

Advancing sustainable port development in the Western Indian Ocean region

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The Western Indian Ocean (WIO) region is experiencing rapid growth in large-scale developments, including ports. These ports play an important role in the region's economy, but they are invariably located in coastal areas with rich natural resources that provide other ecosystem-based societal benefits. Progress has been made towards greater port sustainability in the region in recent years, but there is an urgent need to accelerate regional sustainable efforts. In response, the Nairobi Convention Secretariat initiated the development of a 'Toolkit for Sustainable Port Development'. This was rooted in an Integrated Port Management (IPM) framework comprising four key phases: planning, design, construction, and operations. A systematic and incremental approach is recommended for implementation, first adopting the IPM framework and then applying eco-friendly technologies and practices based on place-based priorities to reduce environmental impacts and unacceptable socio-economic consequences. This will contribute significantly to sustainable port development in the WIO region.

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Introduction

Increasing societal and regulatory pressures are compelling port authorities around the world to pursue

greater sustainability to safeguard their 'license to operate' and to grow their economic and environmental competitiveness [39]. In response to this, the concept of 'Green Ports' emerged, focusing on balancing environmental challenges and economic demand [3]. The concept of 'sustainable port development' builds on that of 'Green Ports' by also considering social sustainability, in essence advocating port development to balance the needs for economic growth, environmental protection and social accountability [28,45,56] towards achieving Agenda 2030s Sustainable Development Goals [12]. Sustainable development is a key aspiration of Agenda 2063: The Africa We Want, a master plan to transform Africa into a global powerhouse by 2063 [1]. Specifically, Aspiration 1 calls for inclusive and sustainable growth and development, also through blue economies that include port and maritime operations.

The Western Indian Ocean (WIO) includes countries and island states of Comoros, Kenya, Madagascar, Mauritius, Mozambique, Reunion, Seychelles, South Africa, Somalia and Tanzania. It is experiencing rapid large-scale development, including in seaports, driven by large infrastructure demands and financial inflows [34,55]. Most of these developments are in their early stages of design and implementation. This offers the opportunity to ensure that they follow sustainable trajectories. Development and economic growth are necessary for countries in the region to address social challenges, such as poverty and inequality, but failing to undertake this in a sustainable manner will inevitably result in detrimental impacts on coastal ecosystems and associated coastal livelihoods and economies [29]. This paper reflects on the current situation in respect to port sustainability initiatives in the WIO region and outlines a regional response to facilitate sustainable port development in future.

Regional status quo

There are more than 100 ports and harbours, ranging from large commercial ports to small fishing jetties in the WIO region (see [Supplementary Material, Appendix A](#)). These ports play an important role in the region's economy, but they impact natural coastal resources that provide other valuable ecosystem-based societal benefits [50]. Data to quantify these impacts are not readily available in the WIO region, but the international literature offers sufficient evidence of environmental problems associated with port development and operations.

These include physical alteration and destruction of habitat, air, water sediment and soil pollution, noise and artificial light, introduction of harmful marine organisms and pathogens, and climate impacts [25,30,31].

Recognising the need for greater sustainability to secure their 'license to operate', several port authorities in the WIO region have started to adopt green or sustainable port initiatives [17]. For example, Kenya Ports Authority (KPA) has adopted a Green Port Policy to address the negative impacts of port operations and integrate environmental sustainability in port development and operations [26]. The policy focuses on climate change mitigation/adaptation and renewable energy and recognises the importance of involving stakeholders and partners to achieve sustainability outcomes. Currently, the focus is on the Port of Mombasa, but the KPA plans to expand the scope to include other ports, including the ports of Lamu and Kisumu.

In Mozambique, initiatives to reduce the emission of greenhouse gases are being implemented in the Port of Maputo whereby tug and pilot boats are required to turn off their generators when moored, with electricity being supplied by sources installed on the pier [32]. Port authorities are also undertaking tree planting and restoration of forests. The Tanzanian Ports Authority is developing a Green Port Policy, focusing on the Port of Dar es Salaam specifically aimed at greening existing operations and new port development [10,40]. In Madagascar, container reception and storage capacity has been increased at the Port of Toamasina while still pursuing environmental protection as per national law and adopting good practices from other countries in 'going green' [19]. In South Africa, sustainability through the use of alternative energy sources has been one of the National Ports Authority's goals in recent years, with installation of solar technologies to alleviate power challenges and to support greener port operations [48]. The Seychelles Port Authority also has identified the implementation of green port initiatives as a key objective in their strategic plan (2019–2023) [43]. Similarly, with the adoption of their strategic plan, Port Reunion launched a Sustainable Development and Management Plan promoting energy efficiency, environmental quality and social equity [38]. The Mauritius Ports Authority has also embarked upon the implementation of the Green Port Concept, with wide scope pertaining to sustainability initiative to improve energy efficiencies, trans to renewable energy sources attain carbon neutrality and green port operations [11].

There is growing scientific support to achieve sustainable port development in the WIO region and on the wider African continent. Taljaard et al. [45] developed a framework for aligning and integrating environmental processes within the traditional port development cycle,

and Arabi et al. [2] adapted global port environmental management systems to better align with the African context. To assist ports in the assessment of sustainability, specifically across the port–city interface, Ogara et al. [36] developed an indicator-based approach for application in the WIO region.

Whilst progress has been made towards more sustainable port development in the WIO region in recent years, the Contracting Parties to the Nairobi Convention, which aims specifically to address accelerating degradation of ocean and coastal areas in the region through sustainable management and use of the environment, highlighted the need to accelerate regional efforts [34]. Specifically, the Parties called for the development of a toolkit for 'green port development' in the WIO. In doing so, the region would 'greatly benefit due to reduced ecological and environmental impact that are seen today in the traditional ports which are developed and operated without regard to environmental considerations and efficient port operations' ([34], p. 3). In response to this request from the Contracting Parties, the Nairobi Convention Secretariat initiated the development of a 'Toolkit for Sustainable Port Development', which has since been completed [51] and endorsed by the contracting parties for uptake in the region.

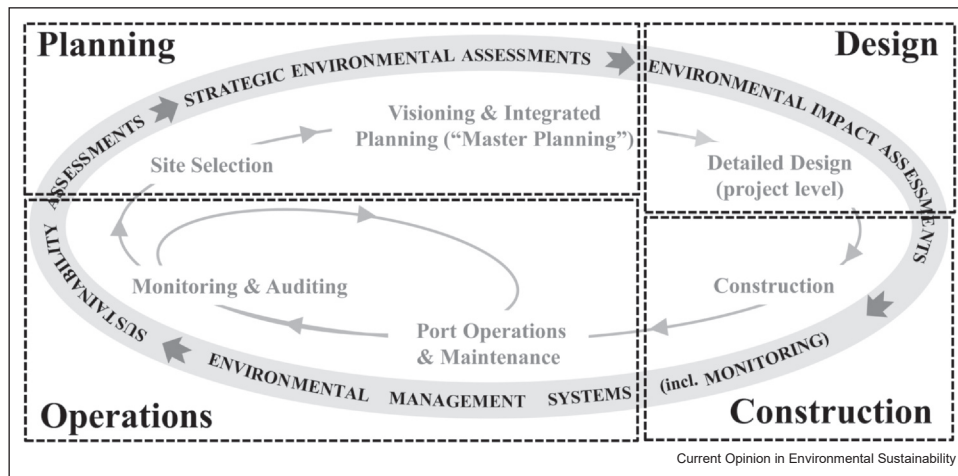
Learning from international best practice

The approach to develop the toolkit started with detailed review of international best practice and the adoption of international tools where appropriate, rather than 're-inventing the wheel'. A situation assessment of potential socio-ecological impacts of port development and operations in the region was undertaken to provide place-based context [52]. At stakeholder workshops attended by environmentalists and port operators from the region, additional regional input was gained. This was combined with place-based experiential knowledge [16] of the authors, gathered over more than two decades in providing science support to address environmental matters in ports in the region.

Recognising the need to co-ordinate environmental and engineering processes in ports, Taljaard et al. [45] developed an Integrated Port Management (IPM) Framework (Figure 1). Key phases of port development that emerge from this framework — planning, design, construction and operations — were used to provide structure to the Toolkit for Sustainable Port Development.

Drawing on the review of international best practice on sustainable (or green) port development and input from regional stakeholders practical tools was distilled and organised within the four phases of the IPM framework (Table 1; see Supplementary Material, Appendix B for details on specific tools).

Figure 1



IPM framework, conceptualising alignment between the traditional port development cycle and key environmental processes, illustrating the four phases of planning, design, construction and operations
Adapted from Ref. [45].

Table 1

Construct of Toolkit for Sustainable Port Development.

Phase	Tool
Planning	Guidance on Strategic Environmental Assessment
	Site Selection and Master Planning
	Planning for Climate Change
Design	Concept of Nature-based solutions
	Scenario Analysis Tools for Planning
	Guidance on Environmental and Social Impact Assessment
	Design for Biodiversity Offsets
Construction	Building-with-Nature Design Approach
	Ecological Enhancement Options
Operations	Construction Environmental Management Plans
	Dredge Management (also in Operations)
	Considerations for Port Decommissioning
	Guidance on Environmental Management Systems
	Circular Economy in Ports
	Examples: Sustainable Port Development Actions
	Securing External Finance for Port Development Projects
	Sustainable Use of Materials and Land
	Energy Efficiency Management
	Management of Carbon Footprint
	Management of Water Consumption
	Waste Management
	Ballast Water Management
	Guidance on Sustainable Hull Cleaning
	Towards Improving Port Environmental Quality
	Ecosystem Restoration
Marine Litter Clean up Technologies	
Oil Spill Contingency Planning	
Environmental Monitoring and Evaluation	
Environmental Information Systems	
Effective Capacity Development	
Introduction to Natural Capital Accounting	
Sustainability Performance Index for Ports	

During the *planning* phase, the primary environmental process to consider is Strategic Environmental Assessment (SEA) [18]. The value of undertaking SEA early in strategic planning for ports (including their location) to ensure timeous consideration of important socio-ecological issues has been well demonstrated [13,14]. Of key importance in the planning phase is to consider measures to mitigate potentially negative impacts of climate change [37], preferably measures relying on nature-based solutions [8]. Scenario analysis has also been proven as a useful technique in forecasting possible futures as part of planning processes in complex socio-ecological systems [15,53] and has potential useful application in the case of ports.

Key during the *design* phase is the assessment of alternative engineering designs as part of environmental and social impact assessments [4]. These should include options considering, for example, building with nature [35], biodiversity offsets [24] and ecological enhancement [27], which all contribute to sustainability in terms of environmental and associated socio-economic benefits.

Environmental damage during the *construction* phase can be significant, and sound environmental management plans are needed to guide and monitor construction activities [33]. Dredging, including options for sustainable use of dredged material, is critical to manage during port construction [22].

During the *operational* phase, Environmental Management Systems are important to achieve environmental sustainability in ports [2]. International best practice offers a wide array of other sustainable tools for consideration in this phase, including tools to improve energy efficiencies [42],

manage carbon footprints [9], ballast water [20,21] and marine litter [41], and restore ecosystems [49]. Monitoring programmes and contingency planning [23] also are important management tools to promote sustainability during this phase. Driven by the increasing demand for sustainable port development, interest in place-based port sustainability performance indices has increased with some valuable tools emerging [44,46,7]. Sustainability can be further enabled through effective financial sourcing [54], sound environmental management information systems [6] and effective capacity development [47,5].

Paving a way forward

Strategically situated along the east coast of Africa, the WIO region offers access to important shipping lanes, which underpin trade routes between Africa, Asia, Europe and the Americas. If serviced with appropriate port infrastructure, this holds great potential for accelerated economic growth to address the region's social challenges. However, failing to develop and operate port infrastructure in a sustainable manner will inevitably result in detrimental impacts on coastal resources and associated societal benefits. Notwithstanding progress towards the 'greening of ports', there is an urgent need for increased sustainability in the region's ports. The development of the '*Toolkit for Sustainable Port Development in WIO region*' is therefore timeous and has immediate application.

There are, of course, considerable potential barriers in the transition to sustainable port development, stemming from underlying challenges, the most fundamental being regulatory and organisational barriers. In the case of the former, the Nairobi Convention is already playing a key supporting role in facilitating regulatory reforms in the region. In the case of the latter, there is good evidence that traditional conservative port culture is being challenged in the region with the adoption of a sustainability agenda and the implementation of various green port initiatives.

Even with these challenges addressed, ports in the WIO region will not be able to adopt every tool in the toolkit in the short-term due to a lack of human and financial resources. However, port operators can work towards achieving environmental sustainability by committing to a process of addressing environmental matters early in new port development planning and identifying priorities specific to their port environments through operational and maintenance initiatives. Stakeholder engagement will be critical to this; port developers and operators, users and tenants, local communities, environmental groups and other stakeholders should all be involved in relevant decision-making processes. Collaboration with industry partners in achieving sustainable and integrated port development is also

encouraged. For example, partnerships with shipping companies can help promote the use of green shipping technologies to reduce carbon emissions.

By adopting a systematic and incremental approach to IPM and by incorporating eco-friendly technologies and practices across port planning, design, construction and operational phases, detrimental environmental impacts and unacceptable socio-economic consequences can not only be reduced; but ultimately proactive sustainable port development in the WIO region can be achieved, with ports that are environmentally responsible, socially equitable and economically viable.

Pilot projects to facilitate national implementation of the toolkit have recently commenced in South Africa and Seychelles, with plans to extend these projects to other countries in the region. In a region constrained by financial and human resources, shared learning will be critical, for example, using platforms such as the Nairobi Convention and the Port Management Association of Eastern and Southern Africa. To facilitate cooperation between countries, regional research studies investigating commonalities, disparities, and success factors for achieving sustainability will be beneficial. Furthermore, such research could inform a standardised approach for measuring and reporting on port sustainability across the WIO region. Finally, a greater understanding of the long-term social and economic benefits of the transitioning to sustainable ports will be needed to motivate for greater public and private support and investment.

Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

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Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.cosust.2024.101489](https://doi.org/10.1016/j.cosust.2024.101489).

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