# Towards Sustainable Port Development in the Western Indian Ocean

## Scenario Analysis

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*To be included in final draft*

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# ACRONYMS

| | |
|---|---|
| AHP | Analytical Hierarchy Process |
| BAU | Business-as-usual |
| CSIR | Council for Scientific and Industrial Research |
| GDP | Gross domestic product |
| GEF | Global Environmental Facility |
| GHG | Green-house gas |
| GPP | Green Port Policy |
| KPA | Kenya Ports Authority |
| MTCC | Maritime Technologies Cooperation Centre |
| OPS | On-shore power supply |
| PMAESA | Port Management Association East and Southern Africa |
| PPP | 'People', 'Planet', and 'Prosperity' |
| RSA | Republic of South Africa |
| SDG | Sustainable Development Goals |
| SES | Socio-ecological systems |
| SSPs | Shared socio-economic pathways |
| TBL | Triple Bottom Line |
| TNPA | Transnet National Ports Authority (South Africa) |
| TPA | Tanzania Ports Authority |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environmental Program |
| WIO | West Indian Ocean |
| WIO-Lab | Addressing Land-based Activities in the West Indian Ocean |
| WIOSAP | Western Indian Ocean Strategic Action Programme |

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# 1 INTRODUCTION

## 1.1 Background

Growing global trade, rapid coastal urbanization, depletion and degradation of natural resources, along with increasing expectations from stakeholder and greater social empowerment and awareness are demanding an accelerated quest for port sustainability. Ports are increasingly being pressurised to take actions, not merely focussing on economic generation, but also to include resilient sustainable strategies pertaining to the environment and society (Lu et al. 2016; Alamoush et al. 2021). The port industry therefore faces a growing challenge to address societal and environmental considerations while at the same time to improve their capacity to provide cost-effective services to traders (e.g., working towards 5th generation ports) (Kaliszewski, 2018; Lam and Van der Voorde, 2012; Roh et al., 2016). Therefore, with increasing societal and regulatory pressures, port authorities around the world are compelled to pursue greater sustainability to safeguard their 'license to operate' and to grow their economic and environmental competitiveness (Lam and Van der Voorde, 2012; Roh et al., 2016).

The Western Indian Ocean (WIO) region is no exception and is experiencing an unprecedented growth in large-scale developments, including ports, driven by large infrastructure demands and financial inflows from different funding streams. Most of these developments are concentrated around coastal zones with rich natural resources. While the region has an opportunity to define sustainable trajectories for these investments, they have potential to significantly impact on the integrity of critical habitats and the resource base that future developments will depend on. Indeed, the WIO Region coastal communities are strongly reliant on coastal resources for their lives and livelihoods.

Complimentary to the *Strategic Framework for Coastal and Marine Water Quality Monitoring and Management in the Western Indian Ocean Region* (UNEP et al. 2021), the activities proposed here seek to facilitate sustainable port development in the WIO by *assessing the environmental impacts of operational, planned, and proposed ports in the WIO Region with the aim of developing different scenarios for future development, produce policy briefs and a Toolkit for Green Port Development in support of sustainable port development in the region.*

## 1.2 Rationale

Although rooted in ancient human history, sustainable development re-emerged as a paradigm in the early 1900s in response to failures of conventional development that focussed only on achieving growth in gross domestic product (Printér et al., 2012; Villeneuve et al., 2017). The inability to distribute wealth fairly, as well as detrimental impacts on the natural environment and society are key failures of this conventional economic development model. Such failures could be alleviated through the implementation of sustainable development principles that consider environmental, social, and economic issues in the light of cultural, historic, and institutional perspectives (Waas et al. 2011).

Sea ports, by their very nature, are complex environmental systems given the magnitude of potential impacts associated with their activities, including atmospheric emissions, dredging, wastewater discharge, and solid waste. Environmental impacts can occur due to normal port activities or by accident (Darbra et al. 2004; Darbra et al. 2005). In their simplest forms 1st generation ports operated in areas of uncontested space, benefiting from seascapes in which they could be situated safely and cost-effectively without competition (Kaliszewski 2018; Lee et al. 2018). However, port systems can no longer operate without acknowledging and incorporating societal and environmental considerations in their planning and management. They face increasing challenges to consider societal and environmental aspects while still having to provide adequate capacity and cost-effective services for trade (Lam and Van der Voorde 2012; Roh et al. 2016).

Such challenges stimulated the development of concepts such as 'Green Ports' with a primary objective of balancing environmental challenges and economic demand and competitiveness (Bergqvist and Monios 2019; Lam and Notteboom 2014) and striving for sustainability through increasing both economic and environmental competitiveness (Maritz et al. 2014; Stein and Acciaro 2020). While green port management may have upfront cost implications, it has been found that ultimately such practice leads to positive outcomes on economic performance (Schipper et al. 2017; Lam and Van de Voorde 2012). With increasing public and regulatory pressures, port authorities around the world are compelled to pursue sustainable port development to safeguard their 'license to operate' and to grow their economic competitiveness (Lam and Van der Voorde 2012; Roh et al. 2016; Darbra et al. 2004). The concept of 'Sustainable Port Development' builds on 'Green Ports' also considering social sustainability, in essence advocating the need for port development to create a balance between economic growth, environmental protection, and social progress to secure its long-term future (Hiranandani 2014; Taljaard et al. 2021).

Climate change and its contribution to sea-level rise and increased storminess, is another major threat to port sustainability. Ports can respond in two ways (HR Wallingford and British Port Association 2021):

- Adaptation - upgrading existing infrastructure and designing new infrastructure to withstand the main impacts of climate change, such as sea level rise and flooding
- Mitigation - reducing greenhouse gas emissions to contribute to the global effort to reduce climate change.

Several initiatives in the WIO region have already started to adopt green port approaches, such as (Nairobi Convention 2021):

- Kenya Ports Authority (KPA) adopting a Green Port Policy (GPP) to enhance environmental conservation, for example requiring ships calling at the Port of Mombasa to use electric power while docked
- Tanzania Port Authorities (TPA) - developing (in conjunction with Deltares) a GPP for the Port of Dar es Salaam, aligned with the World Banks' 'Green Growth' initiative, as well a climate-smart design for the port's expansion and improvement programme
- South Africa's Transnet National Ports Authority (TNPA) maintaining a green status in the Port of Ngqura through several initiatives including unique biodiversity conservation programmes. Other South African ports are at different levels in the greening initiative
- Port Management Association East and Southern Africa (PMAESA) and the Maritime Technology Cooperation Centre-Africa in consultation to sign a memorandum of understanding on baseline energy audit surveys and establishing the extent to which ports in the region have embraced GPP.

Towards achieving greener ports, various environmental assessment and management processes must become integral to traditional port planning and development processes (e.g., Taljaard et al. 2021).

## 1.3 Purpose

This project is part of, and supports the *Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities' (WIOSAP)*. Port operations invariably influence critical coastal and marine resources, the sustainable management of which is the focus of the Nairobi Convention. The scientific outputs generated from this project will be shared with national governments to support and guide development of new policy options on sustainable port development in the WIO region through the Science to Policy Platform supported by the Convention.

This component of the project presents a Scenario Analysis which evaluates development pathways which range from 'business-as-usual' to options incorporating 'green port' considerations. It builds on the Situation Assessment that provided the context and backdrop for greener port operations and development in the WIO region (see Situation Assessment Report).

## 1.4 Structure of this Report

The Report presents the outcomes of the Scenario Analysis evaluating development options from 'business-as-usual' to options incorporating environmental considerations ('green port' option) in the WIO region.

This introductory chapter (Chapter 1) is followed by an overview of international approaches in environmental scenario analysis, including methods to measure green port performance (Chapter 2). Chapter 3 presents the approach adopted for this study, the development and selection of scenarios, and finally the outcome of the scenario analysis.

# 2 OVERVIEW OF INTERNATIONAL APPROACHES

## 2.1 Scenario Analysis Approaches

*A Green Port adheres to the concept of resource saving and environment-friendly development, actively fulfils its social responsibilities, and comprehensively adopts technologies and management measures that are conducive to saving resources and energy, protecting environment and ecology and coping with climate change – Guo and Liu (2018)*

Port environments are complex socio-ecological systems (SES) where many facets of society and the environment interact, often resulting in conflict. Scenario analysis has proven to be useful as a technique to forecast possible futures in these types of complex systems. In this approach, a range of future conditions within which a SES might have to operate is created, generally involving a best case, a worst case, and one or two in the middle. In all scenarios, there will be trade-offs, but trade-offs do not eliminate the possibility of attaining a desired outcome. As a fore sighting approach, scenario analysis is based on the idea that the future may be inherently uncertain (or open) but not entirely unknown nor totally out of our control (Elsawah et al. 2020).

Four features make scenarios analysis a particularly powerful tool for understanding uncertainty and making business decisions (Walker 2019):

- Expands thinking by developing a range of possible outcomes, each backed by a sequence of events that could lead to a desired outcome
- Protects against groupthink, which can inhibit the free flow of ideas
- Helps challenge conventional wisdom when *status quo*-based assumptions may no longer hold true in that it builds alternatives that provide a less threatening way to allowing deviation from *status quo*
- Enables management to steer a course between the false certainty of a single forecast and the confused paralysis that often strikes in chaotic times.

The process of scenario analysis also has other side benefits, such as (Walker 2019):

- Demonstrates how and why things could quickly become much better or worse thereby increasing preparedness for a range of future possibilities
- Assists in forming a better understanding of the major variables that may significantly impact and shape the business future, in both positive and negative ways
- Provides opportunity to employ strategic insights that could help in weathering uncertainty towards achieving a desired outcome.

To inform the approach and the selection of scenarios towards a business case for green port development in the WIO region, the typing of scenarios, the scenario development process, and a few related international case studies are investigated below.

### 2.1.1 Typing of scenarios

Alcamo (2001) and Alcamo and Henrichs (2008) define different types of scenarios that can be considered, namely:

Qualitative versus Quantitative - Qualitative scenarios use words and symbols (narratives) to depict a possible future rather than numerical estimates. Advantages of well-written qualitative scenarios include the ability to represent or incorporate views of numerous role players and stakeholders and provide an easily understandable and interesting way of communicating futures. Their big disadvantage is their inability to provide numerical data to quantify trends. Quantitative scenarios address the latter, but the in providing numerical data they create perceptions of certainty that may not always be true. Quantitative scenarios often draw on computer models that rely on assumptions that may implicitly be narrow in view. Complicated modelling outputs are also often difficult for non-modellers to understand (Alcamo 2001). On the other hand, modellers usually record their assumptions, which provides greater transparency compared with the undeclared assumptions that often underpin qualitative scenarios. Decisions to use qualitative or quantitative approaches depend on the purpose of a scenario analysis. If the aim is to inform possible generic futures, then a qualitative approach may suffice. Where the aim is to inform specific actions, for example to mitigate climate change in specific operations (e.g., reduction of emissions), a quantitative approach may be more appropriate. Qualitative scenarios are well suited options, for example, to stimulate policy ideas, for brainstorming, communication and education, where several views about the future need to be considered, or where modelling tools are not available for quantitative analysis. Quantitative scenarios are options, for example, for assessments that explicitly require data and numbers, or when a 'theory' (model) is required to back-up scenarios. A combination of approaches may also be a consideration.

- Exploratory versus Anticipatory - Exploratory scenarios typically commence in the present and then explore trends into the future. On the other hand, anticipatory scenarios (e.g., worst case, best case, and business-as-usual) prescribe a vision of the future (e.g., by 2030) and then visualise how each of these futures could be realised. Exploratory approaches are appropriate when the aim is to explore consequences of a specified future trend in driving forces, or to investigate the consequences of implementing a policy. Anticipatory approaches are appropriate when the aim is to assess steps that can lead to a specified end state (e.g., achieving environmental or social targets), or to inform policymakers how a 'desirable' end state could be achieved (e.g., how to achieve sustainable development).
- Baseline (reference) versus policy - In the context of environmental studies, baseline scenarios present future states of SESs without policy interventions, or where these may not yet have any marked influence. Policy scenarios, on the other hand, aim to depict the possible effects of various environmental policy interventions, for example when superimposed on baseline scenarios.

### 2.1.2 Scenario development

Methods to develop scenarios span both participatory and analytical approaches (Figure 2.1) (Alcamo 2001; Alcamo and Henrichs (2008). Participatory approaches typically involve consultation with experts and stakeholders to develop scenarios, while analytical approaches include expert systems, decision support systems and computer models.

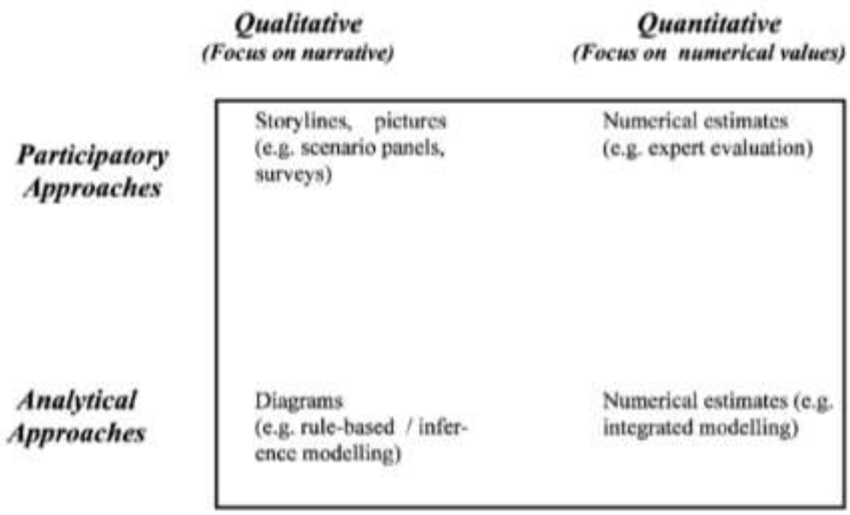


Figure 2.1 Classification of qualitative and quantitative scenarios versus participatory and analytical scenario development methods

### 2.1.3 Examples: Environmental scenario analyses

Critical steps in a scenario analysis process include (Alcamo 2001; Alcamo and Henrichs 2008):

- Step 1: Define focal issue of the scenario exercise and aim of investigation
- Step 2: Identify key driving forces that are likely to shape future outcomes pertaining to the focal issue (e.g., population growth, policy status, technologies)
- Step 3: Build scenarios based on possible future developments of key driving forces
- Step 4: Identify key indicators (or elements) to measure future outcomes (e.g., state of pollution, livelihoods, profitability)
- Step 5: Define anticipated effect of driving forces (or combination of driving forces) on key indicators (either qualitatively [narrative] or quantitatively [numbers])
- Step 6: Determine expected outcomes, in terms of selected key indicators.

The following sections explore a few international case studies useful in informing scenario development and analysis options pertaining to green port development in the WIO region.

#### *2.1.3.1 Shared Socioeconomic Pathways (Climate change)*

The concept of shared socio-economic pathways (SSPs) stems from a scenario framework specifically developed for climate change research (O'Neill et al. 2014). These pathways are combined in a dual axis matrix with possible climate change projections, using an array of simulation modelling techniques, to derive likely future outcomes or scenarios (O'Neill et al. 2014. 2017; Riahi et al. 2017). In essence, the SSPs describe plausible alternative trends in the evolution of the global society and natural systems over the 21st century, without considering climate change. However, to be useful in the context of climate change outcomes, the SSPs designed to span socio-economic 'challenge spaces' in terms of climate change mitigation and adaptation (Figure 2.2).

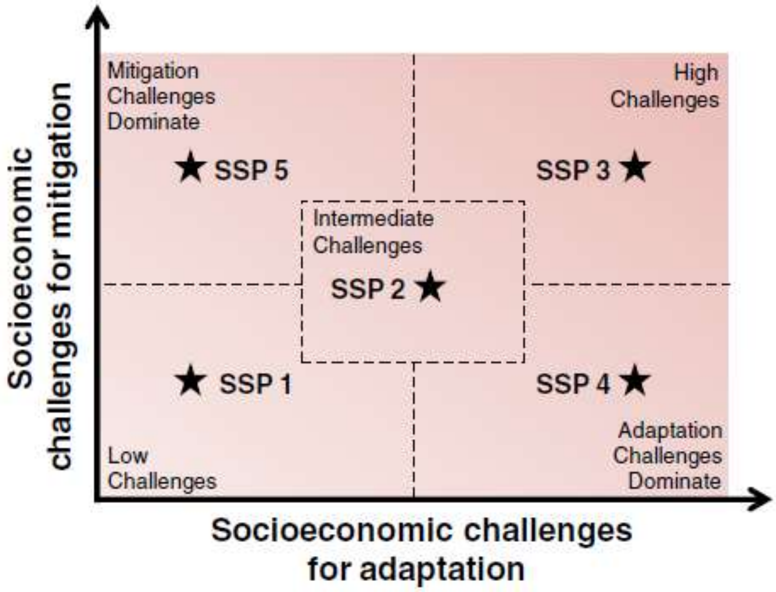


Figure 2.2 Conceptualisation of SSPs across climate change mitigation and adaptation challenge space (Source: O'Neill et al. 2014)

Although the SSPs are differentiated based on pre-specified outcomes, they are constructed from determinants of these outcomes, either expressed qualitatively (narratives) or quantitatively (numbers) (O'Neill et al. 2014). Table 2.1 illustrates examples of driving forces used in the characterization of the SSPs, focusing on determinants potentially influencing climate change mitigation and adaptation outcomes (O'Neill et al. 2014).

Table 2.1: Examples of key driving forces of SSPs potentially influencing climate change adaptation and mitigation outcomes (Source: O'Neill et al. 2014)

| DRIVING FORCE | EXAMPLE |
|---|---|
| Demographics | • Population and age structure<br>• Urban versus rural populations, and urban forms<br>• Coastal versus inland populations |
| Economic development | • Gross Domestic Product (GDP)<br>• Distribution of GDP, including economic catch-up by developing countries<br>• Sectoral structure of economies, especially share of agriculture, and agriculture land productivity<br>• Share of population in extreme poverty<br>• Nature of international trade |
| Welfare | • Human development<br>• Educational attainment<br>• Health, including access to public health and health care facilities |
| Environmental and ecological factors | • Air, water, and soil quality<br>• Fossil fuel resources and renewable energy potentials<br>• Other key natural resources |
| Institutions and governance | • Existence, type, and effectiveness of institutions<br>• Degree of participation<br>• Rule of law |
| Technological development | • Type (slow, rapid, transformational) and direction (environmental efficiency, productivity improving) of technical progress |
| Broader societal factors | • Attitude to environment/sustainability/equity and world views<br>• Lifestyles (including diets)<br>• Societal tension and conflict levels |
| Policies | • Non-climate policies including development policies, technology policies, urban planning and transportation policies, energy security policies, and environmental policies to protect air, soil, and water quality. It is possible that SSPs could be specified partly in terms of policy objectives, such as strong welfare-improving goals, rather than specific policy targets or measures |

Five SSPs for climate change research have been developed as summarised in Table 2.2 (Riahi et al. 2017). These were then described in terms of various elements that address aspects of the selected driving forces.

Table 2.2: Summary of the five SSPs developed for application in climate change research (Source Riahi et al. 2017)

| SCENARIO | ELEMENT (DRIVING FORCE) DESCRIPTION |
|---|---|
| SSP 1 Sustainability – Taking Green Road | • World shifts gradually, but pervasively, toward more sustainable path, emphasizing more inclusive development respecting perceived environmental boundaries<br>• Management of global commons slowly improves, educational and health investments accelerate demographic transition, and emphasis on economic growth shifts toward a broader emphasis on human well-being<br>• Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries<br>• Consumption is oriented toward low material growth and lower resource and energy intensity. |
| SSP2 Middle of Road | • World follows a path in which social, economic, and technological trends do not shift markedly from historical patterns<br>• Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations<br>• Global and national institutions work toward but make slow progress in achieving sustainable development goals<br>• Environmental systems experience degradation, although there are some improvements, but overall, intensity of resource and energy use declines<br>• Global population growth is moderate and levels off in second half of century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain |
| SSP3 Regional Rivalry – A Rocky Road | • A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues<br>• Policies shift over time to become increasingly oriented toward national and regional security issues<br>• Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline<br>• Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time<br>• Population growth is low in industrialized and high in developing countries<br>• Low international priority for addressing environmental concerns leads to strong environmental degradation in some regions |
| SSP4 Inequality – A Road Divided | • Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries<br>• Over time, a gap widens between an internationally connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour intensive, low-tech economy.<br>• Social cohesion degrades and conflict and unrest become increasingly common<br>• Technology development is high in the high-tech economy and sectors<br>• Globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources<br>• Environmental policies focus on local issues around middle- and high-income areas. |
| SSP5 Fossil-fuelled Development – Taking Highway | • World places increasing faith in competitive markets, innovation, and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development<br>• Global markets are increasingly integrated and strong investments in health, education, and institutions to enhance human and social capital<br>• At same time, push for economic and social development is coupled with exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles<br>• All factors lead to rapid growth of global economy, while global population peaks and declines in 21st century<br>• Local environmental problems like air pollution are successfully managed<br>• Faith in ability to effectively manage social and ecological systems, including by geo-engineering if necessary |

Key indicators that were used to depict outcomes or implications of SSPs under different climate change projections, using a set of integrated assessment models, included:

- Energy supply and demand
- Land-use and land cover change
- Green-house gas emissions
- Air pollution and aerosol emissions
- Mitigations costs.

### 2.1.3.2 Land-use Scenario Analysis

Scenario analysis is also widely used to study probable outcomes in land-use change, specifically as it relates to sustainable agriculture and feeding the globe (Alcamo et al. 2008). An array of scenarios has been developed within the context of a range of possible drivers (Table 2.3), typically benchmarked against 'business-as-usual' scenarios.

Table 2.3: Typical drivers and indicators (expression of outcome change) used in land-use scenario analysis (Alcamo et al. 2008)

| DRIVING FORCE | INDICATOR |
|---|---|
| • Demographic<br>– Population size including migration<br>– Size of urban versus rural population<br>• Economic<br>– Average per capita income<br>– Biofuel demand<br>– Food demand<br>– Food/crop prices<br>– Food trade<br>– Status of land tenure/farm size<br>• Technological and Biophysical<br>– Crop yield<br>– Accessibility (infrastructure, travel distance)<br>– Climate<br>– Soil characteristics<br>– Topography<br>• Other Social Factors<br>– Food preferences<br>– Types of governance<br>– Educational level | Land-cover (area change) in terms of:<br>• Urban<br>• Forest<br>• Crop production<br>• Biofuel production<br>• Grassland |

### 2.1.3.3 Port's Role in reducing Green-house Gas Emissions from Ships

A port specific example is provided by a study conducted by Winnes et al. (2015) who used scenario analysis to quantify potential reductions of ships' emissions of green-house gas (GHG) emissions in response to different measures adopted by ports. Their key driving forces included ship traffic and design, fuel options, power supply in ports, ship speeds and port operations (e.g., vessel turnaround times, ship maneuvering) (Table 2.4).

Table 2.4: Driving forces and indicator (expression of outcome change) used in Port GHG emission reduction scenario analysis (Winnes et al. 2015)

| DRIVING FORCE | INDICATOR |
|---|---|
| • Ship traffic and design<br>• Fuel options<br>• Power supply in ports<br>• Ship speeds and operations in port (e.g., turn-over times, manoeuvring) | $CO_2$ emission reduction |

The analysis defined three possible scenarios as summarized in Table 2.5 (Winnes et al. (2015).

Table 2.5: Summary of scenarios used in Port GHG emission analysis (Source: Winnes et al. 2015)

| SCENARIO | DRIVING FORCE |
|---|---|
| Business-as-Usual | Current emissions based on:<br>• Current ship ages<br>• Current fuel practice |
| Scenario 1 'Fuel' | Reduction in emissions through potential fuel shifts:<br>• Liquefied natural gas<br>• Liquefied biogas<br>• Methanol<br>• Bio methanol<br>• On-shore power supply (OPS) |
| Scenario 2 'Design' | Efforts to attract modern ships with more energy efficient designs:<br>• Only modern ships<br>• Ship design improvements (only small ships) |

| SCENARIO | DRIVING FORCE |
|---|---|
| Scenario 3 'Operations' | Improved operations in terms of:<br>• Reduced speed<br>• Reduced lay time at berth<br>• Reduced lay time at anchor<br>• Eco-driving during manoeuvring<br>• Faster connection to OPS |

In this instance the indicator by which outcomes were measured was $CO_2$ emission reduction (Table 2.4). Ultimately, the Business-as-usual (BAU) scenario projected a 40% increase in GHC emissions by 2030 from a 2010 baseline, while Scenario 3 ('Operations') projected the highest reduction in emissions at 10% lower than BAU levels.

## 2.2 Port Performance & Sustainability Indicators

Numerous studies have engaged in the establishment of green performance or sustainability indicators[1] for application in ports (e.g., Chiu et al. 2014; González Laxe et al. 2016; Lu et al. 2016; Schipper et al. 2017; Chen and Pak 2017; Stein and Acciaro 2020).

Chiu et al. (2014) reviewed academic studies and practical experience of several port authorities to identify a set of key factors (as indicators) constituting sustainability in relation to green port operations. Focusing on in-port operation and development planning, specifically *energy conservation, environmental protection, and ecology care*, they categorised the key factors into air pollution, water pollution, noise pollution, land and sediments pollution, materials selection, water consumption, energy usage, general waste handling, hazardous waste handling, habitat quality and greenery, community promotion, education and port staff training. They used a fuzzy Analytical Hierarchy Process (AHP) model to evaluate port performance. AHP is a popular technique used to model subjective decision-making processes based on multiple attributes. Twenty-six experts evaluated the performance of three major ports in Taiwan using fuzzy linguistic rules ('very poor', 'poor', 'normal', 'good', very good') in terms of the selected criteria (indicators). Their approach comprised the following steps:

- Step 1: Set up hierarchy system, decomposing issues into a hierarchy of interrelated decision elements (see Figure 2.3)
- Step 2: Generate input data consisting of a pairwise comparison matrix to find the comparative weight among decision elements
- Step 3: Synthesize judgment and estimate relative weight of decision elements
- Step 4: Aggregate decision elements as per allocated weighting too obtain rating for performance (e.g., rating effectiveness of various policies/strategies)

[1] *The concept of 'Sustainable Port Development' builds on that of 'Green Port' and includes considerations of social sustainability, advocating the need for port development to balance economic growth, environmental protection, and social progress to secure its long-term future (Hiranandani 2014).*

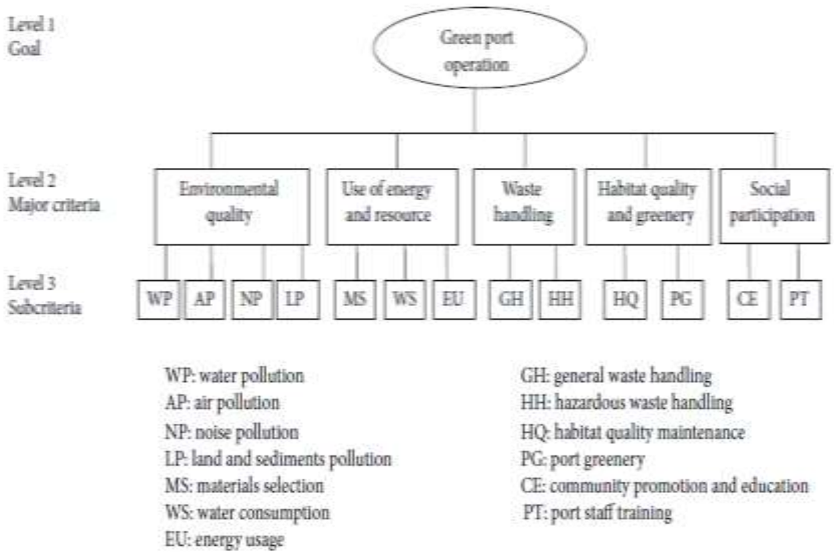


Figure 2.3 Hierarchical model for green port performance assessment (Source: Chiu et al. 2014)

To establish links between the *economic and environmental* dimensions of sustainable development, and port size and operations in Spanish ports, González Laxe et al. (2016) used cluster analysis to establish the influence of port size and operations on environmental and economic outcomes. Their indicators in the environmental dimension were organised into three categories, namely environmental management, eco-efficiency, and environmental quality, while their economic indicators were organised into economic structure, and business and servicing. They also provide useful metrics for measuring these indicators. A study by Lu et al. (2016) distilled and grouped a set of sustainability indicators into four sustainability assessment factors, namely *environmental* material (11), *economic* issues (6), environmental practices (6), and *social* concerns (6) but did not revert to finer categorisation. The indicators were then applied to a selection of ports, in consultation with stakeholders, to prioritise importance in terms of the four sustainability assessment factors (implicitly across the environment, social and economic dimensions).

Schipper et al. (2017) distilled a set of *social, economic, and environmental* key performance indicators to evaluate and interpret future sustainable port-city development *plans* but did not focus on operational performance. Using evidence-based knowledge scoring, these indicators were organised and aggregated into sustainable social-, environmental-, and economic-sustainable measures scores, and then combined into an overall Sustainable Integrated Condition Index. Using this approach, they were able to compare future sustainability based on development planning in a selection of ports across the world. Focusing on green performance, Chen and Pak (2017) identified a set of evaluation indicators for Chinese ports using the Delphi technique and covering mostly *environmental* aspects. Twenty-one green performance indicators were prioritised and categorised in six dimensions, namely liquid pollution management, air pollution management, noise control, low carbon regulations and energy savings, marine biology preservation, and organization and management.

Following a comprehensive, systematic review of international literature covering sustainability assessments in the port sector, Stein and Acciaro (2020) proposed a set of measures (or indicators) to assist ports in assessing corporate sustainability. As in most other examples, their primary dimensions were *environmental, social,* and *economic*. Focusing on indicators from the literature, they grouped indicators within each of these dimensions into several categories, that is environment: water pollution management (4), eco-efficiency (8) and air pollution management (8); social: community impact (5), employment quality (3), legal and political benefits (5); and economic: income and profitability (6), service quality (5) and macro-value (5). Their listing of measurement modes, such as answering a simple existing/non-existing question, is also useful. These are embedded into a corporate sustainability measurement framework for ports to empirically assess the effectiveness of corporate sustainability actions towards environmental, social, or economic value creation (Figure 2.4).

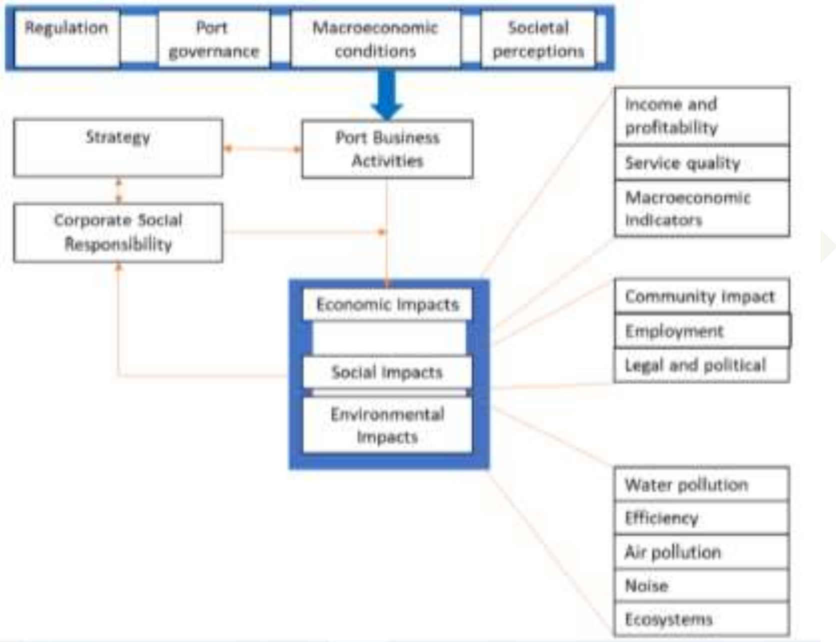


Figure 2.4 Conceptual framework for assessment of Corporate Sustainability in ports (Source: Stein and Acciaro 2020)

Based on these studies, significant commonalities emerge in the array of indicators previously used in port performance and sustainability assessment. Most studies organised indicators into the three interconnected sustainability dimensions: environment, social, and economic. Within each of these dimensions, popular sustainability outcomes included *pollution management, biodiversity and habitat protection, eco-efficiency, community well-being, employee wellbeing*, and *sustainable economic growth and development.* Indicators linked to these outcomes focused on planning efforts, implementation of supporting programmes, and implementation of sustainable technologies. As a measure of the efficiency of plans, programmes and technologies, some studies also included status indicators to reflect the actual condition the environment, social cohesion and economic competitiveness. The scenario analysis that is the subject of this study focused specifically on status indicators as these ultimately reflect the true outcome of sustainability efforts.

# 3 SCENARIO ANALYSIS FOR WIO PORTS

## 3.1 Approach and Method

The WIO region supports a vast array of ports across ten countries. These range from small fishing ports to large commercial ports (see Situation Assessment Report). Depending on their nature, and specific countries' legislation and policies, these ports are subject to a diversity of development and operational practices. This makes a detailed, quantitative scenario analysis approach, representative of specific ports in the region extremely difficult. Detailed information and numerical data on present and future port planning and operations, required for informed quantitative scenario analyses, are not readily available in the region. It was therefore proposed that a qualitative scenario analysis approach be adopted for this study, based on easily understandable narratives describing a range of generic future scenarios for port development in the WIO region, including the 'business-as-usual' scenario and a selection of sustainable green port development options. Further, it was proposed that scenarios be expressed as anticipatory scenarios, describing specific visions of the future (e.g., anticipated outcomes of a worst case, best case, and business-as-usual scenario by 2030/50) rather than following an exploratory approach requiring an evaluation of outcome trends into the future (e.g., outcome trends of a worst case, best case, and business-as-usual scenario anticipated up to 2030/50).

The scenario development and analysis process adopted here, followed six steps (adopted from Alcamo 2001; Alcamo and Henrichs 2008), namely:

Step 1: Define perspective and context of scenario exercise

For this study the context of the scenario analysis was to *conduct scenario analyses on development options from business-as-usual to options that incorporate environmental considerations to make a business case for sustainability/limiting impacts to the environment arising from port development.*

Step 2: Identify key driving forces likely to shape future outcomes

Following consultation with stakeholders in the WIO region in a workshop forum (August 2022, Dar es Salaam), it was acknowledged that driving forces comprise both external and internal driving forces. As a result, both these were identified as part of this assessment (see Tables 3.1 and 3.2). Internal driving forces and associated key issues pertaining to port development in the WIO regions were also verified with stakeholders at the Dar es Salaam workshop.

Step 3: Identify key sustainability criteria (or indicators) by which to measure sustainability outcomes

For this study key sustainability criteria (or indicators) to measure outcomes were drawn from those applied in green port performance indices or port sustainability assessment indices (e.g., Chiu et al. 2014; González Laxe et al. 2016; Lu et al. 2016; Schipper et al. 2017; Chen and Pak 2017; Stein and Acciaro 2020). These were organized into the three *common* sustainability pillars: environmental, social, and economic, to gauge sustainability 'patterns' across future scenarios (see Table 3.3). The list of key sustainability indicators was verified with stakeholders in the WIO region at an in-person meeting (August 2022, Dar es Salaam).

Step 4: Define possible outcomes for selected driving forces

A set of scenarios was built for future of ports development and planning in the WIO region, ranging from 'doing nothing case' to 'supporting sustainable ports' scenario. Each of these scenarios was expressed as a narrative of anticipated trajectories in the selected driving forces and associated issues that were identified by stakeholders.

Step 5: Define anticipated effect of driving force trajectories on selected sustainability indicators

As input to the scenario analysis process, matrices were constructed to rate the anticipated influence, or effect, of various driving force trajectories on each of the selected sustainability indicators. This was necessary to ensure that during the process participants had a common understanding on the expected influence of specific driving force trajectories, which were then integrated using a weighting system.

Step 6: Build scenarios and determine expected sustainability outcomes

In this final step the results from Steps 4 and 5 were aggregated to obtain overall ratings for each scenario, based on its combination of driving force trajectories, and associated effects on sustainability indicators, using an integrated condition index.

## 3.2 Selection of Parameters & Scenarios

### 3.2.1 Key driving forces

Driving forces likely to shape outcomes in port planning and operations in future comprise both external and internal forces. External driving forces relate to factors that are outside the control of port authorities, for example climate change and international market perspectives, growth, and demand. Internal driving forces primarily related to aspects that are within the control of port authorities, such as future port planning and development outcomes. The key envisaged external drivers to influence port planning and development outcomes are:

- Climate Change
- Shipping traffic in WIO Region
- Societal pressure
- International market views

Drawing on international learning relevant to port environments, internal driving forces for inclusion in the WIO port scenario analysis were proposed and motivated for consideration at a stakeholder workshop held in Dar es Salaam, August 2022. The driving forces that were agreed upon for this study are presented in Table 3.1. Specific issues in each of these driving forces categories, relevant in the WIO region, were workshopped with stakeholders (August 2022, Dar es Salaam). These are summarised in the attached Appendix.

Table 3.1: Summary of internal driving forces

| DRIVING FORCE | MOTIVATION |
|---|---|
| Corporate culture and policies | • Economic development direction chosen by ports might influence their ability to balance environmental and social sustainability<br>• Extent to which ports incorporate environmental and social accountability in official policies influences the extent to which port officials can enforce sustainable practices |
| Institutional arrangements | • Establishment of dedicated and empowered institutions (e.g., environment departments in ports) provides a platform to enforce policies and coordinate activities<br>• Extent to which ports communicate and consider wellbeing of local communities/city (in and around ports) will determine social sustainability, as well as level of potential conflict to be dealt with |
| Technological development | • Fuel and energy sources will determine efforts towards climate change mitigation,<br>• Technology development and adoption will influence a ports ability to address and mitigate impacts such as air, water and soil pollution, and destruction of coastal habitats and biota |

| DRIVING FORCE | MOTIVATION |
|---|---|
| Operational efficiency | • Skills, capacity and access to funding is directly correlated to effective implementation of sound environmental/social policies<br>• Level of enforcement determines extent to which port authorities can ensure compliance with environmental/social policies |

### 3.2.2 Key sustainability indicators

An array of performance and sustainability indicators have been developed for application in ports (see Section 2.2). For this analysis, we focus specifically on status indicators as these ultimately reflect the true outcomes of sustainability efforts. The key sustainability indicators chosen for this scenario analysis (as verified with stakeholders at the August 2022 Dar es Salaam workshop forum) fell into three key pillars of sustainability (environment, social and economic, Table 3.2). Therefore, while this scenario analysis has a strong focus on environmental and social aspects, it includes economic indicators that could be driven by a port's level of environmental and social accountability.

Table 3.2: Summary of key sustainability indicators

| INDICATOR | MOTIVATION |
|---|---|
| ENVIRONMENT | |
| GHG emissions | Commitment to climate change mitigation |
| Status of air quality | Commitment to manage and control atmospheric emissions |
| Status of port environmental quality | Commitment to manage and control wastewater, solid waste, and hazardous waste |
| Status of biodiversity & habitat intactness | Commitment to manage port infrastructure development and operations to protect biodiversity and habitat integrity (e.g., implementing biodiversity trade-off policies) |
| SOCIAL | |
| Community Well-being vs Conflict | Commitment to considering community needs, and their involvement in port matter that may affect their livelihoods |
| Port-City Collaboration vs Conflict | Commitment to consult and collaborate with adjacent urban centers |
| ECONOMIC | |
| Climate resilience | Commitment to consider climate change such as increased storminess, SLR etc. |
| Competitiveness (license-to-operate) | Level to which port environmental and social practices enable competitiveness (linked to international and client pressures re sustainability) |

### 3.2.3 Develop possible outcomes for selected driving forces

For this study, expected outcomes of external driving forces were constant across all Scenarios with expected outcomes assumed for this analysis captured in Table 3.3.

Table 3.3: Summary of key external driving forces anticipated to influence port planning, development, and operation outcomes by 2035/50

| EXTERNAL DRIVING FORCE | EXPECTED OUTCOME BY 2035/50 |
|---|---|
| Climate Change | 0.5 m SLR (from 2000 to 2050, assuming a ~1m rise by 2100 - Horton et al. 2020) together with a probable increase in occurrence and intensity of sea-storms |
| Shipping traffic in WIO Region | Shipping traffic to increase markedly, with an associated increase in port traffic |
| Societal pressure | Local societies, supported by international non-government organisations (NGOs), are increasingly empowered to challenge environmental and social decline |
| International market views | Increased international pressure for environmental/social accountability in ports, and therefore more effective competition in port market as 5th generation ports |

Focus was rather given to potential variations in internal driving forces that are within the control of port authorities. Insufficient qualitative data are available on ports in the WIO region to perform a detailed, quantitative scenario analysis. It was therefore decided to present scenarios as narratives, comprising a combination of trajectories across the four driving forces. Based on the key issues identified within the different internal driving force categories by stakeholders (see Appendix) possible outcomes were defined (Table 3.4) for consideration in the construct of the future scenarios (by 2030/50) for port development in the WIO region.

Table 3.4: Potential internal driving force outcomes for consideration in the construct of the future scenarios (by 2030/50) for port development in the WIO region

| DRIVING FORCE | | POTENTIAL OUTCOME |
|---|---|---|
| Corporate culture and policies | A | 'Doing nothing': Effective environmental monitoring/auditing and disaster intervention preparedness (e.g., oil spills) are lacking due to insufficient funding, lack of training and capability development. Lack of management commitment to environmentally operational efficiency. |
| | B | 'Going Greener with climate change mitigation/adaptation': In response to global demand for environmental accountability to secure/grow their market share, port managers implement and enforce overarching policies for greener ports focusing on energy efficiency and renewable energy. These are also reflected in lease agreements with private sector tenants. Lost revenue and rising infrastructure maintenance costs because of climate change impacts convince port authorities to act to increase climate resilience of port infrastructure and operations. However, pollution, waste and wastewater management and control remain neglected. Ports still disregard societal responsibilities, reflected in uncoordinated spatial planning for port development and expansions impacting adjacent communities/cities. |
| | C | 'Going Greener with improved pollution management': In response to global demand for environmental accountability to secure/grow their market share, port managers implement and enforce overarching policies for greener ports focusing on pollution (waste and wastewater management and control). These are also reflected in lease agreements with private sector tenants. Energy efficiencies and renewable energy issues remain neglected and port authorities fail to act to increase climate resilience of port infrastructure and operations. Ports still disregard societal responsibilities, reflected in uncoordinated spatial planning for port development and expansions impacting adjacent communities/cities. |
| | D | 'Supporting sustainable ports': In response to global demand for environmental accountability to secure/grow their market share, port managers implement and enforce overarching policies for greener ports. These are also reflected in lease agreements with private sector tenants. Lost revenue and rising infrastructure maintenance costs because of climate change impacts convince port authorities to act to increase climate resilience of port infrastructure and operations. Pressure from increasingly empowered communities/cities and resulting delays in development projects (with serious cost implications) necessitates port authorities to undertake joint, strategic and integrated spatial planning of port development and expansion. |
| Institutional arrangements | A | 'Doing nothing': Silo-based management within authorities prevails, with no dedicated port environmental department, resulting in uncoordinated planning and management, often with costly consequences (duplication of efforts, critical issues not addressed). No formal institutional structures in place to coordinate activities across port users, risking potential detrimental environmental, social and economic consequences, especially during disasters and emergencies. No forums in place as platforms to facilitate communication and collaboration between port authorities and adjacent communities/cities. |
| | B | 'Going Greener with climate change mitigation/adaptation': The financial and logistical value of functional cross-sectoral institutional structures for cooperative port environmental planning and operations is acknowledged. Dedicated port environmental departments are established and resourced, focusing on climate change mitigation/adaptation. These help drive increased climate resilience of port infrastructure and operations. Increasing global pressure on ports (and port tenants) to account for their social and environmental responsibilities necessitates the establishment of dedicated institutional structures to communicate, coordinate and audit port user performance. Integrated climate change forums are established within port structures. However, dedicated forums to facilitate collaboration/communication between port authorities and adjacent communities/cities are still lacking. |
| | C | 'Going Greener with improved pollution management': The financial and logistical value of functional cross-sectoral institutional structures for cooperative port environmental planning and operations is acknowledged. Dedicated port environmental departments are established and resourced, focusing on pollution management. However, integrated climate change forums are not established within port structures, and climate resilience of port infrastructure and operations is not increased. Increasing global pressure on ports (and port tenants) to account for their social and environmental responsibilities necessitates the establishment of dedicated institutional structures to communicate, coordinate and audit port user performance. Dedicated forums to facilitate collaboration/communication between port authorities and adjacent communities/cities are also still lacking. |
| | D | 'Supporting sustainable ports': The financial and logistical value of functional cross-sectoral institutional structures for cooperative port environmental planning and operations is acknowledged. Dedicated port environmental departments are established and resourced. Increasing global pressure on ports (and port tenants) to account for their social and environmental responsibilities necessitates the establishment of dedicated institutional structures to communicate, coordinate and audit port user performance. Integrated climate change forums are established within port structures. These helps drive increased climate resilience of port infrastructure and operations. Pressure from increasingly empowered communities/cities (which otherwise object to and delay development projects with serious cost implications) necessitates port authorities to establish dedicated institutional structures to facilitate collaboration with society at large. |
| Technological development | A | 'Doing nothing': Energy efficient technologies (e.g., cold ironing) are not implemented and no investment is made in renewable energy. Ports remain strongly reliant on fossil fuels. Innovative waste and wastewater management technologies are also absent, resulting in coastal water and air pollution. Vessel turnover times are long due to poor vessel traffic management and inefficient traffic and cargo handling technologies. |
| | B | 'Going Greener with climate change mitigation/adaptation': In response to global demand for environmental accountability to secure/grow their market share, port managers implement and enforce overarching policies for greener ports focusing on energy efficiency and renewable energy. These are also reflected in lease agreements with private sector tenants. Lost revenue and rising infrastructure maintenance costs because of climate change impacts convince port authorities to act to increase climate resilience of port infrastructure and operations. However, pollution, waste and wastewater management and control remain neglected. Ports still disregard societal responsibilities, reflected in uncoordinated spatial planning for port development and expansions impacting adjacent communities/cities. |
| | C | 'Going Greener with improved pollution management': Pressure from empowered adjacent communities/cities necessitates port investment and implementation of innovative waste and wastewater management technologies to combat coastal water, air and land pollution. Port authorities fail to act to increase climate resilience of port infrastructure and operations and energy efficiencies and renewable energy issues remain neglected. Investment in renewable energy sources and technologies to improve port energy and logistical efficiencies is not made. Customer dissatisfaction remains high and ports lose competitiveness. |
| | D | 'Supporting sustainable ports': Pressured by global demand for environmental accountability and to secure/grow their market share, ports focus on globally visible technological interventions linked to energy efficiency and renewable energy sources (this might also occur due to fossil fuel becoming increasingly expensive). Customer dissatisfaction (e.g., because of long vessel turnaround time) forces port authorities to invest in technologies for improved efficiencies. Pressure from empowered adjacent communities/cities (which otherwise result in increasingly costly legal conflicts) necessitate port authorities to implement innovative waste and wastewater management technologies to combat coastal water, air and land pollution. |
| | A | 'Doing nothing': Effective environmental monitoring/auditing and disaster intervention preparedness (e.g., oil spills) are lacking due to inefficient funding, lack of training and capability development. Lack of management commitment to environmentally operational efficiency. |

| DRIVING FORCE | | POTENTIAL OUTCOME |
|---|---|---|
| Operational efficiency | B | 'Going Greener with climate change mitigation/adaptation': Global pressure for greater environmental accountability necessitates port authorities to implement and enforce environmental monitoring/auditing processes (focusing on energy efficiency and renewable energy sources). Improved environmental practices open selected funding opportunities with investors interested in sustainable port development (e.g., public-private partnerships). Lost revenue and rising infrastructure maintenance costs because of climate change impacts convince port authorities to act to increase climate resilience of port infrastructure and operations. Investment is also made in training and capacity development to focus on energy efficiency and renewable energy, but not on pollution (waste and wastewater management and control). |
| | C | 'Going Greener with improved pollution management': Global pressure for greater environmental accountability and growing need to acquire port environmental certification (e.g., ISO14001) compel port authorities to implement and enforce environmental monitoring/auditing processes focusing on pollution (waste and wastewater management and control). Improved pollution management enables port authorities to identify polluters and direct cost recoveries to their accounts (polluter pays principle) leading to improved compliance with waste regulations. Improved environmental practices open selected funding opportunities with investors supporting sustainable port development (e.g., public-private partnerships). However, energy efficiencies and renewable energy issues remain neglected and port authorities fail to act to increase climate resilience of port infrastructure and operations. Investment in training and capacity development focusses on pollution (waste and wastewater management), but not energy efficiency and renewable energies. |
| | D | 'Supporting sustainable ports': Global pressure for greater environmental accountability and growing need to acquire port environmental certification (e.g., ISO14001) compel port authorities to implement and enforce environmental monitoring/auditing processes. Higher port traffic increases the risk of costly disasters, necessitating authorities to invest in improved disaster preparedness procedures. Improved pollution management enables port authorities to identify polluters and direct cost recoveries to their accounts (polluter pays principle) leading to improved compliance with waste regulations. Significantly improved environmental practices open lucrative funding opportunities with investors wanting to support sustainable port development (e.g., public-private partnerships). Port authorities acknowledge the value of greener ports and the critical importance of adequately trained and motivated staff, to secure long-term (sustainable) economic growth. |

The anticipated influence of these driving force trajectories on the selected sustainability indicators was scored using a 5-point scaling (-2 to +2) (Table 3.5) where the influence was scored as:

- -2 = strong negative influence expected
- -1 = some negative influence expected
- 0 = no marked influence expected
- 1 = some positive influence expected
- 2 = strong positive influence expected.

Table 3.5: Anticipated influence of driving force trajectories on selected sustainability indicators (-2 = strong negative influence expected; -1 = some negative influence expected; 0 = no marked influence expected; 1 = some positive influence expected; 2 = strong positive influence expected)

| INDICATOR | | EXPECTED INFLUENCE OF TRAJECTORY | | | |
|---|---|---|---|---|---|
| | | [A] | [B] | [C] | [D] |
| CORPORATE CULTURE & POLICIES | | | | | |
| 1 | GHG emissions | -2 | 2 | -2 | 2 |
| 2 | Status of Air Quality | -2 | 1 | 1 | 2 |
| 3 | Status of Port Environmental Quality | -2 | -2 | 2 | 2 |
| 4 | Status of Biodiversity & Habitat Intactness | -2 | -2 | 2 | 2 |
| 5 | Community relationship | -2 | -1 | 1 | 2 |
| 6 | Port-City collaboration | -2 | -1 | 1 | 2 |
| 7 | Climate resilience | -2 | 2 | -2 | 2 |
| 8 | Competitiveness | -2 | 1 | 0 | 2 |
| INSTITUTIONAL ARRANGEMENTS | | | | | |
| 1 | GHG emissions | -2 | 1 | 1 | 2 |
| 2 | Status of Air Quality | -2 | 1 | 1 | 2 |
| 3 | Status of Port Environmental Quality | -2 | 1 | 1 | 2 |
| 4 | Status of Biodiversity & Habitat Intactness | -2 | 1 | 1 | 2 |
| 5 | Community relationship | -2 | -1 | -1 | 2 |
| 6 | Port-City collaboration | -2 | -1 | -1 | 2 |
| 7 | Climate resilience | -2 | 2 | -2 | 2 |
| 8 | Competitiveness | -2 | 1 | 0 | 2 |
| TECHNOLOGICAL DEVELOPMENT | | | | | |
| 1 | GHG emissions | -2 | 2 | -2 | 2 |
| 2 | Status of Air Quality | -2 | 1 | 1 | 2 |
| 3 | Status of Port Environmental Quality | -2 | -2 | 2 | 2 |
| 4 | Status of Biodiversity & Habitat Intactness | -2 | -2 | 2 | 2 |
| 5 | Community relationship | -2 | -1 | 2 | 2 |
| 6 | Port-City collaboration | -2 | -1 | 1 | 2 |
| 7 | Climate resilience | -2 | 2 | -2 | 2 |

| INDICATOR | | EXPECTED INFLUENCE OF TRAJECTORY | | | |
|---|---|---|---|---|---|
| | | [A] | [B] | [C] | [D] |
| 8 | Competitiveness | -2 | 1 | 0 | 2 |
| OPERATIONAL EFFICIENCY | | | | | |
| 1 | GHG emissions | -2 | 2 | -2 | 2 |
| 2 | Status of Air Quality | -2 | 1 | 1 | 2 |
| 3 | Status of Port Environmental Quality | -2 | -2 | 2 | 2 |
| 4 | Status of Biodiversity & Habitat Intactness | -2 | -2 | 2 | 2 |
| 5 | Community relationship | -2 | -1 | 2 | 2 |
| 6 | Port-City collaboration | -2 | -1 | 1 | 2 |
| 7 | Climate resilience | -2 | 2 | -2 | 2 |
| 8 | Competitiveness | -2 | 1 | 0 | 2 |

Further, the relative on influence on sustainability indicators may be different across internal driving forces. It is therefore important to also weight relative influence as illustrated in Table 3.6.

Table 3.6: Illustration of relative influence of internal driving forces on various sustainability indicators, also including weighting of indicators within domains, and weighting of domain towards overall sustainability score

| INTERNAL DRIVING FORCE CATEGORY | WEIGHTING (EXPECTED RELATIVE INFLUENCE) OF DRIVING FORCE CATEGORY ON SPECIFIC INDICATORS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | GHG emissions | Status of Air Quality | Status of Port Environmental Quality | Status of Biodiversity & Habitat Intactness | Community relationship | Port-City collaboration | Climate resilience | Competitiveness |
| 1. Corporate culture and policy | 0.20 | 0.30 | 0.30 | 0.30 | 0.40 | 0.30 | 0.40 | 0.20 |
| 2. Institutional arrangements | 0.10 | 0.10 | 0.10 | 0.10 | 0.30 | 0.40 | 0.10 | 0.10 |
| 3. Technological development | 0.40 | 0.30 | 0.30 | 0.30 | 0.10 | 0.10 | 0.40 | 0.30 |
| 4. Operational efficiency | 0.30 | 0.30 | 0.30 | 0.30 | 0.20 | 0.20 | 0.10 | 0.40 |

| INDICATOR | WEIGHTING |
|---|---|
| GHG emissions | 0.25 |
| Status of Air Quality | 0.25 |
| Status of Port Environmental Quality | 0.25 |
| Status of Biodiversity & Habitat Intactness | 0.25 |
| Community relationship | 0.50 |
| Port-City collaboration | 0.50 |
| Climate resilience | 0.50 |
| Competitiveness | 0.50 |

| DOMAIN | WEIGHTING |
|---|---|
| Environment | 0.60 |
| Social | 0.20 |
| Economic | 0.20 |

## 3.2.4 Build scenarios and determine expected sustainability outcomes

Using combinations of the potential driving force outcomes, a series of possible future scenarios for port development in the WIO region was constructed (Table 3.7).

Table 3.7: Construct of proposed future scenarios (by 2030/50) for port development in the WIO region, combining possible internal driving force outcomes (see Table 3.4)

| SCENARIO | | COMBINATION OF INTERNAL DRIVING FORCE OUTCOMES | |
|---|---|---|---|
| 1 | 'Doing nothing' | Corporate culture and policies | (A) 'Doing nothing' |
| | | Institutional arrangements | |
| | | Technological development | |
| | | Operational efficiency | |
| 2 | 'Fixing only institutions' | Corporate culture and policies | (A) 'Doing nothing' |
| | | Institutional arrangements | (D) 'Supporting sustainable ports' |
| | | Technological development | (A) 'Doing nothing' |
| | | Operational efficiency | |
| 3 | 'Fixing only policies & institutions' | Corporate culture and policies | (D) 'Supporting sustainable ports' |
| | | Institutional arrangements | |
| | | Technological development | (A) 'Doing nothing' |
| | | Operational efficiency | |
| 4 | 'Fixing only policies & technologies' | Corporate culture and policies | (D) 'Supporting sustainable ports' |
| | | Institutional arrangements | (A) 'Doing nothing' |
| | | Technological development | (D) 'Supporting sustainable ports' |
| | | Operational efficiency | (A) 'Doing nothing' |

| SCENARIO | | COMBINATION OF INTERNAL DRIVING FORCE OUTCOMES | |
|---|---|---|---|
| 5 | 'Going Greener with climate change mitigation/ adaptation' | Corporate culture and policies | (B) 'Going Greener with climate change mitigation/ adaptation' |
| | | Institutional arrangements | |
| | | Technological development | |
| | | Operational efficiency | |
| 6 | 'Going Greener with improved pollution management' | Corporate culture and policies | (C) 'Going Greener with improved pollution management' |
| | | Institutional arrangements | |
| | | Technological development | |
| | | Operational efficiency | |
| 7 | 'Fixing only policies, institutions & technologies' | Corporate culture and policies | (D) 'Supporting sustainable ports' |
| | | Institutional arrangements | |
| | | Technological development | |
| | | Operational efficiency | (A) 'Doing nothing' |
| 8 | 'Fixing only policies, technologies & operations' | Corporate culture and policies | (D) 'Supporting sustainable ports' |
| | | Institutional arrangements | (A) 'Doing nothing' |
| | | Technological development | (D) 'Supporting sustainable ports' |
| | | Operational efficiency | |
| 9 | 'Supporting sustainable ports' | Corporate culture and policies | (D) 'Supporting sustainable ports' |
| | | Institutional arrangements | |
| | | Technological development | |
| | | Operational efficiency | |

## 3.3 Analysis WIO Port Scenarios

Assuming external driving forces (Table 3.1) remain the same across all scenarios, internal driving force outcomes were analysed based on the combination of outcomes allocated to each scenario (Table 3.5). First, the anticipated influence of selected outcomes on each of the sustainability indicators were obtained using Table 3.8. Weightings were then allocated to reflect the relative influence of internal driving forces on an indicator to obtain indicator ratings per scenario using weighted averages. In turn, the indicators within the environment, social and economic domains were weighted to obtain domain ratings per scenario using weighted averages. Finally, domain ratings were weighted and averaged to obtain an overall sustainability rating per scenario (Table 3.8). To provide for easier interpretation, the indicators, domain, and overall sustainability ratings were normalized within a range from 0 to 100, where scores below 50 were indicative of a negative sustainability trajectory and score above 50 a positive sustainability trajectory.

Figure 3.1 presents a comparison of the expected sustainability outcomes of various future scenarios (by 2030/50), where scores above 50 represent more sustainable positive trajectories and scores below 50 are indicative of less sustainable negative trajectories. Scenario 1 ('Doing nothing') and Scenario 9 ('Supporting sustainable ports') represent the two extreme situations where port authorities either disregard any actions towards sustainable development (Scenario 1) or where port authorities diligently implement interventions to achieved sustainability (Scenario 9). While these extremes are unlikely to be realistic outcomes, they provides the relative end points against which to better calibrate intermediate interventions (i.e. Scenarios 2 to 8).

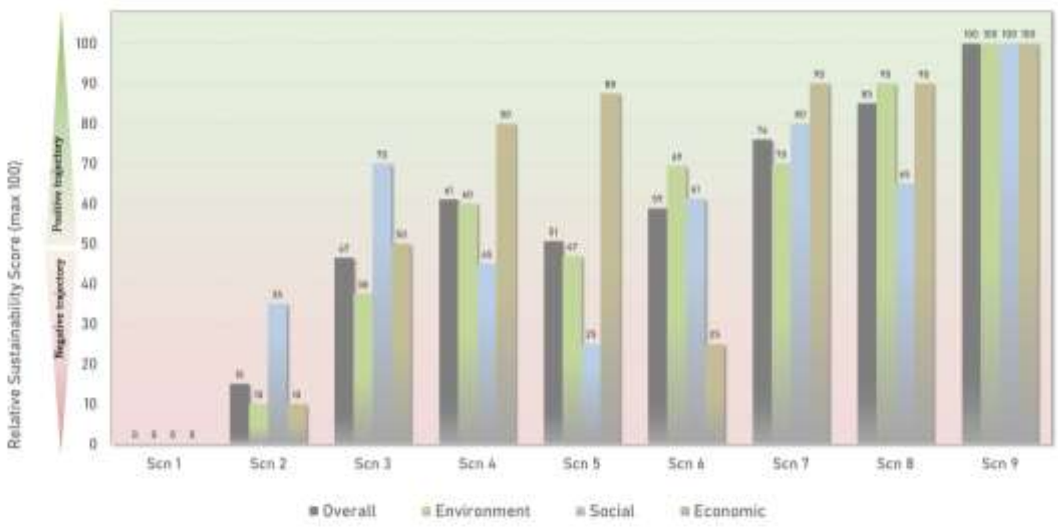


Figure 3.1 Comparison of overall sustainability performance among selected future scenarios for port development in the WIO region

Figure 3.2 schematises the outcomes per indicator for each of the scenarios. As expected, the worst case ('Do nothing', Scenario 1) is unlikely to result in any sustainability. 'Supporting sustainable ports' (Scenario 9) is the ideal sustainability outcome. Scenario 2 ('Fixing only institutions') presents a situation where port authorities only address institutional matters, but do not implement important interventions in the other key driving forces (corporate culture and policies, technological development, or operational efficiencies). Evident from this outcome is that very little is likely to be achieved with 'only talking'.

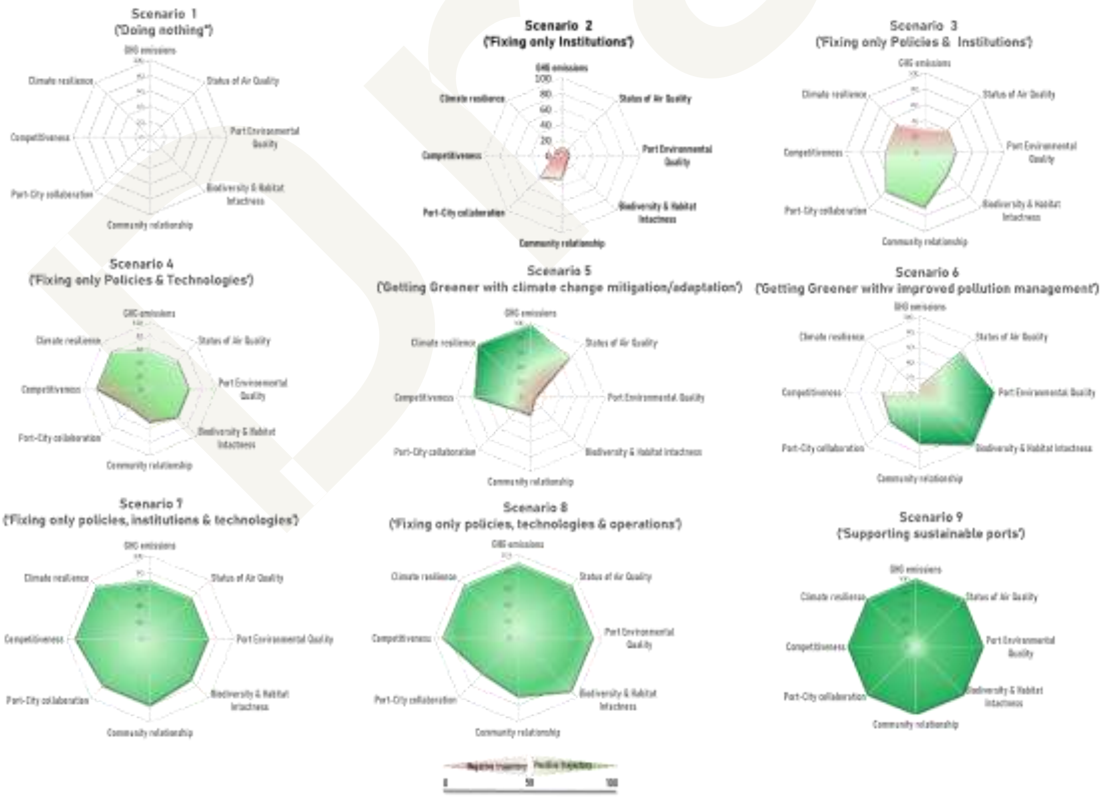


Figure 3.2 Comparison of expected overall influence of various future scenarios on selected sustainability indicators

Table 3.8: Sustainability rating (outcome) of scenarios, based on weighted influence of driving force trajectories on selected indicators

| | | | SCENARIO | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | INDICATOR | Weight | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| ENVIRONMENT | | 0.60 | -2.00 | -1.60 | -0.50 | 0.40 | -0.13 | 0.78 | 0.80 | 1.60 | 2.00 |
| 1 | GHG Emissions | 0.25 | -2.0 | -1.6 | -0.8 | 0.4 | 1.9 | -1.7 | 0.8 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.20 | -2 | -2 | 2 | 2 | 2 | -2 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 1 | 1 | 2 | -2 | 2 |
| | Technological development | 0.40 | -2 | -2 | -2 | 2 | 2 | -2 | 2 | 2 | 2 |
| | Operational efficiency | 0.30 | -2 | -2 | -2 | -2 | 2 | -2 | -2 | 2 | 2 |
| 2 | Status of Air Quality | 0.25 | -2.0 | -1.6 | -0.4 | 0.4 | 1.0 | 1.0 | 0.8 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.30 | -2 | -2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 1 | 1 | 2 | -2 | 2 |
| | Technological development | 0.30 | -2 | -2 | -2 | 2 | 1 | 1 | 2 | 2 | 2 |
| | Operational efficiency | 0.30 | -2 | -2 | -2 | -2 | 1 | 1 | -2 | 2 | 2 |
| 3 | Status of Port Environmental Quality | 0.25 | -2.0 | -1.6 | -0.4 | 0.4 | -1.7 | 1.9 | 0.8 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.30 | -2 | -2 | 2 | 2 | -2 | 2 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 1 | 1 | 2 | -2 | 2 |
| | Technological development | 0.30 | -2 | -2 | -2 | 2 | -2 | 2 | 2 | 2 | 2 |
| | Operational efficiency | 0.30 | -2 | -2 | -2 | -2 | -2 | 2 | -2 | 2 | 2 |
| 4 | Status of Biodiversity & Habitat Intactness | 0.25 | -2.0 | -1.6 | -0.4 | 0.4 | -1.7 | 1.9 | 0.8 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.30 | -2 | -2 | 2 | 2 | -2 | 2 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 1 | 1 | 2 | -2 | 2 |
| | Technological development | 0.30 | -2 | -2 | -2 | 2 | -2 | 2 | 2 | 2 | 2 |
| | Operational efficiency | 0.30 | -2 | -2 | -2 | -2 | -2 | 2 | -2 | 2 | 2 |
| SOCIAL | | 0.20 | -2.00 | -0.60 | 0.80 | -0.20 | -1.00 | 0.45 | 1.20 | 0.60 | 2.00 |
| 5 | Community relationship | 0.50 | -2.0 | -0.8 | 0.8 | 0.0 | -1.0 | 0.7 | 1.2 | 0.8 | 2.0 |
| | Corporate culture and policy | 0.40 | -2 | -2 | 2 | 2 | -1 | 1 | 2 | 2 | 2 |
| | Institutional arrangements | 0.30 | -2 | 2 | 2 | -2 | -1 | -1 | 2 | -2 | 2 |
| | Technological development | 0.10 | -2 | -2 | -2 | 2 | -1 | 2 | 2 | 2 | 2 |
| | Operational efficiency | 0.20 | -2 | -2 | -2 | -2 | -1 | 2 | -2 | 2 | 2 |
| 6 | Port-City collaboration | 0.50 | -2.0 | -0.4 | 0.8 | -0.4 | -1.0 | 0.2 | 1.2 | 0.4 | 2.0 |
| | Corporate culture and policy | 0.30 | -2 | -2 | 2 | 2 | -1 | 1 | 2 | 2 | 2 |
| | Institutional arrangements | 0.40 | -2 | 2 | 2 | -2 | -1 | -1 | 2 | -2 | 2 |
| | Technological development | 0.10 | -2 | -2 | -2 | 2 | -1 | 1 | 2 | 2 | 2 |
| | Operational efficiency | 0.20 | -2 | -2 | -2 | -2 | -1 | 1 | -2 | 2 | 2 |
| ECONOMIC | | 0.20 | -2.00 | -1.60 | 0.00 | 1.20 | 1.50 | -1.00 | 1.60 | 1.60 | 2.00 |
| 7 | Climate resilience | 0.50 | -2.0 | -1.6 | 0.0 | 1.2 | 2.0 | -2.0 | 1.6 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.40 | -2 | -2 | 2 | 2 | 2 | -2 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 2 | -2 | 2 | -2 | 2 |
| | Technological development | 0.40 | -2 | -2 | -2 | 2 | 2 | -2 | 2 | 2 | 2 |
| | Operational efficiency | 0.10 | -2 | -2 | -2 | -2 | 2 | -2 | -2 | 2 | 2 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Competitiveness | 0.50 | -2.0 | -1.6 | 0.0 | 1.2 | 1.0 | 0.0 | 1.6 | 1.6 | 2.0 |
| | Corporate culture and policy | 0.40 | -2 | -2 | 2 | 2 | 1 | 0 | 2 | 2 | 2 |
| | Institutional arrangements | 0.10 | -2 | 2 | 2 | -2 | 1 | 0 | 2 | -2 | 2 |
| | Technological development | 0.40 | -2 | -2 | -2 | 2 | 1 | 0 | 2 | 2 | 2 |
| | Operational efficiency | 0.10 | -2 | -2 | -2 | -2 | 1 | 0 | -2 | 2 | 2 |
| | GHG emissions | | 0 | 10 | 30 | 60 | 98 | 8 | 70 | 90 | 100 |
| | Status of Air Quality | | 0 | 10 | 40 | 60 | 75 | 75 | 70 | 90 | 100 |
| | Port Environmental Quality | | 0 | 10 | 40 | 60 | 8 | 98 | 70 | 90 | 100 |
| | Biodiversity & Habitat Intactness | | 0 | 10 | 40 | 60 | 8 | 98 | 70 | 90 | 100 |
| | Community relationship | | 0 | 30 | 70 | 50 | 25 | 68 | 80 | 70 | 100 |
| | Port-City collaboration | | 0 | 40 | 70 | 40 | 25 | 55 | 80 | 60 | 100 |
| | Competitiveness | | 0 | 10 | 50 | 80 | 75 | 50 | 90 | 90 | 100 |
| | Climate resilience | | 0 | 10 | 50 | 80 | 100 | 0 | 90 | 90 | 100 |
| | Environment | | 0 | 10 | 38 | 60 | 47 | 69 | 70 | 90 | 100 |
| | Social | | 0 | 35 | 70 | 45 | 25 | 61 | 80 | 65 | 100 |
| | Economic | | 0 | 10 | 50 | 80 | 88 | 25 | 90 | 90 | 100 |
| | OVERALL SCORE (100 max) | | 0 | 15 | 47 | 61 | 51 | 59 | 76 | 85 | 100 |

Scenario 3 ('Fixing only institutions and policies') introduces the establishment of policies supporting sustainability, but again 'only talking' and having 'legislation on paper' is unlikely to achieve significant marked progress towards sustainability without addressing practical implementation through, for example technological developments and operational efficiency. In Scenario 4 ('Fixing only policies and technologies') the influence of practical implementation becomes apparent, although in this scenario the lack of institutional progress in terms of community and port-city relationships is clear. Scenario 5 ('Getting Greener with climate change mitigation /adaptation') present a situation where port authorities strongly focus on addressing issues pertaining to climate mitigation and adaptation, showing the effect of this in reducing *GHG emissions* and increasing *Climate resilience*. However, the lack of attention to the management and control of emissions, waste and wastewater, has a clear influence on pollution (environmental quality). On the other hand, in Scenario 6 ('Getting Greener with improved pollution management') authorities tend to focus on emission, waste and wastewater management and control, with clear impact in reducing pollution and improving environmental quality). However, the lack of effort to address climate mitigation and resilience remains an issue.

The value of combining technological developments or operational efficiencies, with supporting policies and sound institutional arrangement is evident in Scenario 7 ('Fixing only policies, institutions, and technologies'). Even greater value for sustainable port development is achieved if technological developments and operational efficiencies are combined with support policies as (Scenario 8, 'Fixing policies, technologies, and operations'). The overall ratings in Figure 3.1 reiterate the greater positive trajectory gained through the incorporation of practical implementation aspects, as represented by technological developments and operational efficiencies (e.g., Scenarios 7 and 8), rather than focusing on policy development and institutional interventions alone (e.g., Scenarios 2 and 3).

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# APPENDIX: KEY ISSUES WITHIN INTERNAL DRIVING FORCES (as identified by Stakeholders)

| INTERNAL DRIVING FORCE | THEME | ISSUE | COMMENT |
|---|---|---|---|
| 1: Commitment & policy | Legislation & policies | Environmental processes | Environmental Impact Assessment: (1) EIAs can be done for new ports to be constructed (feasibility study); (2) Environmental audits for existing ports - check compliance |
| 1: Commitment & policy | Legislation & policies | Environmental processes | Present: SEA and EIA community of ..... |
| 1: Commitment & policy | Legislation & policies | Environmental processes | Future: SEA and EIA |
| 1: Commitment & policy | Legislation & policies | Environmental processes | Commonalities: EIA/SEA ES&IA |
| 1: Commitment & policy | Legislation & policies | International conventions | Regulations/ratification and domestication of conventions |
| 1: Commitment & policy | Legislation & policies | International conventions | Commonalities: Conventions (international) |
| 1: Commitment & policy | Legislation & policies | Port Policy: Climate change | Threat: Climate change |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Future: Operational policies greener |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Mozambique: Policy and management borrowed from SA policy and legislation |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Mozambique: Policy = JV ? |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Policies and regulations |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Current causes: Lack of policy |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Future: Clear integrated policies and systems |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Lack of alignment between regulations and port policies |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Future: National strategy |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Commonalities: Policies - local |
| 1: Commitment & policy | Legislation & policies | Port policy: General | Challenges: .... Maritime national policies not adopted |
| 1: Commitment & policy | Legislation & policies | Private sector involvement | Future: PPP Authorisation |
| 1: Corporate culture & policy | Legislation & policies | Private sector involvement | Kenya: Management is hybrid and involves private sector |
| 1: Corporate culture & policy | Legislation & policies | Private sector involvement | Kenya: Consider management hybrid between governance and private sectors |
| 1: Corporate culture & policy | Legislation & policies | Private sector involvement | Mozambique: Concession to private |
| 1: Corporate culture & policy | Legislation & policies | Private sector involvement | Mozambique: Ownership risks |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Lack of planning (e.g. land use) |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Marine spatial planning |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Future: Will have more ports closer together |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Future: Improved planning and design |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Threats: social trade-offs competition for space |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Threats: Understanding influence zone around ports by managers (e.g. dredging) |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Threats: Lack of planning (both existing and new), costly |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Threats: Lack of land-use planning |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Lack of understanding of broader influence zone of port |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Challenges: Land-based/urban problems |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Challenges: Ports are sensitive areas (pollution, contamination) |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Future: Management of biodiversity areas |
| 1: Corporate culture & policy | Legislation & policies | Spatial planning | Limited area for development |
| 1: Corporate culture & policy | Management commitment | Buy-in: General | Current causes: Commitment of management |
| 1: Corporate culture & policy | Management commitment | Buy-in: General | Future: Improve perception on sustainability for critical stakeholders |
| 1: Corporate culture & policy | Management commitment | Buy-in: Modernisation | Culture: Ports in Mombasa and region are old and over 100 yrs. This is an old culture that needs to be broken. Most still use old systems of thinking, thus change is required quick for a green transition |
| 1: Corporate culture & policy | Management commitment | Buy-in: Social | Culture wise |
| 1: Corporate culture & policy | Management commitment | Buy-in: Social | Future: Social vision |
| 1: Corporate culture & policy | Political | Political will & support | Lack of political will and bilateral ...... |
| 1: Corporate culture & policy | Political | Political will & support | Current causes: Political interference |
| 1: Corporate culture & policy | Political | Political will & support | Commonalities: Port infrastructure and politics |
| 2: Institutional | Environmental department | Environmental department | Need to have dedicated departments wrt environmental issues in port authorities/institutions |
| 2: Institutional | Environmental department | Environmental department | Institutional structure |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Conflict between regulatory body and enforcement body (overlapping mandates of institutions) |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Oil spill contingency plan (how effective it is): (1) Lack of coordination among relevant stakeholders; (2) effectiveness of regional collaboration (MoUs); (3) lack of equipment/finance |

| INTERNAL DRIVING FORCE | THEME | ISSUE | COMMENT |
|---|---|---|---|
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Kenya: Administration… government |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Kenya: Change port management, currently under port authority |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Kenya: Development is an institutional - national |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Threats: Multi stakeholder planning/governance needed |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Multi stakeholder planning/governance/coordination |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Future: Enforcement, need capacity as well as multi-institutional/stakeholder involvement |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Challenges: Point of social and economic conflict |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Current causes: Lack of coordination (silo mentality) |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Current causes: Stakeholder participation in port development (continuous) |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Challenges: City-port interface …. In several countries |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Challenges: Some…. Entities have different management within port infrastructure |
| 2: Institutional | Multi-stakeholder collaboration | Cross-sectoral authorities | Challenges: Available… Committees …. Not efficient |
| 2: Institutional | Multi-stakeholder collaboration | Local communities | Madagascar: National interest and local interest port management |
| 2: Institutional | Multi-stakeholder collaboration | Local communities | Involvement of all stakeholders (proposed) |
| 3: Technological | Energy | Energy efficiency | Mozambique: Equipment used depends on fuel to operator implemented share power |
| 3: Technological | Energy | Energy efficiency | Mozambique: Technology - Fuel energy (power); share-power at dock (Mozambique perspective) |
| 3: Technological | Energy | Energy efficiency | Lack of energy efficiency |
| 3: Technological | Energy | Energy efficiency | Future: More consideration on efficiency of ports (cost/benefit analysis) |
| 3: Technological | Energy | Energy efficiency | Commonalities: Recent technology - port efficiency |
| 3: Technological | Energy | Renewable energy | Use of renewable energy in ports |
| 3: Technological | Energy | Renewable energy | Present: Little renewable energy being used |
| 3: Technological | Energy | Renewable energy | No renewable energy |
| 3: Technological | Energy | Renewable energy | Reliability on fossil energy |
| 3: Technological | Energy | Renewable energy | Planning for alternative energy more environmentally friendly |
| 3: Technological | Energy | Renewable energy | Future: Green energy resources policy |
| 3: Technological | Vessel operations | Vessel logistics | Smart Ports - TOS, VTS, ERP, single window less waiting time/less emission |
| 3: Technological | Vessel operations | Vessel logistics | Future: Tech - track booking and scanning from arrival to exit and info sharing |
| 3: Technological | Vessel operations | Vessel logistics | Mozambique: Future - "tag track" one-gate (in/out) ……… (Mozambique perspective) |
| 3: Technological | Vessel operations | Vessel logistics | Mozambique: Control room - digitalisation of process single window system; track booking system - traffic management (Mozambique perspective) |
| 3: Technological | Vessel operations | Vessel logistics | Future: Embrace technology - cope with bigger ships, monitoring, waste management |
| 3: Technological | Vessel operations | Vessel logistics | Automation of systems |
| 3: Technological | Waste management | Waste management | Addressing waste (integrated waste management) |
| 3: Technological | Waste management | Waste management | Inadequate facilities, e.g. waste management, and monitoring |
| 3: Technological | Waste management | Waste management | Future: Embrace technology - cope with bigger ships, monitoring, waste management |
| 3: Technological | Waste management | Waste management | Commonalities: Recent technology - port efficiency |
| 3: Technological | Waste management | Waste management | Commonalities: Waste management plans |
| 3: Technological | Waste management | Waste management | Challenges: Waste management especially dumping - wastewater, dredged material |
| 4: Operational | Compliance & enforcement | Environmental audits | Challenges: Challenges with port certification |
| 4: Operational | Compliance & enforcement | Environmental audits | Lack of energy audits |
| 4: Operational | Compliance & enforcement | Environmental audits | Mozambique: Environment - compliance with the … (best practice) (Mozambique perspective) |
| 4: Operational | Compliance & enforcement | Environmental audits | Threats: Pollution and oil spills |
| 4: Operational | Compliance & enforcement | Environmental audits | Threats: Waste disposal |
| 4: Operational | Compliance & enforcement | Environmental audits | Threats: Invasive species |
| 4: Operational | Compliance & enforcement | Environmental audits | Threats: Dredging/sedimentation |
| 4: Operational | Compliance & enforcement | Environmental audits | Threats: Weak law enforcement |
| 4: Operational | Compliance & enforcement | Environmental audits | Lack of environmental and social safeguards, including expertise investigating oil spills |
| 4: Operational | Compliance & enforcement | Environmental audits | Weak enforcement |
| 4: Operational | Compliance & enforcement | Environmental audits | Future: Enforcement, need capacity as well as multi-institutional/stakeholder involvement |

| INTERNAL DRIVING FORCE | THEME | ISSUE | COMMENT |
|---|---|---|---|
| 4: Operational | Compliance & enforcement | Environmental audits | Poor performance |
| 4: Operational | Compliance & enforcement | Environmental audits | Commonalities: ISO certification |
| 4: Operational | Financial | Funding | Mozambique: Culture - port built on loans from China etc. who has a say in terms of operations |
| 4: Operational | Financial | Funding | Mozambique: Financially shareholders involved |
| 4: Operational | Financial | Funding | Present: Loans to expand ports or mega development: ownership versus paying loan |
| 4: Operational | Financial | Funding | Mozambique: Financial support |
| 4: Operational | Financial | Funding | Mozambique: Financial funds - no …. (Willingness of stakeholders) (Mozambique perspective) |
| 4: Operational | Financial | Funding | Financial matters |
| 4: Operational | Financial | Funding | Sustainability versus finances |
| 4: Operational | Financial | Funding | Lack of resources |
| 4: Operational | Financial | Funding | Lack of private sector investment and engagement |
| 4: Operational | Financial | Funding | Current causes: Economic factors |
| 4: Operational | Financial | Funding | High costs of infrastructure and technology |
| 4: Operational | Financial | Funding | Limited financial resources |
| 4: Operational | Monitoring | Environmental monitoring | Lack of air and water quality monitoring (sediments) |
| 4: Operational | Monitoring | Environmental monitoring | Challenges: … parameters for port monitoring (environment and waste management) |
| 4: Operational | Monitoring | Environmental monitoring | Future: Embrace technology - cope with bigger ships, monitoring, waste management |
| 4: Operational | Monitoring | Environmental monitoring | Inadequate monitoring tools and systems |
| 4: Operational | Monitoring | Environmental monitoring | Challenges: … parameters for port monitoring (environment and waste management) |
| 4: Operational | Safety & security | Safety & security | Kenya: Upgrade port safety and security |
| 4: Operational | Safety & security | Safety & security | Risk assessment |
| 4: Operational | Safety & security | Safety & security | Commonalities: Health and safety |
| 4: Operational | Training & capacity building | General | Current causes: Knowledge (level of expertise) |
| 4: Operational | Training & capacity building | General | Limited expertise |
| 4: Operational | Training & capacity building | General | Capacity building |
| 4: Operational | Training & capacity building | General | Problem: Training on sustainability; Question of ownership (loans) |
| 4: Operational | Training & capacity building | General | Inadequate capacity, e.g. for monitoring |
| 4: Operational | Training & capacity building | New technology | Role of IMO help developing nations Ito capacity building for green ports, training, facilities/technologies, research |
| 4: Operational | Training & capacity building | New technology | Present: Too many older people working in ports, less capacity of new tech use |
| 4: Operational | Training & capacity building | New technology | Future: Employing younger people who are open to new/greener technologies |
| 4: Operational | Training & capacity building | New technology | Future: Training including sustainability |
| 4: Operational | Training & capacity building | New technology | Mozambique: Capacity building - employ younger people and trained in SA and locally, especially simulation as a means of training |
| 4: Operational | Training & capacity building | New technology | Mozambique: Knowledge - capacity building (training for young); training center (simulation facilities) (Mozambique perspective) |
| 4: Operational | Training & capacity building | Oil spill contingency | Commonalities: Contingency planning - training |
| 4: Operational | Training & capacity building | Oil spill contingency | Challenges: Capacity and …. Oil spills …. |

### Key Issues in WIO ports as identified by Stakeholders (summary of the above):

| | |
|---|---|
| CATEGORY 1: CORPORATE CULTURE & POLICY | Management commitment to adopt policies (environmental assessments, greener ports) |
| | Climate resilience response |
| | Private sector involvement (port ownership & terminal operators) |
| | Strategic spatial planning (e.g., link to zone of influence) |
| | *Political will and support (not sure that this would markedly change over scenario period - 2030-50? Change in port behavior most likely to be driven by external driving forces e.g., climate change, societal pressure, global demand for social/environmental accountability to secure market share)* |
| CATEGORY 2: INSTITUTIONAL ARRANGEMENTS | Dedicated environment department (execution/enforcement) |
| | Cross-sectoral collaboration/coordination of authorities |
| | Multi-stakeholder involvement/participation from role-players (port users) |
| | Local community acknowledgement/conflict |
| 3: TECHNOLOGICAL DEVELOPMENT | Energy efficiency |
| | Renewable energy |
| | Waste management |
| | Vessel logistics (turnover time) |
| CATEGORY 4: OPERATIONAL EFFICIENCY | Environmental auditing/monitoring (enforcement of policies) |
| | Securing Funding |
| | Operational training & capacity development towards greener ports |
| | Disaster preparedness training & capacity development |
| | *Safety & security (while this certainly relates to well-being of employees and port users, this is not considered central to the focus this project, i.e. environmentally sustainable (greener) ports* |