

Sustainable Multi-criteria Decision Port Development Framework

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ABSTRACT: The specific features of various ports create difficulties for county port authorities in Zadar County and other coastal regions of Croatia in effectively performing daily tasks like managing, maintaining, constructing, and operating ports. The reason for this is the increased presence of various elements that directly affect decision-making regarding the port's progress. Therefore, it has been acknowledged that it is necessary to establish a methodology that allows decision-makers (county port authorities) to make objective decisions regarding the future direction of port development. This article presents a methodology proposal based on the AHP (Analytical Hierarchy Process) method of multi-criteria decision-making. When determining the methodology, special attention was paid to the decision-makers, who were found to possess specific professional knowledge in their activity but rarely possess prior expertise in multi-criteria decision-making. Hence, it was crucial to establish a methodology that would be both straightforward and suitable for adoption by decision-makers themselves. The AHP method, aided by a wide range of easily accessible and even cost-free tools, facilitates this through its visual representation of goals, criteria, sub-criteria, interconnections, and subsequent outcomes. This approach ensures the feasibility of ongoing monitoring throughout the decision-making process. Ultimately, the proposed methodology was verified on the examples of five port areas based on conducted empirical research, which, with their properties, satisfy different directions of development. At the same time, the obtained results confirm its applicability.

1 INTRODUCTION

The total length of the sea coastline of the Republic of Croatia is 5,835.3 km. The distance from the northernmost point (Savudrija) to the southernmost point (rt Oštro) is 527 km. Therefore, the indentation coefficient of the Croatian part of the Adriatic coast is 11.1, which ranks the Croatian coast among the most indented in the world. Out of the 1,244 islands, islets, rocks, and reefs in the Adriatic, Croatia is home to 1,185 of them, making it the country with the highest number of islands in the Adriatic Sea and the second highest in the entire Mediterranean, second only to Greece. More precisely, there are 78 islands, 524 islets

and 642 rocks, of which 66 have been inhabited mostly since ancient Greece [12]. Although the islanders' way of life is traditionally linked to the sea (fishing, seafaring, shipbuilding), each inhabited island is a kind of world in miniature. Therefore, it is essential for the Republic of Croatia to preserve and improve life in the Croatian islands.

Transport infrastructure development in the Republic of Croatia is based on the European Union's transport policy principles. The goal of the strategy [24] is to establish a multimodal transport system that is sustainable and efficient, incorporating measures tailored for each sector. Well-connected islands have

stronger tourism development and more favourable demographic trends and structures compared to islands that are isolated and experience depopulation [14]. Transportation connections differ considerably from island to island according to type, capacity, possibility of vehicle and cargo transport, fleet age, transport costs, and other features. In addition, according to islanders, an important factor affecting the efficiency of transportation connections between the island and the mainland is the dependence on weather conditions and sailing schedules [8]. In this context, coastal liner services are important for the development of the islands since they ensure a permanent and regular connection between the islands and the mainland, without which the sustainable development of the inhabited islands in the internal sea waters and the territorial sea of the Republic of Croatia would not be possible. Improving transportation in coastal liner services cannot be emphasised enough. It is crucial for driving economic growth in island and coastal regions and preventing population decline. Therefore, it is necessary to optimise the capacities and efficiency of both the existing and the new infrastructure, promote inter-modality and improve the safety and reliability of the transport network by opening and enhancing the infrastructure for the accommodation of ships that perform transport in coastal liner services and their access infrastructure (access roads, etc.).

The quality of maritime port infrastructure plays a crucial role in developing coastal shipping and accessibility to the islands, as stated in the Transport Development Strategy of the Republic of Croatia for 2014-2020 [24]. The priority in the construction, renovation, and modernisation of infrastructure should be given to ports open to public traffic (coastal shipping berths). These ports must also be designated as ports of county and local importance.

The National Plan for the Development of Ports Open for Public Traffic of County and Local Importance [9] is a document that systematically and comprehensively looks at the needs of the maritime-passenger transport system at the county and local level and provides development guidelines for the future. Such a strategic document enables the unique development of the entire coastal and island area, considering the socio-economic needs of the island population and the economy of that area. The plans determine the development direction of each port, necessary investments, and investment dynamics to monitor real needs realistically and responsibly, i.e., the main guidelines for further investments in port infrastructure and services are defined to achieve general and specific goals.

The national plan emphasises the need to create an effective management and development model for the maritime-passenger transport system while raising the level of connection efficiency between island and coast and the quality of port services. It emphasises the need to implement a policy of sustainable development. Also, it includes the integration of ports into the social and economic development of the local area and the construction of an effective maritime-passenger transport system to enhance tourism potential. The assessment identifies administrative processes, infrastructure, services, and port organisation obstacles. It offers recommendations to

overcome these barriers, which will enhance security levels in seaports, establish effective environmental protection measures in port areas, and optimise energy usage.

The County Port Authorities handle the operational implementation of all the strategic plans in the Republic of Croatia. The legal definition of the term "Port Authority" states that it is a non-profit legal entity established by the Law on Maritime Property and Sea-ports [29] and the Decision on the Establishment of the Port Authority [13]. Hence, it can be concluded that it was established primarily for the management, maintenance, construction, and use of ports of county and local importance under the Regulation on the classification of ports open to public traffic in Zadar County as approved by the Minister of Maritime Affairs, Transport, and Infrastructure of the Republic of Croatia. The role of the County Port Authority is important for the analysis of the port future development, where the primary goal is not to generate as much revenue as possible but to preserve and maintain a port of county and local importance even when no direct economic benefit is involved. This contributes to the development of both the port and the local communities, specifically the widespread islands in Zadar County because of their unique geographic features.

The future Development Plan of Zadar County 2021-2027 [7] aims to further invest in capital infrastructure projects for port infrastructure. It also focuses on the modernisation and improvement of county and locally important seaports and road transport connections.

Finally, we should emphasise the fact that there are 22 County Port Authorities in the Republic of Croatia [18], of which the Zadar County Port Authority manages the most significant number of ports - 113, of which eight ports are categorised as ports of county importance, and 105 of them are categorised as ports of local importance. Managing ports in Zadar County and other coastal regions of the Republic of Croatia can be challenging because of the large number of ports with unique features. County port authorities have a range of responsibilities, such as managing, maintaining, constructing, and utilising ports. However, these tasks can be challenging to accomplish in real-life scenarios because of various factors that directly impact decision-making regarding port development.

Considering the above, it was concluded that a methodology must be determined to assist decision-makers (specifically county port authorities) in making objective and efficient decisions related to port development. This article proposes a methodology based on the AHP (Analytical Hierarchy Process) method of multi-criteria decision-making. While selecting the methodology, particular focus was given to the decision-makers, who were discovered to have specialised expertise in their respective fields but lacked prior experience in multi-criteria decision-making. As a result, it was necessary to develop a clear and user-friendly method that decision-makers could use autonomously. Using various cost-effective tools, including free ones, the AHP method helps to visualise goals, criteria, and sub-criteria, as well as their interconnections. This visualisation supports

continuous monitoring throughout the decision-making process.

It is crucial to highlight that the successful implementation of the suggested approach relies on conducting a comprehensive analysis of the current state and the unique characteristics of each port. This analysis aims to identify strategies for enhancing the ports of county and local importance. This article presents a detailed analysis of 20 ports in the Zadar County area. Out of these, 5 ports that hold county importance have been identified. These ports have specific features that highlight the potential of the proposed methodology.

2 DESCRIPTION OF THE RESEARCH SUBJECT

In the process of evaluating the current situation, it was ascertained that an essential challenge in implementing decision-making methodologies for directing port growth is the unsuitable (existing) criteria used to classify public traffic ports in the Republic of Croatia. While it may seem convenient to point the finger at the legislator, specifically the competent ministry (Ministry of the Sea, Transport, and Infrastructure of the Republic of Croatia), for the current state of affairs, their actions have been influenced by numerous ports of importance (both county and local) in the Republic of Croatia, which required the implementation of general/compromising regulations. Initially, these regulations should adequately fulfil the requirements of all ports, considering their distinct characteristics and needs. Based on empirical experiences at the operational level, particularly the work of decision-makers at county port authorities, it is evident that the existing legislation, in its current form, fails to offer a satisfactory solution.

An analysis of the current legislation was vital to make the proposed decision-making methodology with the AHP method effective. Based on this analysis and the empirical experiences of decision-makers, changes to the criteria were proposed. In line with what has been mentioned before, presented below is an overview of the current criteria, their deficiencies, and a proposal of new criteria regarding the classification of ports open to public traffic in the Republic of Croatia.

2.1 Existing criteria for the classification of ports open to public traffic

The classification of ports is regulated by the Maritime Domain and Seaports Act. It determines the legal status of a maritime domain. It covers a wide range of topics, such as establishing boundaries, managing and protecting the maritime domain, regulating the use and classification of seaports, establishing port authorities, overseeing port activities, constructing and utilising port infrastructure, and addressing critical issues related to order and regulation within seaports.

The Maritime Domain and Seaports Act is a fundamental legal document that categorises ports

into two types: ports open to public traffic and ports of special purposes, based on their intended function. It's crucial to note that both types of ports can facilitate international and domestic traffic.

According to their size and importance for the Republic of Croatia, ports open to public traffic are divided into:

- ports of special (international) economic interest for the Republic of Croatia;
- ports of county importance;
- ports of local importance.

The Government of the Republic of Croatia establishes the classification of ports open to public traffic by using specific criteria:

- the total traffic and characteristics of the port over ten years;
- the operational capacity of the port;
- the condition of the port's infrastructure and superstructure;
- capacity to arrange and provide services;
- maintenance and repair of vessels and ports;
- the importance and quality of transportation links to the nearby region;
- economic possibilities for further development of the port, etc.

The classification of ports depends on their compliance with the guidelines stated in the Regulation on the classification of ports open to public traffic as proposed by the relevant minister.

It is within the jurisdiction of the County Assembly to determine which ports are ports open to public traffic of county and local importance. The assembly defines the port area, adhering to the spatial plan and obtaining approval from the Government of the Republic of Croatia. The port area of ports open to public traffic of county and local importance comprises the allocated space for:

- liner shipping performance;
- communal berth;
- nautical port berth;
- fishing berth;
- berths.

The Government of the Republic of Croatia determines the classification of ports into county importance, following the criteria outlined in the Regulation of the Sorting of Ports Open to Public Traffic and Ports of Special Purpose [26]:

- Average turnaround of over 50,000 tons of cargo per year in the period from 1998 to 2003, or average passenger traffic of over 100,000 passengers per year in the same period in a port exclusively handling passenger traffic;
- Adequate road connection with the hinterland;
- Port capacities for cargo traffic of 50,000 tons, i.e. piers and wharves for accommodating ships up to 80 m and up to 4 m draught;
- At least three lines per month in domestic traffic for passenger-only ports.

The criteria for the classification of ports open to public traffic into ports of local importance is the average traffic of up to 50,000 tons of cargo per year in the period from 1998 to 2003, i.e., the average passenger traffic of up to 100,000 passengers per year in the same period for passenger-only ports.

The established criteria for classifying ports open to public traffic as either ports of county or local importance indicates that these ports are smaller, have lower passenger or cargo traffic, and provide fewer services to users. Also, it has been determined that local ports refer to all ports that are open to the public and have only wharves available for safe berthing of vessels.

When classifying ports open to public traffic, it is crucial to ensure that each port satisfies all the criteria for the corresponding port class. Ports open to public traffic are categorised into passenger ports and cargo ports based on the predominant traffic. If a port meets the requirements for classification in a specific class, it is classified under that class, provided the dominant traffic also meets the required criteria.

Currently, there are 412 ports open to public traffic in the Republic of Croatia. These ports are categorised as either ports of county or local importance. Of these 412 ports, 64 are considered ports of county importance, while the remaining 348 are classified as ports of local importance. The distribution of these ports across each county is presented in Table 1.

Table 1. Ports open to public traffic of county and local importance in the Republic of Croatia.

County	Ports of local importance	Ports of county importance
Split-Dalmatia	6	51
Zadar	8	105
Istra	8	32
Primorje-Gorski Kotar	27	74
Lika-Senj	8	12
Dubrovnik-Neretva	7	74

2.2 Classification of ports open to public traffic in Zadar County

There are 113 ports in Zadar County, out of which 8 are categorised as ports of county importance, while 105 are classified as ports of local importance. The ports of county importance are the Port of Biograd, the Port of Brbinj Lučina, the Port of Fortica, the Port of Pag, the Port of Preko, the Port of Silba, the Port of Žalić, the Port of Tkon, and the Port of Zaglav. These are mainly passenger ports regulated by the Regulation on the classification of ports open to public traffic in Zadar County [10].

Most of the local ports in Zadar County are intended for communal berths. This means that they are primarily intended for the mooring of residents' boats, i.e., for the permanent berthing of a vessel whose owner lives in the area of the local self-government unit or the vessel stays predominantly in that area. The vessel must be registered in the Register of Shipping or boat record book of the harbour master's office or its branch office competent within a particular territory, and for the use of which a permanent berthing contract must be made with the port authority and on which no economic activities can be performed.

Besides its communal purpose, parts of the ports are intended for nautical tourism and nautical moorings, and parts of the ports are operational ones designed for the mooring of vessels in public transport, vessels for the occasional transportation of

passengers, cargo vessels, and other vessels and fishing vessels when performing loading and discharging. These are ports with a less developed infrastructure, mooring equipment, and additional facilities.

The field analysis indicates that these ports offer services such as receiving vessels on a regular basis and providing mooring facilities for recreational and fishing boats. These ports also serve as small local ports.

2.3 Shortcomings of the existing criteria for the classification of ports open to public traffic

The existing criteria for classifying ports specified in the Regulation of the Sorting of Ports Open to Public Traffic and Ports of Special Purpose refer to the traffic and frequency of routes, road, and rail connections with the hinterland, and port capacities. From the presentation of the existing criteria, all the mentioned criteria can be classified as those belonging to the traffic technology criteria. None of the criteria listed in the Regulation belongs to the category of socio-economic criteria.

The current classification criteria for ports open to public traffic are rigid and imprecise, lacking credibility when evaluating the importance of ports for county and regional development. The existing criteria for developing ports do not consider each county's unique geo-graphical, traffic, economic, and social characteristics. This means that the economic interests and needs of the local population are not considered. However, it is imperative to recognise that the local population holds the utmost importance as stakeholders in the development of ports of county and local importance. They are regular users of port services and can experience both positive and negative consequences from the port's development.

The subsequent section provides a thorough outline of the methodology employed to determine the most suitable development direction for ports of county and local importance in the Republic of Croatia, focusing specifically on the ports in Zadar County.

3 METHODOLOGICAL APPROACH TO DETERMINE THE MODEL (FRAMEWORK) OF COUNTY PORT DEVELOPMENT

The successful and rational development of county and local ports requires an assessment of all factors that directly or indirectly impact their functioning. The port's location is one of the most important factors determining its operation. Typically, these ports are situated in the centre of the town, particularly in the Mediterranean countries like Croatia and Italy, where smaller ports are often located near historical centres. Such location has a significant impact on urban and spatial planning, i.e., on planning the development of county and local ports. In addition, the development of ports of the county (and local) importance also depends on the development of neighbouring ports and the entire port system at a particular micro-location.

To determine the future development direction of the county ports in Zadar County, the Analytical Hierarchy Process (AHP) method was applied. The application of the AHP method for identifying the optimal scenario is grounded in comparing scenarios, criteria, and sub-criteria and was chosen for its simplicity and ease of use. Connecting the set goals, criteria, and sub-criteria and maintaining control over their relationship (consistency) allows the decision-maker (in this case, the County Port Authority) to have a precise understanding of the selected/optimal goal, criteria and sub-criteria by conducting a thorough analysis of the port's current state.

The decision-making process involves the assessment of multiple criteria and sub-criteria, which are used to prioritise potential decisions [20]. It is important to follow three distinct steps to effectively use decision-making techniques that involve numerical analysis of alternatives:

- Determine relevant criteria and alternatives;
- Assign numerical measures to the relative importance of criteria and the impact of alternatives;
- Process numerical values to determine the ranking of each alternative [25].

Deciding becomes more complex when multiple interconnected and well-established criteria require multi-criteria decision-making. Multi-criteria decision-making methods help decision-makers understand the dynamics of the problem and offer productive and objective decision-making support [20]. In multi-criteria decision-making, it is possible to use the following methods: Simple Additive Weighting Method (SAW), Data Envelopment Analysis (DEA), DEMATEL method (DEcision MAKing Trial and Evaluation Laboratory), TOPSIS method (Technique for Order Performance by Similarity to Ideal Solution), a set of methods ELECTRE (Elimination and Choice Expressing the Reality), a set of methods PROMETHEE (Preference Ranking Organisation Method for Enrichment of Evaluation), method of Analytic Network Process (ANP), and analytical hierarchical process (Analytical Hierarchy Process, AHP).

The Analytic Hierarchy Process (AHP) method is an invaluable tool in multi-criteria decision-making. It empowers decision-makers to structure their problems by conducting pairwise comparisons and considering expert judgments [16]. It has successfully addressed a wide range of problems, both in individual and group decision-making contexts [4, 5]. Since a decision-maker bases judgments on knowledge and experience and decides accordingly, the AHP approach agrees well with the behaviour of a decision-maker [2]. The AHP method is used to solve complex decision-making problems by breaking them down into smaller components: goals, criteria (sub-criteria), and alternatives. These components are then linked to a hierarchical structure. The AHP supports a methodology for measuring quantitative and qualitative performance [27]. It comprises two phases: defining the hierarchy tree and conducting a numerical evaluation of the tree [3]. The AHP method results in ranking alternatives, just like the TOPSIS, ELECTRE I, ELECTRE II, and ELECTRE III methods. The possibility of controlling the consistency is one of

the most significant advantages of this method (for example, in the TOPSIS, ELECTRE I and ELECTRE II methods, consistency is not controlled) [15]. Vaidya and Kumar [27] provide an overview of 150 scientific studies in which the AHP method was applied, of which 27 were analysed in detail. This method is used in the fields of economy, industry, social disciplines, transport, ecology, politics, military science, etc. Furthermore, it solves problems such as choosing and evaluating decision alternatives and decision factors, resource allocation, analysis of benefits, costs, opportunities, and risks, prediction, analytical planning, construction, and evaluation of development scenarios etc. The AHP method has found its application in specific areas [5, 6, 11, 23, 28].

Considering the research requirements and objectives, the AHP method was chosen among the different multi-criteria methods discussed. This approach provides decision-makers with a clear method to compare values during the process of multi-criteria decision-making. The main justification for selecting this method is that, in contrast to other methods, it allows for the breakdown of the decision-making problem into more manageable components. With the support of the input data, the AHP method establishes a linear hierarchical structure that allows for the ranking of alternatives while effectively managing the procedure's consistency.

The AHP method for assessing the values of the criteria weights ratio and the alter-natives' importance uses Saaty's ratio scale (Table 2) [19]. Elements are then pairwise compared according to a 9-level scale to derive their weights [7]. The alternative indicates the decision between different possibilities for solving the problem.

Table 2. Saaty's Scale [21]

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favour one activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Demonstrated importance	An activity is strongly favoured, and its dominance demonstrated in practice
9	Absolute importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgments	When compromise is needed (i.e., when it is difficult to decide between two odd intensities of importance)

Saaty's scale is a method of assigning values to different criteria based on their relative importance. The scale has five levels of intensity and four intermediate levels. Each level and intermediate level corresponds to a value judgment about how much more important one criterion is than the other. Odd numbers (1, 3, 5, 7, 9) are associated with basic values, while even numbers (2, 4, 6, 8) describe their

intermediate values. When values are reversed in the scale, it indicates ratings that are opposite to those listed. The scale compares two alternatives, and the values represent how often one alternative is more important than the other.

There are four fundamental steps in the implementation process of the AHP method. Figure 1 illustrates the hierarchical structure of the model developed in the first step.

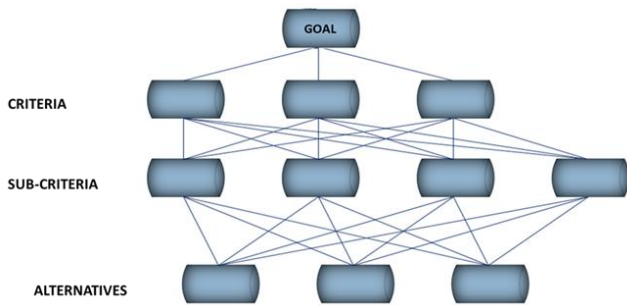


Figure 1. Presentation of the hierarchical structure of the model.

The goal occupies the highest position in the hierarchical structure, followed by the criteria at the first level and the sub-criteria at the subsequent level. Alternatives are at the bottom level of the model's hierarchical structure. All listed elements represent input values. The structure's purpose is to enable the assessment of the importance of the elements of a certain level concerning some or all elements of the neighbouring level [22].

In the second step, a pairwise comparison of elements is performed at every level of the hierarchical structure. By doing so, we can ascertain the degree of significance of the first criterion in relation to the second criterion. The importance of criteria is expressed by the Saaty's scale. Using Saaty's scale enables the comparison of the importance ratio between two criteria, regardless of how they are expressed - whether quantitatively, qualitatively, or in different units of measurement. The consistency check is a significant component of the AHP method and is performed at each comparison level. Given the subjective nature of comparing pairs, inconsistencies can occur. The AHP method states that the consistency index (CI) should not exceed 0.10 for a particular comparison to be valid. However, in situations where it is not possible to fully optimise decision-making, i.e. when the decrease in CI leads to undesirable correlations between the terms being compared, as demonstrated in the model described in this paper, the analysis highlights the recommendation to raise the tolerance of CI values. Nevertheless, the CI must not exceed 0.15, even if reassessing the established model is still required.

In the third step, a mathematical model is employed to calculate the local priorities (weights) of the criteria, sub-criteria, and alternatives. These priorities are then combined to obtain the total priorities of the alternatives.

The fourth step involves conducting a sensitivity analysis to assess how changes in the model's input data impact the priority alternatives. Sensitivity

analysis aims to determine the impact of input data variations on the model variables, irrespective of their connection to the data used in constructing the model or the significance of critical parameters and independent variables in the model. The utilisation of sensitivity analysis improves the model's reliability.

In the model presented in this paper, the AHP scale (Table 2) excluded even numbers, while the odd scale was transformed: $3 \rightarrow 2$, $5 \rightarrow 3$, $7 \rightarrow 4$ and $9 \rightarrow 5$. The interpretation remained consistent with the AHP method, as demonstrated in Table 3. The abovementioned translation was used to ensure consistency with the standard grading system (school/academic) employed in the Republic of Croatia. The intention was to simplify the comparison methodology, reduce the inconsistency of evaluation, and ultimately present the findings to the decision-maker. Once the decision maker completes all comparisons, the values of the gradation scale are once again translated into the corresponding values of the AHP method, i.e., $3 \leftarrow 2$, $5 \leftarrow 3$, $7 \leftarrow 4$ and $9 \leftarrow 5$.

Table 3. AHP evaluation scale adapted to create criteria and guidelines for planning the development of ports of county and local importance.

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Moderate importance	Experience and judgment slightly favour one activity over another
3	Strong importance	Experience and judgment strongly favour one activity over another
4	Very strong, demonstrated importance	An activity is strongly favoured, and its dominance demonstrated in practice
5	Absolute importance	The evidence favouring one activity over another is of the highest possible order of affirmation

This paper conducts a thorough analysis of the multiple factors that have a direct or indirect influence on port operations. "To avoid making incorrect decisions in a particular situation," the decision-making process was customised for each port without conducting a sensitivity analysis for the presented ports and their models.

Before presenting the developed models for the future development of the selected ports using multi-criteria analysis, it is important to highlight how the results obtained from this analysis are interpreted, especially in terms of their graphical representation. Despite the note accompanying each graph, which clarifies that a higher percentage signifies a greater degree of importance in terms of development needs, it is important to emphasise that the results of the multi-criteria analysis should not be interpreted solely based on absolute values and exclusivity. The simultaneous development of various areas is crucial, especially in ports that meet the requirements. By implementing this approach, the order can also be seen as a set of relationships, particularly the absolute values that define it, i.e., proportions through which the mentioned development should be attained.

Finally, it is necessary to take into consideration the specific role of the Zadar County Port Authority, i.e. a factor employed in the multi-criteria analysis captures the County Port Authority's core function of overseeing and advancing ports that lack economic viability but are imperative for the sustainability and advancement of the local community. This is particularly noticeable within the Zadar Port Authority jurisdiction, particularly in its smaller, rural, and island ports.

3.1 Setting goals for the development of the port

To determine the future direction of a port of local or county importance, a comprehensive analysis and evaluation of its present condition and operations is necessary.

In order to address practical concerns and meet the investment needs of port infra-structure and superstructure, three development directions or scenarios have been established for the ports of county importance in Zadar County:

- Development of the public coastal and liner service (Croatian: JDLPP) and/or port economic capacity;
- Development of the ports for nautical tourism and their function;
- Development of small local ports and their function.

The first goal - The development of the public coastal and liner service and/or port economic capacity - has the primary function of improving the public coastal and liner services and boosting the economic capacity of ports. The main emphasis of this goal is to enhance public passenger transport services and optimise the economic role of ports. Overall, this development direction is centred on improving the connectivity between the mainland and the islands, as well as facilitating interconnectivity among the islands. This direction of development also implies the development of accompanying services, which, in the first place, relate to meeting the needs of passengers while awaiting transport.

One aspect of this aim is to boost the economy, specifically by enhancing the functionality of the fishing port. This involves meeting the requirements of local fishermen by providing moorings and supporting port services to ensure proper accommodation and maintenance of fishing boats. It also involves facilitating the transfer of fish and other seafood.

This goal considers the boats owned by the residents, as they are an important factor in the tourist economy. It covers a range of economic activities and services, such as towing facilities and others.

The second goal - The development of the ports for nautical tourism and their function focuses on enhancing the nautical and tourist aspects of the port. This involves improving the port's infrastructure and facilities to accommodate smaller tourist boats, nautical tourism vessels, and boats rented by tourists. This development plan focuses on enhancing nautical tourism and other tourism-related services. It refers to ports with significant potential in developing nautical tourism.

The third goal - The development of small local ports and their function - refers to the development of the communal role of the port and implies meeting the needs of the local population for communal berths. Also, it includes the development of other activities closely related to the life and work of the local population (maintenance and repair of boats, sports activities, fishing for personal needs, etc.)

3.2 Defining criteria and sub-criteria

To achieve the mentioned development goals, two sets of criteria have been established. These criteria consider both the transportation and technological aspects and the socio-economic factors when evaluating the development directions of each county. Each criterion is accompanied by sub-criteria that can be expressed using appropriate descriptive or numerical values in qualitative or quantitative terms. These sub-criteria help evaluate and assess the feasibility of achieving a specific scenario.

Development directions were determined based on the existing situation and adapted to ports open to public traffic of local and county importance within the Zadar County Port Authority area. The process of defining development directions considered the existing state of the ports, their primary function, and the development potential and requirements of all stakeholders involved in the system.

Furthermore, the model sets forth four criteria that determine the selection of the goal - the direction of the port development function:

- Port location;
- Port capacity;
- Port infrastructure and additional services;
- Social acceptability and financial sustainability.

Each of the criteria includes its respective sub-criteria, which are comprehensively listed and described in Table 4.

Table 4. Overview of categories, criteria, and related sub-criteria

Category	Criterion	Sub-criterion
Transport	Port technology location	Natural factors and geographical factors
		Transport connection
	Port capacity	Operational port area Number of berths Vessels entering
Socio-economic	Social acceptability and financial sustainability	Availability and condition of basic infrastructure Mooring equipment Availability of additional port facilities
		The needs of the local population The needs of boaters
		Economic needs Financial sustainability

3.2.1 Port location

This paper considers two sub-criteria to evaluate the port's location: natural geo-graphical factors and transport connectivity.

This criterion is the foundation for assessing the port's geographical location and its connectivity with

other ports, urban areas, and economic centres within and beyond the County.

Natural-geographical factors - this sub-criterion evaluates the suitability of a specific port's development based on natural influences, primarily focusing on wind, waves, tides, and currents.

According to the sub-criterion on natural-geographical factors, the port has:

- safe connection with the open sea;
- a water area that allows unrestricted manoeuvrability (with sufficient depth and width to meet both present requirements and future expansion);
- the oceanographic and meteorological conditions remain favourable all year round.

Transport connectivity is extremely important for developing the islands and improving the local population's quality of life on the islands. To meet the criteria, it is imperative to examine the existing connection between the mainland and islands, as well as the inter-island connectivity. Furthermore, future development needs and possibilities must be considered. The frequency of passenger transportation and multiple shipping lines greatly influence this. When assessing the situation, it is crucial to consider the requirement for increased capacity due to the introduction of new shipping routes, the up-grade of existing facilities to accommodate Ro-Ro ships, and the expected demand for passenger transportation.

It is vital to evaluate the connectivity of a particular port to the road transport system and identify possible opportunities for improvement. This forms the foundation for the sub-criterion of transportation connectivity.

- the availability of a shipping route;
- the existence of occasional passenger transport;
- connection to the road transport network.

3.2.2 Port capacity

The main focus of the assessment is to determine the necessary improvements in port capacities to accommodate incoming ships. This mainly concerns the growth in berth numbers and the expansion of the port's operational shore.

In evaluating these criteria, it is crucial to consider not only the potential and need for expanding capacity within the sub-criteria but also the enhancement of the existing capacities. This approach allows us to identify the areas that require improvement within each sub-criterion.

The operational shore - When referring to the "operational shore", we refer to a coastal zone equipped with the technical and technological features to accommodate ships from both local and distant areas. This area is accessible to all users under the same conditions, i.e., it is not occupied by permanently moored ships and/or boats. Preference is given to ships that operate on established, regular routes.

Number of berths - When it comes to berth allocation, the sub-criterion targets explicitly the number of communal and nautical mooring locations.

Nonetheless, the possibility of enlarging the fishing berths is also being considered.

Vessel entry - This sub-criterion focuses on the average number of ships that enter the port on a daily basis.

3.2.3 Port infrastructure

The aforementioned criterion assesses the service's functionality and technical proficiency. This includes the effectiveness of the port infrastructure, the condition, and quality of mooring devices, and the level and quality of port services and other activities in the port area.

Availability and condition of the basic infrastructure - The assessment conducted within the mentioned sub-criterion entails evaluating the accessibility and state of the fundamental infrastructure, focusing specifically on the port's equipment and its ability to provide transportation services and accommodate different types of vessels. This sub-criterion examines multiple aspects, including water and electricity supply, the existence of a functional port light, the availability of a designated area for towing, a crane for ships, the adequacy of space for people and vehicles along the coast, the quality of vehicle access, and the feasibility of fuel supply for vessels.

Condition of mooring devices - this sub-criterion examines the technical and functional aspects of the mooring devices. The evaluation of the mentioned criterion includes taking into account both needs and potential for growth.

Availability of additional port facilities - When assessing additional port facilities, the analysis focuses on the existing condition within specified sub-criteria, as well as the potential and need to enhance value-added services in a particular port area. When evaluating the feasibility of expanding port facilities, specific considerations include the land area available within the port, the ability to handle vessel waste, the proper management of oily water reception and disposal, the adequate space for technical maintenance of vessels, the provision of essential food supplies, the availability of wireless Internet access, a security service, and the availability of emergency intervention services.

3.2.4 Social acceptability and financial sustainability

The criterion above is utilised to evaluate the level of demand for a particular port service among the system's users. This specific criterion enables the assessment of both the demand for liner services and the demand related to nautical tourism, excursion tourism, communal moorings, and fishing moorings. The assessment also considers how potential development directions would impact users of the port system.

In addition, an assessment is made regarding the contrast between the positive out-comes of a specific development path and its negative consequences.

The sub-criterion of the needs of the local population refers to the needs of those who are regular users of port services.

The needs of boaters – The evaluation within this category considers the needs of boaters, with a particular emphasis on meeting their requirements related to the port's nautical function.

The needs of the economy – This sub-criterion specifically addresses the requirements that emerge from economic activities, particularly fishing-related ones.

Financial sustainability – In relation to the specified sub-criterion, the potential for concluding the financial framework is based on actual revenues and expenditures, i.e., an assessment is conducted on the expenses associated with investing in port infrastructure and its maintenance. Also, the complexity of the necessary operations (construction, re-construction, improvement, modernisation, etc.) is considered.

The subsequent sub-chapter illustrates the correlation and weighting coefficients for each port of county and local importance, based on the described model, set goals, criteria, and sub-criteria, i.e., it demonstrates the optimal development scenarios for each of the ports mentioned.

4 IMPLEMENTING THE MODEL FOR SELECTING PORT DEVELOPMENT DIRECTION

Upon conducting an extensive field analysis of 20 ports falling under the jurisdiction of the Zadar County Port Authority, five ports were selected (Preko, Zaglav, Pag, Silba, Brbinj). The selected ports, each with their own specific conditions, offer valuable insights into the potential application of the AHP method for selecting future port developments.

This paper includes subsequent sections that provide details on the current characteristics of the ports, the analysis performed using the proposed model, and the results obtained from implementing the proposed model. These results are presented in both written and graphical forms.

4.1 Future development analysis model

Table 5 provides a simplified presentation of the (total) comparison values for all ports. The blue value indicates the greater importance of the term listed in the far-right column, whereas the red value signifies the greater importance of the term listed in the left column of Table 4. Instead of listing individual values for each port, the table simplifies the display by showing aggregate values in the middle columns.

4.1.1 Comparison of the criteria in relation to the activities outlined in the scenarios

Comparison of the criteria concerning the activities outlined in the scenarios (development of the public costal and liner service and port economic capacity, development of the ports for nautical tourism and their function, development of small local ports).

Table 5. Giving priority to the most significant criterion for selecting the port development scenario

Criterion	Port Preko	Zaglav	Pag	Silba	Brbinj	Criterion
Port location	2	2	2	2	4	Port capacity
Port location	3	3	3	2	3	Port infrastructure and additional services
Port location	3	2	2	2	2	Social acceptability and financial sustainability
Port capacity	1	3	2	2	2	Port infrastructure and additional services
Port capacity	3	2	2	2	2	Social acceptability and financial sustainability
Port infrastructure and additional services	2	3	2	2	2	Social acceptability and financial sustainability

4.1.2 Comparing sub-criteria within their respective criterion

Table 6. Giving priority to the sub-criterion that holds greater significance for the port location criterion

Table 6. Giving priority to the sub-criterion that holds greater significance for the port location criterion

Sub-criterion	Port Preko	Zaglav	Pag	Silba	Brbinj	Sub-criterion
Natural and geographical position	2	3	2	2	1	Transport connection

Table 7. Giving priority to the sub-criterion that holds greater significance for the port capacity criterion

Sub-criterion	Port Preko	Zaglav	Pag	Silba	Brbinj	Sub-criterion
Operational port area	3	2	3	3	3	Number of berths
Operational port area	2	2	4	2	2	Vessel entry
Number of berths	2	2	2	2	2	Vessel entry

Table 8. Giving priority to the sub-criterion that holds greater significance for the port infra-structure and additional services criterion

Sub-criterion	Port Preko	Zaglav	Pag	Silba	Brbinj	Sub-criterion
Availability and condition of the basic infrastructure	2	2	2	2	2	Condition of mooring devices
Availability and condition of the basic infrastructure	2	3	3	3	2	Availability of the additional port facilities
Condition of mooring devices	2	4	2	2	4	Availability of the additional port facilities

Table 9. Giving priority to the sub-criterion that holds greater significance for the social accept-ability and financial sustainability criterion

Sub-criterion	Port Preko	Zaglav	Pag	Silba	Brbinj	Sub-criterion
The needs of the local population	2	2	2	2	2	The needs of boaters
The needs of the local population	1	2	2	2	3	Economic needs
The needs of the local population	2	2	2	2	2	Financial sustainability
The needs of boaters	1	3	2	2	2	Economic needs
The needs of boaters	2	2	3	2	2	Financial sustainability
Economic needs	2	2	2	2	2	Financial sustainability

4.1.3 Analysing and contrasting different scenarios according to specific sub-criteria

Table 10. Giving priority to the scenario that aligns better with the sub-criterion of natural and geographic location acceptability

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development 1 of the public costal and liner service and/or port economic capacity	1	4	2	2	2	Development of the ports for nautical tourism and their function
Development 1 of the public costal and liner service and/or port economic capacity	1	2	3	3	2	Development of small local ports
Development 1 of the ports for nautical tourism and their function	1	3	3	2	2	Development of small local ports

Table 11. Giving priority to the scenario that aligns better with the sub-criterion of transport connectivity

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development 3 of the public costal and liner service and/or port economic capacity	3	2	3	2	2	Development of the ports for nautical tourism and their function
Development 2 of the public costal and liner service and/or port economic capacity	2	3	2	3	3	Development of small local ports
Development 2 of the ports for nautical tourism and their function	2	3	2	1	1	Development of small local ports

Table 12. Giving preference to the scenario that is more favourable in terms of the port apron sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development 3 of the public costal and liner service and/or port economic capacity	3	4	2	3	3	Development of the ports for nautical tourism and their function
Development 2 of the public costal and liner service and/or port economic capacity	2	3	2	3	2	Development of small local ports
Development of the ports for nautical tourism and their function	2	2	2	1	1	Development of small local ports

Table 13. Giving priority to the scenario that aligns better with the number of berths sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development 2 of the public costal and liner service and/or port economic capacity	2	4	2	3	2	Development of the ports for nautical tourism and their function
Development 2 of the public costal and liner service and/or port economic capacity	2	3	3	2	2	Development of small local ports
Development 2 of the ports for nautical tourism and their function	2	2	4	2	2	Development of small local ports

Table 14. Giving priority to the scenario that aligns better with the sub-criterion of the average number of vessel entries

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development 2 of the public costal and liner service and/or port economic capacity	2	2	3	3	3	Development of the ports for nautical tourism and their function
Development 2 of the public costal and liner service and/or port economic capacity	2	3	2	2	2	Development of small local ports
Development 2 of the ports for nautical tourism and their function	2	2	2	2	2	Development of small local ports

Table 15. Giving priority to the scenario that aligns better with the sub-criterion of the availability and condition of the basic infrastructure

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	2	3	2	3	3	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	2	2	3	2	2	Development of small local ports
Development of the ports for nautical tourism and their function	2	2	2	2	3	Development of small local ports

Table 16. Giving priority to the scenario that aligns better with the condition of the mooring devices sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	2	3	3	3	3	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	2	2	2	2	2	Development of small local ports
Development of the ports for nautical tourism and their function	2	2	4	3	2	Development of small local ports

Table 17. Giving priority to the scenario that aligns better with the sub-criterion of the availability of additional facilities

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	2	2	3	3	3	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	2	1	4	2	2	Development of small local ports
Development of the ports for nautical tourism and their function	2	2	2	2	2	Development of small local ports

Table 18. Giving priority to the scenario that aligns better with the needs of the local population sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	2	2	2	3	3	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	2	1	2	2	2	Development of small local ports
Development of the ports for nautical tourism and their function	2	2	3	2	2	Development of small local ports

Table 19. Giving priority to the scenario that aligns better with the needs of the boaters' sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	3	4	5	4	4	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	2	2	2	2	2	Development of small local ports
Development of the ports for nautical tourism and their function	4	5	5	4	4	Development of small local ports

Table 20. Giving priority to the scenario that best meets the economic needs sub-criterion

Scenario	Port Preko	Zaglav	Pag	Silba	Brbinj	Scenario
Development of the public costal and liner service and/or port economic capacity	2	2	2	2	3	Development of the ports for nautical tourism and their function
Development of the public costal and liner service and/or port economic capacity	3	3	3	2	3	Development of small local ports
Development of the ports for nautical tourism and their function	3	1	2	2	2	Development of small local ports

Table 21. Giving priority to the scenario that aligns better with the financial sustainability sub-criterion

Scenario	Port				Scenario	
	Preko	Zaglav	Pag	Silba Brbinj		
Development 3 of the public coastal and liner service and/or port economic capacity		4	2	2	4	Development of the ports for nautical tourism and their function
Development 2 of the public coastal and liner service and/or port economic capacity		2	2	2	2	Development of small local ports
Development 3 of the ports for nautical tourism and their function		4	4	2	3	Development of small local ports

4.2 Analysis of the received results

4.2.1 Port of Preko

Based on data from the Agency for Coastal Maritime Traffic Lines [1], the port of Preko is among the top three busiest routes in the eastern Adriatic. The port reached its maximum capacity after undergoing reconstruction in 2011. The development of the port of Preko should consider both its economic role and the enhancement of coastal and liner services. The operational shore adequately accommodates the existing routes, and if necessary, a larger ship can be employed on this specific route. At present, there is no urgent need for further investment in port infrastructure, but improvements can still be made to the existing facilities. The port infrastructure does not currently require any additional modifications to accommodate Ro-Ro passenger ships. Considering the prosperous tourism industry, an increase in tourists could necessitate the development of additional amenities for both tourists and the local population. The construction of port basins 1 and 2 is complete, and they are operating at their maximum capacity. To protect the port from the southeast wind, one option is to build an extension of the breakwater in the southern area of the passenger terminal. In addition, the port of Preko has the potential to house additional moorings that would extend along the shore. The port of Preko is situated near Marina Olive Island and Marina Preko. Marina Olive Island in Sutomišćica is not only a marina that accommodates boats but also has the facilities to accommodate larger yachts. In relation to this, the port of Preko can only offer a competitive advantage in terms of service pricing. Marina Preko is located within port basin 1 and is physically connected to Preko Port. Marina Preko provides a range of berths suitable for larger boats and smaller yachts. The marinas mentioned earlier have occupied the nautical berths in the port of Preko. Nevertheless, the passenger terminal can be upgraded to accommodate more berths in the designated area of the Preko port.

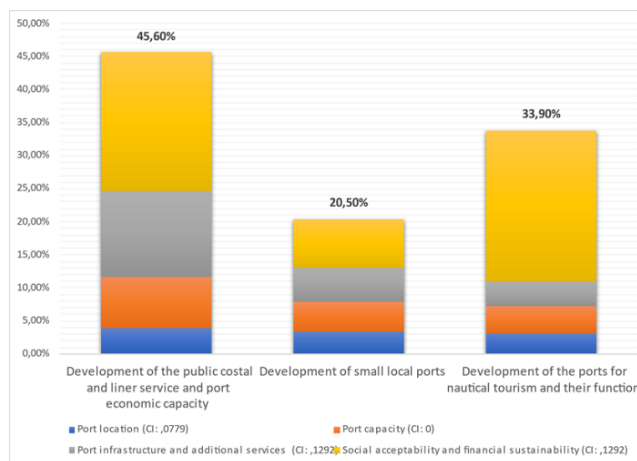


Figure 2. Graphic presentation of the analysis results for the future development of the port of Preko

4.2.2 Port of Zaglav

The port of Zaglav should focus more on the nautical aspect in its future development, considering the existing prerequisites and the potential to boost the tourist economy and other nautical tourism-related activities. In the summer months, the current capacities are inadequate to satisfy the demand for accommodating diverse recreational vessels. The entire bay area, where the port is located, has excellent potential for expanding its nautical tourism capabilities. Enhancing the mooring infrastructure will allow the port to increase its impact. The installation of floating jetties presents a potential solution for expanding the moorings' capacity, while considering the constraints imposed by the nearby gas station (e.g., accommodating larger vessels or those awaiting berths at the gas station within the protected port area, etc.). Taking into account the environmental quality, it is crucial to prioritise the enhancement of the designated coastal area for communal berths and the improvement of nautical capabilities. The present capacities of communal berths are satisfactory. If required, it is possible to modify the coastline so that smaller boats can be accommodated, and the capacity can be expanded. When considering the growth of public coastal and liner services and the economic capacity of ports, it is crucial to highlight the proximity of the port of Zaglav to the towns of Žman, Luka, and Savar. Altogether, these towns have a population of 574, which accounts for 32% of Dugi Otok's total population. The number of passengers on ship line no. 406 and fast ship line no. 9406 has been steadily increasing in the last five years. These facts can provide a basis for the future development of public coastal and liner services, as well as the economic capacity of ports. The existing port capacities meet the current demands. During the tourist season, the operational capacity of the port is partially inadequate, whereas, outside the season, it greatly surpasses the actual mooring requirements. The existing operational shore lacks the potential for further expansion. In the event of an increase in the number of lines, a designated area of the operational shore could be allocated and expanded to accommodate ferries. The port infrastructure has the potential for significant improvements, leading to increased availability of additional facilities across the entire port area. A proposal has been put forward to

improve both the infrastructure and services of the port.

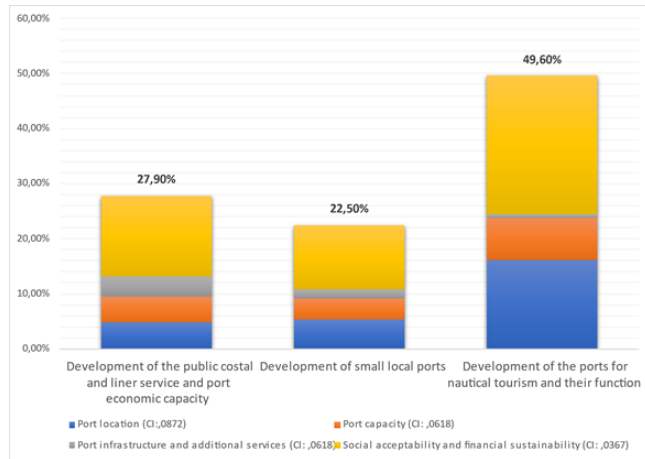


Figure 3. Graphic presentation of the analysis results for the future development of the port of Zagalav

4.2.3 Port of Pag

The future role of the port of Pag is to serve as a haven for the Bay of Pag, a small local port, and a berthing port for tourist vessels, particularly following the deepening of the Privlački Gaz. Considering the influx of fishing boats and ships to the port, it becomes imperative to enhance the port's economic role. If an increase in communal berths is required, it is possible to expand the total capacity by installing supplementary pontoons. There is the potential to upgrade the port infrastructure and expand the range of facilities in certain sections of the port area. A proposition has been put forward to enhance both the port infrastructure and its services.

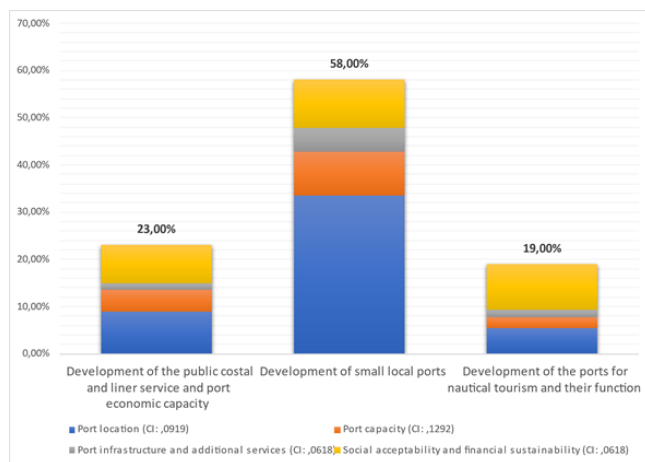


Figure 4. Graphic presentation of the analysis results for the future development of the port of Pag

4.2.4 Port of Silba

In 2020, the port of Silba underwent extensive renovations and reconstruction, resulting in a port infrastructure of exceptional quality. This infrastructure fully satisfies the requirements for the safe accommodation of Ro-Ro passenger ships and passenger ships on the existing routes. The capacity of the port is sufficient as well. The operational shore is

spacious and can handle commercial ships, such as fishing boats, tourist vessels, and smaller cargo ships, as long as they do not interfere with regular passenger traffic. Because of the substantial maritime traffic and frequent calls, the port of Silba has become the dominant port in the broader region. The port of Silba is the sole port on the island of Silba that can accommodate Ro-Ro passenger ships and passenger ships. Therefore, the port's future development should prioritise the enhancement and expansion of the public coastal and liner service, as well as the economic role of the port. The entire port area has the potential to enhance its infrastructure by adding more port facilities. It is advisable for the port to make efforts to improve its port call arrangements. The port's development should prioritise enhancing its local function as well. The focus of development should be on expanding the number of communal berths and upgrading the port infrastructure in the communal area of the port. It is proposed to improve port infrastructure and port services. The positioning of Silba port makes it challenging for fast shipping lines to berth because of the strong winds coming from the southeast, west, and northwest. The objective is to consider the arrangement of the operational shore and allow for the berthing of ferry lines at the port of Silba situated on the eastern side of the island of Silba. Presently, the port lacks the capacity for nautical moorings, which may pose a problem given the in-creasing demand. However, the port's nautical component has limited potential for development.

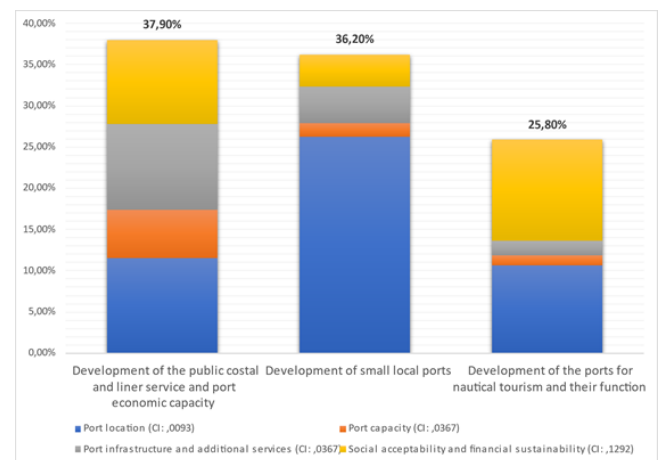


Figure 5. Graphic presentation of the analysis results for the future development of the port of Silba

4.2.5 Port of Brbinj

The port of Brbinj has the potential for growth in all three directions. Therefore, it is necessary to ensure a balanced approach in developing the port, focusing on nautical tourism, public coastal and liner services, as well as the economic and communal functions of the port. The Port of Brbinj is the only ferry connection that links Dugi Otok with the mainland. The analysis of the number of passengers and vehicles over the five years reveals a consistent upward trend. The port's capacities meet the current demands. Should there arise a necessity to accommodate a larger number of vehicles, it is possible to increase the frequency of sailings. The ferries that operate on this route offer a high level of flexibility, as they can accommodate a

large number of vehicles and passengers. This is based on the idea that the mentioned measure would effectively address the increasing vehicle demand with minimal costs compared to expanding the current operational capacity to accommodate bigger Ro-Ro vessels. Considering that the port of Brbinj is the only ferry link between Dugi Otok and the mainland, it is vital to prioritise enhancing the inadequate additional facilities. The redesign of the southern section of the operational plateau would result in the creation of a functional shoreline that is appropriate for transit berths or the mooring of commercial vessels, such as fishing, tourist, and smaller cargo ships. The part of the operational shore intended for the mooring of fast shipping lines needs to be extended. If the coastline in the targeted area of the public section of the port is modified, it could significantly increase the capacity for communal berths, thus addressing the need for more berths. There is a clear requirement for a significant upgrade in port capacities and the provision of additional port facilities within the public section of the port. Given the substantial volume of maritime traffic in the nearby area, it can be concluded that the port is deficient in moorings. The layout of the coastline can be optimised to increase the number of moorings, thus resolving capacity shortages during specific seasons.

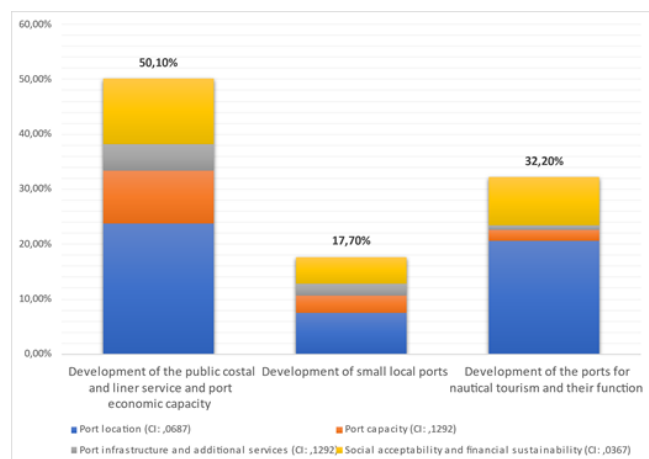


Figure 6. Graphic presentation of the analysis results for the future development of the port of Brbinj

5 CONCLUSION

The article introduces a conceptual multi-criteria decision port development framework based on the APH method for the future development of ports of county (and local) importance over the next decade. The framework, which is grounded in the AHP method, takes into consideration various criteria, emphasising the analysis of 5 selected ports in Zadar County. However, it is crucial to highlight that implementing the mentioned framework requires fulfilling three essential conditions: 1.) conducting a detailed analysis of the actual state of each individual port, respecting the defined criteria and professional standards (expertise); 2.) It is essential that both expert organisations and individuals with decision-making authority actively take part in the decision-making process. 3.) Ultimately, it is crucial to verify all the

results obtained by using this framework, based on the analysis conducted in step 1 and with the assistance of the entity in step 2. Hence, it is important to highlight that this paper meets all the prerequisites through the collaborative work of the authors and the County Port Authority, serving as the supervisory and management entity.

The presented framework exhibits a particular deviation from the recommended consistency index value of the AHP method, as evidenced by the graphs in Figures 2 to 6 in the previous chapter. However, this is precisely where the importance of applying expert knowledge becomes apparent. Based on this, the framework presented in this paper permits certain deviations from the stated value for two specific reasons. The first and most important is that determining the port development function does not solely depend on optimal values and conditions. In some instances, the sustainability of island life must be given priority, even if it means conflicting with other (sub)criteria and resulting in slightly higher consistency index values. The second reason arises from the first and suggests that it is never desirable to subordinate the comparison of criteria and goals' importance to achieving the "optimal" value of the consistency index. However, it is essential to focus specifically on the current state of the port's infrastructure, along with its actual potential and development requirements. While the ports of Preko, Zagrav, and Pag exhibit a distinct direction in terms of port development, the Silba port demonstrates the potential for attaining very close values in this aspect. Once more, it is vital to emphasise the importance of using professional expertise. This will enable the selection of two development paths that align with specific conditions and requirements. Finally, the port of Brbinj exemplifies a scenario where port development leans predominantly in one direction, yet because of its inherent characteristics; it possesses the potential for growth in all directions. Once again, this case emphasises the importance of leveraging expert knowledge and conducting a detailed analysis of the port's condition and developmental needs. This is an essential element in demonstrating the feasibility of the proposed framework.

The authors believe that the suggested framework can be successfully implemented in other port authorities, i.e., ports of county (and local) importance in the Republic of Croatia (and in other Mediterranean ports), which will serve as the focus of future re-search.

REFERENCES

- [1] Agencija za obalni linijski pomorski promet. Available online: <https://agencija-zolpp.hr/> (accessed on 1 May 2024)
- [2] Al-Harbi, K. M. A.-S. Application of the AHP in project management. *International Journal of Project Management*. 2001, 19(1), pp. 19-27. <https://www.sciencedirect.com/science/article/abs/pii/S0263786399000381>
- [3] Bertolini, M.; Braglia, M.; Carmignani, G. Application of the AHP methodology in making a proposal for a public work contract. *International Journal of Project Management*. 2006, 24(5), 422-430.

- doi:10.1016/j.ijproman.2006.01.005,
<https://www.sciencedirect.com/science/article/abs/pii/S0263786306000123>
- [4] Chang, C.-W.; Wu, C.-R.; Lin, C.-T.; Chen, H.-C. An application of AHP and sensitivity analysis for selecting the best slicing machine. *Computers & Industrial Engineering*. 2007, 52(2), pp. 296-307. https://www.researchgate.net/publication/223228484_An_application_of_AHP_and_sensitivity_analysis_for_selecting_the_best_slicing_machine
- [5] Guze, S.; Neumann, T.; Wilczyński, P. Multi-Criteria Optimisation of Liquid Cargo Transport According to Linguistic Approach to the Route Selection Task. 2017, 24, pp. 89-96. <https://sciendo.com/pl/article/10.1515/pomr-2017-0026>
- [6] Lai, V. S.; Wong, B. K.; Cheung, W. Group decision making in a multiple criteria environment: A case using the AHP in software selection. *European Journal of Operational Research*. 2002, 137(1), pp. 134-144. <https://www.sciencedirect.com/science/article/abs/pii/S0377221701000844>
- [7] Liu, Y.; Eckert, C. M.; Earl, C. A review of fuzzy AHP methods for decision-making with subjective judgements. *Expert Systems with Applications*. 2020, 161, article no. 113738. <https://www.sciencedirect.com/science/article/abs/pii/S0957417420305625>
- [8] Marinković V. Croatian Islands - insight into the traffic-geographical features of accessibility. *Geoadria*. 2018, 23(2), pp. 177-205. <https://hrcak.srce.hr/file/321076>
- [9] Nacionalni plan razvoja luka otvorenih za javni promet od županijskog i lokalnog značaja – nacrt konačnog izvješća. Lis-topad 2016. Available online: <https://mmpi.gov.hr/more-86/projekti-113/nacionalni-plan-razvoja-luka-otvorenih-za-javni-promet-od-zupanijskog-i-lokalnog-znacaja/18202> (accessed on 1 May 2024)
- [10] Naredba o razvrstaju luka otvorenih za javni promet na području Zadarske županije. Official Gazette No. 7/2021-149. Available online: https://narodnenovine.nn.hr/clanci/sluzbeni/2021_01_7_149.html (accessed on 1 May 2024)
- [11] Nosal, K.; Solecka, K. Application of AHP Method for Multi-criteria Evaluation of Variants of the Integration of Urban Public Transport. *Transportation Research Procedia*. 2014, 3, pp. 269-278. <https://www.sciencedirect.com/science/article/pii/S2146514001690>
- [12] Novak, G. Hvar kroz stoljeća; Izdavački Zavod JAZU: Zagreb, Croatia, 1972.
- [13] Odluka o osnivanju Lučke uprave. Službeni glasnik Zadarske županije 6/98, 15/03, 14/04, 11/05, 12/05, 9/07, 6/11, 16/15. Available online: <https://vlada.gov.hr/UserDocsImages//2016/Sjednice/2015/246%20sjednica%20Vlade//246%20-%2020d.pdf> (accessed on 1 May 2024)
- [14] Opačić V.T. Geografski aspekt proučavanja trajektnog prometa: primjer hrvatskog otočja. *Geoadria*. 2022, 7(2), pp. 95-109. <https://hrcak.srce.hr/file/14771>
- [15] Özcan, T.; Çelebi, N.; Esnaf, Ş. Comparative analysis of multi-criteria decision making methodologies and implementation of a warehouse location selection problem. *Expert Systems with Applications*. 2011, 38(8), pp. 9773-9779. <https://www.sciencedirect.com/science/article/abs/pii/S0957417411002284>
- [16] Peng, Y.; Kou, G.; Wang, G.; Wu, W.; Shi, Y. Ensemble of Software Defect Predictors: An AHP-based Evaluation Method. *International Journal of Information Technology & Decision Making*. 2011, 10(01), pp. 187-206. <https://www.worldscientific.com/doi/epdf/10.1142/S0219622011004282>
- [17] Plan razvoja Zadarske županije 2021. – 2027. Zadar. 2021. Available online: https://www.zadarska-zupanija.hr/images/dokumenti/314/Plan_razvoja_Zadarske_%C5%BEupanije_za_razdoblje_od_2021._do_2027._godine.pdf (accessed on 1 May 2024)
- [18] Popis lučkih uprava na području Republike Hrvatske. Available online: <https://mmpi.gov.hr/more/lucke-uprave/8456> (accessed on 1 May 2024)
- [19] Saaty, R. W. The analytic hierarchy process-what it is and how it is used. *Mathematical Modelling*. 1987, 9(3-5), pp. 161-176. <https://www.sciencedirect.com/science/article/pii/0270025587904738>
- [20] Saaty, T. L. (2008) Decision making with the analytic hierarchy process. *Int. J. Services Sciences*. 2008, 1(1), pp. 83-98. <https://www.rafikulislam.com/uploads/resources/197245512559a37aadea6d.pdf>
- [21] Saaty, T. L. How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*. 1990, 48(1), pp. 9-26. <https://www.sciencedirect.com/science/article/abs/pii/0377221790900571>
- [22] Saaty, T. L. Decision making for leaders: The analytic hierarchy process for decisions in a complex world; 3rd Revised edition; Pitts-burgh: RWS Publications, 2012.
- [23] Saaty, T. L.; Vargas, L. G. Decision Making with the Analytic Network Process: Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs, and Risks. New York: Springer, 2006. http://www.untag-smd.ac.id/files/Perpustakaan_Digital_1/DECISION%20MAKING%20Decision%20Making%20with%20the%20Analytic%20Network%20Process.pdf
- [24] Strategija prometnog razvoja Republike Hrvatske za razdoblje od 2014. do 2030. godine. Official Gazette No. 131/2014-2465, Available online: https://narodnenovine.nn.hr/clanci/sluzbeni/2014_11_131_2465.html (accessed on 1 May 2024)
- [25] Triantaphyllou E. Multi-criteria Decision Making Methods: A Comparative Study. *Applied Optimization*. 2000, 44, Springer, Boston, MA, 5-6. https://www.researchgate.net/publication/209805531_Multi-Criteria_Decision_Making_Methods_A_Comparative_Study
- [26] Uredba o razvrstaju luka otvorenih za javni promet i luka posebne namjene. Official Gazette No. 110/04, 82/07. Available online: <https://www.zakon.hr/cms.htm?id=29397> (accessed on 1 May 2024)
- [27] Vaidya, O. S.; Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research*. 2006, 169(1), pp. 1-29. <https://www.sciencedirect.com/science/article/abs/pii/S0377221704003054>
- [28] Veisi, H.; Liaghati, H.; Alipour, A. Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP). *Ecological Indicators*. 2016, 60, pp. 644-654. <https://www.sciencedirect.com/science/article/abs/pii/S1470160X15004331>
- [29] Zakon o pomorskom dobru i morskim lukama. Official Gazette No. 158/03, 100/04, 141/06, 38/09, 123/11. Official Gazette No. 83/23. Available online: <https://www.zakon.hr/z/505/Zakon-o-pomorskom-dobru-i-morskim-lukama> (accessed on 1 May 2024)
- [30] Xanthopoulos, Z.; Melachrinoudis, E.; Solomon, M. M. Interactive Multiobjective Group Decision Making with Interval Parameters. *Management Science*. 2000, 46(12), pp. 1585-1601. https://www.researchgate.net/publication/227447278_Interactive_Multiobjective_Group_Decision