

Resilient Port Infrastructure and the Belt and Road Initiative: Climate Adaptation in a Multipolar World

Rafael Ferraz dos Santos¹

 <https://orcid.org/0009-0003-5182-9513>

Víctor Hugo Souza de Abreu¹

 <https://orcid.org/0000-0002-5984-6313>

Andrea Souza Santos¹

 <https://orcid.org/0000-0002-2557-2721>

¹Universidade Federal do Rio de Janeiro (UFRJ). Rio de Janeiro/RJ, Brazil.

Abstract: The intensification of climate change-related risks to port infrastructure presents an unprecedented challenge for global logistics systems, particularly in trade corridors linked to the Belt and Road Initiative (BRI). Given the BRI's extensive reach and influence, this article examines how key ports along the maritime route, including Djibouti, Gwadar, Hambantota, Piraeus, Mombasa, and, more recently, Chancay in Peru, have responded to climate vulnerabilities and adopted adaptive strategies. The central hypothesis is that these ports, due to their strategic relevance in global supply chains, can serve as platforms for building climate alliances that foster alignment between port development and sustainability objectives. Based on a document and exploratory review, our analysis identifies a growing body of scholarly work connecting the BRI to the Sustainable Development Goals (SDGs), highlighting the socio-environmental and socio-economic implications of such interventions. The recent inauguration of the Port of Chancay in 2024 marks a turning point in South America's integration into China's maritime network, signaling a historical shift toward a more multipolar and cooperative global order. In the Brazilian context, bilateral partnerships with China, particularly through the Growth Acceleration Program (PAC), reflect the country's integration into this broader process of logistical reconfiguration and port adaptation in response to climate challenges.

Keywords: Belt and road initiative; ports; climate change; port adaptation; sustainable development goals.

Correspondence:

Rafael Ferraz dos Santos
rafael.ferraz@pep.ufrj.br

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Introduction

The Belt and Road Initiative (BRI) is a far-reaching infrastructure program led by China, aimed at enhancing trade and economic development, particularly across Asia, Africa, and Europe (SARGANA, ASLAM and KHAN, 2023). At the core of this strategy, seaports play a crucial role as interfaces between global trade flows and regional production chains (LI, CHEN, and GRYDEHØJ, 2020).

These port infrastructure projects exhibit convergent structural characteristics, such as the predominance of Chinese investments through long-term concessions, lease agreements, and majority shareholdings. Ports such as Gwadar, Hambantota, Piraeus, Mombasa, Doraleh, and, more recently, Chancay serve as BRI logistics hubs, facilitating the expansion of international trade under Chinese leadership and wielding influence across various strategic regions (GANGTE, 2020; PAPADOPOULOS, 2023; SARGANA, ASLAM and KHAN, 2023). The recent integration of the Port of Chancay in Peru illustrates the BRI's expansion toward Asia-Pacific shipping routes by incorporating South America into globally connected networks.

Recent signs of alignment between Brazil and the BRI have become particularly relevant within the framework of this expansion. In 2025, the two countries signed key bilateral agreements connecting Brazil's Growth Acceleration Program (PAC) to the New Silk Road, with the aim of fostering international logistical integration (INFOMONEY, 2024).

Despite variations in regional contexts and the strategic significance of these ventures, all of these ports share a common feature: growing exposure to climate-related risks (ASARIOTIS, 2021). Sea level rise, intensifying storms, and increasingly frequent heatwaves have placed these infrastructure projects under constant threat. In this context, climate adaptation for BRI-affiliated ports must not be treated as a local concern, but rather as a strategic dimension of global port governance. This article seeks to understand how these ports' climate adaptation efforts can be a platform for building international alliances and strengthening global governance in response to the climate crisis. To this end, it analyzes the climate risks affecting BRI-related ports, examines adaptation measures that have been adopted, assesses the role of multilateral institutions in providing technical and financial support, and investigates the synergies among these actions. Finally, the article reflects on how this agenda may intersect with the Brazilian context, with an emphasis on strengthening partnerships geared toward sustainable development.

Methodology

Our methodological approach is based on a systematic literature review combined with bibliometric analysis, aiming to identify and map the main scientific publications

on port infrastructure associated with the Belt and Road Initiative, BRI. Additionally, a targeted literature review was conducted to explore connections with topics such as climate crisis, adaptation, and sustainability. To ensure rigor, objectivity, and replicability, specific search terms, inclusion and exclusion criteria, and procedures for data retrieval, selection, screening, extraction, and analysis were defined using the Web of Science database.

The search strategy focused on the term “belt and road initiative” in combination with variations related to maritime and port infrastructure, as presented in Table 01. The search string was applied to the topic field, which includes title, abstract, author keywords, and Keywords Plus.

Table 01. Search parameters

Aspect	Description
Search Terms	TS = (("belt and road initiative") AND ("seaport*" OR "port*" OR "port infrastructur*" OR "maritime infrastructur*" OR "harbor infrastructur*"))
Database	Web of Science
Inclusion Criteria	Articles published in indexed journals or presented at internationally recognized conferences; studies with clear and replicable methodologies; clear formulation of the research question and methodological coherence; applicability of findings for the development of adaptation policies and strategies; relevance and timeliness of the study within the context of the Belt and Road Initiative and the port sector
Exclusion Criteria	Records outside the thematic scope of the study; records without a direct relationship with port or maritime infrastructure; records with limited or no connection to the Belt and Road Initiative; duplicate records; records whose content did not contribute to the research objectives

Source: Elaborated by the authors (2025).

The search conducted in the Web of Science database yielded 247 records. These records were screened based on title, abstract, keywords, and, when necessary, full-text reading. After this screening process, 230 records were retained for the bibliometric analysis. The remaining 17 records were excluded because they did not meet the thematic and methodological criteria established for the review.

The 17 excluded records were organized as follows:

1. “The Analysis of Cultural Convergence and Maritime Trade Between China and Saudi Arabia: Toda-Yamamoto Granger Causality”
DOI: 10.3390/su17146501
Reason for exclusion: The study focuses primarily on cultural convergence and bilateral maritime trade, without placing port infrastructure, port governance, adaptation, or sustainability strategies at the center of the analysis.
2. “Regional development implications of the Belt and Road Initiative - a case study of Darwin”

- DOI: 10.1080/21681376.2025.2578943
Reason for exclusion: The article adopts a regional development perspective, and its relationship with port infrastructure is indirect.
3. "Catching China-Europe trains: local agency and Global China in the Polish borderland"
DOI: 10.1080/15387216.2025.2530491
Reason for exclusion: The study focuses on railway transport and local agency, without addressing port infrastructure or maritime infrastructure.
 4. "Marine Atmospheric Corrosion Behavior of Carbon Steel Based on Corrosion Big Data"
DOI: 10.11933/j.issn.1007-9289.20230710002
Reason for exclusion: The article has a technical focus on material corrosion and does not address the Belt and Road Initiative or port infrastructure as an analytical object.
 5. "Short-run and long-run volatility spillovers from China to countries of the Belt and Road Initiative"
DOI: 10.1016/j.ribaf.2025.103106
Reason for exclusion: The article focuses on financial volatility spillovers, without a direct relationship with port infrastructure or maritime transport.
 6. "Dynamic spillover effects and portfolio strategies between WTI crude oil, Natural Gas and Chinese stock markets related to Belt and Road initiative"
DOI: 10.1016/j.eneco.2025.108845
Reason for exclusion: The study focuses on energy markets, financial spillovers, and portfolio strategies, rather than port or maritime infrastructure.
 7. "China's Belt and Road Initiative and Infrastructure Development in Nigeria: Unveiling a Paradigm Shift or Repackaging of Failed Ventures?"
DOI: 10.1177/18681026251330645
Reason for exclusion: The article discusses infrastructure development in a broad sense, without specific focus on port infrastructure.
 8. "Optimal parameters in concession contracts between container terminal operators and investors"
DOI: 10.1080/13675567.2020.1754772
Reason for exclusion: The study addresses concession contracts between container terminal operators and investors, but does not directly address the Belt and Road Initiative or BRI-related port infrastructure.
 9. "A multi-objective optimization approach for the selection of overseas oil projects"
DOI: 10.1016/j.cie.2020.106977
Reason for exclusion: The article focuses on the selection of overseas oil projects, without addressing port infrastructure or maritime logistics.
 10. "Redefining diplomatic discourse on the Belt and Road Initiative: A corpus-based sentiment analysis"
DOI: 10.1177/20578911251366121
Reason for exclusion: The study focuses on diplomatic discourse and

sentiment analysis, without a direct relationship with port infrastructure or maritime transport.

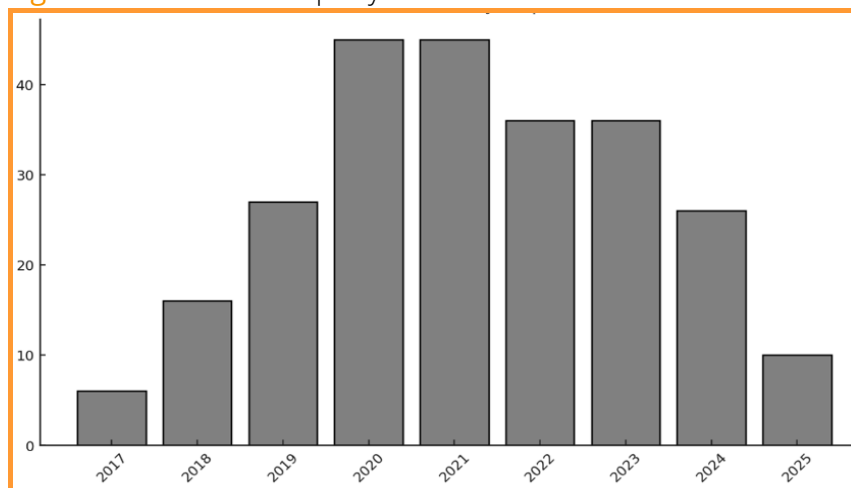
11. "The road to currency internationalization: Global perspectives and Chinese experience"
DOI: 10.1016/j.ememar.2018.11.003
Reason for exclusion: The article examines currency internationalization and financial dynamics, without addressing port or maritime infrastructure.
12. "Mapping China's Belt and Road Initiative in Europe: Developments and Challenges"
DOI: 10.3390/economies13100301
Reason for exclusion: The article provides a broad overview of the BRI in Europe, without specific focus on port infrastructure as the central object of analysis.
13. "A diachronic study on the image construction of the Belt and Road Initiative in mainstream Austrian newspapers"
DOI: 10.1057/s41599-025-05720-z
Reason for exclusion: The article focuses on media discourse and the construction of the BRI's public image, without addressing port infrastructure or maritime logistics.
14. "The impact of the 21st-Century Maritime Silk Road on sulfur dioxide emissions in Chinese ports: based on the difference-in-difference model"
DOI: 10.3389/fmars.2025.1608803
Reason for exclusion: Although the article addresses Chinese ports and the 21st-Century Maritime Silk Road, its main focus is sulfur dioxide emissions and econometric policy evaluation, rather than port infrastructure development, governance, or adaptation strategies.
15. "Only business, no politics: a triangulated discursive analysis of business newsletters of China's Belt and Road on domestic social media"
DOI: 10.1057/s41599-025-05029-x
Reason for exclusion: The article focuses on discourse analysis of business newsletters and domestic social media, without addressing port infrastructure or maritime transport.
16. "Back to the Cold War era in-betweenness: Italy's China strategy in the context of the Indo-Pacific framework"
DOI: 10.1007/s10308-025-00749-w
Reason for exclusion: The article examines Italy's geopolitical positioning toward China within the Indo-Pacific framework, without centrality in port infrastructure or maritime logistics.
17. "Connectivity and Mobility: The Transformative Impact of BRI on Migration Dynamics in the MENA"
DOI: 10.1111/polp.70048
Reason for exclusion: The study focuses on migration dynamics and human mobility, without addressing port infrastructure, maritime corridors, or port-related adaptation and sustainability strategies.

This approach provides a comprehensive and structured overview of the available evidence on the topic, while improving methodological transparency and supporting the replicability of the bibliometric stage.

Systematic review

The bibliometric findings of this research enable an in-depth analysis of emerging trends and patterns in the scientific literature concerning the BRI and port infrastructure. The analyzed dataset comprises a diverse sample, including peer-reviewed articles, conference papers, and other indexed academic outputs retrieved from the Web of Science database and considered relevant after the screening process. Figure 01 presents the number of identified publications per year over the analyzed period.

Figure 01. Publications per year



Source: Elaborated by the authors (2025).

As shown in Figure A1, the number of publications on the relationship between the Belt and Road Initiative and port infrastructure increased notably from 2017 onward, reaching a first peak in 2021, with 38 records. After a decline in 2022, the series reached a new peak in 2023, also with 38 records, followed by a decrease in 2024 and 2025. Therefore, rather than indicating a strictly continuous upward trend, the data suggest an expansion of academic interest after 2017, followed by annual fluctuations in publication volume.

This pattern reflects the growing academic and institutional interest in the connections between the BRI and port infrastructure within the current global context. However, the annual distribution indicates that this interest did not evolve linearly, but through successive moments of expansion, decline, and renewed growth. Such oscillation may be associated with changes in the international debate on

infrastructure connectivity, maritime logistics, geopolitical disputes, sustainability challenges, and the increasing relevance of climate adaptation in port systems.

Climate risks and adaptation strategies in ports associated with the Belt and Road initiative

The expansion of the BRI, led by China, has significantly enhanced global maritime connectivity by integrating strategic ports across multiple world regions (ASARIOTIS, 2021). However, the increasing exposure of these ports to climate risks, including sea level rise, extreme weather events, coastal erosion, and heatwaves, requires the identification of context-specific vulnerabilities and the mapping of adaptive responses across different national settings (CADARIO, 2024). Table 02 synthesizes selected BRI-affiliated ports, highlighting their significance within the initiative, major climate-related threats, and initiatives aimed at mitigating such impacts (CADARIO, 2024; EIB, 2025).

The comparative analysis presented in Table 02 provides a preliminary overview of the institutional responses adopted by ports integrated into the BRI framework (ASARIOTIS, 2021). Building on this synthesis, the following section explores each case in greater detail, examining local specificities, key challenges, and the adaptation strategies either implemented or under development.

Table 02. BRI ports, climate risks, and associated initiatives

Port (Country)	Role within BRI	Main Climate Risks	Adaptation Status and Initiatives
Gwadar (Pakistan)	Strategic terminal of the CPEC Corridor; access to the Arabian Sea	Sea level rise; coastal and pluvial flooding; extreme heat	Highly vulnerable due to low elevation on a peninsula. Seawalls have been constructed along coastal roads (BUTT, 2025). National adaptation planning remains limited due to economic crises. Local communities engage in climate information hubs (ANEES, 2024).
Hambantota (Sri Lanka)	Deep-sea port in the Indian Ocean, part of the Maritime Silk Road	Sea level rise and erosion; storm surges; droughts affecting water supply for operations	Projections indicate sea level rise of +0.7 m in 200 years (UNEP, 2024). The port is included in the National Adaptation Plan (ASARIOTIS, 2021). Long-term needs include elevated infrastructure and coastal protection. No robust public adaptation projects currently in place, though recent focus is on financial sustainability (CADARIO, 2024).
Piraeus (Greece)	Largest Greek port, operated by Chinese firm COSCO;	High tides and storm surges; extreme summer heat;	Involved in EU programs for sustainable ports. The European Investment Bank supports climate risk assessments for Greek ports, including Piraeus, to define

Port (Country)	Role within BRI	Main Climate Risks	Adaptation Status and Initiatives
	key Europe– Asia hub	heavy rainfall events	adaptive measures. The port follows EU Green Deal guidelines aiming at improving resilience and decarbonization efforts by 2030 (EIB, 2025).
Mombasa (Kenya)	Main port in East Africa, connecting the BRI route to the region	Rising sea levels; coastal flooding from intense rains; heatwaves	Vulnerabilities exposed by recurrent urban floods (ASARIOTIS, 2021). Studies estimate 190,000 people and US\$470 million in assets at risk under extreme event scenarios (AWUOR, ORINDI and ADVERA, 2008). Recommendations include improved drainage and green infrastructure (CADARIO, 2024). Green Port programs emphasize energy efficiency (TRADEMARK AFRICA, 2023), but climate adaptation remains essential. Public-private partnerships are being explored to finance resilient upgrades (CADARIO, 2024).
Djibouti (Djibouti)	Red Sea hub serving Ethiopian trade; Chinese logistics base	Severe heatwaves; water scarcity; sea level rise and coastal erosion	Low-lying port city. The World Bank's IDA is supporting transport resilience investments. Plans focus on elevated port infrastructure, coastal barriers, and early warning systems for extreme events (WORLD BANK, 2024).

Source: Elaborated by the authors based on the cited references.

Gwadar (Pakistan)

Gwadar is often described as the ‘crown jewel’ of the China-Pakistan Economic Corridor (CPEC), serving as a strategic outlet for China to access the Arabian Sea. In recent years, however, the city has become a case study in climate vulnerability (Table 03). Located on coastal dunes and home to around 90,000 residents, Gwadar has experienced alternating periods of severe drought and sudden floods, highlighting how the region has been prone to increasing climate variability (BUTT, 2025). In February 2023, the city was hit by unprecedented torrential rains caused by an post-monsoon anomaly, resulting in large-scale flash floods. Recently built infrastructure, such as the Gwadar–Pishukan Road, was destroyed, bridges collapsed, and the peninsula was temporarily cut off (ANEES, 2024).

These events have exposed the fragility of the city's urban and logistics infrastructure. Gwadar has been facing not only recurring floods, but also recurrent issues of saline intrusion and rising groundwater levels. The sea, once central to local livelihoods, has become a threat due to wave encroachment, beach erosion, and saltwater contamination of freshwater wells (BUTT, 2025). Combined with land subsidence, sea level rise is expanding high-tide flood zones, endangering areas once considered safe.

Experts warn that, without effective intervention, the city's lowest-lying zones could be permanently submerged in the coming decades (BUTT, 2025).

Coastal protection efforts have been undertaken to respond to these events, including the construction of the East Bay Expressway, a key arterial road for cargo transportation connecting Gwadar Port to its Free Trade Zone. Designed with six traffic lanes and a 30-meter rail corridor, the expressway incorporates riprap techniques using rock to reduce coastal erosion and provide structural defense against tides and storms. The expressway was built under an Engineering, Procurement and Construction (EPC) contract — where one entity manages all aspects of the project — and funded through an interest-free government loan. The project created approximately 2,000 jobs, 1,700 of which were allocated to local workers (CHINA-PAKISTAN ECONOMIC CORRIDOR, 2025).

While progress has been made, critical gaps remain. Specialized literature identifies priority actions such as updating urban infrastructure (drainage, sanitation, coastal defenses), revising land use policies, securing international financing, enhancing technology transfer, and strengthening community engagement (AZIZ, 2024).

Table 03. Strategic, climate, and adaptation aspects of Gwadar

Aspect	Details	Reference
Strategic Importance	'Crown jewel' of CPEC; outlet to Arabian Sea	BUTT, 2025
Climate Vulnerabilities	Severe droughts, flash floods, saline intrusion, rising groundwater	ANEES, 2024; BUTT, 2025
Recent Extreme Events	Torrential rains in February 2023; road destruction and temporary isolation of peninsula	ANEES, 2024; BUTT, 2025
Coastal Protection Works	East Bay Expressway (06 lanes, rail corridor, riprap techniques)	CHINA-PAKISTAN ECONOMIC CORRIDOR, 2025
Job Creation	2,000 jobs, 1,700 for local workers	CHINA-PAKISTAN ECONOMIC CORRIDOR, 2025
Adaptation Priorities	Infrastructure upgrades, urban planning, international funding, community engagement	AZIZ, 2024

Source: Elaborated by the authors based on the cited references.

Hambantota (Sri Lanka)

The Port of Hambantota has seen significant growth and operational expansion in recent years. In 2024, cargo volumes increased by approximately 22 percent, reflecting a steady recovery in the construction sector and the port's diversification into bulk and LPG cargo segments (LANKA BUSINESS ONLINE, 2025). Strategically

located in the Indian Ocean, near key east–west shipping routes, Hambantota has become a focal point of geopolitical competition between China and India. Heavily financed by China, the port has emerged as a flagship BRI project. In 2017, unable to service its debt, the Sri Lankan government granted China Merchants Port Holdings a 99-year lease, reigniting global debate over the so-called ‘debt-trap diplomacy’. At the 3rd Belt and Road Forum in Beijing (2023), President Ranil Wickremesinghe reaffirmed the country’s commitment to the partnership with China, endorsing Hambantota as a core asset in bilateral cooperation (GANGTE, 2020).

The port’s surrounding coastal region is ecologically sensitive, prompting environmental monitoring and conservation efforts. During port construction (2008–2010), major ecological disturbances were recorded, including the dredging of around 40,000 m³ of sand, which damaged local fauna and degraded habitats. Nearby lies Bundala National Park, Sri Lanka’s first Ramsar wetland, home to diverse bird species and elephants, underscoring the need for strict environmental controls. In response, local stakeholders have implemented several measures to mitigate environmental damage and improve ecological resilience (WIGNARAJA et al., 2020).

A highlight among these initiatives is Sri Lanka’s national program for mangrove restoration and protection. Following the 2004 tsunami, the country adopted stricter environmental policies and, in 2015, became the first in the world to grant full legal protection to mangroves. The government set a target to increase mangrove coverage by 50 percent by 2030, a program that was recognized in 2024 by the UN as a World Restoration Flagship, placing it among the world’s most important ecological restoration efforts. Mangroves near Hambantota are now the first line of defense against climate extremes, reducing erosion and supporting carbon sequestration (UNEP, 2024).

Sri Lanka’s National Adaptation Plan (NAP) 2016–2025 identifies ten priority sectors, including coastal and marine zones and urban infrastructure. In 2020, the country received support from the Green Climate Fund (GCF) to develop provincial adaptation plans across all nine provinces, including in the south where Hambantota is located (STIMSON, 2022). These efforts aim to integrate national adaptation strategies with local realities, fostering synergy among resilient infrastructure, ecosystem protection, and institutional capacity building.

Piraeus (Greece)

Located in the Athens metropolitan area, the Port of Piraeus is Greece’s primary logistics hub and a key gateway for Mediterranean trade between Asia and Europe. China’s state-owned COSCO Shipping has operated the port predominantly since 2016, integrating it into the BRI framework and positioning it as a unique case for analyzing the interplay between global economic interests and stringent European regulations (TSIMONIS, 2023).

Piraeus faces several climate-related risks, including sea level rise and coastal flooding, intensified by storms and surges; Mediterranean cyclones (Medicane¹), which, though rare in the Aegean, can disrupt regional operations; intense rainfall, which overloads drainage systems and floods access roads; and heatwaves, which raise energy consumption and impair equipment functionality (GEORGOULIAS al., 2022; MIGLIETTA et al., 2023).

To address these threats, the port has pursued a range of physical and operational adaptation measures. These include quay and breakwater upgrades, improved drainage systems, and the acquisition of climate-resilient equipment, in line with EU environmental assessments (PLATIAS and SPYROU, 2023). International projects such as ARSINOE support long-term adaptation planning and nature-based solutions, integrating climate alert systems and risk management strategies. ARSINOE (Climate-resilient Regions Through Systemic Solutions and Innovations), funded under the Horizon 2020 program, promotes systemic innovation and multisectoral governance for climate resilience in European regions and cities (ARSINOE – THE PROJECT, 2023, 2022) (Table 04).

On the operational front, Piraeus has improved emergency protocols, enhanced meteorological monitoring, and adopted mitigation measures that also support adaptation, such as equipment electrification and the use of renewable energy (PLATIAS and SPYROU, 2023).

Table 04. Projects and institutions supporting climate adaptation at the port of Piraeus

Project/Institution	Focus	Contribution to Adaptation
ARSINOE (EU/Horizon 2020)	Climate adaptation and innovation	Development of plans and systemic solutions
EIB (European Investment Bank)	Financing and advisory services	Support conditional on sustainability standards
COSCO Shipping	Port management and investment	Alignment with EU environmental regulations
PPA (Piraeus Port Authority)	Port operation and governance	Quality and sustainability policies

Source: Elaborated by the authors.

As a result, Piraeus has emerged as a key node of international cooperation for climate adaptation, promoting the dissemination of sustainable practices and innovative solutions across other COSCO-managed ports. Participation in initiatives like ARSINOE and access to international financing reinforce its role as a regional laboratory for climate innovation. Piraeus illustrates how the integration of port infrastructure, multinational governance, and climate resilience can serve as a replicable model for other regions.

¹Mediterranean Hurricane.

Mombasa (Kenya)

Located on Kenya's coastline, the Port of Mombasa is the main maritime gateway for East Africa, serving as a critical logistics hub for the region. Its strategic location on the Indian Ocean enables access to multiple landlocked countries, collectively supporting the supply of goods for over 200 million people. Traditionally focused on imports, which account for about 90 percent of total cargo handled, Mombasa has sought to diversify its operations to boost regional exports.

The port's logistics network is supported by integrated road and rail infrastructure, particularly the Standard Gauge Railway (SGR), operational since 2017, linking the port to Nairobi and later to Naivasha. This upgrade has reduced travel time, decongested highways, and improved inland container movement. The implementation of the African Continental Free Trade Area (AfCFTA) is expected to further increase cargo flows, reinforcing the need for greater logistical efficiency.

However, Mombasa's coastal location and dependence on fragile ecosystems heighten its vulnerability to climate change. The port faces several risks and potential impacts, summarized in the Table 05.

Table 05. Major climate risks and potential impacts on the port of Mombasa

Risk/Impact	Details	Source
Sea level rise	A 0.3-m rise could submerge 17% of the city and port areas	OBURA, 2020
Population in low-elevation zones	32% of Mombasa's population lives in vulnerable areas	STIMSON, 2021
Estimated annual economic losses	US\$31 million to US\$313 million by 2050 due to flooding and damage	AWUOR et al., 2008
Mangrove loss (2007–2017)	80% lost in Tudor Creek estuary region	REPUBLIC OF KENYA, 2017
Mangroves restored (by 2020)	559 hectares reforested	AWUOR et al., 2008
Coral reef degradation	Bleaching and acidification reducing natural coastal protection	OBURA, 2020

Source: Elaborated by the authors based on the cited references

Sea level rise is the most prominent threat, with potential to inundate port and urban areas, causing considerable economic losses. Coastal erosion and degradation of natural protective ecosystems — particularly mangroves and coral reefs — have accelerated over the past decade. Projected increases in extreme heat and average temperatures may impose additional challenges, affecting working conditions, accelerating structural corrosion, and increasing pest and disease risks (STIMSON, 2022).

Adaptation strategies have been developed at national and local levels. Kenya's National Adaptation Plan (NAP 2015–2030) and National Climate Change Action Plan (NCCAP) emphasize protection of coastal infrastructure and climate-proofing of critical facilities. The 'Green Port of Mombasa' initiative promotes emission reductions and resilience building. Complementing national efforts, Mombasa County's climate action plan prioritizes early warning systems, improved urban drainage, resilient construction standards, and community mobilization

Djibouti (Djibouti)

Strategically located near the Bab-el-Mandeb Strait, through which roughly 15 percent of global maritime traffic passes, Djibouti has consolidated its role as the Horn of Africa's main logistics hub. The port handles about 95 percent of Ethiopia's imports and, also connects the Indian Ocean to the Mediterranean via the Suez Canal (CALABRESE, 2020; DU COUËDIC, 2025). The Addis Ababa–Djibouti electrified railway, inaugurated in 2018, reducing the journey from three days to approximately 12 hours, has enhanced logistics access. The corridor, financed primarily by Chinese banks, cost US\$4 billion and is complemented by upgraded highways. The Djibouti Free Trade Zone, opened in 2018, further reinforces its position as a high-performance regional corridor (DU COUËDIC, 2025).

Despite its strategic relevance, Djibouti is highly vulnerable to climate change (Table 06). Sea level rise is expected to cause chronic inundation and accelerated coastal erosion, threatening port infrastructure situated at low elevations. The city's vulnerability was exposed in 2018 when Cyclone Sagar — the strongest cyclone ever recorded in the country — triggered torrential rainfall and flash floods that affected over 20,000 people and damaged roads and key facilities (OCHA, 2018).

Table 06. Main climate risks for the port of Djibouti

Climate Risk	Vulnerabilities and Potential Impacts
Sea level rise and erosion	Chronic flooding of port infrastructure and urban lowlands; coastline retreat, requiring defenses
Storm surges	Physical damage to quays and breakwaters; increased frequency of flooding disrupting port operations
Extreme heat	Health hazards for workers; potential equipment failures; need for operational pauses
Intense rainfall and floods	Inundation of yards, warehouses, and access roads; landslides affecting roads and railways
Droughts and water scarcity	Water supply constraints for urban and industrial uses; energy shortages impacting operations

Source: Elaborated by the authors based on the cited references.

Extreme heat is projected to increase significantly, as dozens of annual 'tropical nights' with temperatures above 26°C are expected by mid-century, posing risks to public health, worker safety, and port productivity. At the same time, prolonged droughts

and water stress may disrupt water supply and energy generation. More concentrated and intense rainfall is also projected, leading to flash floods affecting roads and port areas and disrupting traffic and access routes (WORLD BANK, 2024).

Djibouti is thus exposed to both marine-coastal and atmospheric-terrestrial risks.

Chinese influence in Djibouti's port infrastructure has intensified over the past decade under the BRI, linking Africa to the Middle East and Asia. Notable investments include the Doraleh Multipurpose Port (2017) and the Djibouti International Free Trade Zone (2018), both developed with China Merchants Port Holdings. These projects have enabled the integration of value chains into port infrastructure and enhanced regional logistics performance.

At the same time, climate financing efforts have accelerated. According to the World Bank's Country Climate and Development Report (CCDR), Djibouti will require over US\$2.8 billion in adaptation investments by 2050, with US\$1.1 billion needed by 2030 for priority measures (WORLD BANK, 2024).

Chancay (Peru)

Located on Peru's central coast, about 80 km north of Lima, the Port of Chancay is the most recent and ambitious port project in Latin America, gaining strategic relevance for both the country and the South American Pacific coastline. Inaugurated in the second half of 2024, the port's rapid execution was driven by an investment of approximately US\$3.6 billion, with a majority stake held by the Chinese state-owned enterprise COSCO Shipping Ports (NOGARIN, 2024).

The project aims to strengthen trade between South America and Asia by establishing a hub capable of directly receiving large vessels from East Asia. It eliminates the need for transshipment at intermediate ports and reduces travel time from around 35 to 23 days, potentially lowering logistics costs by up to 30 percent. Chancay is expected to handle between 30 and 40 percent of Peru's exports to Asia while also receiving vessels from Chile, Colombia, Ecuador, Argentina, Brazil, and Paraguay (NOGARIN, 2024).

Despite its technological infrastructure, Chancay faces major environmental challenges, including projections of sea level rise of up to one meter by 2100, torrential rains, intensified swells linked to El Niño, and coastal changes due to breakwaters and land reclamation (APOSTOLOPOULOU and PIZARRO, 2025) (Table 07). COSCO Shipping Ports, which leads both financing and management, has sparked debate over national sovereignty, social benefits, and environmental trade-offs (APOSTOLOPOULOU and PIZARRO, 2025; FERNÁNDEZ, 2024).

While the port is promoted as a ‘green and smart terminal’, featuring electric trucks, renewable energy use, and mitigation plans, independent assessments suggest that environmental compensations remain insufficient (CERVILLA, 2024). Scientific literature on Chancay's socio-environmental and economic impacts remains scarce, with most information coming from institutional reports and specialized media, highlighting the need for continuous critical monitoring.

Table 07. Main environmental and climate risks for the port of Chancay

Risk or Impact	Description and Implications
Sea level rise and coastal flooding	Temporary submersion of low-lying areas; need to elevate structures and reinforce defenses
Extreme weather events (El Niño)	Heavy rains and swells may overload drainage systems and disrupt operations
Post-construction coastal changes	Breakwaters may alter currents, causing erosion or sedimentation on nearby beaches
Impact on sensitive ecosystems	Degradation of the Santa Rosa wetland complex and decline of local marine fauna

Source: Elaborated by the authors.

Peru has advanced national initiatives such as the National Climate Change Adaptation Plan and the National Strategy for Sustainable Ports. However, the long-term effectiveness of these policies will depend on continuity and rigorous enforcement (SPDA, 2023).

Gaps and opportunities

In recent decades, the intensification of climate risks in global port systems has driven an international agenda focused on adaptive governance, bringing together multiple stakeholders, regulatory frameworks, and regional initiatives. Within this context, BRI-linked logistics corridors have become testing grounds for new practices, while also exposing persistent structural challenges. The following sections present the main gaps identified in the recent literature and the implications for Brazil, particularly in light of expanding multilateral partnerships and a new investment cycle announced through recent bilateral agreements.

Gaps

Despite regulatory advances and a growing number of regional initiatives, recent studies highlight notable shortcomings in port climate adaptation strategies, especially regarding projects under the BRI framework. One of the key weaknesses lies in the insufficient integration between conventional logistics planning and climate planning, with adaptation measures often disconnected from day-to-day operational decision-making. Furthermore, a lack of local empirical and academic data makes it harder to

conduct comparative assessments, and identify priority areas for resilient infrastructure investments (TÜRKİSTANLI et al., 2025).

Implications for Brazil

In May 2025, during an official visit to China, the Brazilian government signed a memorandum of understanding with the National Development and Reform Commission (NDRC) of China, aiming to foster synergies between Brazil's new Growth Acceleration Program (PAC) and the BRI (BRASIL, 2025). The agreed-upon measures include the establishment of bilateral forums to facilitate the participation of Chinese companies in PAC-related infrastructure concession projects, including multimodal transport projects, as well as the creation of mechanisms for strategic financial cooperation, allowing the use of local currencies to facilitate investments (ITAMARATY, 2025).

While these initiatives suggest a closer alignment between the two countries' development agendas, it is still too early to confirm any effective progress or consolidated integration. Brazil had maintained a relatively distant stance toward the BRI until 2024, and such a recent diplomatic shift does not automatically translate into immediate structural change. On the other hand, considering China's trajectory — which includes strong presence in Asia, Africa, and even highly regulated European contexts — its expansion into South America appears to be a natural progression. Therefore, it is essential to closely monitor the evolution of this cooperation and draw on international experiences to guide strategies that enhance benefits and mitigate risks in the Brazilian context

Final considerations

The analysis of port infrastructure projects integrated into the BRI reveals that climate adaptation is fundamental to these facilities' operational resilience and directly affects the security of global supply chains and international cooperation. Our document and bibliometric mapping indicates increasing concern about the climate risks facing ports such as Gwadar, Hambantota, Piraeus, Mombasa, Djibouti, and Chancay. However, gaps remain in the coordination between logistics and climate planning, community engagement, and the institutionalization of adaptation indicators. While international guidelines and the involvement of multilateral banks have shown progress, there are persistent challenges regarding long-term climate financing, the integration of the SDGs, and the implementation of nature-based solutions.

In Brazil's case, the recent rapprochement with the BRI and the inclusion of partnerships under the PAC framework offer new opportunities for knowledge transfer and funding. Nevertheless, these developments still lack detailed study. There is an urgent need to develop standardized indicators for adaptive monitoring and risk

assessment tools tailored to port territories, as well as to explore in greater depth the interface between climate adaptation and socio-environmental justice.

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