PORT LOGISTICS VIABILITY ANALYSIS: CASE STUDY OF THE AUTONOMOUS PORT OF COTONOU (BENIN)

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ABSTRACT

This article aims to perform the logistic viability analysis of the Autonomous Port of Cotonou for West Africa using the AHP multicriteria method. This port contributes largely in the country's economy through customs and tax revenues, the formation of the Gross Domestic Product and also in international trade. Four criteria (quality of infrastructure and services, equipment productivity, and logistics cost of cargo) were modeled. With the result, the port infrastructure criterion is most important, followed by the port equipment criterion. Showing the importance of each port logistics viability criterion (infrastructure, service, equipment, cost), the alternative long-term logistics viability is preferable to the medium-term and short-term. The application of the AHP shows in its result that for long-term port logistics viability, it is preferable to invest more in modern and quality infrastructure and equipment.

Keywords: Port Logistics Viability. AHP. Benin. Autonomous Port of Cotonou.

1. Introduction

The Autonomous Port of Cotonou (PAC) represents an entry and exit gateway for cargoes to neighboring African countries without sea fronts (Niger, Mali, and Burkina-Faso and Chad), and is ranked the best transit port among the 29 selected ports in West and Central Africa (APA, 2019). With the increase in maritime trade and technology, vessels are becoming larger , such as the Suezmax (17 m draft), Post-Panamax (15.2 m draft, 13000 TEU capacity), Capesize (18.91 m draft), Chinamax (24 m draft), Malaccamax (20.5 m draft) and more modern. With the current infrastructure and equipment, a depth of 11 - 15 m in the port and 15 m in the access channel, PAC still does not have the necessary conditions to receive these types of ships, and may lose its position as the best transit port, given the current scenario in which more than 50% of its annual movements are destined for countries without a maritime front (Niger, Burkina-Faso, Mali, and Chad).

PAC participates in 90% of foreign trade, generates up to 60% of the Gross Domestic Product (GDP), contributes up to 80% to the mobilization of customs revenues and between 45% and 50% of tax revenues. This explains that the PAC is the main lungs of the national economy, that the economy of the Republic of Benin has a fundamental basis in its port, because it is the only one that increases the country's customs revenue.

However, PAC has enormous qualities that can be used in favor of its growth and represents a transit port by excellence, and offers many opportunities for regional economies and West Africa in particular. This port is located at a strategic distance (closest to Niger, Mali, Burkina-Faso, northern Nigeria, with the deepest sea coast), and represents a preferred gateway to the hinterland countries and neighboring Nigeria. It also represents an attractive and competitive port, a reliable destination, ensures safety and security, and makes for a close relationship with its customers. With its privileged geographic situation in 2018, 49% of total recorded PAC movements were destined for landlocked countries, and Niger alone weighs in at 37%. The existence of PAC depends on the countries of influence that favor the port's services to reach the international market. The competition between the West African ports of Lomé (Togo), Lagos (Nigeria), Ghana (Tema) and Abidjan (Ivory Coast) and PAC influences their performance. The latter is connected with active rail (one part is being rehabilitated and the other is being built) and road infrastructures connecting it easily with other landlocked countries and represents a great advantage and should facilitate the transfer of cargoes.

To boost its profitability, take advantage of the enormous geostrategic potential, and mobilize high resources needed for its modernization, the government of the Republic of Benin opted for Public-Private Partnership (PPP), delegating the management of PAC to the Port of Antwerp International (PAI), a subsidiary of the Belgian Port of Antwerp, the second largest port in Europe, behind Rotterdam. The management delegation agreement signed on January 8, 2018, focuses on three strategic areas: modernization of facilities and equipment, repositioning, and skills transfer to local staff (PAC, 2019).

This article aims to analyze the logistic viability of PAC in the West African context, using AHP.

Study area location.

The study area is located in Benin, a country in the western region of Africa, at the southern end of Cotonou (6°23′48″S/2°25′33″W, Benin). The port of Cotonou is 115 km from the port of Lagos (Nigeria) and 135 km from the port of Lomé (Togo).

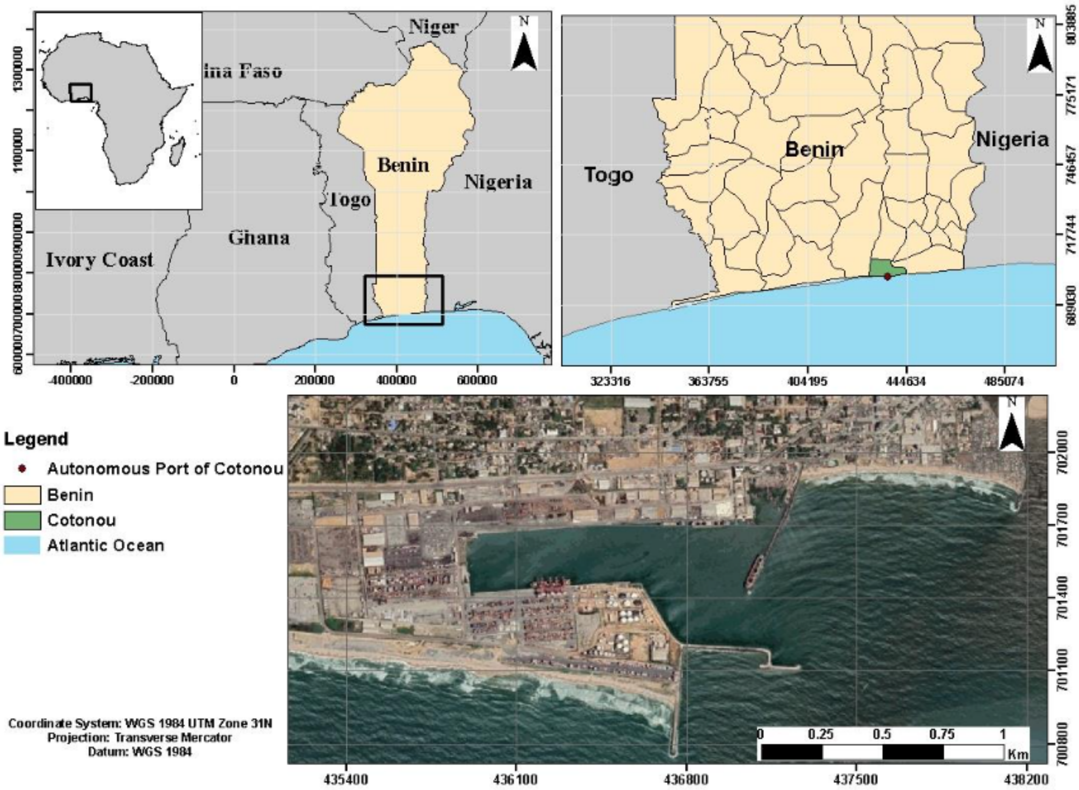

Figure 1 Location Map of the Port of Cotonou (Benin), showing the African continent (gray), Benin (yellow), Cotonou (green) and port.

Characteristics of the study area

The PAC situated in the city of Cotonou, being located at an altitude of 6 m. The climate is tropical type Aw (warm temperate climate with dry winter), the average temperature is 26.8 °C/year, with average rainfall of 1244 mm/year, and average wind of 19km/h. Waves reach a maximum height of 2.2m (Marépeche, 2020). PAC is built on the barrier island, which separates Lake Nokoué from the Atlantic Ocean, representing a flat topography, not exceeding 10m in altitude.

The foreland, or PAC's geo-economic area of influence offshore, is represented by countries from other continents where the world's main consumer markets are, such as North America (United States of America), South America (Brazil, Argentina), Europe (France, Italy, Spain, United Kingdom, among others), Asia (China and Japan).

Table 1 Distance (km and hrs) between PAC and Niamey (Niger), Fada-N'gourma (Burkina Faso) and Ansongo (Mali).

End of Runner	Niamey (Níger)		Fada-N'gourma (Burkina Faso)		Ansongo (Mali)	
Runner Start	Length (km)	Average time (Hrs)	Length (km)	Average time (Hrs)	Length (km)	Average time (Hrs)
Cotonou (Benin)	1181	19h11	1013	16h18	1514	23h48
	1058	18h52	801	14h44	1417	23h30
	1018	16h09	790	13h	1362	21h

The hinterland or continental catchment area comprises the western part of Africa, especially the landlocked countries (Burkina, Mali, Niger, and Chad). Benin's port and road infrastructure is used to transport goods to these countries (Table 1).

2. Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is one of the multicriteria decision making methods (MCDM) well suited for solving complex multi-criteria decisions. The AHP model is a fully multi-criteria complicated decision making tool used for determining priorities. It was introduced and defined by Saaty (1980) as an effective tool to deal with complex decision making and can help the decision maker to prioritize and make the best decision. Saaty (1980) developed AHP as a practical approach to decision making. It helps decision makers identify the best possible ways to understand the problems encountered. Since AHP aims to solve complex decision problems using both qualitative and quantitative criteria measurement (Akyuz et al., 2015), it has been widely applied in various disciplines, (Akyuz, 2015).

The method allows dealing with problems involving both tangible and intangible values, thanks to its ability to create measures for qualitative variables based on subjective judgments issued by decision makers (Saaty, 1991). AHP is appropriate whenever a goal is obviously stated and a set of relevant criteria and alternatives is offered (Bayazit & Karpak, 2005). AHP is an ideal method for ranking alternatives when multiple criteria and subcriteria are present in the decision-making process. In addition, AHP is a popular model for aggregating multiple criteria for decision making. AHP allows the decision maker to structure complicated problems in the form of a decision.

Using the AHP approach offers different benefits (Ekuobase & Olutayo, 2015). An important advantage of AHP is its stability and flexibility regarding changes and additions in the hierarchy. Despite the benefit of AHP, it also has some weaknesses. One of them is the complexity of this method, which makes its implementation quite inconvenient. Another disadvantage of this method is that it does not consider risks and uncertainties (Tam & Tummala., 2001).

In AHP, decision makers provide their preferences on alternatives or criteria by pairwise comparison matrices (PCMs) which are often expressed by the multiplicative reciprocal preference relationship (Li et al., 2017) and require complete information (Oliva et al., 2017). Generally, AHP follows four basic steps: modeling, evaluation, prioritization, and synthesis. Prioritization and synthesis are the most important parts of multiplicative AHP (Changsheng & Gang, 2021). More specifically, throughout the hierarchy created for the decision problem, decision makers first derive the local priority vectors from the pairwise comparison matrices by a given prioritization method, and then perform AHP synthesis to generate the final priority vector of alternatives.

In multiplicative AHP, the pairwise comparison matrix structured on a scale of one to nine is not nearly accurate due to the complexity and uncertainty involved in real-world decision making (Dong et al., 2016). the PCM provided by the decision maker(s) is not perfectly consistent (Csato et al., 2019). It is necessary to revise the judgments in the PCM to achieve accepted consistency (Kou et al., 2016), (Aguaron et al., 2020). The judgments in the pairwise comparison matrix can be assumed as random variables with continuous distributions (Barfod m.b. et al, 2016), such as uniform distribution (Hauser D. & Tadikamalla P, 1996) , gamma distribution (Vargas L.G, 1982) , lognormal distribution (Lin C. & Kou G, 2015), beta distribution (Jalao E.R et al., 2014) and Cauchy distribution (Lipovetsky S. & Tishler A 1999), etc. However, the assumptions about the parametric form in these distributions are quite restrictive and may be inadequate. The decision maker has his prior opinions regarding the judgments of the criteria and alternatives.

As the most important part of the work is the logistic viability, it is worth pointing out about its development whose modernization of its equipment, the construction of new infrastructures, the reductions of waiting times for examples. To achieve these goals, we used the interview with some questionnaires (preferably carried out with Professors of the Port area, Logistics, Port or Port Logistics professionals and Port managers (at least with 5 years of experience) that have the purpose of applying the AHP.

To make a decision in an organized way and generate priorities, one needs to break down the decision into the following steps, as proposed by Saaty (1980):

1. Define the problem and determine the type of knowledge sought;
2. Structure the decision hierarchy from the top with the decision objective and then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (it is a set of alternatives);
3. Construct a set of pairwise comparison matrices. Each element at a higher level is used to compare the elements at the level immediately below it with respect to it;
4. Use the priorities obtained from the comparisons to weight the priorities at the level immediately below. Do this for each element. Then, for each element at the level below, add its weighted values and get its overall or global priority. Continue this weighing and adding process until the final priorities of the alternatives at the lowest level are obtained.

3. Materials and Methods

According to Saaty (1991), the AHP application contemplates the following phases: criteria and alternatives structuring; judgment collection; priority calculation; judgment consistency verification; and, finally, the calculation of alternatives global priorities. The criteria structuring consists in modeling the decision problem in a hierarchical structure, which, starting from the main objective, is broken down into several criteria necessary to reach the objective, forming a criteria layer. Each element of this layer, in turn, can be decomposed into two or more criteria, and so on, making the treatment and comprehension of the problem easier. Each element of the last level (leaf element) is decomposed into alternatives, allowing them to be evaluated in light of each leaf objective.

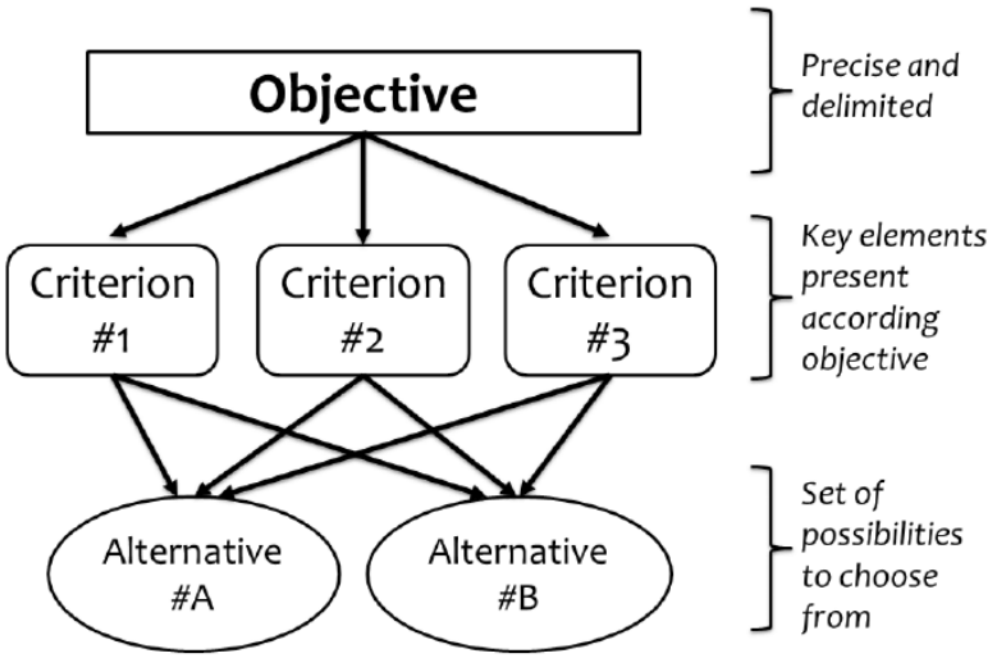

Figure 2 AHP Structure

The application of this model is summarized in an interview structure with elaborate questions that are obtained from problem for prioritized criteria and for the subcriteria with the judgments provided by experts. According to Mello (2015), these judgments must be inserted in comparison matrices. The judgments, inserted in the comparison matrices, are usually based on the Fundamental Absolute Number Scale (Saaty, 2010), that is, a linear scale from 1 to 9 (Saaty, 1980) (Table 2). The value 1 on this scale is used when both objects are judged to have the same priority.

Table 2 Saaty's Fundamental Judgment Scale (1980).

1	Equal importance	The two activities contribute equally to the goal
3	Small importance of one over the other	Experience and judgment favor one activity over the other
5	High or essential importance	Experience or judgment strongly favors one activity over the other
7	Very high or demonstrated importance	One activity is very strongly favored over the other. It can be demonstrated in practice

9	Absolute Importance	The evidence favors one activity over the other, with the highest degree of certainty
2, 4, 6, 8	Intermediate Values	When looking for a compromise condition between two definitions

An implication of using the Fundamental Scale is that the comparison matrix will be a positive reciprocal matrix (Mello, 2015).

However, a maximum number of 7±2 elements in each level should be sought in order to achieve greater accuracy in the comparisons. Also, Alves & Alves (2015) concluded: a high number of comparisons can generate risks of inconsistencies in judgments. Saaty (1991) mentions that there is no standard procedure for raising criteria and objectives. The author suggests the use of brainstorming with specialists and/or bibliographic consultations to help elucidate the criteria and objectives.

According to Saaty (1991), after hierarchizing criteria, judgment is collected from decision makers. Judgment is conducted by means of a paired comparison between two elements of the same level in light of the immediately superior focus element. The elements are compared from a square matrix, whose order is equal to the number of elements subordinate to the immediately superior node. The subordinate elements are arranged in the same order, forming the rows and columns of the matrix.

According to the author, during the judgment, each row element is compared with each column element and the value of the judgment is registered in the matrix in the row and column position referring to the compared elements. Table 3 shows, generically, the judgment matrix of the n alternatives (a1, a2,...,an) in light of the C1 criterion, where xij represents the judgment inputs varying i and j from 1 to n. In comparing the two elements, one should take into account which element is more important in light of the focus criterion and the intensity of this importance.

According to Saaty (1991), the comparison matrix generates reciprocal relations (Table 3). Thus, for each judgment registered in row position i and column j, represented by xij, there is a value equal to 1/xij in the reciprocal position, that is, in row position j and column i. Considering the positions of row and column elements i and j, respectively, varying from 1 to n, the elements xij obey the following rules:

Rule1: If xij = α, then xji = 1/α, α≠0, where α is the numerical value of the judgment based on Saaty's (1991) scale. Thus, we have xji = 1/xij.

Rule2: If ai is judged to be of equal relative importance to aj, then xij = 1 and xji = 1; and, in particular, xij =1,∀i=j.

Table 3 Judgment Matrix

C_1	a_1	a_2	...	Na
a_1	1	X_{12}	...	X_{1n}
a_2	$1/X_{12}$	1	...	X_{2n}
...	...	...	...	...
Na	$1/X_{1n}$	$1/X_{2n}$	...	1

The judgment must be based on Saaty's (1991) scale according to Table 2, seeking first the conceptual judgment and then the conversion to the numerical scale in order to register it in the matrix, as well as the associated reciprocal judgment. It is necessary to perform n (n-1) / 2 comparisons by the decision maker, being in the number of elements compared (Maria & Alex, 2016).

The next stage is to calculate the local and global priorities. It involves calculating the relative contribution of each element in the hierarchical structure with respect to the immediate goal and with respect to the main goal. First, the calculation of the priorities of each element (node) relative to.

To its immediately superior element, finding the local average priority of the node. Then, the global priority (in relation to the main target) of the respective element is calculated by multiplying its local average priority by the local average priorities of the hierarchically superior nodes (Maria & Alex, 2016).

According to Saaty (1991), the local average priorities of the compared elements in the judgment matrix can be obtained through matrix operations, calculating the principal eigenvector of the matrix and then normalizing it.

However, the mentioned author presents other simpler procedures to generate the priority vector with approximate values. One of these procedures was used by Maria & Alex (2016) and adopted in this work: i) the sum of the judgments recorded in each column of the judgment matrix is calculated; ii) a new normalized matrix is created, in which each element is initialized by the element of the original matrix divided by the total of its respective column; iii) the priority is calculated by means of the arithmetic mean of the elements of each row of the normalized matrix.

The result obtained in each row corresponds to the total relative percentage of priorities or preferences in relation to the immediate objective focus. The resulting priority vector is called the eigenvector of the matrix, and the sum of its elements equals 1. After calculating the local priorities in relation to each immediately superior node, the calculation of the consistency of such judgments is performed.

Considering the intrinsic difficulties of human beings in making decisions when facing problems with a lot of information and multiple criteria, Saaty (1991) proposed a procedure to calculate inconsistencies derived from the value judgment among compared elements in a complex decision problem. The said author admits a tolerance of 10% for inconsistencies. Maria & Alex (2016) describe, in a simple way, the steps to verify the consistency of the judgment.

According to Chao et al. (2020), in the first step, the largest eigenvalue of the judgment matrix (λmax) is calculated by summing the product of each total of column j of the original judgment matrix by each element in position j of the priority vector, considering j the column of the judgment matrix ranging from 1 to n. Considering the judgment matrix, the priority vector (calculated priorities of the elements) and the order (n) of the matrix, the eigenvalue calculation is represented by the following formula:

$$\lambda_{max} = \sum_{j=1}^{n} T_j \times P_j \qquad (1)$$

Where Tj is the sum of column j of the judgment matrix and Pj is the priority calculated for the criterion located in row j.

In the second step, the Consistency Index (CI) is calculated.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

In the third step, the Consistency Ratio (CR) is calculated:

$$CR = \frac{CI}{RI} \quad (3)$$

According to Saaty (1991), the Random Index (RI) is the consistency index of a reciprocal matrix randomly generated by the Oak Ridge laboratory. Table 4 shows the RI table containing the random indexes calculated by Oak Ridge laboratory for square reciprocal matrices of order n. According to Saaty (1991), if the calculated RI is less than or equal to 0.10, the trial matrix is considered consistent. Otherwise, the matrix is considered inconsistent, and the judgment must be redone.

Table 4 - Random consistency index table.

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

After verifying the consistency of the judgments, the global performance of the alternatives is calculated. According to Saaty (1991) and based on the AHP hierarchical structure, the global priorities calculated for each criterion correspond to the importance of each criterion in relation to the main objective. However, at the alternatives level, the priority found by multiplying the local priority of the alternative in relation to a given focus by its global priority reflects the impact of the alternative on the main objective, relative to a single criterion. Therefore, to obtain the global priority of the alternatives, the sum of the global priorities of the alternatives calculated in each criterion should be calculated. This priority will determine the contribution of the alternative to the main objective.

4. Results

4.1 Structuring the criteria in the AHP hierarchy

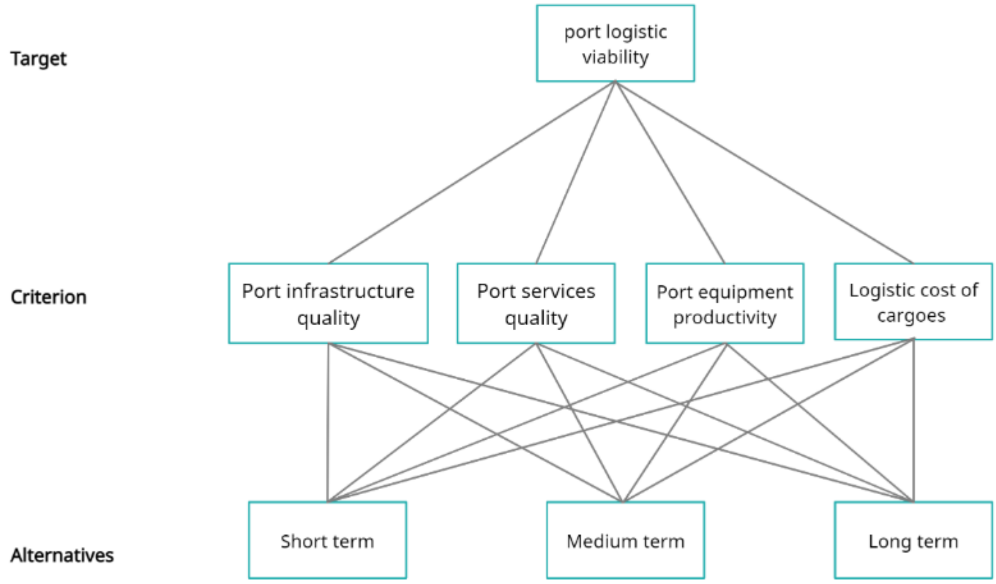

Figure 3 Structure of the criteria in the AHP hierarchy

Based on document consultation, interviews and literature review, the main criteria were identified, in total Four criteria (Quality of port infrastructure, quality of port services, productivity of port equipment and logistic cost of cargoes in the port).

4.2 Collection of criteria judgment, calculation of priorities and consistency

The matrix of pairwise comparison for the criteria (Quality of Port Infrastructure (QI), Quality of Port Services (QS), Productivity of Port Equipment (PE) and Logistic Cost of Cargoes in the (CL), with respect to the objective according to the interview result is presented in table 8. As the matrix is of order 4, the total pairwise comparisons is 6 obtained by the following formula:

$$\frac{n(n-1)}{2} \qquad (4)$$

Where "n" is the number of criteria.

Table 5 Criteria Judgment Matrix

	QI	*QS*	*PE*	*CL*
QI	1	8	3	7
QS	1/8	1	1/3	½
PE	1/3	3	1	5
CL	1/7	2	1/5	1
Total	1,60	14,00	4,53	13,50

4.3 Calculation of priorities and consistency of criteria

Next, table 6 is normalized by dividing the value of each cell by the sum of the respective column.

Table 6 Normalized Matrix

	Normalized Matrix					
	QI	**QS**	**PE**	**CL**	**Priority**	**Overall Priority**
QI	0,62	0,57	0,66	0,52	0,59	59%
QS	0,08	0,07	0,07	0,04	0,07	7%
PE	0,21	0,21	0,22	0,37	0,25	25%
CL	0,09	0,14	0,04	0,07	0,09	9%
Total					**1**	**100%**

With the normalized matrix, the priority vector of the criteria was obtained by calculating the average of the values for each criterion. For example, for the port infrastructure criterion, we have: (0,62+0,57+0,66+0,52) / 4 = 0,59.

Now you have the ranking of the criteria and you know that the port infrastructure criterion is most important (0.59 or 59% of the total importance) followed by the port equipment criterion (0.25 or 25% of the total importance), in third place, the cost criterion (0.09 or 9% of the total importance) and the least important in this analysis is the port services criterion (0.07 or 7% of the total importance).

The AHP calculates a consistency ratio (CR) by comparing the consistency index (CI) of the matrix with our judgments, with the consistency index of a random matrix (RI). Saaty (1991) provides the calculated value of the RI for matrices of different sizes. Then, each value in the first column of the comparison matrix is multiplied by the priority of the first criterion, each value in the second column of the matrix is multiplied by the priority of the second criterion, and so on. The values in each row are added together to get a set of values called a weighted sum. Then the weighted sum vector elements (obtained from the previous step) are divided by the corresponding priority of each criterion.

Table 7 Matrix weights

	QI	**QS**	**PE**	**CL**	**Sum of weight**	**priority**	**weight/priority**
QI	0,59	0,56	0,75	0,63	2,53	0,59	4,288135593
QS	0,07	0,07	0,08	0,05	0,27	0,07	3,886904761
PE	0,20	0,21	0,25	0,45	1,11	0,25	4,426666668
CL	0,08	0,14	0,05	0,09	0,36	0,09	4,047619048
					Total	**1**	**16,64932607**

The average of the values is called Lambda maximum λmax.

$$\lambda_{max} = \sum\left(\frac{weight}{Priority}\right)/4$$

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

$$CR = \frac{CI}{RI}$$

Table 8 Maximum Lambda, CI and CR

λ_{max}	CI	CR
4,162	**0,054**	**0,060**

So the consistency ratio is well below 0.1 tolerated by Saaty and Vargas (2012), that is, the judgment matrix is validated.

4.4 Criteria Rating Scale

Instead of comparing the alternatives, a rating scale was created for each criterion and the alternatives will be scored according to each criterion on this scale.

Table 9a Scale for infrastructure criteria

Scale for infrastructure criteria		
Infrastruture	**Scale**	**Value**
1-4,6	Regular	3
4,7-8,6	Good	5
8,7-10	Excellent	7

Table 9b Scale for port services criteria

Scale for port services criteria		
Services	**Scale**	**Value**
1-4,6	Regular	3
4,7-8,6	Good	5
8,7-10	Excellent	7

Table 9c Scale for port equipment criteria

Scale for port equipment criteria		
Equipment	**Scale**	**Value**
1-23	Regular	3
24-40	Good	5
41-50	Excellent	7

Table 9d Scale for logistics cost criterion

Scale for logistics cost criterion		
Cost	**Scale**	**Value**
100-460	Low	7
461-860	Regular	5
861-1000	High	3

After the scales were created, the alternatives were rated verbally and then the scale labels were replaced with their respective values.

Table 9e The alternatives

Alternatives	Infrastruture	Service	Equipment	Cost
Weight of criteria	**0,59**	**0,07**	**0,25**	**0,09**
Short-term	Regular	Regular	Regular	High
Medium-term	Good	Regular	Good	Regular
Long-term	Excellent	Good	Excellent	Low

Then the overall priorities of the scores were calculated. To express these totals as overall priorities, the totals column was normalized (divide each value by the sum of totals).

Table 9f Normalized Alternatives

Alternatives	Infrastructure	Service	Equipment	Cost	total	**overall priorities**
Weight of criteria	**0,59**	**0,07**	**0,25**	**0,09**		
short-term	3	3	3	3	3	0,20
medium-term	5	3	5	5	4,86	0,33
Long-term	7	5	7	7	6,86	0,47
Soma					14,72	1

For short-term: (0,59*3) + (0,07*3) + (0,25*3) + (0,09*3) = 3
For medium-term: (0,59*5) + (0,07*3) + (0,25*5) + (0,09*5) = 4,86
For the long-term: (0,59*7) + (0,07*5) + (0,25*7) + (0,09*7) = 6,86
In other words, given the importance that was assigned to each port logistics viability criteria (infrastructure, service, equipment, cost), long-term logistics viability (0.47 or 47% of total priority) is preferable to medium- and short-term logistics viability with 33% and 20% respectively.

5. Discussion

Port logistics is one of the main relevant activities in the port job which indicates the position and efficiency of a port and makes it an indispensable link in the chain of port activities, i.e. an optimal layout of space and the coordinated development of the port. AHP is a good multi-criteria tool for complex decision making. Paulo (2015), André (2014), Thiago (2016), Changsheng and Gang (2021) obtained satisfactory results by applying AHP.

With regard to the quality of port infrastructure, PAC is carrying out an improvement in its infrastructure, through suggestions of infrastructure investment projects and logistics. Because the port equipment is aging and the services offered are slow, the flow of ships in the port has decreased compared to neighboring ports. The projected access channel is the same, 15 m, the same number of berths (11), given that there will be no acquisition of new port equipment, and the services will be the same.

The result of the AHP hierarchical method shows that the criteria port infrastructure and port equipment are more prioritized with respectively 59% and 25% of the overall priority ahead of port services and logistic cost of cargoes in the port. The long-term logistic viability alternative is preferred over the medium-term and short-term. A port that has 59% priority for its infrastructure and 25% priority for its handling equipment will have a strong probability of facing long-term logistics viability.

The result of the AHP method shows that the criteria port infrastructure and port equipment have more importance than the other port criteria.

PAC should invest in port infrastructure, logistics, equipment and also in advanced technologies. The access channel must be dredged to 22 m, the depth of the port also to 18 m or 20 m, and thus can allow access to large ships with a greater draft of up to 20 m. On the other hand, the more modern port equipment is very useful for port efficiency, i.e., to foresee the acquisition of the equipment, to reduce the stevedoring and downtime in the port and attract many ships. According to Hsu, Lian and Huang (2020), besides distance, containing both ocean and land, the important attributes that ocean carriers consider when deciding which port to call at are general infrastructure, port tariffs, port efficiency, availability and size of berths. PAC's ocean and land geolocation is favorable for carriers. PAC should computerize its administrative procedures for customers, improve service quality, and establish new rates to be more competitive.

In cases of difficulties to reform in PAC because of the current infrastructure, it would be better to propose a new project for a second port, specialized for container ships (more advisable), with installation of more modern equipment. The physical and operational restructuring of the Autonomous Port of Cotonou will increase its competitiveness within ECOWAS (Economic Community of West African States), with a positive impact on Benin's economy.

6. Conclusion

The result of AHP method shows that port infrastructure criterion is most important, followed by port equipment criterion, in third place is cost criterion and the least important in this analysis is port services criterion. The consistency ratio is well below 0.1 tolerated by Saaty and Vargas (2012) and the judgment matrix is validated. After ranking the criteria by scale and the importance that was assigned to each port logistics viability criteria (infrastructure, service, equipment, cost), long-term logistics viability is preferable to medium-term and short-term.

With the AHP method, port infrastructure and port equipment are the fields that need the most investment for the port to be viable in the long run and comes in third and fourth place the logistic cost of cargoes and port services. So, the Autonomous Port of Cotonou (PAC) as well as the other ports of the world, need a high investment in port handling infrastructure and equipment, a competitive logistic cost, and a very flexible service that result in a long-term viability.

PAC must choose between rebuilding or building quality infrastructure and acquiring new, modern, state-of-the-art computerized equipment, reducing or even excluding some cargo logistics fees, reducing ship and truck queues at port entrances by sea and land, and excluding bureaucratic procedures. These choices would attract attention from the rest of the world that is active in foreign trade, so PAC could become the hub of West Africa.

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