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Planetary boundaries or socio-ecological limits from below? Insights from port cities

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ABSTRACT

This article examines the planetary boundaries framework for environmental governance in port cities, highlighting tensions between planetary metrics and situated socio-ecological limits. Based on ethnographic research in Colombo, Valencia, Genoa and Rotterdam, it shows that environmental issues are experienced as socio-ecological problems affecting livelihoods, public health and territorial identities. While planetary boundaries are useful for diagnosing ecological risk, they hold limited capacity for environmental governance in port cities. Meanwhile, grassroots articulations of socio-ecological limits integrate justice concerns and reveal transformative potential. Ultimately, the operationalisation of planetary boundaries depends on socio-political negotiation, only effective for governance when grounded in local struggles.

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1. Introduction

The concept of planetary boundaries, introduced by the Stockholm Resilience Centre, delineates a 'safe operating space' for humanity by identifying nine critical Earth system processes whose stability underpins planetary resilience. By foregrounding the systemic consequences of anthropogenic pressure, the framework exposes the dominance of economic development as a primary driver of environmental destabilisation. Its analytical strength lies in rendering visible the biophysical thresholds that delimit collective human action and in informing global sustainability agendas and multilateral environmental governance. Yet precisely because it operates through global modelling and aggregated metrics, its translation into situated governance practices reveals a persistent and troublesome politics of scale. The universalisation of planetary limits sits uneasily with the differentiated, institutionally fragmented and socio-ecologically specific arenas in which environmental decisions are made. Quantifications of tipping points and boundary transgressions are calculated at the planetary level, whereas infrastructures and socio-political negotiations unfold within territorially bounded jurisdictions. As a result, the framework powerfully diagnoses systemic failure but remains indeterminate regarding how transformative pathways should be articulated and operationalised within concrete local contexts.

This scalar tension becomes particularly salient when examining critical infrastructures of global circulation. Ports, as logistical infrastructures of global trade, play a catalytic role in processes associated with planetary boundary transgression. They concentrate and amplify material flows that entail toxic and bioaccumulative pollution, soil consumption, hydrological stress and coastal biodiversity degradation (EMSA, 2020). Their contemporary trajectory is marked by persistent expansion, shaped by a dominant development paradigm grounded in limitless spatial growth, naval gigantism and intensifying inter-port competition (Savoldi & Soriani, 2026). Beyond their localised environmental impacts, ports operate as socio-technical systems integral to global capitalism, reorganising supply chains and driving territorial restructuring at a variety of scales (Armondi, 2025), while redefining extractive landscapes across distant regions. In this sense, they are active agents in the production of transcalar environmental change.

At the same time, ports remain materially and politically embedded within urban territories. Despite becoming increasingly deterritorialised (Savoldi, 2024), ports continue to reconfigure urban geographies and reshape socio-ecological relations, generating localised conflicts. Port expansion projects, in particular,

crystallise tensions in port cities between global economic interests and place-based socio-ecological limits. Ports are thus simultaneously implicated in global/planetary-scale transformations and entangled in the everyday politics of urban governance. This dual condition renders ports and port cities analytically productive sites for interrogating how environmental limits are interpreted, contested and negotiated across scales.

The local-global nexus (Cox, 1997; Crang, 2013) is especially visible in port cities, which historically co-evolved as gateways linking urban development to transnational circulations of goods, capital and energy. The 'local' in such contexts cannot be conceived as a static arena; neither, as the terrain whose evolution is deterministically driven by the global trends affecting transportation and logistics' activities. Rather, the 'local' is constituted through dynamic transcalar relations involving local and international stakeholders and national regulation. In this perspective, urban socio-environmental processes in port cities stem from the dialectical interplay between situated cultural values, ecological specificities and ongoing negotiations over power and space, and global economic dynamics.

Focusing on port cities, this article illustrates how translating the standardised metrics of the planetary boundaries framework into governance practices within this context is inherently complicated, as planetary biophysical thresholds must be interpreted through contested, and mutable place-based, socio-ecological realities. Moreover, by emphasising the potential role of infrastructure as catalysts for transformative socio-environmental change, it explores how different discourses on environmental limits are mobilised in port cities, highlighting that while biophysical limits impose real constraints on Earth system processes, the ways in which socio-ecological limits are defined and enforced are socially and politically mediated. The objective is thus to provide a starting point for reconceptualising environmental governance in relation to infrastructure of circulation, which are deeply embedded within both transcalar logics and materially grounded realities. In doing so, the paper treats planetary boundaries as a global diagnostic framework whose political meaning and applicability are contingent on how it is interpreted and contested within specific territories.

The next section develops a discussion on the politics of limits, showing that while limits to Earth system stability are materially grounded, the ways socio-ecological limits are defined, interpreted and governed are shaped by power relations and socio-political processes. It bridges a critical reading of the planetary boundaries framework with emerging theories of socio-ecological limits. We then trace how these debates unfold in port cities, outlining the contemporary dynamics of port development and the socio-environmental challenges it produces – also in relation to its scalar complexity – and examining how civil society actors mobilise different understandings of limits in selected case studies. The analysis draws on ethnographic research conducted between 2019 and 2025, including interviews, focus groups and site visits. The conclusion synthesises these findings to reflect on what planetary boundaries mean for port cities. Rather than proposing a model solution, the article foregrounds the unresolved tension between planetary-scale diagnostics and the situated, justice-oriented struggles through which limits are locally articulated.

2. The politics of limits: from planetary boundaries to limits as socio-political constructs

The planetary boundaries framework was introduced in 2009 by a group of Earth system and environmental scientists led by Johan Rockström. The approach provides a 'snapshot' of progression toward bio-physical limits, with nine processes critical to the stability and resilience of Earth's system as a whole: climate change, biosphere integrity, stratospheric ozone depletion, ocean acidification, biogeochemical flows, land-system change, freshwater use, atmospheric aerosol loading and the introduction of novel entities. The motivation behind the planetary boundaries framework is to identify the biophysical limits within which humanity can safely operate, in recognition that human activities drive climate change, biodiversity loss and pollution. The framework assesses anthropogenic change in significant magnitude, with six of the planetary boundaries now transgressed (Richardson et al., 2023). The framework has informed discussions within the United Nations Environment Programme and have been reflected in successive editions of the Global Environment Outlook, a series of reports that review the state and direction of the global environment. By defining a 'safe and just operating space' it has clarified the sustainability concept at a time when the Anthropocene – a geological era marked by human dominance over the Earth's systems – entered public and academic debates.

However, approaches to the Anthropocene and planetary boundaries have been critiqued for their insufficient engagement with questions of power, inequality, justice and agency, thereby overlooking the socio-political dimensions of environmental change. One of the main critiques of the Anthropocene is its generalisation of a universalised ‘humanity’ as responsible for the ecological crisis. Jason W. Moore (2016) claims that this generalisation obscures the specific social and economic dynamics driving environmental degradation, preferring the term ‘Capitalocene’ to emphasise the role of capitalism in shaping the Earth’s systems. Stefania Barca (2020) highlights the hegemonic nature of the Anthropocene. She argues that the term has produced a dominant metanarrative of ecological crisis and techno-economic solutions. This narrative reflects a new phase in the ideology of modern economic growth – one that promotes a promethean vision of endless expansion. At its core is the historical reliance on fossil fuels, which has enabled this growth while driving environmental degradation.

Critiques of the Anthropocene relay its flattening of the differences in responsibility and burdens under capitalism, but also to its centring of the particular logics, actors and circumstances that generate crisis (Brand et al., 2021). Highlighting the unevenness of the outcomes of resource-based economic growth, Farhana Sultana (2023) argues that the Global North, with its history of industrialisation, high consumption and emissions, has contributed significantly to the transgression of several planetary boundaries, whose consequences are disproportionately burdening the Global South, which has contributed less or nothing to environmental change (Sultana, 2022, 2023).

There is a growing acknowledgment that the current economic system is driving the overshooting of planetary boundaries (Kronenberg et al., 2024), and that to keep our planet within such boundaries, systemic change is needed, instead of simply treating the symptoms (Steffen et al., 2015). According to Barca (2020), the planetary boundaries framework does not call for systemic change – it overlooks the need to transform social structures and the global political economy, promoting a sustainable development model focused on improving and expanding Western scientific and technological methods. This approach makes deeper social-environmental paradigm shifts seem unnecessary (Barca, 2020).

The questions of who speaks, who decides and who bears the costs and benefits – central to critical social science, political ecology and environmental governance – are therefore fundamental to understanding the politics of limits embedded in this kind of boundary-making. Joan Martinez Alier argues that environmental burdens and benefits are unevenly distributed across different social groups, often along lines of class, ethnicity and geography (Martinez Alier, 2002). As Melissa Leach contends, the discourse around planetary boundaries can support top-down governance approaches that prioritise environmental limits over social needs, potentially leading to authoritarianism and the marginalisation of vulnerable groups (Leach et al., 2012). These extend to the marginalisation of local and indigenous knowledge systems in favour of global perspectives that cannot account for regional and cultural differences. Sheila Jasanoff (2021) suggests that these approaches risk the disconnection of environmental management from the lived realities of people in many parts of the world. This is particularly relevant when considering that the risk tolerance of a community depends on the conditions within which it can adapt to rapid change, codetermining the living conditions of its members. What is acceptable for one social group might rely upon unacceptable forms of oppression and exposure to environmental hazards for others (Brand et al., 2021).

The planetary boundaries framework’s non-transformational approach to systemic change can also be traced to its origins in resilience research (Barca, 2020). Sherilyn MacGregor (2017) observes that the emphasis on climate resilience over human vulnerability displaces expectations for citizen resistance to the structural causes of ecological crisis, thereby framing the crisis as both inevitable and apolitical. Alternative visions and practices are then ignored.

The above critiques emphasise that while there are real biophysical limits that alter the Earth system, they are also power-dependent, socio-political constructs. The conventional notion of limits is based on the idea that they are fixed thresholds to be controlled, rather than opportunities for transformative changes. That conventional notion is also based on the idea that objective expertise specialised in particular sciences determine the facts that decide what is best for all of us. However, environmental understanding is necessarily a social process, with the resolution of environmental problems entailing the participation of everyone (Norgaard, 1995). More recent scholarship speaks of limits and boundaries as still influenced by cultural, political and economic factors, rather than objective scientific facts (Kallis, 2021). Relying solely on scientific

calculation to set limits and guide actions excludes diverse perspectives on sustainability, including different ways of understanding, knowing and valuing the world (Nogué Alguero et al., 2023).

Emerging critical theories of limits are highlighting how contested political processes shape and put them in practice (Luks, 2010; Mehta, 2010). These theories question the concepts of scarcity as the conceptual basis on which the notion of limit is produced; they focus on limits as a relational concept, perceived and experienced differently by different actors. In this line, Giorgos Kallis (2019) has shown how diverse communities throughout history have voluntarily embraced cultures of sufficiency, collective self-limitation and sharing, thus deconstructing the notion of limit as a fixed threshold. Complementarily, Paulson (2023) illustrated how different constructions of limits are underpinned by distinct ideological narratives, reflecting opposing values with respect to the principles that should guide economic action – growthism, scarcity, individualism versus degrowth, wellbeing and conviviality.

Castoriadis (1997) elaborates notions of socio-ecological limits as not merely an external, material constraint, but as a socially and politically mediated condition that acquires meaning through collective reflection and institutionalisation. In this perspective, socio-ecological limits are defined when societies confront environmental issues not as a given biophysical fact, but as a challenge that must be negotiated through deliberation, self-limitation and the establishment of norms and practices that sustain liveable and just conditions. These limits recognise both ecological finitude and expressions of social autonomy, emerging from ongoing struggles over values, access and responsibility. By framing socio-ecological limits in this way, they are considered not only as material conditions but also products of the collective imagination and political agency, shaped by how societies choose to define, respect and operationalise their interaction with nature. In this sense, we can frame this conception as ‘limits from below’.

In summary, a politics of limits illustrates that the construction of limits for environmental governance is a power-laden process that involves negotiations on definitions, including who has the authority to set limits, whose knowledge counts and who bears the social and economic costs of staying within them. Differently from the planetary boundaries framework, critical perspectives on socio-ecological limits from below adopt a distinct approach to the material conditions that sustain life, emphasising the complexity, plurality and situatedness of local realities. From this viewpoint, socio-ecological limits are not fixed constraints given once and for all. Rather, they emerge through collective deliberation, political struggle and negotiations among agencies, power relations, material and institutional resources, as well as competing discourses and narratives. In port cities, these processes unfold within transcalar dynamics in which global economic circuits and regulatory frameworks interact with locally embedded actors and conflicts. Environmental governance, therefore, cannot be reduced to the technical translation of planetary boundaries into measurable local targets, but must be understood as a contested and relational process, keeping in consideration a key idea: that environmental understanding is socially produced.

3. Ports, logistics and the global-local nexus of environmental governance

Since the 1980s and 1990s, port infrastructure has become increasingly embedded in global logistical networks, evolving into corporatised, multi-scalar infrastructures (Notteboom & Rodrigue, 2005). The expansion of containerisation has accelerated economic globalisation and facilitated the concentration of maritime power within a small number of shipping alliances, whose dominance over supply chains has reshaped port development trajectories (Slack, 1993). Driven by economies of scale and industrial consolidation, these alliances promoted naval gigantism and reduced transport costs, but also generated structural overcapacity and intensified infrastructural pressures (Bologna, 2017).

Technological and geopolitical transformations have further driven vessel enlargement – from approximately 5000 TEU (twenty-foot equivalent unit) in the mid-1990s to around 25,000 TEU by the mid-2020s – requiring continuous port infrastructure upgrading. These dynamics have transformed the relationship between ports and cities. Rather than simply expanding existing facilities, port growth has contributed to processes of deterritorialisation, in which logistical functions are increasingly integrated into global circulation networks while becoming partially disconnected from local territorial life (Savoldi, 2024). However, despite deterritorialisation, port expansion redistributes environmental pressures across broader coastal and metropolitan spaces.

Environmental conflicts associated with port development illustrate this rescaling. Land consumption, water and energy use, coastal habitat destruction, dredging and land reclamation extend ecological impacts beyond the immediate port boundary (Armas-Díaz & Sabaté-Bel, 2022; Carse & Lewis, 2017; Orihuela, 2024). Displacement processes and socio-environmental tensions have also accompanied waterfront transformation and peripheralisation strategies, including the redevelopment of former docklands into commercial, residential, or touristic spaces. While often framed as environmental or urban improvement, such transformations frequently relocate and expand environmental burdens rather than resolving them.

Port-city spatial separation, as described in evolutionary models of port development (Hoyle, 1989), reflects the combined effects of technological change and logistical optimisation (Hayuth, 1988). Yet the resulting geography does not simply denote a splitting of ‘global’ and ‘local’ spheres. Instead, global logistical imperatives are continuously transmuted into local political, and development arrangements. Port authorities, public-private partnerships, development agencies and sometimes municipalities actively mobilise narratives of economic growth, competitiveness, modernisation and economic regeneration to position territories within transnational infrastructure circuits, including large-scale connectivity initiatives. These dynamics do not simply ‘impact’ the local from above. Rather, they shape a complex local-global nexus where global circulation regimes and local governance projects are produced in tandem. The global and the local are therefore not distinct analytical domains but mutually constitutive dimensions of port-city environmental change. Infrastructure of circulation functions as a transcalar mechanism through which capital reorganises territory, often operating as a spatial fix for surplus accumulation (Apostolopoulou, 2021; Harvey, 2016; Sum, 2019). Such infrastructure-led development models contribute to uneven geographical outcomes, concentrating economic benefits while externalising environmental and social costs to marginalised communities (Kanai & Schindler, 2019; Vegliò et al., 2025; Wiig & Silver, 2019).

Logistical infrastructures thus function as active agents in the production of urban space and socio-ecological relations. Circulation is not only enabled by infrastructure but also constitutes it, shaping urban timescapes and territorial configurations (Altenried, 2019; Lyster, 2016). The rise of logistics-oriented urbanisation – termed supply-chain urbanism – reflects capital’s structural demand for frictionless movement, embedding inequality, dispossession and environmental externalities within the organisation of cities (Chua et al., 2018; Danyluk, 2022). Consequently, port infrastructures materialise power asymmetries by concentrating value while externalising ecological and social costs to peripheral or vulnerable territories (Savoldi, 2024).

Within this logistical regime, environmental problems themselves are reshaped. Relentless port expansion intensifies pressure on the environment, changing their scale and form. Coastal ecosystems, urban communities and global supply-chain operations become intertwined within what may be understood as a logistics-driven socio-ecological system. Sustained by dense transcalar relationships between shipping alliances, port authorities, investors and urban governments, this system accelerates the metabolic throughput of energy and materials, enabling production and consumption cycles organised around speed, efficiency and temporal compression (Birtchnell et al., 2015; Nogueró-Algueró, 2020). As material flows intensify, so too do resource extraction, energy use and ecological disruptions, linking port expansion to the broader transgression of planetary boundaries. At the same time, the territorial concentration of these impacts creates the conditions for the affected communities to articulate new socio-ecological limits from below. Port cities therefore reveal how the global and the local are co-constituted within environmental governance: logistical strategies of global circulation are enacted through local institutional arrangements, while their expansion reshapes the spatial reach and political articulation of environmental conflicts.

4. Exploring limits across ports: insights from case studies

4.1. Method

The socio-environmental impacts associated with port expansion have generated a growing body of scholarship, addressing issues ranging from dredging and habitat disturbance (Carse & Lewis, 2017), environmental toxification and environmental injustice (De Lara, 2018), and air pollution-related health risks (Matsuoka et al., 2011), to broader patterns of environmental conflict (Bartłomiejski, 2016). Despite this growing literature, less attention has been paid to how notions of ecological limits are socially framed

and politically mobilised within port-related environment governance. This section examines how grassroots initiatives opposing port expansion and the intensification of port activities articulate environmental limits through situated practices and discourses.

Grassroots notions of limits built around ports vary across cities and regions, as well as among the different local communities affected by port expansion. Complex socio-economic and cultural relationships exist within diverse environments, and so too do different narratives of living within them. The grassroots construction of limits relates to material realities and embodied experiences, and can go beyond the biophysical, including a sense of place and belonging, or means of social and cultural reproduction. The selected cases of Colombo, Genoa and Valencia presented below, were selected to illustrate how civic movements engaged in contesting port infrastructure construct and mobilise 'limits from below', revealing the plurality of narratives and meanings attributed to limits. These limits range from ecological balance and public health to democratic self-determination and the right to the city. Their relevance lies in the foregrounding of local agency and resistance not as isolated reactions, but as part of a broader, systemic redefinition of port-city relations, capable of shaping infrastructures and imaginaries alike.

The analysis is based on ethnographic research conducted between 2019 and 2025, employing an iterative and reflexive approach attentive to the lived experiences, local knowledge and collective actions of communities residing near port infrastructures. This work was part a broader, multi-stage research project aimed at understanding the contemporary reconfiguration of port-city relations, with a particular focus on the socio-spatial and environmental frictions and governance challenges generated by port expansion. The analysis draws on ethnographic fieldnotes, recorded semi-structured interviews, focus groups and participatory observations undertaken on site, complemented by follow-up conversations with members of communities contesting ports.

Fieldwork in Colombo and Negombo, Sri Lanka, was initiated in 2019 and revisited in 2022. The first phase consisted of two semi-structured interviews in Negombo, one with the director of Sri Vimukthi, a women's fishing organisation, and one with the director of NAFSO (National Fishing Solidarity Organisation). Both organisations were at the forefront in contesting the Port City Colombo project. The interviews explored the impacts of that project on coastal, mainly fishing communities, the reasons and dynamics of the social mobilisation and the imagined alternatives. Subsequent field activities in 2022 included a collective site visit to coastal areas in Colombo and Negombo, further interviews with the same interlocutors, and a focus group with nine fisherwomen affiliated with Sri Vimukthi. These encounters were complemented by periodical follow-ups remotely conducted annually between 2022 and 2025, allowing for a longitudinal perspective on evolving narratives in relation to communities' relationship with the port and its spatial and ecological implications.

In Genoa, Italy, fieldwork was conducted between 2022 and 2024 across two areas particularly affected by port-related impacts: Pra' and Sampierdarena. Four semi-structured interviews were held with residents living adjacent to port infrastructures, complemented by ethnographic site visits to each area. These encounters explored the frictions between residents and port activities and the grassroots activities undertaken by citizens to readdress the port-city relationship. Complementarily, one semi-structured interview was conducted with the president of Eco-Istituto Reggio Emilia e Genova (ECOINSTITUTO RE-Ge), a non-profit association engaged in citizen-led environmental monitoring of air pollution generated by the port in the areas of the city that surround the infrastructure. This interview traced how grassroots environmental actors mobilise citizen science as a strategic tool for questioning port-city relationship and addressing the issue of port-related emissions.

In Valencia, Spain, fifteen semi-structured interviews were carried out in 2023 with residents engaged in mobilisations against port expansion. A focus group was held with members of the civic initiative Comissió Ciutat-Port, which has been central to organising public opposition to the port's expansion. Additional interviews were conducted with representatives of Per L'Horta – an association advocating for the protection of Valencia's peri-urban agricultural landscape threatened by port growth – Acció Ecologista-Agró, and El Litoral per al Poble, a grassroots platform defending public coastal spaces, which include also some dockworkers. These encounters offered insight into the articulation of environmental, territorial and civic claims around port-related urban transformations.

While the analysis of these cases (Colombo, Genoa, Valencia) seeks to reveal how notions of environmental limits emerge from materially situated realities, unpacking the tensions and potential

complementarities between grassroots, locally embedded practices and planetary-level environmental articulations – the case of Rotterdam is included as an analytically distinct case. It allows us to observe how the planetary boundaries framework is mobilised as strategic and normative language in relation to port governance debates. This case is treated as an attempt to make planetary diagnostics actionable in a specific institutional setting, revealing both the political potential and the unresolved limitations of such translation. Rather than resolving the tension between global and local scales, the case of Rotterdam offers a glimpse into the institutional and political mediation required for planetary metrics to acquire meaning within the contested socio-ecological realities of port cities.

With this aim, a semi-structured interview was carried out in 2025 with the co-executive directors of One Planet Port, a Rotterdam-based non-governmental organisation (NGO) that explicitly grounds its mission in the planetary boundaries framework as a mean to redefine the ecological responsibilities of port development. The organisation is included in the study for its distinctive articulation of global environmental discourse within the port governance field. The conversation traced how this framework informs their advocacy work and the modes through which it is operationalised in policy engagement. This interview also enabled an exploration of how planetary-scale framings are strategically adapted when confronted with local governance constraints, institutional fragmentation and distributive tensions surrounding port transitions.

4.2. Colombo: challenging the nature–society divide

Following the 2013 restructuring of the port's management regime – through which China Merchants Port Holdings Company Limited acquired an 85% stake in the Colombo International Container Terminal – the port entered a new phase of expansion accompanied by a large land-reclamation project intended to create a Special Economic Zone. Promoted as a strategic node along the Belt and Road Initiative, Port City Colombo was framed by its developers as a symbol of modernisation and global connectivity. Yet, as one interviewee from the National Fisheries Solidarity Movement (NAFSO) observed, the project also represented 'a continuation of the governments that introduced neoliberal policies in the attempt to liberalise land, water, labour and everything possible'. Its blueprint envisioned a high-end financial district, luxury residential enclaves and a marina – an urban 'New Dubai' in which offshore finance and low-tax enclaves converge with an exclusionary and ecologically precarious model of city-making (Apostolopoulou, 2021).

Institutionally, the project connected global capital with national strategic interests while limiting the participation of the Colombo Municipal Council in decision-making processes. The reclaimed area was placed under a special regulatory regime controlled by the Government of Sri Lanka, with environmental standards negotiated with international contractors such as China Harbour Engineering Company. Although the 269 hectares of reclaimed land fall outside municipal authority, the environmental consequences of the project unfolded across the wider coastal metropolitan territory. Dredging, sand extraction and land reclamation altered sediment flows and seabed morphology along a broad coastal corridor, generating erosion and siltation far beyond the project site. Materials for reclamation were extracted from offshore areas between Negombo and Panadura, triggering widespread ecological degradation of the marine and coastal environment, while disrupting the livelihoods of numerous fishing communities.

For coastal communities, these environmental transformations could not be separated from their social consequences. Fisherfolk along the western coast from Negombo to Kalutara reported declining catches, species loss, coral reef degradation and increased turbidity. Fisherwomen interviewed during fieldwork emphasised not only ecological changes but also their social reverberations: growing economic precarity due to reduced catches, rising indebtedness linked to informal lending systems, and psychological stress associated with the risk of displacement and livelihood loss. In this sense, the environmental transformations produced by the project were experienced simultaneously as ecological disruption and social destabilisation.

These intertwined processes galvanised fisher communities to form the People's Movement Against Port City, a broad coalition of fishers, environmentalists, religious leaders, trade unionists and civic organisations mobilising between 2014 and 2018 to contest the project. Within this coalition, the Sri Vimukthi Fisher Women Organisation and NAFSO played leading roles in articulating demands that explicitly linked livelihood security to the preservation of coastal ecological integrity. Their campaigns reframed environmental

degradation as a threat to the socio-ecological conditions that sustain coastal life. Central to this articulation was the demand that development should operate within socio-ecological limits capable of maintaining viable marine ecosystems and the communities that depend on them. As activists explained, these limits expressed a dynamic notion of balance in which economic activities must be organised in ways compatible with thriving coastal environments. In doing so, they challenged the implicit nature–society divide embedded in mainstream infrastructure planning, which treats environmental impacts as externalities to be managed after development decisions are made.

Rather than fixed ecological thresholds, socio-ecological limits in this context emerge through the interaction between changing ecological processes, social relations and uneven power structures. Activists from the Sri Vimukthi emphasised the importance of enforcing the regulatory mechanisms established under the Coastal Regulation Zone laws, designed to protect both coastal ecosystems and community rights. At the same time, they called for inclusive consultation processes that would allow coastal residents to exercise their agency and mobilise their ecological knowledge in defining and maintaining these limits. NAFSO further politicised this perspective by questioning the ‘national interest’ narrative used to justify the project. By disregarding the deep interdependencies between coastal ecosystems and fishing livelihoods, the organisation’s director warned that the Port City Colombo project risked ‘producing new forms of urban poverty as fisherfolk are forced to abandon declining fisheries and migrate to the city in search of alternative employment. This isn’t national interest’. In this sense, the articulation of socio-ecological limits from below is a response to uneven power relations, through which communities attempt to defend more sustainable society–nature relations when these are threatened by infrastructure expansion.

Ultimately, socio-ecological limits in this context are not simply environmental constraints but legal and political constructs produced through contestation. They are continuously renegotiated as port-driven transformations scales up the reshaping of coastal ecosystems and social relations. The impacts associated with Port City Colombo have consequently prompted organisations such as Sri Vimukthi and NAFSO to intensify their advocacy around environmental impact assessments and coastal management regulations. Their struggle exposes the limits of governance frameworks that treat nature and society as separate domains, and instead foreground the need to govern infrastructure development through an integrated understanding of socio-ecological interdependence.

4.3. Valencia: protecting the ‘common good’

In Valencia, the expansion of the Port of Valencia has been the subject of a four-decade controversy in which debates over infrastructure development have progressively crystallised around the defence of the ‘common good’. Since the late 1980s, when Spain’s integration into the European single market created the conditions for a new wave of logistical expansion in the context of liberalisation and globalisation – the port has undergone successive enlargements that have profoundly reshaped the city’s coastline and its relation to the sea.

The first major southward expansion in 1986 deprived the fishing village of Natzaret of its beach and direct access to the sea, transforming the social and ecological character of the area. During the 1990s, plans to develop a logistics activity zone (ZAL), promoted by the Port Authority and supported by the regional government and large construction firms, led to expropriations in the neighbourhood of La Punta. Hundreds of smallholdings and family homes were evicted, while the partially implemented project generated significant impacts on the surrounding agricultural landscape of La Horta. Changes in land use, together with the concentration of heavy logistics traffic, altered water flows and drainage systems, affecting traditional agricultural productivity while increasing air and soil pollution. The fragmentation of this peri-urban landscape has progressively undermined both the ecological sustainability and the cultural value of a historic agricultural territory.

A new phase of expansion began in 2005 with plans for an ultra-large container terminal and breakwater designed to serve Mediterranean Shipping Company (MSC). The project aimed to strengthen Valencia’s position within global maritime logistics by consolidating transshipment routes linking Asia, Europe and Africa. National and regional institutions, together with local business actors such as Boluda Corporación Marítima and segments of the regional business community, supported the project as a strategy to enhance the port’s competitiveness. Opposition to port expansion, however, gradually coalesced into a broad civic

movement that reframed the issue in terms of the collective interest of the city and its territory. In 2019, amid renewed efforts to advance the terminal project, neighbourhood associations, environmental organisations and trade unions formed the *Comissió Ciutat-Port*. This grassroots coalition coordinated legal challenges, awareness campaigns and street protests contesting the environmental impact assessment and the governance model of the port. Central to these mobilisations were concerns over the consequences for both the urban space and the quality of life, as well as for ecological repercussions of further port expansion, particularly the erosion of local beaches and the risks posed to *Albufera* Natural Park. This lagoon ecosystem sustains approximately 14,000 hectares of rice fields and supports a distinctive wetland biodiversity of high ecological value. Alterations in coastal sediment dynamics associated with port infrastructure could therefore destabilise the hydrological balance of the lagoon, threatening agricultural production, ecological integrity and the broader socio-ecological system on which the territory depends.

Activists often emphasised that these impacts were not isolated environmental issues but cumulative effects of decades of port expansion. As one interviewee observed, ‘the port is like a *Taifa*’, referring to the fragmented kingdoms of medieval al-Andalus. ‘Its way of governing is completely detached from the territory around it’. Another interviewee stressed that ‘we have to live with the accumulated impacts of never-ending port expansion (...) we need to establish and activate limits before our beaches, the *Albufera* and our neighbourhoods disappear’. This articulation of socio-ecological limits emerged as a central tool for defending the common good. For the *Comissió Ciutat-Port*, the common good refers to the collective conditions that sustain urban life: the protection of coastal ecosystems, the preservation of public beaches, the health of agricultural landscapes and the environmental quality of urban neighbourhoods. In this sense, limits are not conceived merely as environmental thresholds but as political instruments aimed at safeguarding commons and communities’ spaces against the cumulative pressures of infrastructure expansion.

Part of the coalition’s work has focused on conceptualising an ecological debt owed by the port to the city after decades of exceeding these limits. By documenting the erosion and disappearance of beaches and the degradation of public spaces, activists highlighted how successive phases of expansion had progressively undermined shared environmental assets. Scientific evidence – ranging from shoreline sediment studies to measurements of air pollution – became central to identifying the points at which port activities had breached socio-ecological limits. Yet the movement’s engagement with limits extended beyond technical assessments. Through collective deliberation, the coalition developed broader proposals for reimagining the relationship between port infrastructure and the city. One such proposal advocated reversing the current expansion by removing the partially constructed breakwater and redirecting the public funds earmarked for port enlargement toward addressing existing environmental damages, improving urban mobility and supporting economic activities less dependent on fossil fuels. In this sense, the articulation of socio-ecological limits became an exercise in democratic deliberation centred on the defence of the common good. By challenging the development narrative promoted by global shipping corporations and the network of transcalar interests supporting port expansion, the movement sought to reclaim civic agency over port governance and redefine the relationship between infrastructure, territory and collective well-being.

4.4. Genoa: defending public health from port emissions

Over the last century, the Port of Genoa has undergone multiple phases of transformation. Following its post-World War II reconstruction and the modernisation of terminals during the 1960s, a major expansion took place in the 1990s with the construction of a new, large-scale container terminal along the western coast. This new facility was built on the beach of *Genoa-Pra’*, a neighbourhood that had long been a seaside resort and a fishing community. The construction of the terminal, was supported by the global actor and Singapore-based PSA that also manages the terminal, the Port Authority, the minister of Transport and the local logistical cluster that include small and medium freight and maritime services companies; on the other side, it was deeply contested by local residents, especially those living in *Pra’* which have lost the beach, a space of economic and social importance for the community; the construction of the terminal led to the disappearance of the beach and of 34 small seaside resorts, radically altering the spatial, environmental and social character of the area (Savoldi, 2024). One interviewee described the transformation as a ‘socio-environmental disaster and a collective traumatic experience’. On the one hand, the episode illustrates how the environmental impacts of port development scale up and increasingly translate into a

social issue. On the other, it reveals the inherently political nature of the matter, epitomised by the profound disconnection between port authorities and the local population.

The way in which an environmental problem is expressed as a social and a political one is well manifested by how citizens experience and react to the intensification of atmospheric pollution caused by the increasing port activity. ‘We constantly breathe heavy polluted air. When I hang white clothes outside, I get them back black due to the smoke coming from the port’ said one Genoa-Pra’ resident. ‘The port has shown no responsibility for the pollution it generates’, said a resident of the nearby Sanpierdarena neighbourhood. Such concerns became the driving force behind a grassroots campaign that linked port infrastructure to public health, understood not merely as a biomedical matter but as an ecological condition shaped by social structures. In doing so, active citizens reframed air pollution as a socio-ecological issue characterised by socio-spatial inequalities, thereby politicising the environmental impacts of port activity. This articulation also foregrounded the governance of the environment as an inherently political matter: public health became a lens through which to question how environmental risks are distributed and what levels of exposure are deemed acceptable. In this way, debates around air pollution evolved into broader struggles over the definition and enforcement of socio-ecological limits.

Following this articulation, several organised citizen groups began investigating the issue and discussing limits to air pollution. Their inquiries soon revealed that concentrations of multiple pollutants, such as NO₂, SO₂, ozone, carbon monoxide, particulate matter and even benzene frequently exceeded the limits defined by the World Health Organisation and the EU Air Quality Directive. ‘Many of us have been denouncing the pollution produced by marine traffic, reporting it to the Port Authority, City Hall and other institutions, but we have been systematically ignored’, explained the president of ECOINSTITUTO RE-Ge. Research conducted by this non-profit institute demonstrated that the official network of air-quality monitoring stations was not strategically located to distinguish between sources of pollution (road traffic, industry and port activities), thereby producing data incapable of identifying port-related emissions. Further investigation revealed that the monitoring of ships’ emissions falls under the jurisdiction of the Port Authority and remains largely ineffective. As the director of the institute noted, ‘in 2021 only seven ships were inspected through direct methods’ (meaning the verification of fuel samples from onboard tanks) ‘with such limited controls, shipping companies can easily use more toxic fuels, saving costs’.

In 2018, a citizens’ committee was formed, collecting over 1700 signatures for a petition demanding institutional accountability for atmospheric pollution, and organising public demonstrations and awareness events. This mobilisation led to the creation of a grassroots citizen-science initiative *Sentinelle dell’aria*, in which residents monitored ship emissions using sensors installed on their balconies and in public spaces. Through these participatory practices, citizens co-produced environmental knowledge that compensated for the lack of reliable institutional data, fostering a collective process of learning and ecological awareness. This bottom-up gathering of evidence became the basis for negotiating emission controls at transcalar level. Generated by citizens, the data reached the Coast Guard and the Port Authority, prompting them to intensify monitoring and enforcement measures targeting both local and international maritime companies docking at the Port of Genoa.

4.5. Rotterdam: conceiving ports within planetary boundaries

Rotterdam is considered in this analysis for two interrelated reasons. First, it hosts Europe’s largest port and one of the world’s largest, whose port–industrial complex generates substantial air and water pollution, with significant implications for public health and surrounding ecosystems. Since the post-Second World War period, Rotterdam has played a pivotal role in shaping the globalised system of logistics, becoming an influential reference model for port expansion and governance – captured in the notion of ‘Rotterdamisation’ (Notteboom, 2018). Second, precisely because of this systemic role, Rotterdam was selected by One Planet Port, a Rotterdam-based NGO founded in 2025 and the first to explicitly address port development through the planetary boundaries framework. Rather than illustrating ‘limits from below’ like the three other cases, Rotterdam shows how the planetary boundary framework is directly mobilised as a political vocabulary and advocacy tool within port governance debates, and how that mobilisation encounters unresolved questions of legitimacy, distribution and institutional power.

As its name suggests, the NGO draws on the ‘One Planet’ concept – the notion that humanity must live within the ecological limits of a single finite planet, respecting the Earth’s biophysical capacity to sustain life and human activity over time. Through this lens, One Planet Port advocates for a profound rethinking of the role of ports within Earth systems, shedding new light on how port governance and infrastructural development intersect with global environmental limits. As the directors explain in our interview, the NGO chose Rotterdam because addressing governance at Rotterdam with planetary boundaries in mind could thus trigger a domino effect, making it a pivotal site for systemic transitions in port governance. According to this perspective, changes in infrastructure, regulatory frameworks or operational technologies at Rotterdam have the potential to propagate through global logistics networks, illustrating the systemic leverage of targeted local interventions.

The framing of this organisation conceives the impacts of ports in a transcalar way; it highlights how ports operations are highly resource-intensive, relying heavily on freshwater inputs and releasing a wide spectrum of pollutants that affect atmospheric and biogeochemical systems. The accumulation of harmful substances, including plastics and heavy metals, not only threatens marine and terrestrial ecosystems but also jeopardises human health beyond the local. As well as its direct impacts that are produced locally and disseminated on a larger scale, the NGO sees the port as a regulating valve of a system – ‘ports are not just points of transit, but gatekeepers of material flows, shaping what a country consumes and produces, actively choosing what to keep out’ co-directors said. Hence this perspective highlights how governing ports within planetary boundaries can have structural effects beyond the port. According to their perspective, governing the port within the planetary boundaries entails a just and equitable reorientation of governance structures, rooted in ecological transition and a commitment to zero-pollution futures. Hence, for Rotterdam, this includes transforming a fossil-fuel-dependent port toward zero greenhouse gas emissions across all activities and industrial sectors by 2050, while ensuring a fair and inclusive transition for workers and communities. Practically, this requires electrifying shipping and port operations, maximising renewable energy deployment, and proactively minimising environmental impacts. One Planet Port situates the interdependencies of global port infrastructures as opportunities for systemic change. Localised interventions, such as banning scrubbers that remove sulphur oxides from ship exhausts but discharge harmful waste into water bodies, are framed as meaningful acts of governance within planetary limits.

In practice, One Planet Port diagnostically references the planetary boundaries framework to outline policy directions that reduce the contribution of port activities to the overshooting of the nine boundaries. Yet the framework itself does not directly orient policy choices: it identifies systemic biophysical constraints, but does not indicate which port-related sectors should be curtailed first, how trade-offs between ecological goals and economic dependence should be negotiated, or how the social and financial costs of transition should be distributed. It therefore leaves open the central political questions of priority-setting, legitimacy and redistribution that determine what ‘staying within limits’ would mean in practice. The work of One Planet Ports can be understood precisely as an attempt to translate this planetary diagnostic into actionable governance proposals. However, the translation of this objective into policies demands a confrontation with the local reality of territories – on the question of how to complement global objectives with local needs, the directors argued for a scalar integration of objectives that should drive port governance, achieved by embracing a mode of sustainable governance that moves beyond consultation towards meaningful participation, where residents, workers and local organisations have a real voice in decision-making:

Communities should have access to clear, transparent information, and benefit directly from green investments through improved health, job opportunities and environmental quality especially where public money is being spent. Engagement processes must be inclusive, accessible and culturally sensitive, with support for local capacity-building and stewardship of the surrounding environment. Ultimately, ports must be accountable not only to markets, but to the people who live and work around them.

This approach underscores that while planetary boundaries define the ecological limits for the planetary stability, their translation into governance requires localised, justice-oriented and participatory mechanisms. For the NGO, governing ports within these limits is simultaneously an ecological and social imperative, demanding co-developed, place-based strategies that both respect planetary thresholds and deliver tangible benefits to port-adjacent communities. This emphasis on participation indicates that planetary boundaries alone does not provide tools for governance: they must be mediated through locally grounded

practices of deliberation and accountability. Therefore, this case illustrates the emergence of new hybrid discourses in which global diagnostics are increasingly invoked to strengthen claims for institutional change. In this sense, the case supports the broader argument of this paper: that environmental limits become a tool for governance only when they are socio-politically articulated and institutionally negotiated. Therefore, the planetary boundary framework can strengthen the legitimacy of environmental claims, but remains abstract unless it meets situated struggles over livelihood, territory and exposure to harm. These struggles involving competing actors contest how limits are defined, by whom and in whose interests, and where local priorities and distributive conflicts shape what forms of restriction become socially acceptable and institutionally enforceable.

5. Conclusion

Via a politics of limits perspective – bridging a critical reading of the planetary boundaries framework with emerging theories of socio-ecological limits – this article rethinks key aspects of environmental governance in relation to ports as infrastructures that are simultaneously implicated in planetary-scale transformations and embedded in the everyday politics of urban territories. By examining how environmental discourses are mobilised at the grassroots level in the contested terrain of port cities, the article contributes to debates on what the planetary boundaries framework might mean for infrastructures and cities. It illustrates that environmental issues are not only biophysical conditions to be managed through technical metrics, but are socially and politically interpreted through processes that, in port cities, unfold across multiple scales. Understanding the environmental implications of ports therefore requires attention to the transcalar entanglements through which logistical regimes, institutional arrangements and local socio-ecological dynamics become mutually constituted. From this perspective, the article highlights the scalar complexities and ontological tensions involved in translating the planetary boundaries framework into a practical tool of environmental governance for ports and port cities.

Port development is shaped by multiscalar constellations of actors who mobilise narratives of competitiveness and modernisation to position territories within transnational infrastructure circuits. In this context, the ‘local’ is not merely the site where impacts become visible or where resistance emerges, but a space where infrastructures are actively negotiated and where socio-ecological limits are articulated by heterogeneous actors and interests. These range from civic mobilisations contesting expansion to institutions promoting investment and territorial restructuring. Recognising this complexity helps move beyond a simple global–local divide, revealing instead how socio-ecological limits are produced through transcalar configurations of power.

Examining limits in the contested terrain of port cities also reveals the difficulty of translating the planetary boundaries framework into territorial governance. Environmental problems as they materialise in port cities are rarely experienced as direct expressions of planetary boundary transgression. Rather, they are lived as socio-ecological disruptions emerging from the entanglement of ecological processes, territorial identities, contested knowledge practices and uneven power relations. The dredging that undermines fish catches in Colombo, the coastal erosion threatening Valencia’s Albufera, and the air pollution accumulating in Genoa’s neighbourhoods illustrate how environmental change becomes politically meaningful through everyday experience and local struggles.

Across the cases, socio-ecological limits emerge not only as scientific thresholds but also as grassroots political constructions grounded in material realities. These ‘limits from below’ carry transformative potential because they open space for rethinking port-city relations and questioning the development paradigms that sustain them. In Colombo, fisher communities articulated limits by linking ecological integrity to livelihood security. In Valencia, civic coalitions framed beaches, agricultural landscapes and urban space as collective goods whose defence justified opposing cumulative infrastructure expansion. In Genoa, citizen science initiatives turned air pollution monitoring into a practice of collective learning and institutional accountability. In each case, limits emerge through embodied experience and collective contestation, expressing local agency in defining the conditions under which infrastructure development might be compatible with collective wellbeing. These experiences point to an important ontological difference between the planetary boundaries framework and socio-ecological limits articulated from below. While the former identifies global biophysical thresholds and offers a powerful diagnosis of systemic environmental pressures,

the latter connects ecological conditions to questions of justice, livelihood and territorial autonomy. In doing so, they expose the assumptions embedded in dominant development models and open space for alternative environmental politics grounded in the plurality of territorial realities.

At the same time, the Rotterdam case shows how planetary boundaries can enter port governance discourses as strategic and normative language. The One Planet Port initiative illustrates how planetary diagnostics can be mobilised to reframe ports as infrastructures of systemic ecological risk. Yet it also confirms that planetary boundaries, on their own, remain politically undetermined. Their translation depends on mediation through socio-ecological claims and negotiations shaped by the specific social, political and ecological characteristics of territories. In this sense, planetary boundaries may strengthen the legitimacy of environmental claims, but they do not substitute the political processes through which socio-ecological limits are defined, contested and enforced. The unresolved challenge for environmental governance is therefore institutional and political: how to create conditions for new governance paradigms capable of linking ecological resilience with social justice. Bridging these dimensions points toward a reorientation of environmental governance in which infrastructures such as ports become sites not only of environmental pressure, but also of political experimentation that redefines the relationships between economy, society and the Earth system.

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Ethics statement

The authors confirm that informed consent was provided for all interviews. Consent was collected written or verbally. Our consent procedure clarified, amongst others, that participation is voluntary and can be stopped at any time without providing a reason, the interviews will be recorded, transcribed and analysed, and that participants retain the right to access, rectify or erase their data at any time. All participants have the contact details of the first author.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author (FS), upon reasonable request.

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