ARSINOE

Greening the Mediterranean Ports

A Case Study in Piraeus, Greece, Limassol, Cyprus & Valencia, Spain

Background

The **Port of Piraeus** is one of Europe's leading seaports and the world's second-largest maritime cluster, excelling in coastal shipping, cruise operations, and containerized cargo. Actively engaged in 14 EU-funded projects, the port is committed to becoming a sustainable, “green,” and financially self-sufficient hub.

The **Port of Valencia** stands as Spain’s foremost Mediterranean port for commercial traffic, serving as a key maritime gateway for trade across the Iberian Peninsula. Its strategic location and infrastructure make it a vital link for regional and international commerce.

The **Port of Limassol** is Cyprus’s primary seaport, handling 90% of the nation’s imports and exports. It also plays a crucial role in passenger traffic, facilitating cruise operations and ferry connections with Greece, Israel, Egypt, and Lebanon, reinforcing its status as a dynamic regional hub.

Key challenges

The key challenges identified in port operations include rising fuel prices, high energy costs, and issues related to energy supply and infrastructure. A lack of expertise in sustainable energy solutions further complicates efforts to transition towards greener operations. Environmental concerns such as pollution, disruptions to the energy ecosystem, and the impact of extreme weather conditions also pose significant risks. Heatwaves, in particular, affect port operations, directly impacting terminal users and passengers. Additionally, climate change has far-reaching consequences on port infrastructure, staff, and overall operational efficiency, raising concerns about long-term resilience and sustainability.

Main goals

The project aimed to significantly reduce health risks associated with extreme weather events such as high summer temperatures, storm waves, and flooding by developing tailored adaptation pathways for seaports. Additionally, it sought to enhance the well-being of adjacent communities while fostering a shift in mindsets among stakeholders and the wider port society. The initiative aspired to replace the perception of ports facing challenges in isolation with a collaborative approach, emphasizing that effective solutions could only emerge through creative synergies.

Expected outcomes and benefits

➔ Strengthen the resilience of seaports by mitigating climate-related risks and ensuring smoother operations;
➔ Improve adaptation strategies to make port infrastructures safer and more efficient;
➔ Reducing disruptions caused by extreme weather conditions;
➔ Drive meaningful change in stakeholder behavior to foster greater cooperation and proactive engagement in sustainability efforts;
➔ Raise public awareness to increase community involvement in climate resilience initiatives, thereby strengthening the long-term sustainability and adaptability of ports in the face of environmental challenges.

Methodology & Approach

Innovative solutions developed, tested and implemented

The **CLEVER TOOL** is an innovative digital solution designed to enhance the understanding of environmental drivers affecting port infrastructures and operations. The tool integrates a climate event registry logger that combines real-time metocean data with historical records of disruptions, enabling precise identification of climatic thresholds that cause operational or structural failures. The tool was developed in a **Test-Driven Development** (TDD) **environment** and underwent multiple iterations based on user feedback. It has been tested in a real operational environment within the Valenciaport ecosystem, providing insights into its usability, accuracy, and effectiveness.

Stakeholder engagement and participatory processes

A co-design approach was employed to ensure the CLEVER TOOL met the specific needs of port operators, decision-makers, and other stakeholders. Fundación Valenciaport played a key role in facilitating engagement with the port community, ensuring that end-users contributed to the development and validation phases. Training sessions and dissemination events were organized to foster adoption, while direct input from selected users during testing ensured the tool's practicality and relevance. Regular stakeholder interactions helped refine the tool's interface, event logging functionality, and predictive capabilities.

Open Tender for Innovation (OTI) solution selected and used

The CLEVER TOOL was designed as an **open technology innovation solution**, leveraging cloud-based architecture, RESTful APIs, and real-time data processing. It integrates existing metocean services with port-specific climate event tracking, allowing seamless data exchange and interoperability with external platforms. The solution ensures security and controlled access through identity management features, while its mobile-friendly interface enables easy reporting and retrieval of climate events. The use of AI-driven analytics enhances predictive capabilities, making it a valuable decision-support tool for port authorities.

Key results & Achievements

The implementation of CLEVER TOOL at Valenciaport demonstrated its **effectiveness in logging and analysing climate-related disruptions.** The tool has demonstrated the ability to integrate real-time observations with historical records, supporting more informed decision-making. Initial user feedback suggests improvements in operational resilience, as stakeholders are able to anticipate and mitigate weather-related risks. Additionally, the tool is progressing toward TRL 7, indicating its potential readiness for deployment in real-world settings.

Local communities and ecosystems

By enhancing climate resilience at Valenciaport, CLEVER TOOL has shown potential in **reducing economic losses** from operational downtimes and infrastructure damages. The improved climate awareness among stakeholders supports **better risk management** and **adaptation strategies**. Moreover, by logging extreme weather events and their impacts, the tool aids in long-term planning, fostering sustainable port operations and reducing environmental risks linked to climate change. The involvement of non-technical users also encouraged citizen science contributions, strengthening **community engagement**.

Lessons learned

Key lessons from the CLEVER TOOL deployment include the importance of **stakeholder involvement in the co-design process**, ensuring that the tool meets real-world operational needs. Additionally, seamless integration with third-party systems was found to be critical for maximizing usability. The project also highlighted the need for **continuous user engagement** to improve the quality and completeness of recorded events. Finally, the challenge of ensuring long-term adoption underscores the necessity of ongoing training and adaptation to evolving climate conditions.

Replicability & Scalability

Potential for replication in other regions

CLEVER TOOL's modular design and adaptability make it **highly replicable** in other port environments worldwide. The ability to integrate local climate data sources and customise event logging criteria ensures that the tool can be applied to different geographical and operational contexts.

Ports facing climate-related challenges, particularly in **coastal regions**, can benefit from its predictive analytics and climate resilience support. **Puertos del Estado**, the management entity responsible for adapting Spanish ports to climate change, has proposed **the development of an Observatory** that, among other information, will be fed by data from all ports.

In this context, the experience of CLEVER TOOL serves as an example or pilot project demonstrating how such information could be collected.

Key success factors

- Strong stakeholder engagement
- Seamless integration with existing infrastructures
- Access to reliable metocean data sources

Barriers to consider

- Potential resistance to digital transformation among traditional port operators
- Variations in data availability across regions
- Need for sustained financial and technical support for long-term implementation

Continuous collaboration with port authorities, policymakers, and technology providers

Conclusion

To ensure the longevity of CLEVER TOOL, efforts will be made to integrate it into **standard operational practices** at Valenciaport. Continuous updates, user training, and technical support will be provided to maintain system efficiency. Collaboration with Puertos del Estado and other institutions will also **support long-term data collection and refinement.** Additionally, incorporating machine learning models will enhance the tool's predictive capabilities over time.

Future initiatives will focus on **expanding CLEVER TOOL's functionalities**, including AI-driven predictive modelling and broader data integration with international metocean services. **Partnerships with other European ports** will be pursued to test its applicability in different climatic conditions. Further **research projects**, possibly under Horizon Europe or similar funding programs, will be explored to enhance the tool's capabilities and drive large-scale adoption.

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The ARSINOE consortium

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