ISSN: 2754-4982

Journal of Civil Engineering Research & Technology

SCIENTIFIC Research and Community

Review Article

Open Access

Prioritizing Port`s Development Directions By Analytic Hierarchy Process Method

Deda Delovic

Port of Bar JSC, Bar, Montenegro and University Adriatic, Faculty of maritime studies, Bar, Montenegro

ABSTRACT

Ports are no longer the simple maritime services providers of the past. They are multimodal transport and logistics centres and hubs for sustainable industry and clean energy. The transition to sustainable ports, digital nodes, and energy hubs requires the radical system-led changes in the ports based on new knowledge and innovation.

After a theoretical analysis of port development trends and management models used in the port development process, in this paper is proposed an approach for selecting port development priorities for the future ten years period, based on Analytic Hierarchy Process (AHP) method. Three potential development scenarios are analyzed and evaluated based on following three selection criteria: level of revenue/profit, level of productivity, contribution to safety/security/ environmental protection in the port. AHP Hierarchy framework used was a three level model: "level 0" – goal; "level 1" – criterion; "level 2" – choice. Results of research shown that the optimal development senario is "Scenario 1", which includes: optimizing utilization rate of existing capacity; optimizing port safety and security; optimizing environmental protection in the port; investing in keeping existing capacity unchanged, with priority investments in building new objects of port superstructure and improvements in cargo handling technologies, in accordance with concrete customer demands; introducing elements of circular economy; Results of the research can be used for prioritizing port development actions and can be taken as a realiable bases of the author`s further reaserches in this domain. Object of the research is the Port of Bar (Montenegro).

***Corresponding author**

Deda Delovic, Port of Bar JSC, Bar, Montenegro and University Adriatic, Faculty of maritime studies, Bar, Montenegro.

Received: December 14, 2023; **Accepted:** December 19, 2023; **Published:** December 26, 2023

Keywords: Port, Priority, Development Scenario

Introduction

Ports are no longer the simple maritime services providers of the past. They are multimodal transport and logistics centres, hubs for sustainable industry and clean energy, ... [1]. Ports are crucial for the transport business and have a huge potential for job creation and investment [2]. At the same time, ports are an integral component of the marine transportation system - the vital link between all subjects participating in the logistic system [3]. Different aspects of the port importance are pointed out in the reference [4], too – where a port is seen as a large infrastructure that is critical to a city's (and wider) economy. As well, in the reference [5] is stated that port is an essential element in a transportation system that supports a region's economy.

The major challenges facing ports are [2]: High predicted growth, the changing nature of shipping (The size and the complexity of the fleet are increasing, Deployment of bigger vessels for short sea shipping and feeder services), Recent trends in logistics and distribution systems attract more value added services within a port's area, Energy trades are changing, etc.). To the group of mentioned challenges can be added and those analyzed in some of available literature sources: longly neglected port infrastructure and waterway maintenance projects, existing and forecasted effects of climate change, legal constraints on port development [3]; experiencing great uncertainties, growing risks and decreasing returns, administrative problems, management inefficiency, shorter and shorter investment life cycles [6]; there are likely to be further demands for port capacity which will require additional port area [7-8]; many logistical, technological and economic uncertainties [9]; some major sustainability challenges, like tackling the pollution generated from port activities [10-11]; the circular economy transformation challenges [12]; importance of hinterland connections and international logistics chains [4].

Pre-existing megatrends – generators of port development, according to [13] are: geopolitical, technological, and environmental. In the recent technology-in-maritime report issued by the American Bureau of Shipping (ABS) [14] future maritime technologies are organized into three major categories or trends: digitalisation (AI, digital twins, autonomous operations, …), applied research (new materials, green ecosystems, blue economies, …) and clean energy transition. Going further through available references related to port development trends, it is worthy to point out a forecasts of Deloitte Global Port Advisory [15], who recognized following key development trends in the port sector in the time horizon to 2030: Changes in supply and demand; More technological solutions; More cyber risk; Less focus on physical infrastructure investments; Shift from big, bigger, biggest to green, greener, greenest; Sustainability; ... In addition, in references [16-17] is stated that the starting point of the maritime traffic

study in Europe in the 2040 Horizon has been to identify the trends which have the highest degree of consensus: Economic trends, Environmental trends, Social trends, The development of electronic commerce and circular economy; Trends in maritime transport, mainly the development of mega-ships, etc.

With the port development are dealing numerous available literature sources. Some of them are taken into consideration in the further part of this chapter.

By the reference [3] is proposed a tool that might prove useful Future Ports Scenarios which seek to construct a group of possible "futures" for the port, enabling an identification of factors important for decisions making process. In the research presented in the reference [4], authors pointed out that development of port does not guarantee that its competitiveness remains the same over the years. Reference [5] is referred on different aspects of the port connectivity (maritime connectivity, connectivity with hinterland, connectivity at the port) as one of the key influential factor on port development. In the reference [6] is taken into consideration potential for port land development, pointing out that ports have transitioned from a state of growth to one of value transactions. Reference [7] is dealing with potential changes in ports to 2050 under four climate□based scenarios which aim to explore changes in international maritime trade consistent with global temperature increases. In the reference [8] are presented elements of the initiative, called Port 2050, resulted in the identification of several drivers of change and four scenarios of the Port of Vancouver development. These scenarios were named: "The Great Transition", "Rising Tide", "Missed the Boat" and "Local Fortress". The outcome of Port 2050 resulted in an outlook that combines elements of "Rising Tide" and "The Great Transition" scenarios. Starting from the statement that the Master Planning approach is static and inadequately deal with the many uncertainties in the port and shipping industry, authors of the reference [9] are proposing an adaptive model combined of Assumption-Based Planning and Adaptive Policy Making in managing port development. Reference [10] brings in the first plan necessity to direct a port development to "green port" by introducing energy efficient mobility options. In the reference [11] are identified four features make port development scenarios analysis a particularly powerful tool for understanding uncertainty and making business decisions. In the focus of the reference [12] is CE (Circular Economy) transition of ports which implies smart digitalization and more data control.

In the reference [18] is considered an approach to sustainable development of a port in the specific circumstances characterized by existence of nearby under-exploited cultural and tourist capacities. Authors of the reference [19] characterizes smart ports and Port 4.0 with three key focus areas: automation, sustainability and collaboration and using the scenario building theory construct four alternative scenarios for future smart ports. Reference [20] is focusing the future prospects of digitalization in ports in the context of three alternative scenarios: digital supremacy; business as usual; and digital failure. By the reference [21] is pointed out that incorporating advanced technologies connected with the fourth industrial revolution has become a strategic direction towards sustainable development of modern ports. In the reference [22] are analyzed the technological modifications in the functioning of the port and abandoning of industrial production in the proximity in order to optimize port-city relations. In the reference [23] is stated that organisation of work and application of technology in the port of the future is likely to intensively change within the forthcoming period. Research whose results are shown with reference [24] is aiming in establishing bases to support effective policy-making, emphasizing the need of measuring parameters characteristic for the port – city relationships. In the reference [25] is considered the question of how port cities can steer their development paths and outcomes, taking into account inter-connected economic, social, political and technological factors. Research presented in the reference [26] resulted with conclusion that socio economic factors and human actions are exerting greater influence on development of ports. In the reference [27] are analyzed effects generated by intensive use of local land by ports, with focus on effects caused by cargo containerization. Reference [28] considers classification criteria that will serve as a basis for the formation of development directions for ports. Reference [29] introduces an approach for generating scenarios of seaport terminals development (with special focus on container terminals), outlining the parameters that are important to produce realistic scenarios of high practical relevance. In the reference [30], the author has defined three models of port development according to the degree of private investors' involvement: status quo, minimal participation and maximal participation of private sector. Reference [31] is dealing with different aspects of the ports development, taking into account the recent dynamics that are currently shaping the logistic maritime economy. Authors of the reference [32] presented the result of the port development scenario building analysis: Scenario One - Benign Global Environment and Critical Domestic Reforms Implemented; Scenario Two - Supportive Global Environment and Limited Domestic Reforms Implemented; Scenario Three - Global Discord and Domestic Instability.

In the reference [33], the UNCTAD Three Generation Port Model is examined in the light of research realized under the WORKPORT project funded by the European Commission, 1998–1999. Research results show that, instead of developing in discrete steps (what is the key characteristic of the UNCTAD model), ports evolve continuously, adapting to new technologies, updated legislation, revised working practices and other influences. Authors of the reference [34] analyze correlation between the port development and economic development of its hinterland and examine ways the modern port affects the economic development of its hinterland. Reference [35] is focused on implications of different strategic choices of port development and how changes progress. Reference [36] deals with the spatial evolution characteristics of the port development. By the reference [37] are examined strategies of port development companies through applying the business ecosystem perspective. In the reference [38] is stated that UNCTAD (1999) in its newsletter proposed the concept of "fourth generation port", referring to vertical and horizontal integration port strategies. As well, in that reference is described the "fifth generation port" with the introduction of "port ladder" for customer centric community-focused port. By the reference [39] is explored development model of inland ports and summarized through the literature synthesis. Authors of the reference [40], based on the reliable literature basis, are pointing out that ports develop in an evolutionary rather than a revolutionary way and that the political dimension can also play an important role in port evolutionary paths. Reference [41] examines a group of models from the port development literature and proposes an approach for modelling the strategic development of a port's collaboration with local operators and the local hinterland. By the reference [42] are considered some basic perspectives for the development of the ports respecting necessity of their adaptation to actual port development trends. Reference [43] is focused on the driving factors to promote development of the low-carbon port. With the reference [44] is considered a port regionalization phase in port and port system development.

Development directions/trends of the ports are treated in different documents of global importance, too.

Sustainable and Smart Mobility Strategy – putting European transport on track for the future [45]: ports should become multimodal mobility and transport hubs, linking all the relevant modes. Inland and sea ports have a great potential to become new clean energy hubs and test beds for waste reuse and the circular economy.

The European Green Deal [46]
The European Green Deal calls for a 90% reduction in greenhouse gas emissions from transport, in order for the EU to become a climate-neutral economy by 2050, while also working towards a zero-pollution ambition. To achieve this systemic change, it is needed to [45]: (1) make all transport modes more sustainable, (2) make sustainable alternatives widely available in a multimodal transport system and (3) put in place the right incentives to drive the transition.

The 2030 Agenda for Sustainable Development [47]
At its centre are the 17 Sustainable Development Goals (SDGs). The 17 SDGs are integrated—they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability [48]. Following SDGs are directly connected with reducing environmental impact of the port area: SDG3- good health and wellbeing, SDG7 – affordable and clean energy, SDG8 – decent work and economic growth, SDG9 – industry, innovation and infrastructure, SDG11 – sustainable cities and communities, SDG12 – responsible consumption and production, SDG13 – climate action, SDG14 – life below water, SDG15 – life on land, SDG17 – partnership for the goal.

In order to establish adequate additional bases for further considerations, it is important to analyze some more available sources of information, of different nature, where port development directions/goals are treated:

- In the reference [49] is stated that technology is not only revolutionizing ports to speed up and simplify the flow of trade but also cutting their carbon footprints.
- The transition to sustainable ports, digital nodes, and energy hubs requires radical system-led changes based on new knowledge and innovation. Ports become and energy hubs by facilitating the transition from fossil fuels to renewables [50].
- Maritime transport was identified as the most carbon-efficient mode of transport, with the lowest carbon dioxide (CO2) emissions per distance and weight carried. However, shipping contributes to greenhouse gas emissions (GHG) because of the great volumes involved, representing around 13% of the overall EU (European Union) GHG from the transport sector [51].
- Global climate change are causing serious threats to human society. Such threats include rising sea levels, loss of land, biodiversity loss, more frequent and damaging weather events, etc. [52]. In this context, it is important to add that climate change knows no borders, and its impacts are felt globally [53].
- The term 'innovation ecosystem' has become popular among stakeholders involved in innovation. Its importance for the ability of ports to continue to create 'value for society' is analyzed in reference [54];
- Digitalisation can be instrumental in reducing the environmental impacts of both passenger and freight transport in urban and non-urban settings. Realising a modal shift to more sustainable transport modes is one of the domains in which digitalisation can be an enabler [55].
- There is strong evidence that significant investments in the circular economy (CE) are being made in port areas. To ensure an efficient use of port resources in view of this transition, impacts should be adequately monitored [56].
- In 2015, the Paris Agreement on climate change was agreed by parties to the United Nations Framework Convention on Climate Change (UNFCCC). It entered into force on 4 November 2016. Its goal is to keep global temperature rise below 2°C above pre-industrial levels, and preferably limited to 1.5°C [57].

Object of the Research
The Port of Bar is a landlord port [58]. It is functioning based on the Montenegrin Law on ports. At the port area are operating two main Port Terminal Operators: The Port of Bar JSC and the Port of Adria JSC. Main cargo groups which are handled in The Port of Bar are: liquid bulk cargoes; dry bulk cargoes; general cargoes; containers; Ro-Ro cargoes. In the throughput structure appear passengers, too. Dry bulk cargoes are dominating in the overall throughput structure, with average share of over 70% in the last ten years. The Port of Bar is facing significant variations in market demands which do not enable establishing optimal planning bases for the port development process.

Methods
In the process of selecting/considering the ports development models, in the available literature are used different models: scenario building theory [3, 11, 19, 23, 32], direct observation method [6], adaptive approach combined of assumption based planning and adaptive policy making [9], multi-criteria analysis [10, 30], a qualitative method for assessment of decisions [18], SWOT and PESTEL framework [20], HHI index and spatial economics [21], fuzzy analytic hierarchy process method [23], contingent valuation method [24], simulation model [29], etc.

Research whose results are shown in this paper is conducted using Analytic Hierarchy Process (AHP) method.

In the reference [59] are analyzed areas where the Analytic Hierarchy Process (AHP) method is implemented (with mentioning related literature sources): manufacturing systems, software evaluation, supplier selection, selection of recycling technology, construction method selection, warehouse selection, technology evaluation, etc. There are numerous available references where results of researches connected with ports - from different aspects - are shown: port selection [60-64], port competitiveness [65], selection of cargo handling equipment [66], etc.

In general, the AHP is a method purposed for solving complex problems at different hierarchical levels, where the goal is at the top, the intermediate levels being the criteria and sub-criteria and the lowest level being alternatives (choice) [67]. Principal steps in the process of using AHP method are (adjusted based on references [67-69]):

1. Define the objective
Objective of the research is: selecting the priority development scenarios of the Port of Bar (Montenegro), for the period of the next 10 year.

2. Collection of empirical information and data

Values of some indicators which characterize functioning of the Port of Bar in the period from the year 2020 to the year 2022 are systematized in the next table (Table 1). Values related to the year 2020 are taken as a base (and replace with "1") and, after that, relative weights are established.

Table 1: Values of indicators characteristic for the Port of Bar (period: 2020 – 2022)

Indicator/Year	2020	2021/2020	2022/2020	Comment
Throughput [t]	1	0.84	1.54	Relation 2020/2019 is 1.07 (throughput in the first COVID year was for 7% bigger than in the pre-COVID year).
Productivity [t/employee]	1	0.78	1.07	Productivity [t/employee] = (throughput)[t/year]/(number of employees)
Revenue [EUR/year]	1	1.09	2.25	
Operational costs [EUR/year]	1	1.16	2.02	
Emissions [kgCO2ekv/year]	1	1.54	2.23	Emissions related to the port machinery, calculated based on the yearly fuel consumption and values of TTW emission factor according to Global Logistics Emissions Council Framework (GLEC Framework, version 3.0, available on https://www.smartfreightcentre.org)

(source: author)

3. Setting potential development scenarios. Setting selection criteria.

Having in mind values of indicators shawn in the Table 1 and values of the principal input parameters which characterize current situation in the analyzed port [58]:

- existing capacity of the port,
- utilization rate of the existing port capacity,
- results of market researches – market position of the port: current and expected demands of customers,
- existing capacity of port`s infrastructural links with hinterland and plans for their increasing in the next 10 years,
- results of comparisons between port capacity and capacity od connecting infrastructure with hinterland, current and expected,
- parameters which characterize port safety and security system,
- parameters which characterize port environmental protection system,
- parameters which characterize current level of circular economy implementation,
- as well as considerations of port development trends done in the first chapter of this paper, following potential development scenarios are defined (Table 2):

Table 2: Potential development scenarios

Scenario	Elements of the scenario
Development Scenario 1	optimizing utilization rate of existing capacity; optimizing port safety and security; optimizing environmental protection in the port; introducing elements of circular economy; investing in keeping existing capacity unchanged, with priority investments in building new objects of port superstructure and improvements in cargo handling technologies, in accordance with concrete customer demands;
Development Scenario 2	Elements of the Development Scenario 1 + investing in new object of port superstructure (new warehouses, ...); investing in new object of port infrastructure (extension of operational quay, ...);
Development Scenario 3	Elements of the Development Scenario 1 + Elements of the Development Scenario 2 + investing in building new port terminals;

(source: Author).

In the process of defining potential development scenarios of the analyzed port are taken into consideration remarks given in the reference [41] that the smaller ports (like the analyzed port is) do not have the same resources and knowledge to implement the techniques that have been developed for the larger ports and the smaller ports do not have the economics of scale to support more complex developments.

Selection criteria are as follows: Selection criterion 1, C1: level of revenues/profit; Selection criterion 2, C2: level of productivity; Selection criterion 3, C3: contribution to safety/security/environmental protection in the port;

In the context of selecting optimal development scenario for the analyzed port, it is important to point out and some more results of researches related to port development process. Relevant research shows that, in general, the main influencing factors of port development include the economic development degree of the port hinterland, port location, logistics infrastructure, aggregation of enterprises in the logistics industry, and external policy environment [70]. Three major phases identified so far in the port development process involve setting, expansion, and specialization [71]. The following three key factors contribute to port productivity improvement at organisational level [72]: (1) the quality and appropriateness of the technology; (2) the management skills in developing relevant strategies and integrating human

and other resources and (3) the amount and focus of the effort expended by people.

4. Construct a hierarchy framework for the analysis
Form of the Hierarchy framework for the analysis is shown with Figure 1.

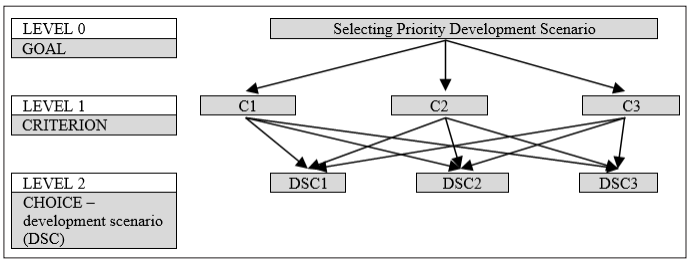

Figure 1: Hiearchy framework for the analysis

5. Pair-wise comparisons and consistency tests
In order to conduct pair-wise comparisons of identified port development scenarios and related consistency tests, it is necessary to conduct activities foreseen by the references [67-69], taking into account number of items for comparison, n (Table 3), Saaty`s fundamental scale of absolute numbers (Table 4) and values of Random Consistency Index (Table 5).

Table 3: Number of comparisons

Number of things	1	2	3	4	5	6	7	n
Number of comparisons	0	1	3	6	10	15	21	n (n-1)/2

Table 4: Saaty`s fundamental scale of absolute numbers

Intensity	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

Table 5: Random Consistency Index (RI)

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Characteristic parameters are calculated based on following equations:
Consistency Index (CI)
$CI = (\lambda_{max} - n)/(n - 1)$ (1)
where: λ_{max} - principal Eigen value; n – number of comparisons;

Consistency Ratio (CR)
CR = CI/RI (2)
where: CI – Consistency Index; RI - Random Consistency Index (values from the Table 5);
If the value of Consistency Ratio is under 0.10, than made evaluation is consistent

Overall Consistency of Hierarchy

$$\overline{CR} = \frac{\sum_i w_i CI_i}{\sum_i w_i RI_i} \quad (3)$$

If the value of overall Consistency Ratio is under 0.10, than made evaluation is consistent.

6. Calculate the global weights
Overall composite weight for analyzed development scenarios, DSCi, is calculated based on following relation:
DSCi = Σ(relative weight of the criterion cj, from the comparison matrix respected to the goal) x (relative weight of the development scenario DSCi based on criterion cj, from comparison matrices with respect to criterion cj) (4)
where:
i = 1, 2, 3 – number of development scenarios;
j = 1, 2, 3 – number of selection criteria;

7. Synthesizing the results and final ranking

Results
Pair-Wise Comparisons and Consistency Tests
A) Paired comparison matrix – level 1 – with respect to the goal

Criterion	C1	C2	C3	Priority Vector
C1	1.000	2.000	3.000	0.5242
C2	0.500	1.000	3.000	0.3335
C3	0.333	0.333	1.000	0.1413
sum	1.83	3.33	7.00	1.0000

Principal Eigen value, λ_{max} = 3.0616; Consistency Index, CI: 0.0308; Random Consistency Index, RI: 0.58; Consistency Ratio, CR = 0.0531; Consistency Ratio is under 0,10, what means that made evaluation is consistent.

B) Paired comparison matrix – level 2 – with respect to the criterion C1

Criterion C1	DSC1	DSC2	DSC3	Priority Vector
DSC1	1.000	3.000	7.000	0.6428
DSC2	0.333	1.000	5.000	0.2825
DSC3	0.143	0.200	1.000	0.0737
sum	1.48	4.20	13.00	0.9990

Principal Eigen value, λ_{max} = 3.0937; Consistency Index, CI: 0.0469; Random Consistency Index, RI: 0.58; Consistency Ratio, CR = 0.0808; Consistency Ratio, CR, is under 0,10, what means that made made evaluation is consistent.

C) Paired comparison matrix – level 2 – with respect to the criterion C2

Criterion C2	DSC1	DSC2	DSC3	Priority Vector
DSC1	1.000	2.000	3.000	0.5242
DSC2	0.500	1.000	3.000	0.3335
DSC3	0.333	0.333	1.000	0.1413
sum	1.83	3.33	7.00	0.9990

Principal Eigen value, λ_{max} = 3.0616; Consistency Index, CI: 0.0308; Random Consistency Index, RI: 0.58; Consistency Ratio, CR = 0.0531; Consistency Ratio, CR, is under 0,10, what means that made evaluation is consistent.

D) Paired comparison matrix – level 2 – with respect to the criterion C3

Criterion C3	DSC1	DSC2	DSC3	Priority Vector
DSC1	1.000	2.000	2.000	0.4900
DSC2	0.500	1.000	2.000	0.3116
DSC3	0.500	0.500	1.000	0.1974
sum	2.00	3.50	5.00	0.9990

Principal Eigen value, λ_{max} = 3.0577; Consistency Index, CI: 0.0288; Random Consistency Index, RI: 0.58; Consistency Ratio, CR = 0.0497; Consistency Ratio, CR, is under 0,10, what means that made made evaluation is consistent.

Calculating Overall Composite Weights (Synthesizing Results) and final Ranking

Overall composite weight for analyzed development scenarios, DSCi, is calculated based on relation (4).

DSC1 = (0.5242 x 0.6428) + (0.3335 x 0.5242) + (0.1413 x 0.4900) = 0.5810

DSC2 = (0.5242 x 0.2825) + (0.3335 x 0.3335) + (0.1413 x 0.3116) = 0.3033

DSC3 = (0.5242 x 0.0737) + (0.3335 x 0.1413) + (0.1413 x 0.1974) = 0.1136

Overall composite weight of analyzed alternatives is presented in the following matrix:

	C1	C2	C3	Composite weight
DSC1	0.6428	0.5242	0.4900	0.5810
DSC2	0.2825	0.3335	0.3116	0.3033
DSC3	0.0737	0.1413	0.1974	0.1136
	0.9990	0.9990	0.9990	0.9980

Overall consistency of hierarchy, CR, calculated based on the equation (4), is 0.0601 (under 0,10), what means that complete evaluation (at level 1 and level 2) is consistent.

Dıscussıon and Conclusions

Based on the results shown in previous chapters, following ranking of analyzed development scenarios of the port in the next ten years, by level of their priority, taking into account used selection criteria, can be done:

- Rank 1: Development Scenario 1, with overall composite weight of 0.5810 (58.10%);
- Rank 2: Development Scenario 2, with overall composite weight of 0.3033 (30,33%);
- Rank 3: Development Scenario 3, with overall composite weight of 0.1136 (11.36%);

It can be concluded that, respecting defined ranks, managerial efforts, in the period of next ten years, should be directed towards optimizing utilization rate of the existing port capacity, maintenance and other necessary activities for keeping capacity at the unchanged level; priority investments in new objects of port superstructure and investments in the cargo handling technology, primarily based on concrete demands of existing and new port customers; optimizing port safety and security system; optimizing port environmental protection system; introducing elements of the circular economy;

Results of the research suggest that investment in the port infrastructure (extenstion of the operational quay, ...) and building new terminals do not belong to the group of the development priorities of the analyzed port in the next ten years period.

Development Scenario 1 is, as well, ranked as the first priority and by results of models paired comparisons based on used selection cirtieria:

- Related to selection criterion 1 (revenue/profit): rank 1, with weight of 0.6428 (64.28%);
- Related to selection criterion 2 (productivity): rank 1, with weight of 0.5242 (52.42%);
- Related to selection criterion 3 (contribution to the safety/security/environmental protection in the port): rank 1, with weight of 0.4900 (49.00%);

Research results fully confirm that AHP method is appopriate for selecting development priorities of a port. Plan of a author is to extend the research to the whole Montenegrin port system, including panel of experts whose opinions will be systematized and analyzed using AHP method.

It is important to have in mind that results of this research can be used correctly only if the initial values of inputs remain unchanged (or at the level very closed to the initial one). In case of important changes of those inputs, results have to be recalculated.

References

1. ESPO Green Guide (2021) A Manual for European Ports Towards a Green Future https://www.espo.be/media/ESPO%20Green%20Guide%202021%20-%20FINAL.pdf.
2. European Commission (2013) Europe's Seaports 2030: Challenges Ahead, Brussels. https://europe.eu.
3. Allen CH (2011) Future Ports Scenarios for 21st Century Port Strategic Planning. Journal of Transportation Law. Logistics & Policy 79: 80-50.
4. Wahyni S (2019) Innovation in Port Development. The Quad Helix Model In: Infrastructure Investment in Indonesia: A Focus on Ports, Cambridge: Open Book Publishers.
5. Indriastiwi F, Hadiwardoyo SP, Nahry (2020) Port Connectivity Model in The Perspective of Multimodal Transport: A Conceptual Framework. IOP Conference Series: Materials Science and Engineering, Volume 1052, The 5th International Conference on Marine Technology (SENTA 2020) 8th December 2020, Surabaya, Indonesia. https://iopscience.iop.org/article/10.1088/1757-899X/1052/1/012008.
6. Bulletin fall (2016) https://repositorio.cepal.org/server/api/core/bitstreams/1e9d475e-70e5-41a2-a1c9-7d8b7351db4d/content.
7. Hanson SE, Nicholls RJ (2020) Demand for ports to 2050:

Climate policy, growing trade and the impacts of sea-level rise. Earth's Future 8.
8. Deloitte Inc (2015) Port 2050 Scenarios Update Final Report. https://www.portvancouver.com/wp-content/uploads/2015/03/2015-04-07-Port-2050-Scenario-Refresh-Final-Report-with-appendices.pdf.
9. Taneja P, Walker WE, Ligteringen H, van Schuylenburg M, van der Plas R (2009) Future scenario's, Implications for port planning. Proceeding from the WCTRS ConferenceAntwerphttps://www.researchgate.net/publication/284150234_Future_scenario's_Implications_for_port_planning.
10. Vilke S, Ukić Boljat H, Grubišić N, Maglić L (2021) Application of multi-criteria analysis for the introduction of green port management practices: an evaluation of energy efficient mobility in nautical ports. Scientific Journals of the Maritime University of Szczecin 65: 72-83.
11. Taljaard S, Weerts S (2023) Towards Sustainable Port Development in the Western Indian Ocean. Scenario Analysis. United Nations Environment Programme, Nairobi Convention Secretariat and Council for Scientific & Industrial Research. Nairobi, Kenya https://www.nairobiconvention.org/clearinghouse/sites/default/files/WIOSUS~2.PDF.
12. Haezendonck E (2022) Port Strategy for Sustainable Development. Sustainability https://webaplicacion.apn.gob.pe/proyecto/wp-content/uploads/2022/01/Port-strategy-for-sustainable-development.pdf.
13. UNCTAD (2021) Review of maritime transport, United Nations, Geneva. https://unctad.org.
14. American Bureau of Shipping (2022) Revolutionary Maritime Technology Trends https://ww2.eagle.org/en/innovation-and-technology/technology-advancements/abs-tech-trends.html.
15. Deloitte Global Port Advisory (2020) Global Port trends 2030, the future port landscape https://www2.deloitte.com/.
16. https://www.porttechnology.org
17. https://piernext.portdebarcelona.cat
18. Ghennaï A, Said Madani S, Hein C (2023) Evaluating the sustainability of scenarios for port city development with Boussole21 method. Environment Systems and Decisions 43: 87-106.
19. Heikkilä M, Saarni J, Saurama A (2022) Innovation in Smart Ports: Future Directions of Digitalization in Container Ports. J. Mar. Sci. Eng 10: 1925.
20. Inkinen T, Helminen R, Saarikoski J (2021) Technological trajectories and scenarios in seaport digitalization. Research in Transportation Business & Management 41.
21. Pham TY (2023) A smart port development: Systematic literature and bibliometric analysis. The Asian Journal of Shipping and Logistics 39: 57-62.
22. Mrak I (2013) Locally Based Development Tools for Identifying Opportunities and Evaluating Port Area Strategies of Rijeka. Sustainability 5: 4024-4056.
23. Duin H, Gorldt C, Thoben KD, Pawar K (2015) Challenges for the port of the future: Findings from a scenario Analysis. Proceeding from International Conference on Engineering, Technology and Innovation/ International Technology Management Conference, Belfast, Ireland 21.
24. Del Saz-Salazar S, García-Menéndez L, Merk O (2013) The Port and its Environment: Methodological Approach for Economic Appraisal, OECD Regional Development Working Papers, 2013/24, OECD Publishing.
25. Ravetz J (2013) New Futures for Older Ports: Synergistic Development in a Global Urban System. Sustainability 5: 5100-5118.
26. Mei-e R, Baoguo Y (1998) Factor affecting port development in China, with special reference to Shanghai International Shipping Center. Acta Geographica Sinica 53: 193-199.
27. Ducruet C, Reka J, Nagy DK, Steinwender C (2020) All aboard: the effects of port development.
28. Jugović A, Jardas Antonić J, Aksentijević D (2023) An Overview of Criteria and Scenarios Relevant for Development of Seaports of County and Local Importance in the Republic of Croatia. Transactions on Maritime Science 12.
29. Hartmann S (2002) Generating scenarios for simulation and optimization of container terminal logistics, Manuskripte aus den Instituten für Betriebswirtschaftslehre der Universität Kiel, No. 564, Universität Kiel, Institut für Betriebswirtschaftslehre, Kiel.
30. Perić Hadžić A (2022) Evaluation of development partnership scenarios of the Croatian seaports using MAMCA analysis. Pomorstvo 36: 135-146.
31. Deandreis M, Panaro A, Ferrara O (2022) Maritime Scenario in the Mediterranean: Analysis of the Competitiveness and Investments of the Major Logistics Players 07-22.
32. Lakshman Kadirgamar Institute of International Relations and Strategic Studies (2020) Port City Sez – a catalyst for modern services in Sri Lanka. https://www.portcitycolombo.lk/downloads/2020R-Port-City-SEZ-22-05-20.pdf.
33. Beresford AKC, Gardner BM, Pettit SJ, Naniopoulos A, Wooldridge CF (2004) The UNCTAD and WORKPORT models of port development: evolution or revolution? Maritime Policy & Management 31.
34. Pardali A, Stathopoulou C (2006) The Post-War Port Industry Development Models: The Effects on the Economic Development of the Portâ€™s Hinterland.
35. Andersen T, Aryee J, Acheampong G, Skovsted Hansen AS (2023) The continuous search for new port governance models: experiences from a developing country. Journal of Shipping and Trade.
36. Liu L, Ping H (2020) Study of the Influencing Factors on Development of Ports in Guangdong, Hong Kong, and Macao from the Perspective of Spatial Economics. Mathematical Problems in Engineering.
37. W de Langen P (2023) The strategy of the port development company; a framework based on the business ecosystems perspective and an application to the case of Port of Rotterdam. Maritime Transport Research 4.
38. Lee PTW, Lam JSL (2016) Developing the Fifth Generation Ports Model. In: Lee PTW, Cullinane K (eds) Dynamic Shipping and Port Development in the Globalized Economy. Palgrave Macmillan, London 186-210.
39. Dong S (2019) China's inland port development model. World Maritime University Dissertations https://commons.wmu.se/cgi/viewcontent.cgi?article=2470&context=all_dissertations.
40. Pettit SJ, Beresford AKC (2009) Port development: from gateways to logistics hubs. Maritime Policy & Management 36: 253-267.
41. Olesen PB, Dukovska-Popovska I, Henrik Hvolby HH, Jensen KS (2014) Strategic port development: identifying a development approach for small and medium-sized ports. Proceedings from the Annual Transport Conference at Aalborg University.
42. Krivokapic R (2022) Perspectives for the Development of Small Seaports, with Reference to the Adriatic Seaports. Transformations in Business & Economics 21: 21-33.
43. Zhang X (2020) Port Development Model based on Low-carbon Economy. International Core Journal of Engineering 6: 160-169.

44. Notteboom TE, Rodriguez JP (2005) Port regionalization: towards a new phase in port development. Maritime Policy & Management 32: 297-317.
45. European Commission (2020) COM/2020/789 final Sustainable and Smart Mobility Strategy. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0789
46. European Commission, (2019) COM/2019/640 final European Green Deal https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/transport-and-green-deal_en.
47. https://sdgs.un.org/goals
48. https://www.undp.org
49. Wang CN, Nguyen NAT, Fu HP, Hsu HP, Dang TT (2021) Efficiency Assessment of Seaport Terminal Operators Using DEA Malmquist and Epsilon-Based Measure Models. Axioms 10.
50. Lind M, Wolfgang Lehmacher, Andreas Netz, Richard T Watson (2023) System Demonstrators: Swedish Ports as a Case Study for Innovation.
51. European Commission (2023) The EU Blue Economy Report. 2023. Publications Office of the European Union. Luxembourg.
52. G7 Science and Technology Ministers' Communique Sendai (2023). https://www8.cao.go.jp/cstp/kokusaiteki/g7_2023/230513_g7_communique.pdf
53. Pels Z (2023) Universities play a key role in driving EU climate transition, An Update from Amsterdam University of Applied Sciences. https://sciencebusiness.net/network-updates/auas-universities-play-key-role-driving-eu-climate-transition
54. Mendes C, de Langen PW, Pruñonosa SF (2023) Innovation ecosystems in ports: a comparative analysis of Rotterdam and Valencia, Journal of Shipping and Trade 8.
55. European Environment Agency (2022) Transport and environment report 2022: Digitalisation in the mobility system: challenges and opportunities, Luxembourg: Publications Office of the European Union. https://www.eea.europa.eu/publications/transport-and-environment-report-2022/transport-and-environment-report/view
56. Faut L, Soyeur F, Haezendonck E, Dooms M, de Langen PW (2023) Ensuring circular strategy implementation: The development of circular economy indicators for ports. Maritime Transport Research 4.
57. Nikolic D (2023) Global aspects of decarbonization of ports and maritime transport. Workshop under project "Promoting Resilient, Sustainable, and Smart Transport and logistic activities in the South Adriatic Area -PORTS PLUS/No. 552/SMALL/CAPITALIZATION restricted procedure".
58. Port of Bar (2023) Documentation of the Development Department.
59. Ishizaka A, Labib A (2011) Review of the main developments in the analytic hierarchy process. Journal Expert Systems with Applications 38: 14336-14345.
60. Georgoulas D, Koliousis I, Papadimitriou S (2023) An AHP enabled port selection multi-source decision support system and validation: insights from the ENIRISST project, Journal of Shipping and Trade 8.
61. Lirn TC, Helen T, Malcolm JB, Anthony Kenneth CB (2004) Application of AHP on Transhipment Port Selection: A Global Perspective. Journal Maritime Economics & Logistics 6: 70-91.
62. Ugboma C, Ogochukwu U, Innocent O (2006) Analytic Hierarchy Process (AHP) Approach to Port Selection Decisions-Empirical Evidence from Nigerian Ports. International Journal of Maritime Economics 8: 251-266.
63. Park BI, Min H (2011) The selection of transshipment ports using a hybrid data envelopment analysis/analytic hierarchy process. Journal of Transportation Management 22: 47-64.
64. Mittal N, McClung D (2016) Shippers' Changing Priorities in Port Selection Decision-A Survey Analysis Using Analytic Hierarchy Process (AHP). JTRF https://ideas.repec.org/a/ags/ndjtrf/262668.html.
65. Lee S, Jumi S, Sung JP, Bo RS (2014) A Study on the Comparative Analysis of Port Competitiveness Using AHP. Journal of Maritime Affairs and Fisheries 6: 53-71.
66. Satoglu SI, Türkekul I (2021) Selection of Material Handling Equipment using the AHP and MOORA. Jurnal Teknik Industri 22: 113-124.
67. Maletič D, Hana P, Anna N, Boštjan G, Matjaž M (2021) Framework Development of an Asset Manager Selection Based on Risk Management and Performance Improvement Competences. Journal Safety https://ro.uow.edu.au/test2021/2065/.
68. Saaty TL (2008) Decision making with the analytic hierarchy process. Journal Services Sciences 1: 83-98.
69. Saaty RW (1987) The Analytic Heirarchy Process-What it is and how it is used. Journal Math Modelling 9: 161-176.
70. Liu L, Ping H (2020) Study of the Influencing Factors on Development of Ports in Guangdong, Hong Kong, and Macao from the Perspective of Spatial Economics. Mathematical Problems in Engineering 2020: 1-12.
71. Rodrigue JP (2020) The Geography of Transport Systems, New York: Routledge. https://transportgeography.org/.
72. Meletiou M (1998) Improved port productivity through a partnership between human beings and technology. Journal Transactions on the Built Environment 36.