Transport and Telecommunication, 2025, volume 26, no. 4, 373-385
Transport and Telecommunication Institute, Lauvas 2, Riga, LV-1019, Latvia
DOI 10.2478/ttj-2025-0029

INTEGRATING SMALL AND MEDIUM-SIZED PORTS INTO GREEN SHIPPING CORRIDORS: A CASE STUDY OF SILLAMÄE-KOTKA FERRY LINE

Georgi Hrenov[1], Eunice O. Bark[2], Gunnar Prause[1,2], Wolfgang Gerstlberger[1]

[1]Department of Business Administration, School of Business and Governance
Tallinn University of Technology
Tallinn, Estonia, Ehitajate tee 5
[2]Wismar Business School, Wismar University of Applied Sciences
Wismar, Germany, Philipp-Müller-Str. 14
[1]Georgi.Hrenov@taltech.ee, [2]Eunice.Bark@hs-wismar.de

The green transition remains a top priority on the European agenda, with targets to reduce greenhouse gas emissions by 55% by 2030 and achieve climate neutrality by 2050. The European transport sector contributes approximately 20% of total CO_2 emissions, strongly necessitating the need for sustainable transport solutions, so that the assessment of the maritime transport system is considered beyond time and costs to include environmental issues and regional development.

This research examines the potential environmental impact of a newly proposed ferry connection between Eastern Finland and Eastern Estonia, focusing on its role in advancing sustainable transport in the region. The study combines case studies, expert interviews, and survey data collected as part of an ongoing EU project between 2023 and 2025. The findings indicate that by 2030, the Sillamäe-Kotka ferry route could reduce annual CO_2 emissions by over 51 million tonnes, which would be a substantial contribution to regional decarbonization, enhanced freight and passenger transport efficiency, and alignment with the International Maritime Organization's emission reduction targets. At the same time, this research highlights how maritime connectivity can contribute to a just transition process in Estonia's Ida-Viru County, a region severely affected by the downturn in the oil shale industry, by facilitating new green economic opportunities, regional labour mobility, and sustainable tourism.

Keywords: Decarbonization, new ferry link, sustainable regional development, green shipping, just transition

1. Introduction

The Green Shipping Corridor (GSC) model is a pivotal step in the maritime sector's decarbonization strategy. Defined by the Global Maritime Forum as zero-emission maritime routes between major port hubs, including intermediary stopovers (GMF, 2021; Jugović *et al.*, 2025), GSCs aim to accelerate the adoption of alternative fuels, green port infrastructure, and low-carbon technologies by creating concentrated pathways of innovation and investment (Otsason *et al.*, 2025). By focusing on specific, high-volume trade routes, the model not only reduces emissions but also enables coordinated regulatory frameworks, public–private partnerships, and knowledge transfer across regions (Ismail *et al*., 2024). In this sense, GSCs serve as both experimental testbeds for new technologies and catalysts for systemic transformation, which position them as critical instruments in achieving the International Maritime Organization's climate targets and advancing global sustainability agendas (Jugović *et al*., 2025).

While GSCs are often spearheaded by large ports handling over 10 million tonnes of cargo annually, small ports (less than 1 million tonnes), medium-sized ports (between 1 and 10 million tonnes), collectively referred to as Small and Medium-Sized Ports (SMSPs), also play a critical, yet underexplored, role in shaping regional supply chains and fostering economic development within the context of the maritime energy transition (Lagdami *et al.*, 2024). Prause (2014) asserts that ports serve as multimodal logistics hubs, connecting maritime, rail, road, and inland waterways. For SMSPs, their strategic importance is amplified at the regional level, where they support local businesses, tourism, and short-sea shipping (Karimah and Yudhistira, 2020). However, SMSPs often face limitations in infrastructure, finance, technology, and human capital, which hinder the adoption of sustainable solutions (Mańkowska *et al.*, 2020).

The Baltic Sea Region (BSR) exemplifies these issues, with 66% of its ports classified as SMSPs (Meyer *et al*., 2023). Developing GSCs demands that SMSPs evolve into logistically intensive clusters, integrating digitalization and co-creation of value (Kitzmann *et al.*, 2020). Many proactive measures, such as shore-side electricity, improved logistics, low-carbon fuel bunkering, and energy-efficient infrastructure, can significantly reduce GHG emissions and help ports manage EU ETS-related costs (Alamoush *et al*., 2020).

Addressing these challenges requires enhanced collaboration between BSR ports (Atari, 2018). SMSPs in European countries, including those located along key BSR trade routes, must balance efficiency and sustainability to maintain competitiveness (Kitzmann *et al*., 2020). In this context, strengthening maritime links between strategically positioned ports like Sillamäe and Kotka could provide a sustainable framework for regional integration and competitive advantage.

The Port of Sillamäe, classified as a medium-sized port within the category of SMSP and designated as a core TEN-T node, is actively seeking to adapt to these emerging regulations while competing with larger ports. Traditionally focused on cargo operations, the Port of Sillamäe is now exploring the possibility of the revival of the Sillamäe–Kotka passenger and freight route, emphasizing sustainability. Yet the ports face major constraints: the need for infrastructure upgrades, limited access to green financing, and competition from Tallinn and Helsinki. Its strategy includes plans for green hydrogen and ammonia production and biomethane bunkering to attract eco-conscious shipping line operators and shipowners. The tourism-energy-emissions nexus, as discussed by Zeng *et al.* (2025), reveals that post-COVID tourism recovery and growth are closely intertwined with energy prices and carbon policy, making investments in GSC infrastructure increasingly urgent.

While major ports frequently dominate discussions on maritime logistics and sustainability and are increasingly central to urban and regional development, where environmental and economic priorities converge (Karimah and Yudhistira, 2020), SMSPs, such as those at Sillamäe and Kotka, often remain overlooked despite their strategic potential to foster regional connectivity, innovation, and sustainable maritime growth. For Sillamäe City and Ida-Viru County, development must align with local socio-economic needs and implement the principles of a just transition, ensuring that this region, historically dependent on carbon-intensive industries, is not left behind in the transition to a greener economy. Given its proximity to Natura 2000 protected areas, stringent safeguards are essential to position these ports as potential models of sustainable "blue growth" (Notteboom *et al*., 2022; Prause *et al.*, 2019). Restoring the Sillamäe-Kotka ferry line connection could increase regional tourism, reduce road congestion, and help capitalize on the EU's sustainable tourism agenda. This approach aligns with GSC principles, emphasizing safe, efficient, and sustainable logistics (Schröder and Prause, 2016).

The transition to alternative fuels demands significant capital investment in production and bunkering infrastructure (Hrenov *et al.,* 2025). However, existing research on GSCs predominantly focuses on large ports, often overlooking the realities of SMSPs like the Port of Sillamäe (Jugović *et al*., 2025). While the literature extensively addresses decarbonization strategies, alternative fuels, emerging technologies, and regulatory frameworks (Ampah *et al.,* 2021), the topic of integration of SMSPs into GSCs and the impact of carbon emission taxation remains largely understudied (Zeng *et al.*, 2025).

Framed within the EU's decarbonization agenda and regulatory pressure, this study adopts a mixed-method approach to evaluate the environmental and economic feasibility of establishing a low-emission ferry corridor between Sillamäe (Estonia) and Kotka (Finland). The analysis addresses two key research questions: (1) What role can the Sillamäe-Kotka ferry play in enhancing cross-border transport efficiency while supporting regional emission reduction targets? (2) How can the ferry connection strengthen labor mobility and drive socio-economic growth between Southeast Finland and Estonia's Ida-Viru County?

To answer these, the study integrates operational performance modelling that includes demand forecasting based on regional socio-economic indicators, a comparative assessment using reference benchmarks from high-capacity routes Helsinki–Tallinn, and draws on technical specifications of RoPax vessels, emission factors from International Maritime Organization (IMO) guidelines, and regional transport statistics to simulate route-specific outcomes under alternative energy configurations.

The remaining part of this paper is structured as follows: Section 2 reviews the relevant literature on maritime decarbonization, alternative marine fuels, and the evolving role of SMSPs within GSCs. Section 3 outlines the research methodology and describes the design of the qualitative research component conducted in Ida-Viru County. Section 4 presents the findings, and Section 5 provides policy recommendations and considerations. Section 6 concludes the paper and highlights limitations and directions for future research.

2. Literature review

2.1. Ferry connectivity, environmental performance, and regional economic growth

Port-city ecosystems act as regional economic drivers, extending far beyond traditional trade functions (Efimova and Gapochka, 2020; Jansen *et al.,* 2021). These systems may support regional development, tourism, and cultural exchange while generating layered economic effects beyond GDP metrics. Their value appears in jobs, demographic shifts, spatial renewal, and innovation ecosystems, revealing how maritime infrastructure and urban development mutually reinforce one another (Yu *et al.*, 2025). SMSPs are essential components of Europe's maritime and territorial framework, serving as strategic complements to larger transport hubs (Lagdami *et al.*, 2024). While their freight volumes are typically limited and their locations often peripheral, SMSPs can substantially support regional economic development, tourism, and sustainable transitions (Karimah and Yudhistira, 2020).

However, as Efimova and Gapochka's (2020) comparative study of Russian and Western European ports demonstrates, their economic impact varies substantially depending on governance structures and industrial integration, with SMSPs generally showing weaker correlations between cargo turnover and regional GDP than major hubs like Rotterdam or Antwerp. Under growing pressure to decarbonize maritime transport, particularly since the 2024 implementation of the EU ETS system (EC, 2024), SMSPs have become key actors in adopting green shipping practices that advance both socio-economic and environmental sustainability at regional scales (Akhavan, 2025).

Ports and their surrounding urban areas constitute interconnected socio-economic, institutional, spatial, and ecological systems (Yu *et al.*, 2025), shaped by the dynamic interplay of maritime, urban, and hinterland forces (Jansen *et al*., 2021). These integrated Port-City Ecosystems combine infrastructure, governance mechanisms, and socio-commercial networks to enhance regional competitiveness. Andersen *et al.* (2018) confirm this, showing that permanent links expand labor markets by increasing travel between islands and mainland cities, which strengthens urban-rural ties.

A striking example emerges from the Great Port of St. Petersburg, where federal control and low industrial integration have effectively decoupled cargo turnover from local economic benefits - a pattern that stands in sharp contrast to Western European models. In ports like Rotterdam and Antwerp, industrial activity within port zones contributes nearly half of regional value-added (Efimova and Gapochka, 2020). Functioning within municipal boundaries, ports orchestrate complex flows of goods, people, energy, and knowledge, generating both direct and indirect economic impacts on urban economies (Yu *et al.*, 2025). Yet quantifying indirect effects remains difficult due to complex interdependencies across the broader port-city system.

Regular maritime routes integrated into GSCs can enhance these benefits in the near future by reducing the price gap between conventional and alternative fuels under the EU ETS, attracting environmentally conscious visitors, creating jobs in the service and tourism sectors, and supporting local businesses through sustainable maritime connectivity. Andersen *et al.* (2018) highlight that to fully realize the potential of regional development, infrastructure investments must take into account social impacts such as changes in housing and labor markets, and this lesson applies equally to SMSP planning.

2.2. Green Shipping Corridors (GSCs)

GSCs are recognized as a strategic instrument in efforts to decarbonize the maritime sector and were introduced through the Clydebank Declaration at COP26 in 2021 (Ismail *et al.*, 2024). It was initially endorsed by 24 countries and later expanded to 27. The concept reflects a growing international commitment to collaborative climate action aimed at zero-emission shipping. Several scholars have expanded the conceptual framing of GSCs as collaborative frameworks that bring together diverse stakeholders to align national priorities with the broader goal of decarbonizing international shipping (Psaraftis and Kontovas, 2021). In practical terms, GSCs are typically referred to as designated maritime trade routes linking major port hubs where zero-emission vessels, alternative fuel infrastructure (e.g., for hydrogen, ammonia, and biofuels), and energy-efficient logistics systems are already in place or under active development (Jesus *et al.*, 2024).

The successful implementation of GSCs depends on cooperation among a wide range of stakeholders, including ports, shipowners, cargo operators, fuel suppliers, technology providers, and regulatory bodies (Olaniyi *et al*., 2024). Central to this collaboration is the introduction of viable alternative fuels, which will play a critical role in achieving the emissions reduction targets set by the GSC initiatives. The Los Angeles–Shanghai Green Corridor, a transpacific initiative based on a “gate-to-gate” emissions reduction strategy, brings together ports, shipping lines, and local governments through shared commitments to deploy zero-lifecycle carbon vessels by 2030 and is regarded as a model for similar future corridors (Akhavan, 2025).

According to Ismail *et al.* (2024), by 2023, at least 41 GSC initiatives were either active or planned, with a concentration in Europe, East Asia, and North America. Among these are the Singapore–Rotterdam corridor, the Silk Alliance, and the Nordic GSCs, which aim to strengthen sustainable trade links. The FIN-EST corridor, which aims to connect Finland and Estonia, is emerging as a regionally significant initiative in the Baltic Sea (Hrenov *et al.,* 2025). These corridors are not only testing grounds for new governance models but also critical platforms for scaling up alternative fuel infrastructure and technologies. In parallel, the Green Ports Forum, coordinated by the C40 Cities network, a global network of city leaders working to address the climate crisis, includes 22 cities working to integrate port and urban sustainability. This platform focuses on aligning municipal and maritime sustainability goals, supporting infrastructure investments, promoting zero-emission technologies, and fostering public-private cooperation to support the goals of GSCs (Akhavan, 2025).

Despite ongoing progress, some authors report that several challenges continue to affect the development of GSCs. One of the most pressing issues is the transition to alternative fuels, with 41% of initiatives yet to define a clear pathway (Jesus *et al.,* 2024). This reflects broader uncertainties around the scalability of alternative fuel production, infrastructure capacity, and the consistency of regulatory frameworks across jurisdictions (Zeng *et al.,* 2025). Another challenge involves managing diverse stakeholder expectations and coordinating implementation timelines, which calls for governance models that support consensus-building. From a planning perspective, GSCs introduce an additional layer of transport and energy infrastructure, requiring integration into urban and regional development strategies (Wang and Zhang, 2020; Jurković and Lovoković, 2023).

In addition to climate change tools, GSCs serve as platforms for innovation and global leadership. Akhavan's (2025) concept of GSCs as "special economic zones at sea" captures their potential perfectly. These maritime hubs bring together policymakers, new technologies, and sustainable business approaches to accelerate clean shipping. While they're creating global networks that connect ports and shipping routes, their real value lies in how they're driving faster adoption of environmental regulations, clean energy solutions, and operational upgrades - benefits that could eventually extend to land-based port operations as well (Robaina and Neves, 2021).

3. Methodology

In the context of the study on the Sillamäe-Kotka ferry route, the authors used a combination of both quantitative and qualitative approaches to gain a comprehensive understanding of the environmental and economic trade-offs involved. These are data used to model emissions, operational feasibility, and economic performance obtained from experts' interviews from Estonia (Port of Sillamäe (Sillamäe Sadam); Port of Tallinn (as a reference) and Finland (Port of Kotka (part of the Port of HaminaKotka)); Port of Helsinki (as a reference).

The qualitative method provides contextual and interpretive insights, particularly valuable for understanding stakeholder perspectives and policy relevance. This is achieved through document analysis of national maritime strategies and regional development plans in Estonia and Finland. It also includes case study comparisons of small-port ferry operations in Norway, Sweden, and the Baltic states, offering empirical benchmarks for sustainable maritime practices. Finally, scenario framing is used to apply assumptions related to fuel viability and route planning under conditions of uncertainty, including variables such as policy incentives and technology readiness.

The emissions modelling involves technical data on vessel type, fuel type, distance, speed, and load factors to calculate CO_2 and other emissions under different scenarios (e.g., conventional fuel vs alternative fuels). For the evaluation and comparison of the emissions of the land-based transport comprising passenger commuter services with cars and buses, as well as cargo transport, the authors used the official average values from the emission study of the German Environmental Authority (Umweltbundesamt, 2023).

Demand forecasting was used to estimate passenger and vehicle volumes using regional socio-economic data, tourism flows, and population mobility patterns. Operational data from established routes like Helsinki–Tallinn was used to model potential efficiencies or inefficiencies (comparative benchmarking).

The techno-economic assessment presented is based on a representative medium-tonnage RoPax vessel, which serves as the analytical platform for evaluating fuel consumption, emissions, and operating costs throughout the life cycle. This reference vessel corresponds to the "old vessel" scenario defined in the Cost–Benefit Analysis of the Sillamäe-Kotka ferry project (CBA, 2023) and reflects typical design and operational characteristics of ferries currently operating in BSR.

Using a comprehensive economic evaluation framework, the authors assess the viability of restoring the Sillamäe-Kotka ferry route. The analysis incorporates three primary cost categories of Total Costs of Ownership (TCO): capital expenditures (CAPEX), fuel expenditures (FUELEX), and operational expenditures (OPEX). All cost streams are projected over a 30-year analysis period (2026–2055), in line with typical vessel lifespans used in maritime investment appraisals.

4. Results and analyses

4.1. Case study: The restoration of Sillamäe-Kotka ferry route in the context of GSCs

The outcome below is gathered from interviews and benchmarked governmental reports and technical reports from Hilmola (2014), CBA (2023), Finnish Shipowners' Association (2025), and others.

The Sillamäe-Kotka ferry connection serves as a strategic maritime corridor in the Gulf of Finland, spanning 160 kilometers (86 nautical miles) between Estonia's Port of Sillamäe and Finland's Hamina-Kotka port complex. Designed to bypass Russian waters near Gogland Island, the route addresses both regulatory compliance and geopolitical security concerns while offering an alternative to the congested Tallinn-Helsinki crossing. Its establishment would connect two industrially significant but underserved regions - Estonia's Ida-Viru County and Finland's Kymenlaakso - potentially enhancing regional trade, labor mobility, and tourism in Northeastern Estonia.

Operational plans center on a single daily round-trip with overnight accommodation. Departures from Kotka at 09:00 arrive in Sillamäe by 15:00, with return voyages from Sillamäe at 22:00 reaching Kotka by 07:00 the following morning. This schedule accommodates truck drivers' rest periods, reduces port congestion, and aligns with intermodal freight requirements. Crossing times of 4-6 hours match Baltic Sea service standards, varying by vessel type and weather conditions.

Historical operation during 2006-2007 demonstrated initial promise, transporting 22,000 passengers and 10,000 vehicles in its first year, with monthly passenger numbers growing from 1,475 in June 2006 to 2,998 by July 2006. However, the service ultimately failed due to inadequate freight volumes, substandard amenities, and geopolitical impacts on cargo flows (CBA, 2023). Current demand projections suggest potential recovery, possibly reaching 52,000 passengers by 2028, and for the coming years after 2028, an annual growth rate of 5% for the passenger volume will lead to a long-term target of beyond 65,000 annual passengers using the Sillamäe-Kotka ferry. As a reference for these estimations, the current 120,000 annual passengers of the Paldiski-Kapellskär route can be taken as a comparable case, though this depends on competitive pricing and infrastructure improvements.

Concerning the possible cargo volumes that can be forwarded with the Sillamäe-Kotka ferry, it is necessary to consider the statistics and studies of both countries. First important fact is that about 90% of the transported cargo between Finland and Estonia is realized by passenger vessels, i.e. the related cargo type represents general cargo transported by RoRo ferries on truck and trailers (Finnish Shipowners' Association, 2025) The total volume of transshipped general cargo between Finland and Estonia sums up to about 5 million tons and ca. 20% of this volume is handled between Helsinki port and Eastern Finland (Hilmola, 2014). Hence, the potential of the truck-based general cargo transport volume for the Sillamäe-Kotka ferry can be estimated to 1 million tons in 2025 and about 1.2 million tons around 2030.

The route's strategic value is enhanced by Sillamäe's proximity to the TEN-T network's Tallinn-St. Petersburg axis and Kotka's connections to Finnish inland transport align with IMO and GSC objectives. Decarbonization efforts further support this potential, with Sillamäe exploring green ammonia infrastructure (Hrenov *et al*., 2023) and Kotka-Hamina already operating a BioLNG terminal since 2025 (Rohe Solutions, 2025). A planned Power-to-Gas plant in Mussalo (Kotka) targeting 2028 completion would produce green hydrogen and e-methane (Ren-Gas, 2025), enabling vessel retrofits for alternative fuels like BioLNG, green ammonia, and hydrogen derivatives.

However, economic and operational challenges persist. Studies indicate the route requires €5-7 million in annual public subsidies to achieve viability, with private investment unlikely without such support (CBA, 2023). Forest industry cargo volumes remain committed to existing supply chains, limiting projected freight shifts to the Sillamäe-Kotka axis. Modern, environmentally compliant vessels demand substantial capital investment despite uncertain returns, while passenger demand faces competition from the faster, more established Tallinn-Helsinki route. Additional barriers include Sillamäe's inadequate terminal facilities and limited regional tourism infrastructure (Ahlberg, 2024).

Nevertheless, the route's strategic importance extends beyond immediate profitability. Its potential for geopolitical risk mitigation, supply chain diversification, and climate-adapted tourism growth may justify targeted investments aligned with EU sustainability goals (Ahlberg, 2024). As a potential model for implementing GSC principles, the Sillamäe-Kotka connection represents a test case for integrating peripheral ports into Europe's emerging zero-emission maritime network while addressing regional development objectives in Ida-Viru County.

The subsequent analysis examines the route's feasibility through techno-economic lenses, evaluating alternative fuel adoption under evolving EU regulations. Combining economic modeling with stakeholder input, this study assesses the service's implementation potential within the GSC framework.

4.2. The socio-economic potential Sillamäe-Kotka ferry connection

The proposed Sillamäe-Kotka ferry connection offers substantial socio-economic promise, yet this realization depends on how the regions are able to overcome notable financial, infrastructural, and operational hurdles. With a sea distance of roughly 180 km and a journey time ranging from 4 to 6 hours, the route presents a strategic alternative to the popular but saturated Helsinki–Tallinn corridor. Passenger transport viability hinges on convenience and onboard experience, given the longer journey time. While this poses a disadvantage compared to Helsinki–Tallinn's 2-hour crossing, tourism development in Eastern Estonia, especially around Narva and Sillamäe, offers affordability and cultural richness.

Historically, after a pilot test was conducted, the result shows that the route has been underutilized, with a usage of only 400 out of the 1,200 lane meters between 2006 and 2007 (Ahlberg, 2024). Despite these challenges, the route's appeal has been renewed due to shifts in regional trade, particularly following the loss of 9 million cubic meters of Russian timber imports, redirecting supply chains through the Baltic states and increasing activity at the Port of HaminaKotka. Although this requires extensive marketing and infrastructure investments, freight remains the more critical component for route sustainability, with its success depending on cargo volume, vessel efficiency, and green compliance under EU ETS regulations (EC, 2021). Environmentally advanced ships, such as Wasaline's Aurora Botnia, provide operational models for eco-conscious maritime links (Wasaline, 2025).

The socio-economic gains extend beyond transport. The connection is expected to directly create 65 jobs (55 ship-based, 10 port-based), expanding to 160 within five years across tourism, logistics, and hospitality sectors. The Port of Sillamäe, with 13 deep-water berths and multimodal connectivity, and the Port of HaminaKotka, handling over 14 million tonnes annually, provide robust infrastructure for this development (Ahlberg, 2024).

Tourism potential is notable, especially in Eastern Estonia's Narva and Sillamäe, where prices are up to 30% lower than in Tallinn, and Ida-Viru County's GDP per capita is just 58% of Estonia's national average, which further emphasizes the need for revitalization through improved logistics and employment opportunities. On the other hand, regional governance frameworks, particularly in Finland, support such projects through municipally owned port structures and operational reinvestment strategies (Rönty *et al.,* 2011). The Finnish national planning policies also prioritize polycentric development and inclusion of lagging regions (Purkarthofer *et al.,* 2021). In addition, Kotka's LNG terminal investment of €95 million indicates readiness for sustainable maritime operations. The Gulf of Finland's advanced vessel traffic systems further enhance safety and environmental oversight (Rosqvist *et al.,* 2002). Furthermore, strong community engagement in Kotka highlights the potential for civil society to drive equitable growth via infrastructure-led regeneration. While economic feasibility remains uncertain, the ferry link aligns with broader EU climate goals, regional cohesion strategies, and evolving supply chain demands, which makes it a compelling candidate for public-private partnership and long-term strategic investment.

Sadly, the journey duration remains a barrier; trips over 4 hours may deter passengers unless onboard experiences are enhanced. Thus, cargo revenue must underpin economic viability, with passenger traffic serving as supplementary income. Wasaline's Vaasa–Umeå route offers a model for integrating public-private investment and environmentally conscious operations. Broader regional goals, such as reducing road transport by 300 km and decentralizing economic activity, align the project with national cohesion strategies in both Finland and Estonia (Purkarthofer *et al*., 2021). Governance models, particularly Finland's municipally owned port structures, offer a stable framework for financing necessary upgrades (Rönty *et al*., 2011). If supported by sustained cooperation, strategic marketing, and investment in green technology, the Sillamäe-Kotka route holds strong potential to enhance regional integration, resilience, and economic sustainability.

4.3. The socio-economic fit between Ida-Viru County and Southeast Finland's labor demand

The socio-economic structure of Estonia's Ida-Viru County aligns closely with the occupational needs of Southeast Finland. Table 1 summarizes this relationship.

Table 1. Comparative overview of labour demand in Finland and labour supply in Ida-Viru County

Finnish Occupational Demand	Ida-Viru County's Labor Supply Characteristics
Industrial Workers **(Welders, Machine Operators)**	Ida-Viru County has a large pool of industrial workers from the oil shale, chemical, and metal industries, many of whom possess welding and machine-shop skills. In Southeast Finland, particularly in Kotka's shipyards, metal factories, and power plants, there is sustained demand for such workers. Labor supply and demand align well in this sector, although Finnish employers typically require fluency in English or Finnish and certification that meets EU standards.

Continuation of Table 1

Finnish Occupational Demand	Ida-Viru County's Labor Supply Characteristics
Logistics Personnel and Drivers	The Port of Sillamäe is a deep-water seaport with strong marine, rail and road connections, complemented by several regional transport companies that contribute to a pool of logistics workers. In Southeast Finland, major hubs such as the ports of Kotka and Hamina, Lappeenranta Airport, and key rail freight lines face chronic shortages of drivers. Ida-Viru County can offer experienced drivers and logistics workers. Higher wages in Finland further incentivize labor mobility.
Construction Workers	Following a slowdown in local construction, many skilled tradespeople from Ida-Viru County (e.g., carpenters, masons, and electricians) are underemployed. By contrast, the Finnish construction sector, particularly in Kymenlaakso and South Karelia, continues to require workers for residential and infrastructure projects, though at a slower growth rate. Historically, many Estonian construction workers have sought employment in Finland due to significantly higher wages, suggesting that Ida-Viru County remains a viable source of experienced builders.
Maintenance Technicians	Mining and energy operations in Ida-Viru County have trained a substantial workforce of maintenance specialists, electricians, and instrument technicians (e.g., oil shale plant mechanics). As these industries decline, many of these skilled workers are underutilized. Southeast Finland's industrial facilities, including paper mills, chemical plants, and power stations, frequently require qualified technical personnel. Regional labor forecasts predict continued demand for metal and mechanical technicians, particularly in shipbuilding and energy sectors (including nuclear). Ida-Viru County's underemployed specialists, many of whom still reside in the region, could meet this demand.
Tourism and Hospitality Staff	South Karelia's tourism sector contracted sharply following the decline of Russian visitors, who previously accounted for 96.5% of foreign tourist spending. Nevertheless, domestic and Nordic tourism to the Lake Saimaa area and Lappeenranta continues to grow, with seasonal employers reporting persistent labor shortages in hospitality. Vocational schools in Ida-Viru County graduate many catering and service professionals. Additionally, local youth, often multilingual in Estonian, English, and Russian, are well-positioned for seasonal employment in Finland. Language barriers, particularly limited Finnish proficiency, remain a challenge, though many young people are pursuing English language studies with employment abroad in mind.
Health Care Workers	Southeast Finland, including Kymenlaakso and South Karelia, faces acute shortages of health care professionals, with an estimated need for approximately 3,000 additional practical nurses per year, and ward closures due to staff shortages. Rural Finland also has high vacancy rates for general practitioners and health care specialists (25–35%). Estonian medical graduates from Ida-Viru County are eligible to pursue Finnish licensing under EU regulations, making them a potential source of health care labor for the region.

Note. Compiled by the authors.

The estimated number of total passengers of the Sillamäe-Kotka ferry in the coming years also impacts the economic development of the surrounding port regions due to passenger spending during port times. By assuming the estimated number of 52,000 passengers in 2025, together with an annual growth rate of 5% to a passenger volume of 65,000 annual passengers after 2028 using the Sillamäe-Kotka ferry, the financial inflow in both port regions is significant. These passengers will leave the ferry during their port time, and some of them represent tourists who take the ferry back to their home destination and can be considered as 1-day cruise passengers.

Studies from the cruising industry in BSR estimate the daily spending of cruise passengers ashore to about 80 EUR (Menke zum Felde, 2020). Hence, under the assumption that about 50% of the ferry passengers can be characterized as 1-day cruise passengers, the annual inflow into both port regions sums up to about 2 million EUR in 2025 and to 2.7 million EUR after 2028. Provided that we have a balanced distribution of the passenger spending in both ports, each port region will be able to expect additional annual financial inflow between 2 and 2.3 million EUR, spurring the local economy.

4.4. Sillamäe-Kotka and Tallinn-Helsinki ferry route comparison

In Table 2, a comparative overview of the Sillamäe-Kotka and Tallinn-Helsinki ferry routes is drawn, focusing on key operational parameters such as distance, vessel specifications, passenger capacity, and voyage frequency. It highlights the scale difference between a proposed low-demand regional route and a high-volume, established corridor, providing essential context for evaluating emissions efficiency, economic feasibility, and potential for green maritime transition in the Gulf of Finland.

Table 2. Comparative Overview of the Sillamäe-Kotka and Tallinn-Helsinki Ferry Routes

Parameter	**Sillamäe-Kotka Ferry**	**Tallinn-Helsinki Ferry**	**Unit**
Route characteristics			
Route length	160	80	km
Sailing distance	86	43	nautical miles (nm)
Average voyage duration	4 - 6	2	h
Operational days per year	232	262	days
Operating schedule	09:00 (Kotka) / 22:00 (Sillamäe)	every 2 h (daily)	-
Vessel characteristics (RoPax type)			
Length overall	190.00	212.40	m
Beam (width)	26.00	30.60	m
Gross tonnage	25,000.00	50,629.00	GT
Deadweight tonnage	N/A	5936	DWT
Maximum speed	N/A	27.00	knots
Average service speed	N/A	21.50	knots
Operational capacity			
Passenger capacity	500	2800	persons
Crew	44	300	persons
Cabins	60	46	units
Vehicle capacity	100	100	cars
Heavy vehicle capacity	50	50	units
Traffic volumes (annual)			
Passenger volume	52,000	7,500,000	passengers/year
Car volume	N/A	2,000,000	cars/year
Cargo volume	N/A	5,500,000	tonnes/year

Note. Compiled by the authors.

The comparative analysis of the Sillamäe-Kotka and Tallinn-Helsinki ferries reveals fundamental differences in operational capacity, environmental impact potential, and passenger throughput that are crucial for evaluating the viability and sustainability of maritime connectivity across the Gulf of Finland.

The average speed of the Tallink vessel (21.5 knots) and its optimized daily frequency point to a mature, demand-driven operation with tightly controlled voyage emissions. Meanwhile, the Kotka–Sillamäe route, though slightly longer in linear distance, suffers from slower voyage times and suboptimal daily schedules, leading to less efficient utilization of energy per trip. Assuming both vessels use similar propulsion systems and marine fuels, the lower energy efficiency and limited passenger density on the Kotka–Sillamäe line make it less sustainable from both economic and environmental perspectives unless supported by targeted modal shifts or green fuel subsidies.

The higher throughput and economies of scale for the Tallinn-Helsinki ferry allow for more efficient fuel use per unit of cargo and per passenger, significantly reducing the per capita CO_2 emissions on the Helsinki route despite the vessel's larger size and power requirements.

Although the Sillamäe-Kotka ferry route demonstrates comparatively lower passenger volumes and operational intensity than the well-established Tallinn-Helsinki service, this disparity should not be interpreted as a weakness. Instead, it reveals a unique strategic opening for innovation at the intersection of regional equity and environmental policy. Precisely because of its smaller scale and lower commercial pressure, the Sillamäe-Kotka route offers an ideal platform for piloting green maritime technologies, testing alternative fuel systems, and implementing decarbonization strategies aligned with the EU's Fit for 55 and ETS frameworks. Far from being a marginal corridor, it exemplifies the kind of low-demand route that requires targeted public intervention to unlock socio-economic integration, reduce regional disparities, and demonstrate how sustainability transitions can extend beyond core urban hubs to the maritime periphery. In this sense, the apparent limitations of the route become its most valuable features for advancing climate-smart, inclusive maritime connectivity.

Building on the operational and capacity characteristics of the Sillamäe-Kotka and Tallinn-Helsinki ferry routes presented in Table 2, the following analysis (Table 3) projects the expected passenger and freight transport volumes and their associated CO_2 emissions. This allows the authors to make comparisons between service features and their anticipated environmental impacts to link route design and vessel operations to sustainability outcomes.

Table 3. Projected Passenger and Freight Transport Volumes and CO_2 Emissions (2025 vs. Post-2028)

Parameter	2025	Post-2028	Unit
Route characteristics			
Route description	Kotka – Helsinki – ferry – Tallinn – Sillamäe		
Total route length	325	325	km
Passenger transport			
Total passengers	52,000	65,000	persons/year
Specific CO_2 emissions per passenger – bus	9,750	9,750	g CO_2/pkm
Specific CO_2 emissions per passenger – car	53,300	53,300	g CO_2/pkm
Share of bus passengers	30	30	%
Share of car passengers	70	70	%
Total CO_2 emissions – bus transport	49,432.5	61,790.6	t CO_2
Total CO_2 emissions – car transport	630,539.0	788,173.8	t CO_2
Total annual CO_2 emissions (passenger transport)	**679,971.5**	**849,964.4**	**t CO_2**
Freight transport			
Freight volume (general cargo)	1,000,000	1,200,000	tonnes
Specific GHG emissions – heavy-duty truck (>12 t)	249	249	g CO_2/tkm
Specific GHG emissions – articulated truck	101	101	g CO_2/tkm
Share of heavy-duty trucks	20	20	%
Share of articulated trucks	80	80	%
Total CO_2 emissions – heavy-duty trucks	16,185,000	19,422,000	t CO_2
Total CO_2 emissions – articulated trucks	26,260,000	31,512,000	t CO_2
Total annual CO_2 emissions (freight transport)	**42,445,000**	**50,934,000**	**t CO_2**

Note. Compiled by the authors.

The results in Table 3 show the possible upward trajectory in both passenger and freight activity on the Kotka–Helsinki–Tallinn–Sillamäe corridor between 2025 and the period after 2028. On the passenger side, volumes are projected to rise from 52,000 to 65,000 passengers (an increase of 25%). However, since the modal split remains constant at 30% bus and 70% car, the growth in emissions is directly proportional to the increase in demand. As a result, bus-related CO_2 emissions will likely grow from approximately 49,433 tons to 61,791 tons, while car-related emissions rise from 630,539 tons to 788,174 tons when the aggregate passenger emissions increase from 680,000 to 850,000 tons annually, without any efficiency gains or modal shift benefits. This indicates that unless there are changes in technology (e.g., adoption of low-emission vehicles) or behavioural interventions to encourage bus use, the environmental burden from passenger travel will scale linearly with demand.

The freight sector shows even more pronounced effects. Cargo volumes are projected to increase from 1 million tons to 1.2 million tons, reflecting a growth of 20%. The vehicle mix remains unchanged, with 20% heavy trucks and 80% trailer trucks. However, the CO_2 emissions intensity is much higher for heavy trucks (249 g/tkm) than for trailers (101 g/tkm). As freight demand grows, emissions rise from 42.45 million tons in 2025 to 50.93 million tons post-2028. Compared to passenger transport, freight emissions are two orders of magnitude larger, contributing more than 98% of the corridor's total transport-related emissions. This stark imbalance suggests that freight transport overwhelmingly dominates the carbon footprint of this route.

However, these projected traffic volumes and emissions for the Sillamäe-Kotka route are important to understand the broader environmental implications. Table 4 shows the potential annual CO_2 savings, translating the detailed transport data into a tangible measure of the route's contribution to sustainable regional transport and climate mitigation.

Table 4. CO_2 Savings by using Sillamäe-Kotka Ferry

Year	Passenger Transport Savings (t CO_2)	Freight Transport Savings (t CO_2)	Total Annual Savings (t CO_2)
2025	~680,000	~42,445,000	~43.1 million
2030	~850,000	~50,934,000	~51.8 million

Note. Compiled by the authors.

Clearly, Table 4 shows that by 2030, shifting traffic to the Sillamäe-Kotka ferry route could cut over 51 million tonnes of CO_2 annually. A confirmation of its major role in advancing sustainable regional transport. From a regional perspective, the implications are significant. The projected annual savings of approximately 43 million tonnes of CO_2 in 2025, rising to over 51 million tonnes by 2030, demonstrate that this route can substantially lower emissions from both passenger and freight transport. For the Baltic region, which faces increasing pressure to decarbonize transport and meet EU climate targets, the route offers a practical and scalable measure to reduce environmental impact while maintaining vital logistics and passenger connectivity.

On a global scale, these savings align with the emission reduction goals of IMO. By shifting freight and passenger flows from higher-emission alternatives (such as cars and heavy trucks) to a RoPax ferry with optimized capacity utilization, the Sillamäe-Kotka route will contribute directly to these objectives. It represents a tangible measure by which the region can participate in global decarbonization efforts, indicating how modal shifts in maritime transport can achieve both operational and environmental efficiency.

5. Recommendations and policy considerations

The analysis shows targeted government intervention remains crucial to make cleaner fuels economically viable. While passenger transport emissions are not negligible, their relative share is marginal compared to freight. This suggests that mitigation measures targeting car travel alone (e.g., encouraging public transport use or vehicle electrification) will have only a limited impact on the total emissions profile of the corridor. Instead, the most substantial climate benefits will arise from addressing freight decarbonization.

The persistence of current modal splits in both passenger and freight sectors implies that behavioral and structural factors are resistant to change. For passengers, car dominance (70%) reflects convenience and flexibility, while in freight, the overwhelming reliance on trucks and trailers reflects entrenched logistics practices. Without interventions such as pricing incentives, modal shift policies (e.g., rail or sea alternatives), or stricter emissions regulations, the carbon intensity of the corridor will continue to rise in line with demand growth.

The findings point toward an urgent need for technological and systemic innovation. In the short to medium term, investments in fuel efficiency, alternative fuels, and electrification of road transport could reduce emissions intensity. In the longer term, structural changes in the freight system, such as a modal shift toward rail or short-sea shipping, would be required to achieve substantial decarbonization. For passenger transport, policies that incentivize bus or low-emission car use could curb growth in emissions. Ultimately, the study highlights that freight transport is the critical bottleneck for achieving climate goals on this corridor and that addressing this sector must be a strategic priority.

Establishing a Green Shipping Corridor for the Sillamäe-Kotka route could unlock valuable EU support. By bringing together ports, shipping companies, and authorities in a collaborative partnership, the route could qualify for technical assistance and co-funding through programs like CEF Transport or the Innovation Fund.

Infrastructure improvements are equally important, as the Port of Sillamäe is currently only ready to bunker with grey ammonia. BioLNG, green hydrogen, and green ammonia projects are in the feasibility analysis phase, so investments in new refuelling systems and shore power connections will be very important. EU regional development funds could help finance these upgrades.

These additional benefits are a strong argument for considering public subsidies for the restoration of the Sillamäe-Kotka ferry line, including it as a pilot project to test decarbonisation strategies on smaller but strategically important routes. Government support could therefore serve dual purposes: stimulating regional development while advancing sustainable shipping objectives.

6. Conclusion

The analysis of the possibilities for restoring the Sillamäe-Kotka ferry line serves as an instructive case study for examining how carbon taxation can affect shipping routes and the integration of this corridor into green shipping initiatives. This study also contributes to the just transition literature: while most studies focus on multi-level governance, stakeholder engagement, or labor market restructuring, this case study highlights how green shipping corridors can serve as concrete instruments for just transition, linking decarbonization with regional development and socio-economic sustainability.

A strategically important corridor could connect Estonia's industrial northeast with the Kotka-Hamina port complex, as well as regions in Southern Finland, demonstrating both the potential and challenges of maritime decarbonization policies. Beyond environmental benefits and economic viability, the route may diversify and strengthen supply chains and tourism flows, while also supporting regional development in Ida-Viru County, which is experiencing socio-economic decline due to the transition from oil shale energy.

While this study provides valuable insights into the environmental and socio-economic potential of the Sillamäe-Kotka ferry route, it is based on projections and secondary data that should be validated through operational trials and long-term monitoring. Further research could assess financial feasibility, technological requirements for low-carbon operations, and stakeholder acceptance to ensure successful implementation, but the overall findings clearly demonstrate the route's strategic value for regional sustainability and decarbonisation. To translate these findings into practice, policy action will be required at both the regional and European levels.

The resumption of the Sillamäe-Kotka ferry connection not only represents a practical step towards reducing regional transport emissions but also offers an experimental platform for the development of sustainable and resilient maritime systems in the Baltic Sea Region.

Acknowledgements

The authors gratefully acknowledge the financial support provided through the "*Increasing the knowledge intensity of Ida-Viru entrepreneurship*" project, co-funded by the European Union. This support played a key role in conducting the research and analysis presented in this article.

Ethics declaration

This study was conducted in accordance with established ethical standards. Ethical approval for qualitative interviews was obtained from the Research Ethics Committee of the University of Tartu (387/T-28, 19.02.2024).

Declaration of Generative AI and AI-assisted technologies in the writing process:

- During the preparation of this manuscript the author(s) used ChatGPT (OpenAI) in order to assist with English-language proofreading and stylistic editing. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

References

1. Ahlberg, A. (2024) *Kotka-Sillamäe connection potential.* South-Eastern Finland University of Applied Sciences. Regional Council of Kymenlaakso. Available at https://www.xamk.fi/app/uploads/sites/2/2024/08/Kotka-Sillamae-connection-potential-report-020824.pdf (Accessed 1 October 2025).
2. Akhavan, M. (2025) Decarbonising maritime transport: The role of green shipping corridors in making sustainable port-city ecosystems. *Ocean and Society,* 2, 9411. DOI:10.17645/oas.9411.
3. Alamoush, A.S., Ballini, F., and Ölçer, A.I. (2020) Ports' technical and operational measures to reduce greenhouse gas emission and improve energy efficiency: A review. *Marine Pollution Bulletin,* 160, 1–21. DOI:10.1016/j.marpolbul.2020.111508.
4. Ampah, J. D., Yusuf, A. A., Afrane, S., Jin, C., and Liu, H. (2021) Reviewing two decades of cleaner alternative marine fuels: Towards IMO's decarbonization of the maritime transport sector. *Journal of Cleaner Production*, 320, 128871. DOI:10.1016/j.jclepro.2021.128871.
5. Andersen, S. N., Díez Gutiérrez, M., Nilsen, Ø. L., and Tørset, T. (2018) The impact of fixed links on population development, housing and the labour market: The case of Norway. *Journal of Transport Geography*, 68, 215-223. DOI:10.1016/j.jtrangeo.2018.03.004.
6. Atari, S., Bakkar, Y., Olaniyi, E. O., and Prause, G. (2019) Real options analysis of abatement investments for sulphur emission control areas compliance. *Journal of Entrepreneurship and Sustainability Issues,* 6(3), 1062–1086. DOI:10.9770/jesi.2019.6.3.1.
7. CBA. (2023) *Cost-benefit analysis of restoring Sillamäe-Kotka travel traffic*. Feasibility and profitability analysis of restoring passenger traffic between Sillamäe and Kotka, and analysis of socio-economic impacts (Sillamäe-Kotka reisiliikluse taastamise teostatavus- ja tasuvusanalüüs ning

sotsiaalmajanduslike mõjude analüüs). Civitta Estonia AS, Cumulus Consulting OÜ, Geomedia OÜ, Taltech.
8. EC. (2021) *Integration of maritime transport in the EU Emissions Trading System.* Berlin/Brussels. Available at https://www.transportenvironment.org/uploads/files/2021_07_Integration-of-maritime-transport-in-EU-ETS.pdf (Accessed 1 October 2025).
9. EC. (2024) *European Commission. EU Emissions Trading System (EU ETS).* Available at https://climate.ec.europa.eu/eu-action/euemissions-trading-system-eu-ets_en (Accessed 1 October 2025).
10. Efimova, E. G., and Gapochka, A. A. (2020) Seaports as drivers of regional economic development: The case of Saint Petersburg and Leningrad Province. *Case Studies on Transport Policy*, 8(2), 383–393. DOI:10.1016/j.cstp.2019.10.003.
11. Finnish Shipowners' Association. (2025) *Key figures of maritime transport in Finland*. https://shipowners.fi/en/competitiveness/key-figures-of-maritime-in-finland (Accessed 1 October 2025).
12. GMF. (2021) *The next wave green corridors: A special report for the getting to zero coalition.* Global Maritime Forum. Available at https://www.globalmaritimeforum.org/content/2021/11/The-Next-Wave-Green-Corridors.pdf (Accessed 1 October 2025).
13. Hilmola, O.-P.K. (2014) Growth drivers of Finnish-Estonian general cargo transports. *Fennia - International Journal of Geography*, 192(2), 100–119. DOI:10.11143/41327.
14. Hrenov, G. Reinhold, K. Järvis, M., and Prause, G. (2025) Charting a Course for Sustainable Port Operations: Insights on Green Ammonia Production and Bunkering. In: *Proceedings of the 24th International Conference Reliability and Statistics in Transportation and Communication (RelStat-2024)*, Riga, September 2024. LNNS, 1337, 399–412 Springer, Cham. DOI:10.1007/978-3-031-87532-8_35.
15. Hrenov, G., Reinhold, K., Järvis, M., Tint, P., and Prause, G. (2023) Managing the hazards of ammonia in seaports as a potential alternative fuel for green shipping. In: *Proceedings of the 33rd European Safety and Reliability Conference*, Southampton, September 2023. University of Southampton, 1110-1117. DOI:10.3850/978-981-18-8071-1_P399-cd.
16. Ismail, A. M., Ballini, F., Ölçer, A. I., and Alamoush, A. S. (2024) Integrating ports into green shipping corridors: Drivers, challenges, and pathways to implementation. *Marine Pollution Bulletin,* 209 (Part B), 117201. DOI:10.1016/j.marpolbul.2024.117201.
17. Jansen, M., Brandellero, A., and van Houwelingen, R. (2021) Port-city transition: Past and emerging socio-spatial imaginaries and uses in Rotterdam's Makers District. *Urban Planning*, 6(3). DOI:10.17645/up.v6i3.4253.
18. Jesus, B., Ferreira, I. A., Carreira, A., Erikstad, S. O., and Godina, R. (2024) Economic framework for green shipping corridors: Evaluating cost-effective transition from fossil fuels towards hydrogen. *International Journal of Hydrogen Energy*, 83, 1429-1447. DOI:10.1016/j.ijhydene.2024.08.147.
19. Jugović, A., Sirotić, M., Jugović, T. P., and Žgaljić, D. (2025) Green shipping corridors: A bibliometric analysis of policy, technology, and stakeholder collaboration. *Applied Sciences*, 15(6), 3304. DOI:10.3390/app15063304.
20. Jurković, Ž., and Lovoković, D. (2023) Corridor planning-sustainable planning? *Sustainability*, 15(21), 15502. DOI:10.3390/su152115502.
21. Karimah, I.D., and Yudhistira, M.H. (2020) Does small-scale port investment affect local economic activity? Evidence from small-port development in Indonesia. *Economics of Transportation,* 23, 100180. DOI:10.1016/j.ecotra.2020.100180.
22. Kitzmann, H., Falko, S., and Prause, G. (2020) Risk assessment of logistics hub development along green transport corridors: The case of Paldiski Port. In: *Proceedings of the 19th International Conference Reliability and Statistics in Transportation and Communication Conference (RelStat-1019), Riga, October 2019*. Lecture Notes in Networks and Systems, 341−350. Springer. DOI:10.1007/978-3-030-44610-9_34.
23. Lagdami, K., Dalaklis, D., and Christodoulou, A. (2024) New technologies in small and medium-sized ports: Its impacts on the future of work. *Journal of Maritime Research*, 21, 150-156. DOI:10.13140/RG.2.2.25247.33442.
24. Mańkowska, M., Kotowska, I., and Pluciński, M. (2020) Seaports as nodal points of circular supply chains: Opportunities and challenges for secondary ports. *Sustainability,* 12(9), 3926. DOI:10.3390/su12093926.
25. Menke zum Felde, I. (2020) *Impact of cruise tourism in Baltic destinations.* Schleswig-Holstein Cooperative University of Applied Sciences (DHSH), Lübeck.

26. Meyer, C., Gerlitz, L., and Prause, G. (2023) Small and medium-sized port greening initiatives as trigger for a servitisation port ecosystem. *Environmental and Climate Technologies,* 27(1), 476-488. DOI:10.2478/rtuect-2023-0035.
27. Notteboom, T., Pallis, A., and Rodrigue, J.-P. (2022) *Port economics, management and policy* (1st ed.). Routledge. DOI:10.4324/9780429318184.
28. Olaniyi, E. O., Solarte-Vasquez, M. C., and Inkinen, T. (2024) Smart regulations in maritime governance: Efficacy, gaps, and stakeholder perspectives. *Marine Pollution Bulletin,* 202, 116341. DOI:10.1016/j.marpolbul.2024.116341.
29. Otsason, R., Laasma, A., Gülmez, Y., Kotta, J., and Tapaninen, U. (2025) Comparative analysis of the alternative energy: Case of reducing GHG emissions of Estonian pilot fleet. *Journal of Marine Science and Engineering*, 13(2), 305. DOI:10.3390/jmse13020305.
30. Prause, G. (2014) Sustainable development of logistics clusters in green transport corridors. *Journal of Security and Sustainability Issues*, 4(1), 59-68. DOI:10.9770/jssi.2014.4.1(5).
31. Prause, G., Tuisk, T., Olaniyi E.O. (2019) Between sustainability, social cohesion and security. Regional development in North-Eastern Estonia. *Entrepreneurship and Sustainability Issues*, 6(3), 1235–1254. DOI: https://doi.org/10.9770/jesi.2019.6.3(13).
32. Psaraftis, H. N., and Kontovas, C. A. (2021) Decarbonization of maritime transport: Is there light at the end of the tunnel? *Sustainability,* 13(1), 237. DOI:10.3390/su13010237.
33. Purkarthofer, E., Humer, A., and Mattila, H. (2021) Subnational and dynamic conceptualisations of planning culture: The culture of regional planning and regional planning cultures in Finland. *Planning Theory & Practice,* 22(2), 244–265. DOI:10.1080/14649357.2021.1896772.
34. Ren-Gas. (2025) Green hydrogen and e-methane plant under development in Mussalo, Kotka. Available at https://ren-gas.com/en/projekti/kotka-2/ (Accessed 1 October 2025).
35. Robaina, M., and Neves, A. (2021) Complete decomposition analysis of CO_2 emissions intensity in the transport sector in Europe. *Research in Transportation Economics,* 90, 101074. DOI:10.1016/j.retrec.2021.101074.
36. Rohe Solutions. (2025) Rohe carries out first ever Bio-LNG bunkering in Hamina in collaboration with E&S Tankers. Press release of 05.04.2025. Available at https://www.rohe.fi/en/news/rohe-carries-out-first-ever-bio-lng-bunkering-in-hamina-in-collaboration-with-es-tankers/ (Accessed 1 October 2025).
37. Rönty, J., Nokkala, M., and Finnilä, K. (2011) *Port ownership and governance models in Finland: Development needs & future challenges* (VTT Working Papers 164). VTT Technical Research Centre of Finland. Available at https://publications.vtt.fi/pdf/workingpapers/2011/W164.pdf (Accessed 1 October 2025).
38. Rosqvist, T., Nyman, T., Sonninen, S., and Tuominen, R. (2002) The implementation of the VTMIS system for the Gulf of Finland – A FSA study. In: *Proceedings of the RINA International Conference on Formal Safety Assessment*, 151–164.
39. Schröder, M., and Prause, G. (2016) Transportation of dangerous goods in green transport corridors: Conclusions from Baltic Sea region. *Transport and Telecommunication,* 17(4), 322–334. DOI:10.1515/ttj-2016-0029.
40. Umweltbundesamt. (2023) Comparison of average emissions from individual modes of transport (Vergleich der durchschnittlichen Emissionen einzelner Verkehrsmittel), Tremod 6.61C, German Federal Environmental Authority, Dessau-Roßlau (in German).
41. Wang, H., and Zhang, P. (2020) Urban green corridors analysis for a rapid urbanization city exemplified in Gaoyou city, Jiangsu. *Forests,* 11(12), 1374. DOI:10.3390/f11121374.
42. Wasaline (2025) *Our ferry Aurora Botnia.* Available at https://www.wasaline.com/en/our-ferry (Accessed 1 October 2025).
43. Yu, T., Li, H., Zhou, T., Zhao, N., and Yang, Z. (2025) Evaluation and strategy development of port-industry-city integration: A China's case. *Research in Transportation Business & Management,* 60, 101375. DOI:10.1016/j.rtbm.2025.101375.
44. Zeng, H., Abedin, M. Z., Ahmed, A. D., and Huang, Q. (2025) Extreme risk connection among the European tourism, energy and carbon emission markets. *Research in International Business and Finance,* 74, 102693. DOI:10.1016/j.ribaf.2024.102693.