their extensive impermeable surfaces generate vast amounts of stormwater runoff that rapidly transports pollutants into drainage networks, rivers, and ultimately the sea.[40] As rainwater flows across asphalt, rooftops, and industrial zones, it mobilises a wide range of contaminants — including hydrocarbons, heavy metals, agrochemicals, plastics, hazardous household waste, detergents, and industrial effluents. Contamination stems from agriculture, industrial discharges, and especially urban wastewater, which often carries organic matter, nutrients, and untreated sewage as well as emerging pollutants such as pharmaceuticals and microplastics.[41] Many urban wastewater systems are ageing or insufficient, meaning that untreated or partially treated sewage frequently reaches coastal waters.

Coastal cities are major gateways through which contaminants enter marine ecosystems

Sewage is a major global problem, consisting of liquid waste or waste matter usually carried away by sewers. Urban areas are particularly vulnerable, as high population density results in high demand and equally high volumes of contaminated return flows.[42]

Surrounding agricultural hinterlands compound the problem: runoff rich in topsoil, fertilisers, herbicides, and insecticides is washed into rivers during rainfall events. Urban areas add to this load: stormwater runoff transports nutrients from lawns, detergents, organic waste, and eroded soils, while untreated or insufficiently treated sewage releases concentrated nutrients directly into

40. Zhou, Y., Wang, L., Zhou, Y., & Mao, X. (2019). Eutrophication control strategies for highly anthropogenic influenced coastal waters. The Science of the Total Environment, 705, 135760. https://doi.org/10.1016/j.scitotenv.2019.135760

41. One Ocean Foundation. (2025). Ocean Impact Initiative: Utilities industry review. https://www.1ocean.org/news/behind-the-scenes-of-daily-life-the-ocean-cost-of-water-waste-and-energy

42. Rebello, T. A., Chhipi-Shrestha, G., Hewage, K., & Sadiq, R. (2022). Environmental, economic, and social sustainability of urban water systems: a critical review using a life-cycle-based approach. Environmental Reviews, 31(1), 26–44. https://doi.org/10.1139/er-2021-0126 waterways.[43] These nutrient-laden flows, especially high concentrations of nitrogen and phosphorus, strongly associated with human activities, are the primary drivers of eutrophication, a process in which excess nutrients stimulate harmful algal blooms. Over time, this process depletes biodiversity, disrupts food webs, and degrades habitats such as seagrass beds and coral reefs, leaving coastal ecosystems less resilient to other climate-related-stressors.

In addition, in coastal areas, desalination plants — often developed to address freshwater scarcity driven by population growth, tourism, and limited natural water resources — may also introduce chemical residues, such as chlorine and antifouling agents, as well as concentrated brine, which may alter local salinity levels and stress marine life.[44] These facilities are particularly common in arid and semi-arid coastal regions, as well as on islands, where access to reliable freshwater supplies is constrained, and seawater represents an abundant alternative source. Poorly managed infrastructure, leakages, and inadequate monitoring systems can further amplify these risks.

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43. Laino, E., & Iglesias, G. (2025b). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

44. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). Additional sector guidance – Water utilities and services. https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

GOOD PRACTICES

Coastal cities can mitigate contamination through various strategies and innovative urban practices designed to stop pollutants before they reach the sea.

Cities are increasingly investing in green infrastructure such as bioswales, rain gardens, permeable pavements, and constructed wetlands to filter stormwater runoff and trap contaminants at the source. Strengthening and expanding wastewater treatment, including tertiary treatment and nutrient removal, is an effective measure, as it prevents untreated sewage, chemicals, and micro-pollutants from entering coastal waters.

Green infrastructure such as bioswales, rain gardens, permeable pavements, and constructed wetlands can help reduce pollution

Smart stormwater systems, equipped with sensors and real-time monitoring, help manage overflows during heavy rainfall and prevent sewage spills.[45] Many coastal cities are also restoring blue-carbon ecosystems — mangroves, marshes, and seagrass beds — which naturally filter contaminants, stabilise sediments, and improve water quality.

Crucially, integrating these technical solutions with public engagement, strict regulation of industrial effluents, and circular-economy waste policies ensures long-term reduction of contamination while strengthening urban resilience and protecting marine ecosystems.

45. Laino, E., & Iglesias, G. (2025c). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

CASE STUDY

*A notable example of advanced coastal-monitoring practice comes from **Gdansk**, where the Baltic Sea Monitoring Program provides continuous, high-value data on coastal water quality, particularly in response to flooding events and industrial runoff.* [46]

This system supports cross-city and cross-border cooperation, enabling Baltic-region municipalities to share insights, harmonise standards, and jointly address transboundary pollution challenges. The program demonstrates how coordinated monitoring can strengthen early detection of contamination, guide targeted interventions, and support long-term coastal management strategies.

Expanding access to real-time water-quality sensors, remote sensing technologies, and predictive modelling tools would significantly enhance the ability of coastal cities to anticipate contamination risks — especially during extreme weather events that mobilise urban and industrial pollutants.

46. Laino, E., & Iglesias, G. (2025c). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

CASE STUDY

***Oarsoaldea** has become an example of how coastal cities can use Sustainable Urban Drainage Systems (SUDS) to reduce flooding and prevent stormwater pollution.*

To manage increasing runoff, the city introduced permeable pavements, green roofs, and constructed wetlands in flood-prone areas.[47]

These systems allow rainwater to infiltrate the ground and be naturally filtered before reaching rivers or coastal waters.

As stormwater passes through soils and wetland vegetation, contaminants such as heavy metals, sediments, and excess nutrients are removed.

This approach has significantly lowered pollutant loads, improved water quality, and strengthened the protection of local ecosystems — demonstrating how green infrastructure can deliver both climate resilience and environmental benefits for coastal communities.

47. Laino, E., & Iglesias, G. (2025c). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

INTRODUCTION OF MARINE LITTER

Solid waste management is a growing challenge for coastal cities around the world, driven by rapid urbanisation, expanding populations, tourism pressure, and concentrated industrial activities. Cities generate vast quantities of household, commercial, and industrial waste, yet many lack adequate systems for collection, recycling, and safe disposal. As urbanisation and population growth will continue, it is expected that municipal solid waste generation will double by 2025.[48] As a result, large volumes of unmanaged or poorly managed waste are washed into rivers and streams, which carry debris directly to the ocean.

Poor collection systems, illegal dumping, and inadequate landfill infrastructure often result in plastics and other debris being carried by wind, rain, and rivers into coastal waters.[49] Moreover, even functioning wastewater-treatment plants cannot fully capture microplastics and synthetic particles, allowing them to reach coastal waters.[50]

Poor collection systems and inadequate landfill infrastructure can contribute to the accumulation of marine litter

Coastal cities also produce significant amounts of waste from construction and maintenance activities, including pipe repairs, dredging, and port operations.[51] If not properly managed, these processes can unintentionally release debris into the surrounding environment. This waste stream includes conventional construction materials such as bricks, concrete, plasterboard, asphalt, and rocks, as well as general refuse like plastics, paper, and insulation foam. In addition, it may contain organic and natural materials used in

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48. UN-HABITAT. (2018). Solid Waste Management in Cities

49. One Ocean Foundation. (2025). Ocean Impact Initiative: Utilities industry review. https://www.1ocean.org/news/behind-the-scenes-of-daily-life-the-ocean-cost-of-water-waste-and-energy

50. Ibidem

51. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). Additional sector guidance – Water utilities and services. https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

certain building practices, including wood, straw, bamboo, cellulose insulation, sand, clay, soil, and natural finishes such as paints, oils, and waxes.[52]

Tourism significantly exacerbates the problem of solid waste in coastal cities. As popular travel destinations, these areas experience sharp seasonal increases in population that can overwhelm local waste management systems.
Beaches, vital economic and cultural assets, often become littered with waste, diminishing their appeal and negatively affecting local businesses.[53] Much of this waste consists of packaging and single-use plastics, which are lightweight and easily carried by wind, tides, and storms into marine environments.

With millions of tourists visiting each year, the volume of waste generated can exceed the capacity of landfills and wastewater treatment facilities, leading to overflows and environmental leakage. Improper disposal practices by tourists, as well as by hotels, restaurants, and other coastal businesses, further intensify the issue, endangering ecosystems and ultimately reducing the attractiveness of these destinations.
Marine debris, predominantly plastic, accumulates along coastlines and in the ocean, where it gradually breaks down into microplastics. These pollutants harm marine life through ingestion and entanglement, damage habitats, degrade water quality, and threaten the ecological and economic sustainability of coastal regions.

52. One Ocean Foundation. (2023). Ocean Disclosure Initiative: Construction and building materials industry review.https://cdn.1ocean.org/657c37f52226aaf27b688f0c_ODI_Construction_Industry_20_Review_final_compressed_092e5574fc.pdf

53. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Coastal and marine tourism industry review. https://cdn.1ocean.org/66a2005ee6de9abbaa0a67b6_2024_07_19_20_V2_20_Coastal_20and_20_Marine_20_Tourism_compressed_8064ab3a7a.pdf

GOOD PRACTICES

Adopting sustainable waste management practices is essential to reduce marine litter in coastal areas. Implementation of efficient waste collection systems that ensure materials are properly captured and recovered before they can enter the environment.[54] This should be supported by the waste management hierarchy — prioritising minimisation, reuse, and recycling over final disposal.[55] Regular maintenance of equipment and infrastructure is also necessary to prevent leaks and inefficiencies. In addition, all types of industrial waste, whether solid or liquid, must be handled in accordance with national regulations and industry best practices.[56] This includes safe transportation, controlled storage in designated areas isolated from the environment, and the use of protective measures such as containment curbs and spill trays to prevent accidental releases.

Cities can implement efficient waste collection systems that ensure materials are properly captured and recovered

The municipalities can also implement local initiatives, including community stewardship programs, education campaigns, and incentive schemes that encourage proper waste disposal.[57]

Collaboration with the private sector is equally important: coastal businesses such as hotels, restaurants, and port operators can reduce their environmental footprint by minimising packaging, improving waste separation, and adopting sustainability certifications.[58] At the same time, investments in port waste reception facilities and innovative cleanup technologies — such as skimmers, floating barriers, and smart waste capture systems — can help intercept both floating and submerged debris, contributing to cleaner and more resilient coastal ecosystems.

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54. One Ocean Foundation. (2025). Ocean Impact Initiative: Utilities industry review. https://www.1ocean.org/news/behind-the-scenes-of-daily-life-the-ocean-cost-of-water-waste-and-energy

55. United States Environmental Protection Agency (EPA). (2016). Guide for Industrial Waste Management. https://www.epa.gov/sites/default/files/2016-03/documents/industrial-waste-guide.pdf

56. Ibidem

57. Willis, K., Hardesty, B. D., Vince, J., & Wilcox, C. (2022). Local waste management successfully reduces coastal plastic pollution. One Earth, 5(6), 666–676. https://doi.org/10.1016/j.oneear.2022.05.008

58. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Coastal and marine tourism industry review. https://cdn.1ocean.org/66a2005ee6de9abbaa0a67b6_2024_07_19_20_V2_20_Coastal_20and_20_Marine_20_Tourism_compressed_8064ab3a7a.pdf

CASE STUDY

***Singapore** has developed one of the world's most advanced coastal waste-management systems.*

The pressure to manage its solid waste and the lack of land led to Singapore's decision to develop the world's first offshore landfill.

Its strategy combines waste-to-energy (WTE) incineration, which reduces waste volume by up to 90%, with the Semakau offshore engineered landfill, designed with impermeable membranes and clay bunds to prevent marine contamination.[59] *Singapore further deploys smart waste-collection technologies, such as vacuum pneumatic systems and AI-enabled sorting bins, reducing the chance that solid waste spills into drains and coastal waters.*[60]

These innovations keep marine litter at minimal levels despite Singapore's dense population and high waste production.

59. Joane (J.), Duque. (2026). Beyond Waste: Transforming Semakau Landfill Ash into Sustainable Construction Resources A Strategic Valorization and Circular Economy. DO - 10.13140/RG.2.2.28005.05600

60. Seaside Sustainability. Beyond the Bin: Unveiling Singapore'sTrash Transformation. https://www.seasidesustainability.org/post/beyond-the-bin-unveiling-singapore-strash-transformation

INTRODUCTION OF ENERGY

Coastal cities introduce significant levels of noise and light pollution into marine environments, primarily through ports,[61] shipping lanes, maritime transportation and coastal infrastructures are highly frequented by people.

In coastal areas where marine mammals are present not far from the shore, exposure to underwater noise can lead to changes in both physical and acoustic behaviour, as well as hearing loss, stress, and the masking of communication and echolocation signals.[62]

In addition, bright lighting from hotels, resorts, restaurants, and other coastal establishments can disorient marine animals. For example, newly hatched baby sea turtles, who rely on natural light cues from the moon, can get confused by the proliferation of artificial lights along coastlines and head in the opposite direction from the water.[63]

Coastal cities can contribute to light pollution through bright light from hotels, ports, and other coastal establishments

GOOD PRACTICES

To reduce the ecological impacts of noise and light pollution, coastal cities can adopt a range of measures. Operational measures such as vessel speed reductions, re-routing away from sensitive areas, and minimising ship traffic during critical migratory or breeding periods can further reduce acoustic disturbance.[64] Ports can also implement noise-management plans, regular hull maintenance, and incentives for operators who adopt quiet-vessel practices.

In parallel, cities can greatly reduce ecological harm from artificial lighting by using dark-sky-compliant lighting, low-intensity and warm-spectrum bulbs, and installing dimmers, motion sensors, and timers to limit unnecessary nighttime illumination,[65] particularly in ports, promenades, and beachfront areas where wildlife is most vulnerable. Such measures help prevent disorientation and disruptions of coastal and marine fauna. success and the individual survival, in addition to other "silent" disturbances in the biochemical processes.

Using dark-sky-compliant lighting and installing motion sensors and timers can help to limit nighttime illumination

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61. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Ports and warehousing industry review https://www.1ocean.org/news/ports-warehousing-industry-review-its-impact-on-the-ocean-and-possible-solutions

62. Erbe, C., Marley, S. A., Schoeman, R. P., Smith, J. N., Trigg, L. E., & Embling, C. B. (2019). The effects of ship noise on marine mammals—a review. Frontiers in Marine Science, 606

63. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Coastal and marine tourism industry review. https://cdn.1ocean.org/66a2005ee6de9abbaa0a67b6_2024_07_19_20_V2_20_Coastal_20and_20_Marine_20_Tourism_compressed_8064ab3a7a.pdf

64. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Maritime transportation industry review.https://cdn.1ocean.org/65cf7e25547ebdf0b5d292f0_ODI_Industry_20_Review_20_Maritime_20_Transportation_1a0149828c.pdf

65. One Ocean Foundation. (2024). Ocean Disclosure Initiative: Coastal and marine tourism industry review. https://cdn.1ocean.org/66a2005ee6de9abbaa0a67b6_2024_07_19_20_V2_20_Coastal_20and_20_Marine_20_Tourism_compressed_8064ab3a7a.pdf

CASE STUDY

The Port of Vancouver, *one of North America's largest coastal ports, has become a leading example of how coastal cities can mitigate noise and light pollution through targeted operational and technological measures. As coastal shipping traffic intensified in the Salish Sea — an important habitat for endangered killer whales,*[66] *the port collaborated with scientists, maritime operators, and regulators to reduce underwater noise from commercial vessels.*

To address noise impacts on cetaceans, the Port of Vancouver implemented one of the world's first voluntary vessel slow-down programs as part of its Enhancing Cetacean Habitat and Observation (ECHO) initiative.[67] *These slow-downs meaningfully decrease underwater radiated noise, reducing the masking of whale communication frequencies and lowering the physiological stress marine mammals experience in busy shipping lanes, consistent with international scientific findings on vessel-noise impacts on cetaceans.*[68]

The port authority introduced a differentiated harbour-dues structure that reduces ship-harbour fees by 47% and 23%, depending on a vessel's performance in noise and environmental criteria[69]*. In 2023, Vancouver expanded this policy by adding a 75% fee-reduction option for vessels meeting advanced environmental measures, such as using cleaner marine fuels, connecting to shore power while at berth, or obtaining internationally recognised underwater-noise notations.*[70] *These initiatives are further supported by Canada's national commitment to prevent increases in anthropogenic ocean-noise levels over time, reinforcing long-term protection efforts.*[71]

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66. Port of Vancouver. (2024). Reducing underwater noise from shipping at the Port of Vancouver. https://wwwcdn.imo.org/localresources/en/About/Events/Documents/Presentations%20-%20IMO-WMU%20Workshop%20on%20Underwater%20Radiated%20Noise%202024/Session%203/Port%20of%20Vancouver%20presentation%20for%20GloNoise%20October%2016,%202024.pdf

67. Parker Maritime Technologies. (2024). The Port of Vancouver: Ship Slow Down Ocean Noise Reduction Program. https://parkermaritimetechnologies.com/the-port-of-vancouver-ship-slow-down-ocean-noise-reduction-program/

68. Rojano-Doñate, L., Lamoni, L., Tougaard, J., & Findlay, C. R. (2023). Effect of Vessel Noise on Marine Mammals and Measures to Reduce Impact. In Springer Nature Link. https://doi.org/10.1007/978-3-031-10417-6_138-1

69. Parker Maritime Technologies. (2024). The Port of Vancouver: Ship Slow Down Ocean Noise Reduction Program. https://parkermaritimetechnologies.com/the-port-of-vancouver-ship-slow-down-ocean-noise-reduction-program/

70. Port of Vancouver. (2024). Reducing underwater noise from shipping at the Port of Vancouver. https://wwwcdn.imo.org/localresources/en/About/Events/Documents/Presentations%20-%20IMO-WMU%20Workshop%20on%20Underwater%20Radiated%20Noise%202024/Session%203/Port%20of%20Vancouver%20presentation%20for%20GloNoise%20October%2016,%202024.pdf

71. Parker Maritime Technologies. (2024). The Port of Vancouver: Ship Slow Down Ocean Noise Reduction Program. https://parkermaritimetechnologies.com/the-port-of-vancouver-ship-slow-down-ocean-noise-reduction-program/

Suzhou, China

In-depth: nature-based solutions for sustainable coastal urban development

Nature-based solutions (NbS) are increasingly recognised as an effective and sustainable approach for addressing the complex challenges faced by coastal cities. Rather than relying solely on hard infrastructure such as seawalls and breakwaters, NbS harness the protective and regenerative capacities of natural ecosystems to reduce risks associated with climate change, including sea-level rise, coastal erosion, and flooding.[72]

At their core, NbS are inspired by natural processes and aim to work with nature instead of against it. For example, planting native vegetation on sand dunes can stabilise sediments and prevent erosion more effectively over time than artificial barriers. Similarly, conserving or restoring ecosystems such as mangroves, salt marshes, coral reefs, and seagrass meadows can significantly reduce the impacts of storm surges and wave action. Dense mangrove forests and marsh vegetation can reduce wave heights by up to 90% over relatively short distances, while coral reefs can dissipate up to 97% of wave energy. Coastal dunes also play a crucial role, reducing wave energy by up to 40% and acting as natural buffers against extreme sea levels.[73]

Beyond coastal protection, NbS provide a wide range of co-benefits that contribute to the overall sustainability and liveability of urban environments. These include improving water quality by filtering pollutants, enhancing biodiversity by creating habitats for marine and terrestrial species, and offering recreational spaces that promote physical activity and mental well-being. Integrating NbS

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72. URBANET. (2022). Nature Will Guide You: Co-Creating Nature-Based Solutions in European Coastal Cities. https://www.urbanet.info/nature-based-solutions-in-european-coastal-cities/

73. The Intergovernmental Panel on Climate Change (IPCC). (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

74. UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/wcr/

75. Laino, E., & Iglesias, G. (2025d). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

76. Ibidem

into urban design — through features such as green roofs, living walls, and interconnected blue-green infrastructure — can further enhance resilience while improving the quality of life for residents.[74]

Real-world examples demonstrate the effectiveness of NbS in coastal contexts. In Piran, a Slovenian town, the restoration of coastal wetlands has created natural buffers that absorb excess water during storms and filter contaminants such as nutrients and heavy metals, thereby improving the quality of the Adriatic Sea.[75] Similarly, in the Italian city of Massa Carrara, the restoration of coastal dunes and the implementation of living shorelines have helped stabilise the coastline, reduce erosion, and limit the transport of pollutants into the Tyrrhenian Sea. These interventions not only protect urban areas but also support ecosystem restoration and biodiversity.[76]

However, despite their many advantages, NbS are not without challenges. Their successful implementation requires site-specific knowledge, science-based design, and continuous monitoring to ensure long-term effectiveness.[77] Additionally, issues such as land-use conflicts, competing economic interests, and the need for ongoing maintenance can limit scalability and replicability. Political barriers and limited stakeholder engagement may also hinder adoption, particularly when the economic benefits of NbS are not immediately visible.

In conclusion, nature-based solutions represent a promising and holistic approach to coastal urban resilience. By leveraging the inherent strengths of natural systems, cities can address environmental risks in a cost-effective and sustainable manner while simultaneously enhancing ecosystem health and human well-being. To fully realise their potential, however, NbS must be supported by strong governance, interdisciplinary collaboration, and long-term planning strategies.

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74. UN habitat. (2024). World cities report 2024: Cities and Climate Action. https://unhabitat.org/wcr/

75. Laino, E., & Iglesias, G. (2025d). Extreme weather events and environmental contamination under climate change: A comparative review of ten European coastal cities. Current Opinion in Environmental Science & Health, 45, 100606. https://doi.org/10.1016/j.coesh.2025.100606

76. Ibidem

77. The Intergovernmental Panel on Climate Change (IPCC). (2022). IPCC Sixth Assessment Report: Cities and Settlements by the Sea. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf

ONE OCEAN
Foundation

secretariat@1ocean.org
1ocean.org