



Portable Innovation Open Network for
Efficiency and Emissions Reduction Solutions

Deliverable 2.15:

PIONEERS' Best Practise Master Plan and Handbook

Disclaimer

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1 Landscape

1.1 Introduction

Within the Multi-Level Perspective (MLP), the **Landscape** represents the broader socio-economic, environmental, technological and political context within which port systems evolve. The Landscape developments originate largely outside the direct influence of ports. They emerge gradually over long periods and create persistent pressures that shape the decisions of governments, industries and infrastructure operators. Consequently, ports cannot control these developments, but they must continuously adapt to them to remain competitive, resilient and sustainable¹.

Historically, ports developed primarily in response to economic growth, increasing cargo volumes and advances in transport technologies. Today, this development model is being reshaped by the combined influence of Global Megatrends, including Climate Change, Energy Transition & Decarbonisation, the Technological and Digital Revolution, Shifting Global Trade & Geopolitical Order, Demographic & Socio-economic Transformation, and Resilience & Systemic Awareness. These trends interact and reinforce one another, creating cumulative pressures that transform the existing port regime. Climate policies accelerate technological innovation, digitalisation supports decarbonisation, geopolitical instability reshapes supply chains, and evolving societal expectations influence investment priorities and governance. Together, these developments redefine ports from transport gateways into integrated logistical, industrial and energy supplying ecosystems, providing the broader context for the subsequent Scenario Analysis and the development of Green Port Masterplans².

1.2 Global megatrends

Climate Change is one of the most significant Landscape developments shaping the future of ports, affecting the operational capabilities of ports, the physical resilience of port infrastructure and the strategic direction of port development. More frequent extreme weather events, sea-level rise and changing hydrological conditions increase the vulnerability of maritime and inland transport systems, requiring ports to integrate climate adaptation into long-term infrastructure planning and asset management. At the same time, Climate Change acts as a catalyst for broader systemic transformation by accelerating the Energy Transition & Decarbonisation, strengthening Regulation and Policy Pressure, and stimulating investments in renewable energy, resilient infrastructure, nature-based solutions and low-carbon logistics. Consequently, ports are shifting from reactive risk management towards adaptive planning, where resilience, environmental performance and economic competitiveness are considered as a combined objective. Climate Change should therefore be understood not only as an environmental challenge but as a structural driver of technological, institutional and economic transformation across the port system³.

¹Becker, A. H., Acciaro, M., Asariotis, R., Cabrera, E., Creteigny, L., Crist, P., Esteban, M., Mather, A., Messner, S., Naruse, S., Ng, A. K. Y., Rahmstorf, S., Savonis, M., Song, D.-W., Stenek, V., & Velegrakis, A. F. (2013). A note on climate change adaptation for seaports: A challenge for global ports, a challenge for global society. *Climatic Change*, 120(4), 683–695

² 2] K. Mutombo and A. Ölçer, “Towards port infrastructure adaptation: A global port climate risk analysis,” *WMU Journal of Maritime Affairs*, vol. 16, no. 2, pp. 161–173, 2017,

³ International Energy Agency. (2025). *Breakthrough Agenda Report 2025*. IEA. <https://www.iea.org/reports/breakthrough-agenda-report-2025>

Energy Transition & Decarbonisation is closely linked to Climate Change and is fundamentally redefining the role of ports within regional energy and industrial systems. Driven by international climate commitments and European policies such as the European Green Deal, Fit for 55 and FuelEU Maritime, the transition from fossil fuels to renewable electricity and sustainable alternative fuels (SAF) is transforming both cargo flows and port functions. Rather than serving solely as transport gateways, ports are increasingly evolving into integrated energy hubs that support renewable energy generation, alternative fuel distribution, energy storage and industrial decarbonisation. This transition also stimulates technological innovation, Circular Economy initiatives and significant Infrastructure Investments, while creating uncertainty regarding future fuel demand and technology pathways. Consequently, Green Port Masterplans need to adopt flexible and adaptive strategies that integrate transport, energy and industrial development, ensuring that infrastructure remains resilient and relevant under different transition scenarios⁴.

The **Technological and Digital Revolution** is transforming port systems by reshaping how infrastructure, operations and supply chains are managed. Advances in Artificial Intelligence (AI), the Internet of Things (IoT), Digital Twins, automation and advanced data analytics enable real-time monitoring, predictive decision-making and more efficient coordination across increasingly interconnected logistics networks. As an enabling Landscape development, digitalisation supports Climate Change adaptation, the Energy Transition & Decarbonisation and Circular Economy initiatives by improving resource efficiency, energy management and operational resilience. However, greater digital integration also increases dependence on secure data sharing, interoperability and cybersecurity. Consequently, the challenge for ports is not simply to adopt new technologies, but to develop integrated and secure digital ecosystems that enhance resilience, sustainability and long-term competitiveness.

Shifting Global Trade & Geopolitical Order is reshaping the operating environment of ports through increasing geopolitical tensions, supply chain disruptions, changing trade patterns and growing economic uncertainty. Recent crises, including the COVID-19 pandemic and regional conflicts, have highlighted the vulnerability of global logistics networks and demonstrated the need for more resilient and diversified supply chains. As a result, ports are increasingly recognised as critical infrastructure that supports not only trade but also national energy security, industrial competitiveness and economic resilience. These developments reinforce the Energy Transition & Decarbonisation and the Technological and Digital Revolution by stimulating investments in regional energy corridors, strategic industries and integrated logistics infrastructure. At the same time, they increase the importance of cybersecurity, digital sovereignty and adaptive governance. Consequently, future port competitiveness will depend not only on operational efficiency but also on the ability to respond flexibly to evolving geopolitical and economic conditions.

Demographic & Socio-economic Transformation influences port development through ageing populations, labour shortages, changing skill requirements and rising societal expectations regarding sustainability and quality of life. These developments encourage greater automation and digitalisation while increasing the need for investment in education, workforce development and new technical competencies to support the transition towards renewable energy and digital logistics. At the same time, communities increasingly expect ports to contribute not only to economic growth but also to environmental quality, social well-being and transparent governance. Consequently, future port competitiveness will depend as much on attracting skilled labour, fostering stakeholder collaboration and maintaining societal support as on investing in physical infrastructure, reinforcing the need for integrated and inclusive Green Port Masterplans⁵.

⁴ IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

⁵United Nations Environment Programme (2025): Adaptation Gap Report 2025: Running on empty. <https://www.unep.org/resources/adaptation-gap-report-2025>.

Resilience & Systemic Awareness has become a defining Landscape development as ports face increasingly complex and interconnected disruptions arising from climate change, geopolitical instability, cyber threats, pandemics and economic uncertainty. Rather than focusing solely on recovering from operational disturbances, resilience is now understood as the capacity of infrastructure, institutions and supply chains to anticipate, adapt and continue functioning under changing conditions. This shift promotes adaptive planning, flexible infrastructure and stronger interoperability, enabling ports to respond effectively to multiple future scenarios. As resilience depends on digital technologies, diversified energy systems and regional collaboration, it acts as an integrating principle that connects the other Global Megatrends and supports the long-term sustainability, competitiveness and adaptability of port systems⁶.

1.3 Meso-Level Responses

The interaction between the Global Megatrends gives rise to a series of **Meso-Level Responses** that gradually transform the existing port regime. Unlike the Landscape, which represents external developments beyond the direct influence of ports, these responses emerge through the combined actions of governments, industries, infrastructure managers and technology providers. They translate long-term global pressures into tangible changes in policy, investment, governance and operational practice.

One of the most visible responses is the increasing emphasis on the **Circular Economy**, which extends the traditional logistics function of ports towards resource efficiency, industrial symbiosis and closed material cycles. Ports are increasingly viewed as locations where industrial activities, waste management, renewable energy production and logistics can be integrated to maximise resource utilisation while reducing environmental impacts. This development reflects the combined influence of Climate Change, Energy Transition & Decarbonisation and changing societal expectations, demonstrating how environmental objectives increasingly shape economic development strategies.

Simultaneously, **Regulation and Policy Pressure** has become one of the strongest drivers of change within port systems. International climate agreements, European legislation and national sustainability strategies establish progressively stricter requirements regarding greenhouse gas emissions, air quality, energy efficiency and environmental performance. European policy pressure is reflected in the European Climate Law, the EU ETS and the Fit for 55 package, which establish increasingly stringent requirements for emissions reduction, energy efficiency and low-carbon investment. For ports, these requirements are reinforced by policies such as AFIR and FuelEU Maritime, while the Clean Industrial Deal and the proposed 2026 EU ETS revision seek to balance decarbonisation with industrial competitiveness and investment capacity. Rather than responding voluntarily to sustainability objectives, ports increasingly operate within regulatory frameworks that influence investment priorities, infrastructure design and operational practices. Policy therefore acts as a mechanism that accelerates the translation of Landscape pressures into structural transformation of the port regime.

The transition also strengthens the strategic role of **Ports as Energy Hubs**. As renewable energy production expands and alternative fuels become increasingly important, ports evolve into critical nodes within regional energy systems. Hydrogen production, offshore wind integration, electricity distribution, battery storage and carbon management become additional functions alongside conventional cargo handling. This diversification demonstrates that future competitiveness depends not only on transport performance but also on the capacity to integrate logistics, energy and industrial development within a single ecosystem.

Digital technologies provide another essential response through the implementation of **IoT, Digital Twins and Interconnected Logistics**. These technologies improve situational awareness, optimise resource utilisation and

⁶ Geels, F.W. (2004). *From Sectoral Systems of Innovation to Socio-technical Systems*. *Research Policy*, 33(6–7), 897–920.

strengthen collaboration between stakeholders. Together with increasing **Automation**, they address labour shortages, improve operational efficiency and enhance safety while supporting more flexible and resilient logistics networks. At the same time, digitalisation creates new governance challenges related to cybersecurity, interoperability and data sharing, requiring coordinated standards and institutional cooperation.

Finally, **Societal Expectations** and **Infrastructure Investments** increasingly reflect a long-term transition perspective rather than isolated infrastructure expansion. Investments are expected to contribute simultaneously to economic competitiveness, environmental sustainability and regional resilience. Consequently, future infrastructure is increasingly designed as multifunctional systems that integrate transport, renewable energy, digital technologies and ecological considerations. These responses collectively illustrate that port development is no longer driven by cargo growth alone but by the need to respond to interconnected societal, technological and environmental transitions.

The Landscape Analysis demonstrates that multiple Global Megatrends are major drivers of the port transformation rather than by individual developments in isolation. These developments are transforming ports into multifunctional logistics, industrial and energy ecosystems, where competitiveness increasingly depends on resilience, sustainability, digitalisation and collaborative governance. As these Landscape pressures continue to evolve, Green Port Masterplans need to adopt integrated and adaptive planning approaches that recognise the interdependencies between environmental, technological, economic, societal and political transitions. Landscape Analysis therefore provides the strategic context by identifying the external drivers that shape future port transformation pathways.

Table 1: Analytical synthesis of the Landscape Analysis

Global Megatrend	Main Pressure	Landscape	Meso-Level Responses and Derivatives	Strategic implication for ports
Climate Change	Physical climate risks and decarbonisation requirements		Circular Economy, Regulation & Policy Pressure	Climate-resilient infrastructure and adaptation become strategic priorities.
Energy Transition & Decarbonisation	Transition towards renewable energy and alternative fuels		Ports as Energy Hubs, Infrastructure Investments	Ports evolve into integrated energy and industrial ecosystems.
Technological & Digital Revolution	Digitalisation, automation and data-driven decision-making		Artificial intelligence, IoT, Digital Twins, Automation	Improved efficiency, predictive management and resilient operations.
Shifting Global Trade & Geopolitical Order	Supply chain disruption and changing trade patterns		Infrastructure diversification and regional cooperation	Greater emphasis on resilience, strategic autonomy and flexible logistics.
Demographic & Socio-economic Transformation	Labour shortages and changing societal expectations		Automation, Societal Expectations	Investment in skills, innovation and collaborative governance.
Resilience & Systemic Awareness	Increasing frequency of complex disruptions		Integrated planning and adaptive infrastructure	Long-term resilience becomes a central planning objective.

1.4 Identifying, structuring and estimating the impact of trends on the port system

The Landscape Analysis identifies the long-term external developments that influence the future of the port system but remain largely outside the direct control of the port authority. Rather than producing a comprehensive inventory of global trends, the analysis should focus on those developments that are expected to influence the port's strategic development during the planning horizon. The objective is to understand how external pressures reshape the operating environment and to translate these insights into priorities for the GPMP.

In order to incorporate the landscape trends, we propose a stepwise approach as summarised in the Table 2 and explained further below.

Table 2: Landscape Analysis Guidelines

Step	Description	Output
1. Identify Global Megatrends	Identify the long-term global and European developments affecting ports using scientific literature, international reports and European policy.	List of Global Megatrends.
2. Identify National Policy Trends	Analyse the national strategies, legislation and policy frameworks that translate global developments into the national context.	Overview of National Policy Trends.
3. Identify Meso Trends	Identify the regional, cross-border and local developments that shape the operating environment of the port.	Overview of Meso Trends.
4. Analyse Trend Interactions and Strategic Implications	Analyse how developments across the three Landscape levels interact and assess their implications for the port system.	Strategic opportunities, risks and planning challenges.
5. Integrate the Findings into the GPMP	Use the Landscape Analysis as the strategic foundation for the Regime Analysis, Innovation Assessment, Scenario Development and Roadmap.	Strategic priorities for the GPMP.

Step 1 – Identify Global Megatrends

The first step establishes the global transition context within which the port system operates. It identifies the long-term structural developments that are expected to influence ports over the planning horizon and that are largely beyond the direct influence of individual port authorities. The analysis should be evidence-based and draw upon scientific literature, international organisations and European policy documents. Rather than compiling an extensive list of trends, the objective is to synthesise the most significant developments into a concise set of Global Megatrends that provide the foundation for the Landscape Analysis.

Step 2 – Identify National Policy Trends

The second step examines how the identified Global Megatrends are translated into national policy. National strategies, legislation and investment programmes define the regulatory and institutional framework within which ports operate and determine how international ambitions are implemented at country level. Analysing National Policy Trends provides insight into the policy drivers influencing infrastructure development, freight transport, energy transition, environmental performance and spatial planning.

Step 3 – Identify Meso Trends

The third step focuses on the regional, cross-border and local developments that directly shape the operating environment of the port. Meso Trends reflect the geographical, economic, institutional and environmental characteristics of the region, including regional governance, labour markets, infrastructure networks, energy systems and spatial constraints. Together with the Global Megatrends and National Policy Trends, these developments provide a complete understanding of the external Landscape surrounding the port system.

Step 4 – Analyse Trend Interactions and Strategic Implications

Once the three Landscape levels have been identified, the fourth step examines how they interact and reinforce one another. Global Megatrends influence national policy, while national frameworks shape regional developments and local implementation. Analysing these relationships provides a systems perspective that reveals how external developments collectively influence the future of the port. The resulting strategic implications are assessed for infrastructure, logistics, energy systems, industrial development, environmental performance, governance and stakeholder collaboration, helping to identify the principal opportunities, risks and investment priorities.

Step 5 – Integrate the Findings into the GPMP

The final step integrates the findings of the Landscape Analysis into the wider GPMP. Rather than producing recommendations independently, the Landscape Analysis establishes the strategic context for all subsequent planning activities. The identified Global Megatrends, National Policy Trends, Meso Trends and their interactions provide direct input to the Regime Analysis, Innovation Assessment, Scenario Development and Strategic Roadmap. This ensures that strategic decisions are grounded in a comprehensive understanding of the long-term developments shaping the future of the port system.

1.5 Best practise example: Landscape analysis in the Port of Venlo

The PoV provides a practical example of how the Landscape Analysis methodology can be applied within the development of a GPMP. The analysis followed the five-step approach presented in the GPMP toolbox, to ensure that external developments were systematically identified, structured and translated into strategic implications for the port. Rather than focusing solely on trends, the methodology connected long-term global developments with the realities of port planning and decision-making.

Step 1 – Identify Global Megatrends

The first step established the global transition context affecting the Port of Venlo. A structured literature review was conducted using scientific publications, European policy documents and reports from international organisations, including the European Commission, OECD, IPCC, IEA and UNCTAD. Rather than compiling an extensive inventory of trends, the analysis synthesised the findings into six Global Megatrends that were considered most relevant for the long-term development of inland ports:

- Climate Change;
- Energy Transition and Decarbonisation;
- Technological and Digital Revolution;
- Shifting Global Trade and Geopolitical Order;
- Demographic and Socio-economic Transformation; and
- Resilience and Systemic Awareness.
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These Global Megatrends provided the strategic context for the remainder of the Landscape Analysis and established the long-term external developments influencing the future of the PoV.

Step 2 – Identify National Policy Trends

The second step translated the identified Global Megatrends into the Dutch policy context. National climate, energy, transport, spatial planning and inland shipping strategies were analysed to understand how international ambitions are implemented within the Netherlands and how these influence future port development.

The analysis included national policy frameworks such as the Dutch Climate Agreement, the National Environmental Vision (NOVI), freight transport strategies, energy transition policies and programmes supporting inland shipping and clean energy hubs. Together, these National Policy Trends provided the regulatory and institutional framework within which the Port of Venlo must operate and highlighted the principal policy drivers influencing future investments and strategic decisions.

Step 3 – Identify Meso Trends

The third step focused on the regional and cross-border developments that directly shape the operating environment of the PoV. The analysis considered the specific characteristics of the Limburg region, including spatial constraints, hydrological variability, regional energy infrastructure, cross-border logistics networks, labour market developments, circular economy initiatives and governance arrangements.

Particular attention was given to the shared BluePort Limburg vision for Limburg's inland ports, recognising that many future opportunities and challenges can only be addressed through regional collaboration. Together, these Meso Trends complemented the Global Megatrends and National Policy Trends by providing a detailed understanding of the regional context in which the PoV operates.

Step 4 – Analyse Trend Interactions and Strategic Implications

Following the identification of the Global Megatrends, National Policy Trends and Meso Trends, the analysis examined how developments across the three Landscape levels interact and reinforce one another. Rather than considering each trend independently, a systems perspective was adopted to understand how global developments are translated into national policies and subsequently influence regional developments and local implementation. The resulting strategic implications were assessed for the Port of Venlo across several key themes, including infrastructure, logistics, energy systems, industrial development, governance, environmental performance and stakeholder collaboration. These findings enabled the project team to identify the principal opportunities, risks and investment priorities that require attention within the GPMP.

The preliminary findings were subsequently discussed with representatives of the PoV, the municipality and other key stakeholders. Their input was used to validate the analysis, identify additional regional developments and prioritise strategic themes according to the implementation horizons for 2025, 2030 and 2050.

Step 5 – Integrate the Findings into the Green Port Master Plan

The final step integrated the Landscape Analysis into the wider GPMP. The findings were not treated as a standalone assessment but formed the strategic foundation for the subsequent analytical stages. The identified Global Megatrends, National Policy Trends, Meso Trends and their strategic implications provided direct input to the Innovation Assessment, Scenario Development and Strategic Roadmap.

Continuous stakeholder engagement throughout the development of the GPMP ensured that the Landscape Analysis remained relevant to the local context while maintaining alignment with national policy objectives and long-term European transition ambitions. This integration enabled every strategic recommendation within the GPMP to be traced back to the external developments shaping the future operating environment of the PoV.

Key Lessons from the Port of Venlo

The application of the Landscape Analysis methodology in the PoV demonstrates that an effective Landscape Analysis extends beyond identifying external trends. Its value lies in combining evidence from multiple governance levels into a coherent understanding of the external environment within which the port operates. By systematically identifying Global Megatrends, National Policy Trends and Meso Trends, analysing their interactions and validating the findings through continuous stakeholder engagement, the Port of Venlo developed a transparent, evidence-based and transferable methodology for strategic port planning. The resulting Landscape Analysis provided a robust foundation for the GPMP and can serve as a best practice example for other inland and maritime ports seeking to develop long-term transition strategies towards climate neutrality.