Logistics Service Centers as Drivers of Innovation and Competitiveness in Nautical Tourism Ports – Case Study of ACI Marina Šimuni

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This study investigates the integration of a Logistics Service Center (LSC) within ACI Marina Šimuni as a model for enhancing economic performance, operational efficiency, and environmental sustainability in nautical tourism ports. Specifically, the research provides an in-depth examination of how LSC implementation addresses service gaps, mitigates ecological impacts, and aligns effectively with Croatia's strategic objectives for sustainable tourism development. The research combines qualitative and quantitative methodologies. Data collection involves a detailed analysis of marina infrastructure, operational capacity, and environmental effects, complemented by projections of revenues and costs. Financial viability is assessed using the payback period, net present value (NPV), and internal rate of return (IRR) methods. Environmental assessments focus on antifouling systems and wastewater management. The LSC requires an investment of 1.17 million EUR over two years, with cumulative net cash flow turning positive in 2031 and reaching 642,388.11 EUR by 2035. Service revenues are projected to grow from 360,000 EUR in 2026 to 430,233 EUR in 2035. Positive NPV and an IRR of 9.94% confirm long-term profitability. From an environmental perspective, advanced cleaning systems and eco-friendly antifouling technologies reduce copper leaching and biofouling, while facility enhancements, such as a modular hangar and travel lift, improve service quality and operational efficiency. The integration of the LSC at ACI Marina Šimuni demonstrates transformative potential in balancing economic growth with environmental stewardship. The project's financial viability, supported by positive NPV and IRR values, underscores its attractiveness to investors. On an environmental level, the adoption of advanced waste management practices and antifouling technologies aligns closely with EU sustainability standards, thereby safeguarding marine ecosystems. Strategically, the LSC enhances the marina's competitiveness, providing opportunity to position it as a leader in sustainable nautical tourism. The proposed integration model offers practical insights that can be scaled to other nautical ports, thus reinforcing Croatia's broader strategy for sustainable maritime development.

KEYWORDS
~ Nautical tourism
~ Nautical tourism ports
~ Logistics service centers
~ Sustainable management

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1. INTRODUCTION

Nautical tourism encompasses a spectrum of leisure activities centered around marine environments, including sailing, yachting, and other water – based recreations. Defining nautical tourism is complex due to its multifaceted nature, which integrates leisure, sports, and maritime activities. Luković (2007) defines nautical tourism as a collection of diverse activities and interactions involving tourists-boaters, whether within or outside nautical tourism ports, utilizing boats or related facilities for purposes such as recreation, sports, entertainment, or other leisure needs. Marinas, known as nautical tourism ports, serve as the infrastructural backbone of this sector, providing essential services such as: (1) Mooring; (2) Berthing; (3) Maintenance; and (4) Amenities for vessels and their occupants (Ivanić, Perić Hadžić & Mohović, 2018).

The economic implications of nautical tourism ports in the Republic of Croatia are substantial. They act as hubs for nautical tourism, attracting both domestic and international visitors, thereby generating revenue and employment opportunities. Ports dedicated to nautical tourism generate approximately 95 million euros annually, with the majority of revenue—over 70% in some cases—attributed to berth fees (Ivanić, Perić Hadžić & Mohović, 2018). In 2023, Croatian nautical ports generated a total revenue of €161 million (excluding VAT), marking a 12.1% increase compared to 2022. Of this revenue, €115 million, or 72%, was derived from berth rentals, reflecting a 14.6% rise from the previous year. All Adriatic counties experienced growth in nautical tourism revenue, with Dubrovnik-Neretva County leading with a 19.6% increase, totaling €9 million. Šibenik-Knin County reported the highest revenue at €39.6 million, an 8.3% increase from 2022. Other notable revenues include Split-Dalmatia County with €38.7 million (+12.4%), Zadar County with €31.4 million (+15.6%), Istria County with €21.7 million (+14.1%), and Primorje-Gorski Kotar County with €20.4 million (+8.7%). These figures underscore the significant economic impact of nautical tourism across Croatia's coastal regions (Ministry of Tourism and Sports, 2023). Furthermore, a study on the Croatian Nautical Ports System revealed a strong correlation between natural resources, especially water surface area, and revenue generation (Marušić, Šoda, & Vujović, 2024). This correlation emphasizes the importance of strategic management of natural resources to optimize economic outcomes within the Croatian Nautical Ports System.

Even though the economic benefits are significant, the environmental footprint of marinas within the Croatian Nautical Ports System is a subject of growing concern. Marine pollution linked to Croatia’s nautical tourism sector arises from various sources and activities, creating notable environmental challenges: (Kovačić and Horvat, 2021): (1) Vessels contribute extensively to pollution through discharges of bilge, ballast water and oily residues; (2) Coatings used in ship maintenance and antifouling paints release harmful toxins and biocides into port waters, adversely affecting local marine life; (3) Noise and light pollution from increased vessel traffic disrupt marine species’ communication and natural behaviors, compounding ecological strain; (4) Overcrowding and unsustainable resource use in marinas and coastal areas amplify habitat degradation and put pressure on facilities; (5) Irresponsible actions by tourists, including illegal fishing, littering, and improper waste disposal, further exacerbate these issues. (6) Lack of adequate facilities for waste disposal, resulting in uncontrolled discharges of black and grey water that degrade water quality and disrupt ecosystems; and (7) Limited awareness of environmental regulations and inadequate monitoring systems hinder efforts to identify and mitigate pollution, threatening the long-term sustainability of Croatia's nautical tourism sector. Consequently, the development and operation of these facilities can significantly disrupt habitats, degrade water quality, and increase coastal risks.

The future trajectory of nautical marinas within the Croatian Nautical Ports System is influenced by several factors, including: (1) Technological advancements; (2) Changing tourist preferences; and (3) Environmental stewardship (Roška, Soldo, & Osmanović, 2024). The increasing demand for larger berths to accommodate larger tourism vessels, the integration of modern technologies for enhanced service delivery, and the necessity for climate resilience are shaping the evolution of marina infrastructures. Additionally, the concept of "blue tourism," which emphasizes sustainable interaction with marine environments, is gaining traction and may redefine operational paradigms within the sector (Martínez Vázquez, Milán García, & De Pablo Valenciano, 2021). Strategic investments in infrastructure coupled with adherence to sustainable development policies could further enhance Croatia's competitive position as a leading nautical destination for future generations, underscoring the importance of balancing economic growth with environmental preservation for sustained maritime attractiveness.

Sustainable management of nautical tourism ports involves balancing economic objectives with environmental stewardship (Jugović, Kovačić, & Hadžić, 2011). This includes implementing eco-friendly infrastructure, adopting waste management protocols, and engaging in continuous environmental monitoring. This paper addresses existing gaps in sustainable management practices of nautical tourism ports by examining the development and integration of a Logistics Service Center (LSC) at ACI Marina Šimuni, aiming to foster environmentally responsible and efficient operations. The paper seeks to provide a thorough understanding of the economic, environmental, and strategic dimensions associated with this initiative within the context of Croatia’s nautical tourism sector.

2. THEORETICAL FOUNDATIONS OF LOGISTICS SERVICE CENTERS INTEGRATION IN NAUTICAL TOURISM PORTS: IMPLICATIONS FOR ECONOMIC COMPETITIVENESS AND DEVELOPMENT REGARDING ACI MARINA ŠIMUNI

The integration of logistics and supply chain management practices into nautical tourism ports is increasingly recognized as a solution to contemporary operational challenges (Cruz – Perez et al. 2021). The stated strategies are with proven efficiency gains and competitive advantages within the maritime industry. Although integrating logistics service centers (LSCs) into nautical tourism ports remains relatively underexplored and in its early stages compared to commercial port settings, these centers possess promising potential to optimize the movement, storage, and distribution of nautical freight.

Integrating logistics service centers into nautical tourism ports can effectively support essential activities, including: (1) Supplying pleasure craft with materials, (2) Delivering maintenance services, and (3) Providing nautical tourism – related products. Recent literature suggests that while supply chain management practices in nautical tourism ports are not fully matured, their growing importance is increasingly acknowledged.

Ascencio et al. (2014) propose a three-pillar logistics framework for port operations grounded in Supply Chain Management principles: (1) Management of Port Logistics; (2) Logistics Management Plan; and (3) Port Logistics Operations Model. Furthermore, the scholars identify three technological enablers: (1) Demand Management System; (2) Order Placement Management System; and (3) Vehicle Management System. The scholars' findings indicate that establishing collaborative governance, integrating information-management systems for supply and demand matching, and introducing vehicle-to-cargo scheduling are viable strategies for nautical tourism ports aiming to optimize: (1) Leisure – boat servicing, (2) Internal resource allocation; and (2) Environmental sustainability.

Cruz-Pérez et al. (2021) study the environmental footprints of nautical tourism ports in European island contexts, and indicate that applying SCM principles can aid in reducing carbon emissions. The scholars' research emphasizes that integrating LSCs can enhance sustainability by: (1) Consolidation of operations; (2) Reduction of external vehicle movements; and (3) Facilitation towards the shift to renewable energy sources. Additionally, the centralized approach is further detailed through the categorization of Scope 2 emissions (electricity demands) and Scope 3 emissions (dependence on external suppliers, visitor schedules, and other third-party services). The scholars also propose collaborative strategies which can be beneficial for LSC integration into nautical tourism ports. Two notable strategic approaches are: (1) The necessity of coordinated stakeholder engagement regarding the adoption of sustainable practices; and (2) Digitalization of services adoption. Consequently, an LSC can effectively function as a central hub for information exchange and environmental monitoring, directly addressing environmental challenges and maintaining operational efficiency in nautical tourism ports.

Alavi et al. (2018) further emphasizes the necessity of integrated logistics practices to enhance competitiveness in ports and terminals, a finding that is equally applicable to leisure marinas as they emerge as critical nodes in the supply chain. In accordance to the scholars' finings, a fully integrated LSC should adhere to the following seven factors to achieve framework integration compliance: (1) Information and Communication Integration; (2) Value-Added Services; (3) Processes and Operations; (4) Logistics Practices; (5) Organizational Activities; (6) Institutional Support; and (7) Resource Sharing. Adherence to these factors can promisingly enhance nautical tourism ports by: (1) Value – added services; (2) Aligning with stakeholder activities; which in turn, can reduce operational efficiencies and promote sustainable, integrated logistics solutions in nautical tourism port environments.

Despite these insights, there remains a notable gap in the literature, as few studies provide detailed overviews or strategic approaches for logistics integration in marinas or nautical tourism ports. Considering the unique challenges faced by these facilities, such as: (1) Limited logistics operational space and (2) The necessity of balancing tourism demands with environmental sustainability. Thus, effective logistics integration requires coordinated efforts among marina operators, yacht owners, suppliers, and local authorities to develop tailored and comprehensive solutions. In order to alleviate the stated gap, Figure 1 contains a methodological workflow for integrating a Logistics Service Center into Nautical Tourism Ports.

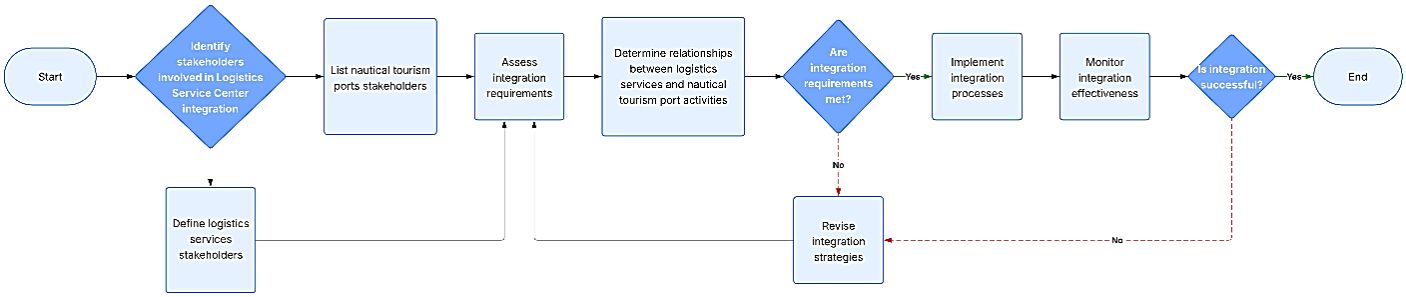

Figure 1. Workflow for Integrating a Logistics Service Center into Nautical Tourism Ports (Source: Authors' Elaboration)

This workflow addresses identified gaps by providing a structured method: stating the relevant stakeholders, identification of needs for logistical services, and specification of required and optimal relationships between tourism-oriented port activities and supply chain operations (Jugović et al., 2011; Kovačić et al., 2016). The workflow emphasizes early collaboration among port managers, yacht owners, suppliers, and government bodies, recognizing space limitations within marinas and the critical need to protect natural ecosystems. At the same time, according to Kovačić and Luković (2015), spatial resource management and high-quality infrastructure are the keys for the environmental tranquility and the promotional growth of nautical tourism ports. In addition, the process of combining managerial best practices (Bukša et al., 2019) and strategic investments (Andrés et al., 2017) cultivates competencies and synergies that absorb the dynamic nature of market changes and customer expectations, helping maintain ecological integrity and quality, while securing sustainable long-term economic performance.

During this workflow (Figure 1), the iterative monitoring confirms that any LSC adoption can be flexible in the face of evolving policies, customer expectations, and ecological constraints (Carreno & Lloret, 2021; Spinelli & Benevolo, 2022). Previous studies on the pollution caused by antifouling paint, and maintenance activities emphasize the importance of stringent waste disposal and thorough environmental assessments (Briant et al., 2013, 2016; Oricchio et al., 2019). Innovative monitoring technologies and remediation strategies can be simultaneously implemented to reduce toxic discharges while satisfying the demands of tourism services (Luiza Dy Fonseca Costa & Wallner-Kersanach, 2015). The management of tourist behavior variability is also critical; Jovanovic et al. (2013) demonstrate that perceived constraints are influenced by factors such as income and education and that targeted planning can improve visitor satisfaction. As Ye Shen et al. (2021) validate, effective service delivery enhances tourist loyalty, strengthening a "blue tourism" proposition (Martínez Vázquez et al., 2021) that holistically scopes the economic, managerial, and environmental aims of maritime destinations.

These considerations support the argument that integrating Logistics Service Centers into nautical tourism ports—exemplified by ACI Marina Šimuni in subsequent sections; addresses both theoretical and industry gaps. It allows to better asses service quality, optimized berth utilization and increase revenue by investing in new infrastructure like travel lifts and modular hangars (Schiozzi, 2023). Moreover, sustainable waste and water management practices foster environmental stewardship, aligning marinas with regional objectives of blue tourism (Martínez Vázquez et al., 2021). Thus, this SCM-driven workflow not only addresses the existing gaps in maritime logistics integration, but it also provides nautical tourism ports with a strategic, sustainable, and economically viable basis for future development. Such a holistic, data-driven approach can create conditions to enhance maintenance services, provisioning capabilities, and visitor experiences, thereby improving competitiveness within dynamic coastal environments characteristic of nautical tourism ports.

3. ANALYSIS OF EXISTING SERVICES AND INFRASTRUCTURE OF ACI MARINA ŠIMUNI

3.1. Sustainability and Environmental Considerations of Integrating a Logistics Service Center

Coastal areas, islands, and marine channels visited by recreational boaters are of significant ecological, social, and economic importance, with rich marine biodiversity being a key attraction. Recreational vessels, however, can unintentionally facilitate the spread of biofouling organisms, including invasive species, as they travel between locations, posing ecological risks by introducing these organisms to less trafficked areas such as small harbors, anchorages, and inland waters (Costello et al., 2022). Marinas often host a higher number of invasive aquatic species than commercial ports due to the longer stationary periods of recreational vessels and slower travel speeds, which increase opportunities for non-native species to attach and colonize new habitats.

3.1.1. Micro location of LSC in ACI Marina Šimuni

The island of Pag, with its indented coastline, coves, and beaches, attracts a large number of recreational boats (Magaš, 2000). Located 12 km from the town of Pag and 10 km from Novalja, Šimuni has evolved from a fishing village into an established auto-camp and LNT. Its natural bay, protected by the islets of Maun and Škrda, provides optimal conditions for sustainable nautical tourism. Šimuni accommodates 248 recreational boats at permanent moorings. Table 1 depicts approximate leaching of toxic elements from biocidal antifouling paints (cooper) for permanently moored vessels in 2022 in Šimuni (Both Ports).

Vessel Length	Number of Vessels	Average Surface Below the Waterline (in cm²)	Average Leaching Rate of Dissolved Copper (4 µg/cm²/day)	Average Total Leaching per Vessel (in grams per day)
3 - 5	12	840.000	0.000004	3,36
5 – 7	55	6.930.000	0.000004	27,72
7 – 9	**74**	13.320.000	0.000004	**53,28**
9 – 11	**95**	25.080.000	0.000004	**100,32**
11 - 13	9	2.808.000	0.000004	11,232
> 13	3	1.260.000	0.000004	5,04
Total	**248**	**50.238.000**	**0.000004**	**200,952**

Table 1. Approximate Leaching of Toxic Elements from Biocidal Antifouling Paints (Cooper) for Permanently Moored Vessels in 2022 in Šimuni (Both Ports) (Source: (Ivče, Paparić, Zekić, & Škapul, 2020))

The analysis of copper leaching from biocidal antifouling paints in Šimuni ports indicates a substantial environmental burden attributable to the 248 permanently moored vessels. The total average surface area below the waterline across all vessels is 50,238,000 cm², with an average leaching rate of 4 µg/cm²/day, leading to a total daily copper leaching of 200.952 grams.

Collectively, vessels measuring 7–9 m account for the greatest share of copper discharge (53.28 g per day), whereas the 9–11 m class releases the highest load per vessel, amounting to 100.32 g per day. These findings highlight the disproportionate environmental impact of larger vessels, underscoring the need for sustainable antifouling practices to mitigate ecological harm in the area.

In ACI Marina Šimuni, the large number of recreational vessels, coupled with inadequate cleaning infrastructure and the continued use of copper- and zinc-based antifouling paints, raises four specific environmental concerns (Schiozzi, 2023):

- Antifouling Paint and Copper Leaching (Lagerström et al., 2020): (1) It is assumed that the underwater part of boats is protected with antifouling paints containing copper; (2) Heavy metals are non-degradable, and their concentration increases over time;
- Inadequate Infrastructure for Cleaning (Eichelberger et al., 2021): (1) Both ports in Šimuni lack proper cleaning platforms for vessels, and contaminated washing water often returns directly to the sea or soaks into the ground at the platform site; (2) Metallic and toxic compounds from antifouling can be washed away by heavy rain or extreme high water, ultimately ending up on the seabed of the surrounding area.
- Sustainable Vessel Maintenance Practices (Ytreberg et al., 2019): (1) Today, most boat owners use high-pressure water sprayers to save time and make cleaning more efficient; (2) The rinsed water contains not only dirt and marine organisms but also metallic and toxic antifouling compounds, resulting in higher levels of pollutants.
- Impact on Local Ecosystems and Tourism (Tsypko, 2024): (1) The quality of life in the island settlement, fishing, and many tourist activities depend on the long-term sustainability of marine resources and the ecological health of the associated ecosystems; (2) Reducing potential pollutants from antifouling is a significant step in protecting the marine environment.

The construction and operation of the LSC aims to mitigate environmental impacts by including advanced infrastructure for proper waste management on land and eco-friendly cleaning systems for vessels. Special attention will be given to minimizing marine pollution through safe biofouling removal and the reduction of toxic antifouling leaching.

3.1.2. The Role of LSC in ACI Marina Šimuni Regarding Environmental Impact Minimization

The strategic location of the LSC at ACI Marina Šimuni has been carefully selected to minimize environmental disruption while integrating key sustainability considerations. The positioning ensures that natural ecosystems in the area are preserved, with development plans designed to harmonize with the surrounding environment, reducing ecological impact and promoting sustainable operational practices.

The operational cleaning of vessels in the LSC consists of four phases: (1) Washing and cleaning the underwater part of the vessel; (2) Lifting the vessel; (3) Cleaning the vessel trailer; and (4) Addressing biofouling niches. The aforementioned four phases are briefly outlined as follows (Schiozzi, 2023):

1. Washing and cleaning the underwater part of the vessel:
    - Contaminated water from vessel washing contains toxic antifouling substances and must not be discharged into the sea or absorbed into the ground. It should be collected, treated to remove pollutants, and safely disposed of or discharged through approved systems (Zahed et al., 2010);
    - High-pressure washing disperses toxic substances, but safer alternatives like vacuum blasting can control and collect harmful particles effectively;
    - The LSC must implement water collection and treatment systems to manage washing residues, minimizing environmental harm. Although a capital expense, these systems are essential for marine preservation;
    - Educational efforts should inform vessel owners and authorities about non-biocidal antifouling paints and encourage the use of eco-friendly alternatives (Abdurahman et al., 2022);
    - Owners should adopt practices like wiping waterlines and removing outboard motors to reduce fouling and pollution;
    - The LSC should also provide access to eco-friendly cleaning products to promote sustainable maintenance practices;

2. Lifting the Vessel:
    - Lifting and transferring vessels is the process of physically moving vessels between the sea and land;
    - This operation is carried out using canes, which can be either mobile or fixed, and are equipped with arms or hooks to securely handle vessels (Jang, Kim, & Kwak, 2014);
    - To ensure safety, these cranes are specifically designed to lift, lower, and transport vessels between the marina, dry docks, or the LSC;
    - Lifting the vessel from the water and placing it on land prevents biofouling and facilitates the cleaning and collection of biofouling waste;
    - The longer the vessel remains out of the water, the more effective the drying process is in damaging aquatic organisms (Livingstone, 2001);

3. Cleaning the Vessel Trailer:
    - Vessel trailers can spread non – native species due to untreated surfaces and must be thoroughly inspected after water contact (Rothlisberger et al., 2010);
    - Key areas like the frame, axle, tires, and cavities should be cleaned using brushes, scrapers, or high – pressure washers.
    - Even minimally contaminated trailers should be pressure – washed, as some species are not visible;
    - Trailers must also be dried before transport to prevent the spread of invasive species across waterways, including beyond the Adriatic Sea.

4. Addressing biofouling niches:
    - Niche areas are 2.6 times more prone to biofouling than flat hulls due to varying flow conditions and often have inadequate or absent coatings;
    - Critical components like cooling systems, rudders, and propellers require regular cleaning for safety, while other niches may be less critical (Akinfiev, Janushevskis, & Lavendelis, 2007);
    - Their varying shapes and sizes necessitate tailored cleaning methods and effective debris collection systems.

These four cleaning phases ensure efficient vessel maintenance while minimizing environmental impact and supporting sustainable operations at the LSC in ACI Marina Šimuni.

3.1.3. Possible Advanced Cleaning Systems for the LSC in ACI Marina Šimuni

The International Maritime Organization (IMO) uses the term "antifouling system," defined as "a coating, paint, surface treatment, surface, or device used on a ship to control or prevent the attachment of unwanted organisms" (OECD, 2005). The most commonly used protective method for preventing marine biofouling on ships is antifouling paint. However, there are other antifouling systems and methods that can be taken into consideration for the LSC in ACI Marina Šimuni, as stated in Table 2.

Category	Details
Alternative Antifouling Systems	- Hard coatings for releasing debris - Coatings releasing unpleasant substances - Liquid surface technology - Ultrasonic systems - Other alternatives (e.g., UV light, biodegradable biocides)
Hard Coatings	- Made from epoxy, polyester, vinyl ester, or ceramic-epoxy composites, sometimes reinforced with glass flakes - Require routine cleaning (e.g., high-pressure washing or underwater cleaning) - Advertised as durable (up to 10 years)
Non – Biocidal Coatings	- Smooth, water-insoluble surface - Organisms detach during vessel movement or are easily removed when hauled out - Based on silicone elastomers, fluoropolymers, or both
Liquid Surface Technology	- Nano-/micro structured porous material infused with lubricating liquid - Forms a thin, slippery surface reducing fouling
Ultrasonic Systems	- Small transmitters placed inside the hull emit ultrasonic waves (~23 kHz) - Vibrations disrupt biofouling growth on the hull
Other Alternative Systems	- UV light damages the DNA of marine organisms, preventing biofilm growth - Biodegradable biocides remain within the coating

Table 2. Overview of Alternative Antifouling Systems and Technologies (Source: (Yebra, Kiil, & Dam-Johansen, 2004))

The analysis of Table 2 indicates that Alternative antifouling systems encompass a range of technologies, including hard coatings, non-biocidal coatings, liquid surface technology, ultrasonic systems, and innovative solutions such as UV light and biodegradable biocides. Hard coatings, made from durable materials like epoxy or ceramic composites, require routine cleaning to maintain effectiveness, while non-biocidal coatings rely on smooth, water-insoluble surfaces to naturally reduce biofouling attachment (Yebra, Kiil, & Dam-Johansen, 2004). Liquid surface technology minimizes biofouling by creating a slippery surface through nano-structured porous materials infused with lubricants. Additionally, ultrasonic systems use vibrations emitted by small transmitters to disrupt biofouling growth, offering a chemical-free alternative for hull maintenance. Considering these advanced systems could greatly enhance the LSC's ability to provide environmentally sustainable and efficient vessel maintenance solutions.

3.2. Strategic Rationale for Integrating a Logistics Service Center

The main purpose of the Logistics Service Center (LSC) is to meet the needs of both permanent and transient nautical tourists. The analysis of capacity utilization at ACI Marina Šimuni for 2021 and 2022 further emphasizes the importance of such an investment, as presented in Table 3.

Indicator		2021	2022	2022/2021	2022 – 2021
Number of Vessels	Capacity	236	246	4%	10
	Realization	175	177	1%	2
	Utilization	74,2%	72,0%	-3%	-2,2%
Boat Days	Capacity	79.111	82.761	5%	3.650
	Realization	66.790	68.758	3%	1.968
	Utilization	84,4%	83,1%	-2%	-1,3%
Meter Days	Capacity	913.468	949.968	4%	36.500
	Realization	696.247	714.799	3%	18.552
	Utilization	76,2%	75,2%	-1%	-1%

Table 3. Capacity Utilization of Marina Šimuni for 2021 and 2022 (Source: (Schiozzi, 2023))

The capacity for Number of Vessels increased by 4% (from 236 to 246), while realized stays grew by only 1% (from 175 to 177), with utilization falling from 74.2% to 72% (-2.2 percentage points). Boat Days indicate a 5% capacity increase (from 79,111 to 82,761), but utilization dropped from 84.4% to 82.9% (-1.3 percentage points). Meter Days show a 4% capacity increase, but utilization decreased from 76.2% to 75.2% (-1 percentage point). Despite capacity expansion, the declining utilization rates indicate challenges in attracting additional users and effectively leveraging the expanded resources.

The limited growth in realized stays reveals deficiencies in technical and logistical services, such as the insufficient capacity of the 15-ton crane, which restricts the marina's ability to accommodate larger vessels and yachts. The lack of diverse services, such as a centralized logistics and service center, may be a key factor reducing the marina's competitiveness. From the data provided, it is evident that there is a need to establish an LSC that, with its geographic location, range of service offerings, and quality of services, could meet the needs of both permanent and transient nautical tourists, as well as the demands of the growing charter fleet.

3.3. Geographical Location and Strategic Importance

ACI Marina Šimuni is situated on the western coast of Pag Island, within the Maunski Kanal, positioning it as a critical entry point into the Dalmatian nautical network (ACI Marinas, 2025). The nautical tourism port occupies a total area of 35,200 m^2, with 21,200 m^2 dedicated to its aquatic zone and 14,000 m^2 to its terrestrial facilities (Schiozzi, 2023). Its strategic location, combined with year-round operational capacity, establishes ACI Marina Šimuni as a critical hub for nautical tourism in the region, providing efficient connectivity to prominent northern Adriatic destinations such as Istria and Opatija, as well as key southern areas including Kornati and Šibenik.

3.4. Existing Facilities and Service Offerings

ACI Marina Šimuni was constructed in 1989. Since its construction, the nautical tourism port has not undergone any significant structural upgrades. However, in the spring of 2014, the workshop building underwent complete renovation, and the facades of the reception building, sanitary facilities, shop, and restaurant were refurbished. All existing structures have been regularly maintained and remain in good mechanical and operational condition. The marina includes a wastewater separator and waste disposal facilities, complying with ecological standards for nautical tourism ports operations. The depth of the seabed varies from 2 to 15 meters, depending on the specific location within the marina’s aquatic zone.

ACI Marina Šimuni provides a total of 191 wet berths and 45 dry berths, accommodating vessels up to 18 meters in length for daily mooring and up to 14 meters for annual contracts (ACI Marinas, 2025). The nautical tourism port offers a range of services, including (Schiozzi, 2023):

- General Amenities: ATM, Free Wi–Fi, Parking Lot, Reception with currency exchange, Restaurant, Sanitary facilities, Sanitary facilities adapted for persons with special needs, and Grocery store.
- Technical Services: 15 – ton capacity crane, a Slipway, and technical vessel maintenance services.

The nautical tourism port is accessible via local and state roads, with connections to the mainland through ferry lines and the Pag Bridge. Although these facilities meet the basic requirements of recreational boating, their capacity and

functionality are inadequate to accommodate the increasing demands of modern nautical tourism, particularly with respect to larger vessels and the provision of advanced technical servicing.

3.5. Assessment of Service and Infrastructure Gaps

ACI Marina Šimuni holds a strategic geographical position, serving as a pivotal hub within the regional nautical tourism network. While its foundational services provide a strong operational base, the marina is constrained by several critical operational and infrastructural challenges (Schiozzi, 2023):

- Technical Limitations: (1) The 15 – ton crane is inadequate for servicing larger vessels or superyachts, necessitating investment in a higher – capacity crane of 20 to 25 tons carrying capacity. A more technically viable alternative to a crane would be the development of a dedicated basin to accommodate a smaller travel lift, enhancing operational efficiency and capacity. (2) Absence of a dedicated fuel station, with the nearest located 7 nautical miles away in Novalja, creates inefficiencies for transient and permanent users. A floating fuel station, operating during peak months, is proposed as a feasible solution.
- Space Constraints: (1) Limited terrestrial area restricts the expansion of dry berths and supporting infrastructure, including storage and service facilities. (2) Existing land use optimization is required to address these constraints without compromising operational efficiency.
- Environmental Challenges: The marina's location with an L – shaped bay provides natural protection, but leaves it susceptible to strong Bura winds, especially during winter, which can pose risks to moored vessels.

Addressing these challenges is crucial for enhancing the operational efficiency, service quality, and overall competitiveness of ACI Marina Šimuni within Croatia's nautical tourism sector.

3.6. Environmental and Sustainability Considerations

ACI Marina Šimuni has implemented a variety of initiatives to promote environmental sustainability and reduce its ecological footprint. These efforts focus on integrating eco-friendly practices into daily operations and ensuring compliance with international environmental standards. Specific initiatives include (Schiozzi, 2023):

- Waste Management: (1) Facilities for waste disposal include seven large containers (1,100 liters each) for general waste within the marina area, with the concession area, 11 containers (1,100 liters each) for solid waste, one 5 m^3 container for large solid waste, a 1,000-liter tank for used motor oil, a container for lead batteries, and barrels for hazardous waste near the service workshop; (2) Technological wastewater from boat cleaning undergoes physical and chemical treatment before being discharged into the sea.
- Water Management: Internal water supply systems provide an average of 3,500 m^3 annually, with approximately 62% allocated to vessel servicing.
- Ecosystem Protection: Measures to mitigate environmental impact include adherence to regulations outlined in the Marina's Waste Management Plan and Harbor Regulations.

These measures underscore ACI Marina Šimuni's commitment to integrating environmental sustainability into its operations, ensuring compliance with regulatory standards while supporting the ecological balance of its surrounding marine environment.

4. ENHANCING ACI MARINA ŠIMUNI COMPETITIVENESS VIA INTEGRATION OF A LOGISTICS SERVICE CENTER

4.1. Economic and Financial Implications of Integrating a Logistics Service Center

The establishment of the LSC in ACI Marina Šimuni is planned with a two-year implementation period and a 12-year operational phase, ensuring long-term viability. All financial analyses are based on incremental cash flows, focusing solely on revenues and expenses directly tied to the project, with a fixed financial discount rate of 4.00%. Prices for services are expressed in EUR, excluding VAT, and have been adjusted for inflation and market stability to ensure accuracy.

4.1.1. Investments in Fixed Assets

The establishment of the LSC at ACI Marina Šimuni involves a capital investment of 1.17 million EUR (excluding VAT) to repurpose unused land adjacent to the marina entrance into a dedicated facility for vessel servicing and maintenance. The project scope encompasses the development of infrastructure, including a modular hangar, travel lift, and advanced equipment installation, aimed at increasing operational capacity and efficiency. Additionally, environmental sustainability is integrated through the implementation of systems for solid waste, liquid waste, and oily water collection,

ensuring compliance with ecological standards. Table 4 indicates the amount and distribution of the planned total investment during the two – year implementation period.

Element	Description	Purchase Value	Year	
			1	2
Modular Hangar	Construction and installation of a prefabricated hangar according to required specifications	200.000,00		200.000,00
Travel Lift	Specialized crane for lifting ships from water and their transport	320.000,00		320.000,00
Preparatory Works on Land	Ground preparation, foundation of the area for the hall with all necessary technical preparations (excavations, drainage, preparation of connections - water, electricity, waste water, oily water remover, etc.	300.000,00	300.000,00	
Preparatory Works Ashore	Construction of the receiving part of the sea coast for operational part of lifting ships, that is tracing the operational part of the trailer lift	200.000,00	200.000,00	
Equipment	Cranes and other equipment (weights, milling machines, saws, compressors, straighteners, thickeners, presses, pipe systems, professional grinders and others)	100.000,00		100.000,00
Design and Supervision Costs	Technical documentation, obtaining permits and supervision of works	50.000,00	40.000,00	10.000,00
Total		**1.170.000,00**	**540.000,00**	**630.000,00**

Table 4. Amount and distribution of the planned total investment during the two – year implementation period (Source: (Schiozzi, 2023))

The total planned investment for the Logistics Service Center (LSC) amounts to 1,170,000 EUR, strategically distributed over two years, with 540,000 EUR allocated to the first year and 630,000 EUR to the second year. This phased investment approach ensures a gradual financial commitment while prioritizing the enhancement of infrastructure and operational capabilities critical to the LSC's functionality. The disproportionate allocation in the second year, comprising 54% of the total budget, is primarily attributed to the acquisition of a specialized travel lift, essential for operational efficiency. Furthermore, the investment integrates sustainable development measures, particularly through comprehensive preparatory works on land and along the shore, aimed at ensuring long-term operational resilience and environmental compliance.

4.1.2. Revenue Projection Analysis

The revenue projection for the Logistics Service Center (LSC) is based on estimates of future performance, incorporating the investor's experience and development projections, while accounting for potential risks. Revenue generation is expected to commence immediately after the completion of investments, starting in the third year of the LSC, and spans a 12-year period (Schiozzi, 2023). A consistent annual revenue growth of 2% is projected throughout this period. Prices used in the projections are benchmarked against similar facilities and expert assessments, expressed excluding VAT, with operations assumed to run 365 days per year.

Capacity utilization has been projected based on past operational data, expert estimates, and performance metrics of similar facilities, taking into account the market potential of the location. The primary sources of revenue are vessel servicing and overhauls, which include a range of services such as engine repairs, metalwork, and servicing of vessels made of plastic, wood, and iron. Overhauls involve extensive vessel repairs, installations, and reconstructions.

Table 5 provides a detailed summary of the projected revenues from servicing, maintenance, and other related economic activities over the 12-year observation period.

Description	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Revenues from services	0	0	360.000	367.200	374.544	382.035	389.676	397.469	405.418	413.527	421.797	430.233
Other Revenues	0	0	35.000	35.700	36.414	37.142	37.885	38.643	40.204	40.204	41.008	41.828
Total	0	0	395.000	402.900	410.958	419.177	427.561	436.112	444.834	453.731	462.805	472.062

Table 5. Projected revenues from servicing, maintenance, and other related economic activities over the 12-year observation period (Source: Schiozzi, 2023)

The table projects annual revenue growth for the Logistics Service Center (LSC) starting in 2026, with service revenues increasing from 360,000 EUR in 2026 to 430,233 EUR by 2035, and other revenues rising from 35,000 EUR in 2026 to 41,828 EUR by 2035, reflecting a steady annual growth rate. Total revenues demonstrate consistent growth, reaching 472,062 EUR in 2035, ensuring long-term financial sustainability.

4.1.3. Cost Distribution Analysis

The establishment of the Logistics Service Center (LSC) in ACI Marina Šimuni necessitates the consideration of six distinct types of costs, covering: (1) Human resources; (2) Materials; (3) External services; (4) Maintenance; (5) Space leasing; and (6) Miscellaneous expenses. The adherence to the aforementioned costs is critical for ensuring operational efficiency and maintaining long – term financial sustainability. Cost breakdown is as follows (Schiozzi, 2023):

- Employee Costs: Includes wages for 16 employees (11 current and 5 additional hires due to the project), with a 2% annual salary growth. The company also invests in training for employees lacking relevant experience.
- Material Costs: Represents raw materials and consumables necessary for operations, including safety equipment, work uniforms, small inventory, electricity, and fuel, accounting for 20% of revenue.
- External Services Costs: Covers expenses for phone services, deliveries, external contractors, equipment rental, bookkeeping, and utilities, with an additional estimated cost of 25,000 EUR.
- Maintenance Costs: Encompasses regular and extraordinary equipment inspections as per regulations, with costs starting at 0.5% of investment value in the first 5 years and increasing to 0.75% thereafter.
- Leasing Costs: Additional 1,000 m² of space is required at a rate of 5.00 EUR/m² annually, with an additional variable rent of 1.5% of revenue generated on the leased area.
- Other Costs: Includes insurance, employee benefits, marketing, payment processing, membership fees, and other administrative costs, estimated at 15,000 EUR annually with a 2% annual growth rate.

This comprehensive cost analysis provides the financial foundation for establishing and operating the LSC effectively. Table 6 provides a comprehensive overview of cost distribution regarding the establishment of the Logistics Service Center at ACI Marina Šimuni.

Description	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Employee Costs	0	4.800	82.800	84.456	86.145	87.868	89.625	91.418	93.246	95.111	97.013	98.954
Material Costs	0	0	54.000	55.080	56.182	57.305	58.451	59.620	60.813	62.029	63.270	64.535
External Services Costs	5.000	5.000	25.000	25.500	26.010	26.530	27.061	27.602	28.154	28.717	29.291	29.877
Maintenance Costs	0	0	5.850	5.850	5.850	5.850	5.850	8.775	8.775	8.775	8.775	8.775
Leasing Costs – Fixed Component	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Leasing Costs – Variable Component	0	0	5.925	6.044	6.164	6.288	6.413	6.673	6.673	6.806	6.942	7.081
Other Costs	1.000	1.000	15.000	15.300	15.606	15.918	16.236	16.892	16.892	17.230	17.575	17.926
Total	11.000	15.800	193.575	197.230	200.957	204.759	208.637	219.553	219.553	223.669	227.866	232.148

Table 6. Cost distribution regarding the establishment of the Logistics Service Center (Source: (Schiozzi, 2023))

The table presents a detailed cost projection for the LSC at ACI Marina Šimuni covering 2024 – 2035, revealing a steady rise across every major cost category. Employee costs start at 4,800 EUR in 2025 and steadily grow, reaching 98,954

EUR by 2035, reflecting staff expansion and salary growth. Material costs, which begin at 55,080 EUR in 2026, demonstrate consistent increases, reaching 64,535 EUR in 2035, driven by operational scaling. Lease costs include both fixed (5,000 EUR annually) and variable components, the latter rising from 5,925 EUR in 2026 to 7,081 EUR in 2035. Overall, total expenditures escalate from €11,000 in 2024 to €232,148 in 2035, underscoring the LSC's expanding operational footprint and resource requirements.

4.1.4. Dynamic Assessment of Project Profitability

The dynamic financial evaluation of the Logistics Service Center (LSC) relies on three complementary capital-budgeting techniques: (1) The payback period method (Boardman, Reinhart, & Celec, 2006); (2) The net present value (NPV) method (Xu, 2015); and (3) The internal rate of return (IRR) method (Miletić & Latinac, 2020).

The payback-period method estimates how long it will take to recover the initial investment by comparing the project's cash outflows with its cumulative net cash inflows. This method emphasizes the LSC's liquidity and the efficiency of capital recovery, making it a crucial criterion in investment decision-making. Table 7 summarizes the calculated payback period for the proposed LSC at ACI Marina Šimuni.

Period	Business Year	Net Cash Inflows of Economic Flow	Cumulative Net Cash Flow
1	2024	-551.000,00	-551.000,00
2	2025	-645.800,00	-1.196.800,00
3	**2026**	**193.998,35**	-1.002.801,65
4	2027	196.953,42	-805.848,23
5	2028	199.957,08	-605.891,15
6	2029	203.009,86	-402.881,29
7	2030	206.112,32	-196.768,98
8	**2031**	203.266,48	**6.497,50**
9	2032	206.469,89	212.967,39
10	2033	209.724,55	422.691,94
11	2034	213.031,00	425.998,39
12	2035	216.389,72	642.388,11

Table 7. Payback period of the Logistics Service Center (LSC) in ACI Marina Šimuni (Source: (Schiozzi, 2023))

The investment in the Logistics Service Center is expected to incur initial losses, but cumulative net cash flow turns positive in the eighth year (2031) at €6,497.50, marking the break-even point. Positive yearly net cash inflows begin in 2026, steadily increasing thereafter. By 2035, cumulative net cash flow is projected to reach €642,388.11, indicating strong long-term profitability.

The primary limitation of this method lies in its inability to incorporate discounted cash flows or consider factors related to the project's financing structure. Accordingly, this metric should be used in tandem with other dynamic evaluation techniques for a more comprehensive assessment; hence it is complemented by the net present value (NPV) and internal rate of return (IRR) methods.

The net present value (NPV) method accounts for the time value of money by discounting future net cash inflows to their present value (Xu, 2015). Using a 4 percent discount rate—reflecting the cost of capital for the LSC at ACI Marina Šimuni—the project yields a positive NPV, satisfying the investor's acceptance criterion (Illés, 2020). The NPV for the LSC is positive at the end of the observation period, making the project viable for the investor. Consequently, the internal rate of return (IRR) measures the project's annual accumulation rate and serves as the maximum interest rate the project can sustain on borrowed funds (Miletić & Latinac, 2020). For the LSC, the IRR is 9.94%, making it acceptable to the investor.

In conclusion, the integration of a Logistics Service Center at ACI Marina Šimuni demonstrates long-term financial viability, with a break-even point projected in the eighth year (2031) and steady profitability thereafter, as reflected by a cumulative net cash flow of 642,388.11 EUR by 2035. The positive net present value (NPV) and an internal rate of return (IRR) of 9.94% further confirm the project's financial feasibility, making it an attractive investment for stakeholders.

5. DISCUSSION

5.1. Economic Aspects

The economic implications of nautical tourism ports in Croatia are substantial, as demonstrated by their significant revenue contributions. In 2023, Croatian nautical tourism ports generated €161 million (excluding VAT), representing a 12.1 % year-on-year increase, with berth fees contributing 72 % of this amount (Ministry of Tourism and Sports, 2023). ACI Marina Šimuni itself showcases untapped economic potential. Despite a 4 % expansion in vessel capacity between 2021 and 2022, realized stays rose by only 1 %, and overall utilization declined from 74.2 % to 72 %.

The integration of an LSC addresses key service gaps that hinder economic performance. The €1.17 million, two-year investment in advanced infrastructure—including a travel lift and a modular hangar—aims to strengthen vessel servicing and maintenance capabilities. Revenue projections indicate steady growth, with service revenues expected to rise from €360,000 in 2026 to €430,233 by 2035 (Schiozzi, 2023). This growth reflects the center's potential to attract both transient and permanent users, boosting the marina's financial sustainability.

The staged investment approach supports financial viability, with the project expected to break even in its eighth year of operation (2031). The resulting positive NPV and an IRR of 9.94 % confirm the project's long-term profitability, making it a safe economic proposition for stakeholders (Schiozzi, 2023). Moreover, the establishment of the LSC fosters employment opportunities, with the addition of five new employees and ongoing training programs to upskill the workforce. This aligns with regional economic development goals, further solidifying the nautical tourism ports' role as an economic driver.

The introduction of modern logistical services is expected to align more closely with visitor expectations, particularly those of high-value visotors seeking premium offerings. This differentiation can enhance the competitiveness of ACI Marina Šimuni within the Adriatic region, ensuring long-term economic benefits.

5.2. Environmental Aspects

While the economic benefits of nautical tourism are evident, its environmental footprint remains a growing concern. Pollution arising from copper-based antifouling paints, bilge discharges, and inadequate waste management presents substantial ecological challenges in Croatian marinas (Zahed et al., 2010). For example, in 2022, the total daily leaching of copper from antifouling paints in Šimuni's ports reached 200.952 grams, with larger vessels contributing a disproportionate share of this contamination.

Sustainability is embedded in the LSC's design: advanced solid- and hazardous-waste facilities, together with eco-friendly cleaning technologies, are intended to curb the environmental impact of routine vessel maintenance. The adoption of non-biocidal antifouling paints and alternatives such as ultrasonic systems further exemplify efforts to reduce marine pollution (Zahed et al., 2010). Moreover, integrated water-collection and treatment units ensure that contaminated wash water is captured and treated before discharge, thereby safeguarding local marine ecosystems.

Educational initiatives targeting vessel owners are also crucial for promoting sustainable practices (Abdurahman et al., 2022). By providing eco-friendly cleaning products and raising awareness of regulatory requirements, the LSC fosters a culture of environmental stewardship among marina users.

Furthermore, the development of the LSC aligns with Croatia's commitments to EU environmental standards and sustainable tourism policies (Boromisa, Funduk, & Tišma, 2024). It serves as a model for integrating ecological considerations into infrastructure development, demonstrating that economic growth can coexist with environmental integrity.

5.3. Strategic Aspects

Strategically, ACI Marina Šimuni occupies a pivotal position within Croatia's Nautical Ports System, providing a vital link between northern Adriatic destinations and key southern Adriatic cruising areas (Schiozzi, 2023). This geographic

advantage, together with its year-round operational capacity, underscores the marina's role as a central hub for nautical tourism.

The integration of an LSC aligns with global trends in sustainable tourism and technological innovation. By addressing service deficiencies, such as the absence of a high-capacity crane and inadequate cleaning infrastructure, the LSC enhances the nautical tourism ports' ability to accommodate larger vessels and meet the demands of the growing charter fleet. Moreover, adopting advanced logistics systems and sustainable practices can position ACI Marina Šimuni as a regional leader in environmentally responsible nautical tourism endeavors (Schiozzi, 2023).

Strategic infrastructure investments also strengthen the marina's competitive edge, enabling it to attract high-value clientele while remaining consistent with the principles of "blue tourism" (Martínez Vázquez, Milán García, & De Pablo Valenciano, 2021). This approach ensures that economic growth remains balanced with environmental preservation, maintaining Croatia's appeal as a premier nautical destination.

Additionally, by prioritizing operational efficiency through features such as a travel lift and modular hangar, the LSC expands the marina's capacity to accommodate growing traffic and larger vessels. These upgrades can improve the nautical tourism port's service offerings and strengthen its integration into regional and international nautical networks.

5.4. Broader Implications and Future Research

The findings underscore the transformative potential of integrating LSCs within Croatia's Nautical Ports System. By balancing economic, environmental, and strategic objectives, Croatia's nautical tourism sector can achieve sustainable growth while preserving its natural resources. Future research should therefore examine the scalability of this model across other Adriatic nautical tourism ports and assess the long-term effects of LSCs on regional competitiveness and environmental sustainability.

To maximize the value of Logistics Service Centers (LSCs) in nautical tourism ports, several elements are critical: (1) Uninterrupted (24/7) access, (2) Specialized management, (3) Qualified staff, and (4) Reliable supplies of fuel and other resources. LSCs should ensure efficient marina access and secure storage, while employing trained staff to provide high-quality services, from maintenance to advanced repairs. Specialized management can tailor offerings to diverse owner requirements, enhancing satisfaction and efficiency. Additionally, providing fuel, water, food, and supplies supports vessels and improves user experience, positioning LSCs as essential hubs in customer-focused and sustainable nautical maritime operations.

Furthermore, comparative studies between nautical tourism ports with and without integrated LSCs could identify best practices and reveal opportunities for further optimization. The inclusion of stakeholder perspectives, such as tourists, local communities, and policymakers, would enrich the understanding of how LSCs can advance sustainable nautical tourism port development.

6. CONCLUSION

The integration of a Logistics Service Center (LSC) at ACI Marina Šimuni has a transformative potential in enhancing the economic, environmental, and strategic dimensions of nautical tourism ports. A methodological workflow for integrating a Logistics Service Center into Nautical Tourism Ports on the case study of ACI marina Šimuni is developed, as few studies provide detailed overviews or strategic approaches for logistics integration in marinas or nautical tourism ports. The workflow addresses identified gaps by providing a structured method by identifying relevant stakeholders, clarifying logistics – service needs, and specifying required and optimal relationships between tourism-oriented nautical tourism port activities and supply chain operations.

Economically, the LSC addresses critical service gaps, improves operational efficiency, and provides a sustainable revenue growth model, contributing to the competitiveness of Croatia's nautical tourism sector. Environmentally, the LSC embodies sustainable practices, from advanced waste management systems to eco-friendly cleaning technologies, aligning with Croatia's and the EU's environmental commitments. Strategically, the LSC positions ACI Marina Šimuni as a leader in customer-focused, sustainable nautical tourism, leveraging its geographic and operational advantages to attract high-value clientele and meet evolving market demands.

In addition to these benefits, the establishment of the LSC introduces several key advancements. The development of a professionally managed center equipped with modern vessel servicing and waste neutralization technologies ensures both operational efficiency and environmental sustainability. By adopting eco-friendly antifouling systems and reducing harmful discharges into marine environments, the LSC supports the long-term preservation of the marine ecosystem.

Moreover, the LSC's proactive and educational initiatives create the potential to reduce marine pollution in the ACI Marina aquatorium and beyond. As an "eco-friendly" enterprise with socially responsible operations, the LSC has the potential to become a recognized and accepted infrastructural asset within the local community, fostering stronger ties with stakeholders. Additionally, its ability to create permanent or seasonal employment opportunities underscores its role as a driver of socio-economic development in the region.

By balancing economic growth with environmental stewardship, the LSC integration model offers a scalable blueprint for sustainable development across Croatia's Nautical Ports System. Future studies should explore the scalability of such models across other Adriatic ports and investigate the role of advanced technologies in optimizing logistics and environmental outcomes. This approach ensures that Croatia maintains its appeal as a premier nautical destination while safeguarding its natural resources for future generations.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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