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Evaluation of Occupational Health and Safety Management System Performance in Shipyard Businesses with FAHP and FPROMETHEE Methods

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ABSTRACT

Shipyards are places where new ships are built, routine and mandatory maintenance and dismantling of ships are carried out and a wide range of work equipment and chemicals are used during these processes. The fact that most of the world is covered with water and that maritime transportation is advantageous compared to other types of transportation brings maritime transportation to the forefront. This situation also leads to an increase in work intensity in shipyards. Therefore, occupational health and safety (OHS) practices are also important in shipyards. In this context, this study aims to evaluate the OHS Management System (OHSMS) performances of shipyard enterprises and to rank the shipyard enterprises selected as alternatives according to their OHSMS performances in line with the determined criteria. In the first stage, five main and 16 sub-criteria as OHSMS performance criteria and five alternative shipyard enterprises were identified through literature research. In line with the expert opinions, the weights of the criteria were found with the Fuzzy Analytic Hierarchy Process (FAHP) method, one of the multi-criteria decision-making methods, and the alternative priority order for the criteria was determined with the Fuzzy PROMETHEE (FPROMETHEE) method using the results obtained from the FAHP method. As a result of the analysis, the main criterion “Management Review” was determined as the criterion with the highest weight ratio. As a result of the operations carried out with the criterion weights determined by FAHP, Shipyard 3 alternative was ranked first in terms of OHSMS performance in the priority ranking made by using FPROMETHEE method. In this study, OHSMS performance evaluation in shipyard enterprises has been carried out by using FAHP and FPROMETHEE methods, which are multi-criteria decision-making methods, and the findings have contributed to the shipyard sector and the literature.

1 Introduction

Shipyards are a branch of industry where a wide variety of industries such as manufacturing, painting, electricity/electronics, iron, steel, etc. work and ships are built by working in accordance with a certain methodology (Menteşe et al., 2017). From a sectoral perspective, shipyard enterprises carry out maintenance-repair, shipbuilding, administrative, etc. services together. Since a wide range of industrial branches were also involved in shipbuilding, it had an impact on the development of other sectors. Therefore, all activities in shipyards should be carried out in a systematic way (Altundağ & Koçak, 2021).

Shipyard enterprises are important organizations that provide significant foreign currency inflow to the national economy and contribute to employment. However, the activities in these enterprises have high levels of complexity and various risks. OHS measures must be taken to protect human, marine and environmental health (Yorulmaz, 2021). Therefore, shipyard enterprises establish Occupational Health and Safety Management System (OHSMS) for the systematic execution of OHS activities. The continuity of the system is ensured by conducting performance evaluations at certain intervals to determine the advantages and drawbacks of the OHSMS. Measuring and evaluating the performance of the OHSMS applied in shipyard enterprises, which take place as production enterprises within the maritime transportation system and have an important place in the functioning of the maritime transportation system in terms of the products they produce, is a necessity from a holistic perspective.

In this context, this study aims to measure and evaluate OHSMS performance in shipyard enterprises. Performance evaluation is to determine which of the Policy, Planning, Implementation and Operation, Control, Management Review steps and sub-criteria affecting the functioning of these steps are more effective, and to rank the performance of the shipyards determined as alternatives in terms of the determined criteria and sub-criteria, limited to and among themselves. For the purpose of this study, Fuzzy Analytical Hierarchy Process (FAHP) and Fuzzy PROMETHEE (FPROMETHEE) methods, which are Multi-Criteria Decision Making (MCDM) methods, were used in an integrated manner. When the literature is examined, Inan et al. (2017) compared the OHSMS performance of three companies operating in the packaging sector using Simos Procedure and VIKOR methods. Korkusuz et al. (2020) conducted an OHS performance evaluation in the health sector using AHP and PROMETHEE methods. Fifteen public hospitals in Izmir and Istanbul were evaluated in terms of their OHS performance. When the literature is examined, there is no study on the evaluation of OHSMS performance in shipyard enterprises by using FAHP and FPROMETHEE methods within the scope of the problem hierarchy. In this study, it is aimed to evaluate OHSMS performance in shipyard enterprises with FAHP and FPROMETHEE methods and it is expected to contribute to the literature in this respect.

2 Occupational safety and work accidents in shipyard enterprises

In shipyards, industrial products such as ship building materials and some chemicals etc. are brought together using appropriate methods and materials and the ship is formed as the final product (Toprak, 2009). One of the works carried out in shipyards is ship maintenance, repair and drydocking. Maintenance and repair works are carried out after the ships are dry-docked. Maintenance and repair operations are carried out for post-accident modification requirements and seaworthiness certificate regulations. In general, drydocking refers to the process of taking the necessary operations on specially prepared blocks in order to process the underwater parts of the ships coming to the pool for repair operations. Cleaning the ship's surface from rust, oil, etc. by scraping or washing with water, priming and painting, maintenance of direction mechanisms, control and maintenance of machinery and equipment used (Tari, 2014). Most end-of-life ships are dismantled and used as scrap. This process allows the reuse of material resources such as steel, copper, aluminum, etc. in ships, providing both economic advantage and preventing environmental pollution (Bilir, 2019).

The methods applied during the work carried out in shipyards, the equipment and materials used, the level of education of the employees employed, and the wide variety of work being carried out at the same time have an impact on the possibility of occupational accidents. Occupational accidents can occur due to personal factors, material/equipment-related factors, environmental factors and managerial factors. In order to prevent accidents, training, human-machine harmony, ensuring the suitability of the working environment and good management of organizational conditions are required (Yorulmaz & Öztürk, 2022). There are various risks that may cause occupational accidents depending on the activities carried out in the shipyard, the nature of the work, the training and competence of the employee, the quality or suitability of the materials, the suitability of the work area. Depending on these risks; equipment and vehicle-related traffic accidents, crashes, etc. accidents, fire, explosion, material fall, splash, crushing, poisoning, electric shock, fall, etc. work accidents may occur (Turan & Süslü, 2021). Creating a safe working environment in workplaces is an indicator of the reputation of the workplace and the value it gives to its personnel. A safe working environment is a factor that increases the enthusiasm and enthusiasm of employees. When necessary precautions are not taken in workplaces and the necessary preventive equipment is not provided for employees, work accidents and workday losses occur. OHS management systems are established in workplaces to prevent these negativities (İşlek, 2010). Providing a safe working environment for employees will be more possible with the establishment and effective implementation of a continuous management system.

3 OHS management systems

The general purpose of OHSMSs is to ensure that measures are taken, existing measures are improved, developed and sustained before near misses, occupational accidents, occupational diseases, etc. occur in OHS activities. OHSMS ensures a safe and healthy working environment in workplaces. It is a scientific and systematic approach to provide a better working environment in terms of OHS, to identify and eliminate hazards and risks (Yıldırım, 2019).

3.1 OHSAS 18001

The OHSAS 18001 standard was prepared by making adjustments to BS 8800 (Occupational Health and Safety Management System Guidance Standard) published by BSI (British Standards Institution), the UK national standards body, in 1999 (Önbey, 2019). OHSAS 18001 is a system created to control, manage and ensure the continuity of OHS risks (Marhani et al., 2013). Since businesses that offer a healthy and safe working environment will come to the fore when choosing the workplace where people will work, businesses that establish and implement OHSMS will become more advantageous and preferred in the sector. This will make it mandatory to establish the system in workplaces that do not yet have OHSMS. It will also be a factor that ensures its continuity. The OHSAS 18001 standard in workplaces It aims to encourage the systematic promotion of good practices in terms of OHS in order to protect the health and safety of workers. It enables risks in the workplace to be identified, controlled, accidents to be reduced, the workplace to be in compliance with the law and performance to be better (Fernández-Muñiz et al., 2012).

Since OHSMS will provide a proactive approach in workplaces, it can prevent negative situations such as occupational accidents and occupational diseases that businesses may experience. Therefore, the system must be set up in an appropriate and feasible way at every stage. The continuity of each stage must be ensured, as a failure at any stage may cause the entire system to fail.

3.2 ISO 45001

ISO 45001 OHSMS is the first ISO standard created to ensure that employees work in a safe and healthy environment in workplaces, to prevent injuries and deaths as a result of occupational diseases and work accidents, and to improve OHS conditions (Çakmak, 2019). For the ISO 45001 management system to be successful, objectives such as the voluntary duty of senior management to be more, the inclusion of service providers in the OHS process, taking employee opinions, and improving the quality of OHS activities in the workplace should be realized (Kurt, 2020). Therefore, although both management systems have different aspects, they aim to ensure that OHS activities are carried out in an easy and organized manner and that any negativity and disruptions that may occur are prevented with proactive approaches.

3.3 Benefits of OHSMS

Since the OHS Management System aims to provide a safe and healthy working environment for employees, it will prevent occupational accidents and occupational diseases. It requires planned and organized work. In general, OHSMS will provide benefits such as minimizing risks during work, increasing OHS awareness of employees because of trainings, ensuring compliance of the workplace with the laws, etc. In addition, indirect benefits such as increased work efficiency, improved employee performance, competitive advantage for the workplace, increased trust in the company, etc. can also be counted (İri, 2007).

As a result, both OHSAS 18001 and ISO 45001 will allow OHS activities to be carried out smoothly. An efficiently implemented management system will provide a healthy and safe working environment for employees as it will ensure the prevention of risks that exist or may occur in the workplace. A workplace where employees will be satisfied will ensure more work efficiency. At the same time, since risk control will be ensured, situations such as work accidents and occupational diseases will be prevented, and there will be no legal and prestige problems.

4 Literature review

In order to help in the explanation of the MCDM methods used in this study and in determining the necessary criteria, a literature search was conducted and the studies conducted with OHSMS and FAHP and FPROMETHEE methods were investigated.

4.1 Studies on OHS management system

When the literature on OHSMS is examined; Erol (2019), in this study, the OHSMS performance of a company over the years according to OHSMS performance indicators was evaluated by using TOPSIS method, which is one of the MCDM methods. Ghahramani (2016), in the study, obstacles that will reduce the effectiveness of OHSAS 18001 in companies and situations that will increase its effectiveness were determined. Bevilacqua et al. (2016), the study identified the factors that facilitate the implementation of OSHSAS 18001 and the problems that may be encountered in implementation. Abad et al. (2013), the study examined the link between the adoption of OHSAS 18001 OHSM System in the workplace and productivity. Janackovic et al. (2020) examined the key indicators for OHSMS improvement in the electricity distribution company. Haas & Yorio (2016) in their study, OHSMS performance tools in the mining sector were examined. Mohammadfam et al. (2016), a method for measuring the performance of the OHSAS 18001 management system is proposed. Mohammadfam et al. (2017), in the study conducted by the Ministry of Labor and Social Security, OHSMS indicators of three companies with and without OHSMS certification were compared. Yan et al. (2017), OHS performance for a fuel company by determining a set of indicators. Azadeh et al. (2012), in this study, power plant OHSMS performance evaluation was conducted. Yorulmaz & Aksu (2021), in this study, the importance levels and impact measure of OHS implementation performance dimensions were calculated using the AHP method.

4.2 Studies on FAHP and FPROMETHEE methods

In the literature review on FAHP and FPROMETHEE Method; Yılmaz & Dağdeviren (2010), in this study, the problem of welding machine selection in an enterprise was analyzed using PROMETHEE and FPROMETHEE methods. Zangoueinezhad et al. (2011), the study investigated supplier selection in shipyards according to their characteristics and competitiveness. Supplier criteria weights were found using the FAHP method. Hsu (2012), in this study, FAHP method was used to determine the qualities that will improve the service qualities of ports related to ship navigation works and enable the preparation of policies for ship navigation safety. Balin et al. (2015), in this study, FAHP and Fuzzy VIKOR method were used for fault detection of ship main engine auxiliary systems. Pak et al. (2015), in this study, the factors affecting navigational safety in ports and the extent to which these factors affect port safety were examined using the FAHP method. Ding et al. (2019) in their study, they aimed to select middle managers for global transportation logistics service providers using the Fuzzy AHP method. Türk & Özkök (2020), in this study, FAHP and Fuzzy TOPSIS method were used in shipyard location selection. Balbaş & Turan (2019), FAHP and BTOPSIS methods were used to determine the type of ship that can be built in a private shipyard.

Çelik & Gök Kısa (2017), in this study, FAHP and FPROMETHEE were used together to evaluate the e-service quality of websites.

According to the literature review, it is seen that there are various studies on OHSMS. Similarly, FAHP and FPROMETHEE methods are used in studies conducted for various sectors. However, the inadequacy of OHSMS performance evaluation studies in shipyard enterprises, especially by using these two methods, emerges. However, OHSMS should be established in shipyards in order to carry out OHS activities efficiently and OHSMS performance should be evaluated by appropriate methods in order to ensure continuity. Therefore, OHSMS performance evaluation in shipyard enterprises and the methods used will contribute to the sector.

5 Material and Method

In this study, FAHP and FPROMETHEE methods were used together to evaluate OHSMS performance in shipyard enterprises. FAHP method was used to determine the criterion weights and FPROMETHEE method was used to rank the alternatives.

5.1 Fuzzy logic

Fuzzy logic is a numerical discipline that we use very often and allows us to interpret our actions. In traditional logic, there are (1) and (0) values, but fuzzy logic goes further than indicating whether a situation is effective or ineffective by using not only these values but also intermediate values, and it also indicates to what extent it is effective or ineffective (Engelkıran, 2001).

The problems encountered in daily life are often such that they cannot be expressed in exact numbers. Decision-makers who will make the selection or the comparison, their decisions necessarily involve uncertainty. Fuzzy logic is a method that can help in solving this uncertainty both in terms of defining more effective linguistic expressions and increasing the accuracy and validity of the results obtained after the operations to be performed (Yılmaz, 2010).

5.2 Fuzzy AHP method

The AHP method was developed by Saaty to facilitate the solution of multi-attribute problems. AHP is used to evaluate the knowledge of experts. However, it does not provide clear answers to some uncertainties. Fuzzy AHP is preferred for solving such problems. In the AHP method, experts are asked to use values between 1-9 when making pairwise comparisons. It is not always possible to make decisions with these net values in real life. In fuzzy AHP, the decision is made by using intermediate values instead of clear values (Vatansever & Uluköy, 2013). Fuzzy AHP method is the determination of the weights of the criteria using a fuzzy pairwise comparison matrix in order to make more precise decisions. It was developed by Buckley (Yürüyen & Ulutaş, 2020). Chang used triangular fuzzy numbers in pairwise comparisons and extended order analysis method to find the stage values of pairwise comparisons (Akay, 2021).

5.3 Fuzzy PROMETHEE method

Fuzzy PROMETHEE (FPROMETHEE) is an MCDM method that combines PROMETHEE and fuzzy numbers. The FPROMETHEE algorithm is generally the same as PROMETHEE, but fuzzy numbers are added to the methodology (Yılmaz, 2010).

In the FPROMETHEE method, alternative evaluations are expressed in fuzzy numbers. The use of fuzzy numbers increases the precision of the result and its closeness to reality (Uslu, 2022).

The fuzzy number representation and importance scale to be used in the evaluation of alternatives according to the criteria are given in Table 1.

The joint preference function for each pair of alternatives is given in Table 2.

The indifference value q is the largest difference between the decision points of the evaluation factors that may be considered unimportant, and p is the smallest difference that is considered sufficient to form a definite preference.

Table 1 Linguistic variables used for alternatives, fuzzy numbers and questionnaire equivalent (Kabak & Erdebilli, 2021)

Linguistic Variable	Survey Prepared in Return	Fuzzy Number (m, a, b)
Strongly Disagree	Very Bad	(0,00; 0,00; 0,15)
Disagree	Bad	(0,15; 0,15; 0,15)
Slightly Disagree	A Little Bad	(0,30; 0,15; 0,20)
No Idea	Middle	(0,50; 0,20; 0,15)
Somewhat Agree	A Little Good	(0,65; 0,15; 0,15)
I agree	Good	(0,80; 0,15; 0,20)
Strongly Agree	Very good	(1,00; 0,20; 0,00)

Table 2 Preference functions used in PROMETHEE method (Brans & Vincke 1985; Özdağoğlu, 2013; Kabak & Erdebilli, 2021)

Type	Parameters	Function
Primary Type (Ordinary)	-	$P(d) = \begin{cases} 0, & d \leq 0 \\ 1, & d > 0 \end{cases}$
Second Type (U Type)	q	$P(d) = \begin{cases} 0, & d \leq q \\ 1, & d > q \end{cases}$
Type Three (Type V)	p	$P(d) = \begin{cases} 0, & d \leq 0 \\ d/p, & 0 \leq d \leq p \\ 1, & d > p \end{cases}$
Type Four (Leveled)	p, q	$P(d) = \begin{cases} 0, & d \leq q \\ 1/2, & 0 \leq d \leq p \\ 1, & d > p \end{cases}$
Type Five (Linear)	p, q	$P(d) = \begin{cases} 0, & d \leq q \\ (d-q)/(p-q), & q < d \leq p \\ 1, & d > p \end{cases}$
Type Six (Gaussian)	s	$P(d) = \begin{cases} 0, & d \leq 0 \\ 1 - e^{-d^2/2s^2}, & d > 0 \end{cases}$

Parameters used in the preference function: q: indifference value, p: precision value threshold

Where d is the difference between the values of the two decision points in terms of the evaluation factor. The preference function shows the degree to which alternative a is preferred to alternative b. The degree of preference is determined by the variables d, q, p (Limoncuoğlu Eren, 2021).

5.4 Identification of the problem

Law No. 6331 on Occupational Health and Safety, published in 2012, has generally eliminated deficiencies in OHS. Performance measurements can determine how the changes and new practices introduced by the law affect OHS performance in the workplace. OHS performance helps us understand the effectiveness of OHS work in the workplace and the adequacy of inspections (Korkusuz et al., 2020).

Performance measurement is the process of systematically obtaining, analyzing and reporting data in order to monitor the organization's resources, what it produces and the profits and losses achieved with them. It helps to determine progress in terms of achieving predefined goals and objectives. Performance measurement should be carried out at regular intervals for the continuity of the organization's development (Ediz et al., 2017).

Therefore, it is an important issue to periodically evaluate and report OHS performance in order to assess the effectiveness of OHS activities in workplaces, to identify improvement aspects and deficiencies, if any, and to take necessary actions.

5.5. Criteria and alternatives

Criteria and sub-criteria were selected to enable performance evaluation of OHSMS. Five shipyards operating in Yalova-Altınova Shipyards Region were determined as alternatives to be evaluated in terms of OHSMS performance. Criteria and sub-criteria were determined through literature research.

The referenced sources for the criteria and sub-criteria are shown in Table 3.

Table 3 Criteria and sub-criteria used in OHS performance assessment and their sources

Criteria	Sub Criteria	Source
Policy (PO)	(PO1) Senior management support	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(PO2) Simplicity and understandability of the OHS policy	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(PO3) Measure the initial risk in order to develop the OHS policy	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(PO4) Employee participation	(Ediz ve diğ. 2017; Erol, 2019)
Planning (PL)	(PL1) Units use OHS data for development purposes	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(PL2) Financial resources allocated to OHS programs	
	(PL3) Announcement of OHS programs.	
Implementation and Operation (IO)	(IO1) Rate of non-adoption of OHS rules by employees	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(IO2) OHS documentation and regulations	(Kurt, 2020; Erol, 2019; Ediz et al. 2017; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(IO3) Emergency response drills	(Kurt, 2020; Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
Control (CO)	(CO1) Frequency of OHS audits	(Kurt, 2020; Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(CO2) Continuous review of OHS audits	(Kurt, 2020; Erol, 2019; Ediz et al. 2017; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(CO3) Review of accident investigations	(Kurt, 2020; Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
Management Review (MR)	(MR1) OHS activity results available at the time of the inspection	(Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015)
	(MR2) Announcement of accident results to employees	(Erol, 2019)
	(MR3) The presence of responsible persons at review meetings	(Erol, 2019)

The criteria set are as follows:

Policy (PO): Refers to the OHS objectives and commitments established by the top management of the organization.

Planning (PL): Refers to the programs and definitions prepared to achieve the objectives and commitments of the organization.

Implementation and Operation (IO): It refers to the determination of authorities, necessary trainings, emergency measures within the organization.

Control (CO): It refers to keeping records of all kinds of incidents (accidents, near misses, etc.) and conducting inspections.

Management Review (MR): Refers to checking the system at certain periods.

Alternatives:

Within the scope of the study, the shipyards whose OHSYS performances will be evaluated were determined as five shipyards operating in Yalova Altınova Shipyards Region. In the selection of shipyards, shipyards that build similar ship types and accept to provide data for the research were preferred.

5.6. Obtaining the data

A questionnaire was developed to obtain the data. The questionnaire was evaluated by five people with an average age of 42 years and an average experience of 17.6 years who are working as B/C class occupational safety experts in shipyard enterprises. The questionnaires were delivered to the experts via e-mail. In the questionnaire, the effects of the criteria and sub-criteria on each other were made as pairwise comparisons according to the 1-9 scoring scale shown in Table 4.

Table 4 AHP Evaluation Scale

Impact Degree	Description
1	Equally effective
3	Moderately effective
5	Strongly effective
7	Very strongly effective
9	Extremely effective

Example 1:

When comparing the criteria, if the criterion on the left (A1) is considered to be moderately effective compared to the criterion on the right (A2), the number "3" on the left should be marked as shown in Table 5.

Table 5 Example 1 Demonstration

A1	9	7	5	3	1	3	5	7	9	A2
				S						

Example 2:

When comparing criteria, if the criterion on the right (A2) is considered to be very strongly influential compared to the criterion on the left (A1), the number "7" on the right should be marked, as shown in Table 6.

Table 6 Example 2 Demonstration

A1	9	7	5	3	1	3	5	7	9	A2
								S		

The shipyards to be evaluated as alternatives were compared with each other in terms of the main criteria according to the 0-6 scoring scale in Table 7.

Table 7 PROMETHEE Evaluation Scale

Very Bad	0
Bad	1
A Little Bad	2
Middle	3
A Little Good	4
Good.	5
Very good	6

Write "1" if you think Shipyard 1 is "very bad" in terms of Policy and "2" if you think Shipyard 2 is average.

The sample application is shown in Table 8.

Table 8 PROMETHEE Evaluation Example Demonstration

	Policy	**Planning**	**Implementation and Operation**	**Control**	**Management Review**
Shipyard 1	1	...			
Shipyard 2	2	...			
...	...	...			

6 Material and method

6.1 Solution with fuzzy AHP method

After the criteria and sub-criteria were identified through literature research (Erol, 2019; Inan et al. 2017; Mohammadfam et al. 2017; Mohammadfam et al. 2016; Podgórski, 2015; Ediz et al. 2017), the hierarchical structure in Figure 1 was created.

A pairwise comparison matrix is created according to the experts' assessments. It is translated into fuzzy scales corresponding to the linguistic variables specified in Table 9.

The superiority of the criteria covering the fuzzy scales against each other was created by processing and calculating the survey values into the Microsoft Office Excel program.

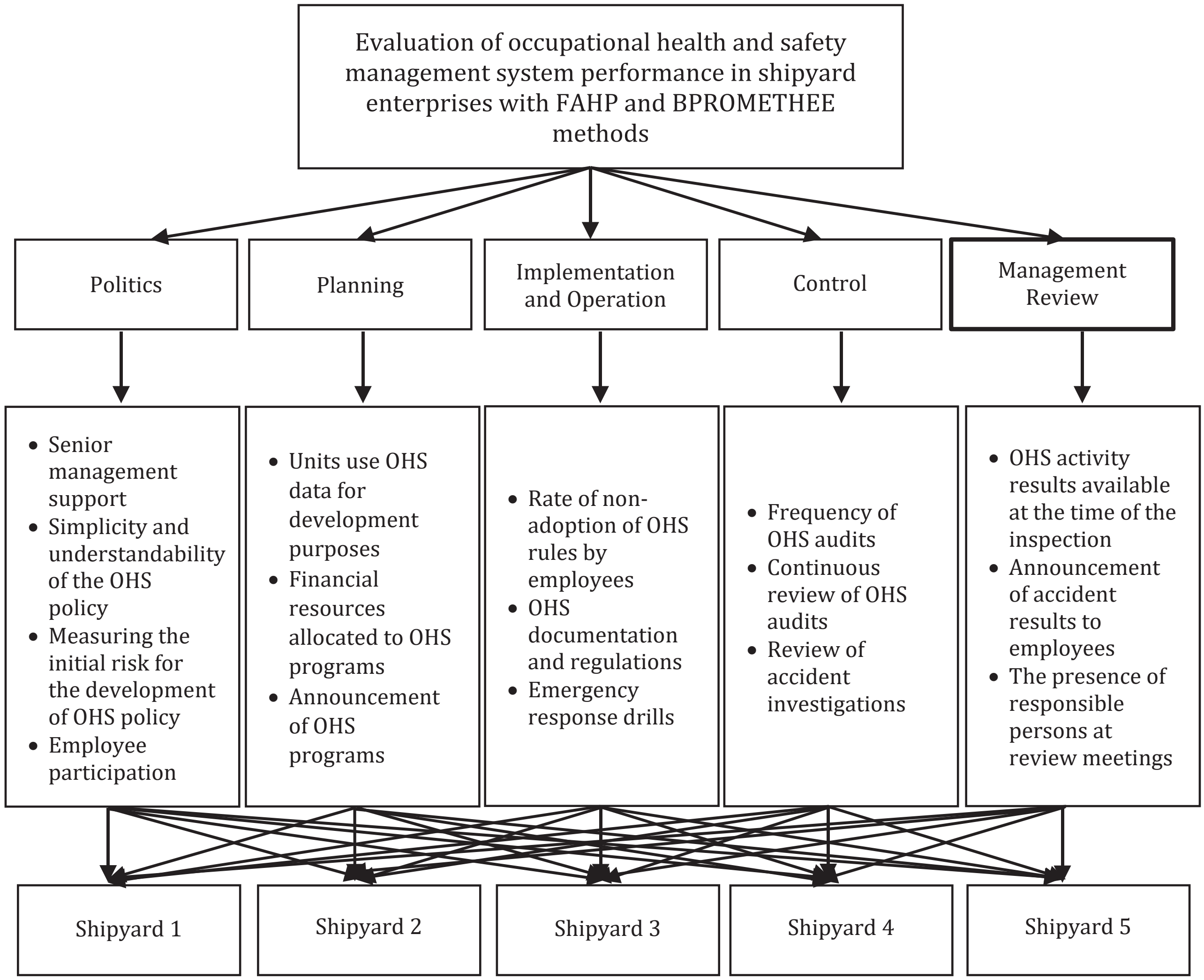

Figure 1 Hierarchical structure

Table 9 Linguistic variables and triangular fuzzy numbers (Akyol, 2022; Palabıyık, 2022)

Variables	**Triangular Fuzzy Scale**	**Triangular Fuzzy Reciprocity Scale**
Equally effective	(1,1,1)	(1,1,1)
Medium effective	(1,3,5)	(1/5,1/3,1)
Powerfully effective	(3,5,7)	(1/7,1/5,1/3)
Very powerfully effective	(5,7,9)	(1/9,1/7,1/5)
Extremely effective	(7,9,9)	(1/9,1/9,1/7)
Intermediate values	(1,2,3)	(1/3,1/2,1/1)
	(3,4,5)	(1/5,1/4,1/3)
	(5,6,7)	(1/7,1/6,1/5)
	(7,8,9)	(1/9,1/8,1/7)

Table 9 shows the various degrees of effectiveness and their fuzzy equivalents in the decision-making process. These fuzzy scales are used to determine the relative importance of decision criteria and allow decision makers to express uncertainties and imprecise judgments between criteria. Thus, a more flexible and realistic decision-making process is created (Barbaroz, 2021).

Pairwise comparison matrices prepared according to the survey data is given in Table 10 and Table 11.

Table 10 Fuzzy pairwise comparison matrix for main criteria

Main Criteria	Politics	Planning	Implementation and Operation	Control	Management Review
Politics	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	(1/9,1/9,1/7)
Planning	(1,3,5)	(1,1,1)	(3,5,7)	(5,7,9)	(1/5,1/3,1)
Implementation and Operation	(1,3,5)	(1/7,1/5,1/3)	(1,1,1)	(1/7,1/5,1/3)	(1/9,1/7,1/5)
Control	(1/5,1/3,1)	(1/9,1/7,1/5)	(3,5,7)	(1,1,1)	(1/5,1/3,1)
Management Review	(7,9,9)	(1,3,5)	(5,7,9)	(1,3,5)	(1,1,1)

Table 11 Clarified matrix for main criteria

Main Criteria	Politics	Planning	Implementation and Operation	Control	Management Review
Politics	1,00000	0,42222	0,42222	3,00000	0,11640
Planning	3,00000	1,00000	5,00000	7,00000	0,42222
Implementation and Operation	3,00000	0,21270	1,00000	0,21270	0,14709
Control	0,42222	0,14709	5,00000	1,00000	0,42222
Management Review	8,66667	3,00000	7,00000	3,00000	1,00000

CR=0,07<0,10 so the matrix is consistent. The weights of the main criteria were calculated as W= (0,05094, 0,36613, 0,00556, 0,11762, 0,45975). Therefore, the main criterion "*management review*" has a higher weight ratio than the others. On the other hand, the "*implementation and operation*" criterion has the lowest weight ratio.

Calculations of sub-criteria of the main criteria:

The pairwise comparison matrix prepared according to the survey data is given in Table 12 and Table 13.

Table 12 Fuzzy pairwise comparison matrix for sub-criteria of the main policy criterion

Policy Main Criteria Sub Criteria	Senior management support	Simplicity and understandability of the OHS policy	Measuring the initial risk for the development of OHS policy	Employee participation
Senior management support	(1,1,1)	(1,3,5)	(1/7,1/5,1/3)	(1/5,1/3,1)
Simplicity and understandability of the OHS policy	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(1/9,1/7,1/5)
Measuring the initial risk for the development of OHS policy	(3,5,7)	(1/5,1/3,1)	(1,1,1)	(1/9,1/9,1/7)
Employee participation	(1,3,5)	(5,7,9)	(7,9,9)	(1,1,1)

Table 13 Clarified matrix for sub-criteria of the main policy criterion

Policy Main Criteria Sub Criteria	Senior management support	Simplicity and understandability of the OHS policy	Measuring the initial risk for the development of OHS policy	Employee participation
Senior management support	1,00000	3,00000	0,21270	0,42222
Simplicity and understandability of the OHS policy	0,42222	1,00000	3,00000	0,14709
Measuring the initial risk for the development of OHS policy	5,00000	0,42222	1,00000	0,11640
Employee participation	3,00000	7,00000	8,66667	1,00000

CR=0,061<0,10 so the matrix is consistent. The weights of the policy sub-criteria were determined as W= (0,04232, 0,03305, 0,16337, 0,76126). In this context, the "*employee participation*" sub-criterion has the highest weight ratio, while the "*Measuring the initial risk for the development of OHS policy*" sub-criterion has the lowest weight ratio.

The pairwise comparison matrix prepared according to the survey data is given in Table 14 and Table 15.

Table 14 Fuzzy pairwise comparison matrix for sub-criteria of the main planning criterion

Planning Main Criteria Sub Criteria	Units use OHS data for development purposes	Financial resources allocated to OHS programs	Announcement of OHS programs
Units use OHS data for development purposes	(1,1,1)	(1/5,1/3,1)	(1,3,5)
Financial resources allocated to OHS programs	(1,3,5)	(1,1,1)	(3,5,7)
Announcement of OHS programs	(1,1/3,1/5)	(1/7,1/5,1/3)	(1,1,1)

Table 15 Clarified matrix for sub-criteria of the main planning criterion

Planning Main Criteria Sub Criteria	Units use OHS data for development purposes	Financial resources allocated to OHS programs	Announcement of OHS programs
Units use OHS data for development purposes	1,00000	0,42222	3,00000
Financial resources allocated to OHS programs	3,00000	1,00000	5,00000
Announcement of OHS programs	0,42222	0,21270	1,00000

CR=0,033<0,10 so the matrix is consistent. The weights of the planning sub-criteria were calculated as W= (0,37545, 0,57335, 0,05120). In this evaluation, the sub-criterion "*Financial resources allocated to OHS programs*" has the highest weight rate, while the sub-criterion "*Announcement of OHS programs*" has the lowest weight rate.

The pairwise comparison matrix prepared according to the survey data is given in Table 16 and Table 17.

Table 16 Fuzzy pairwise comparison matrix of sub-criteria of the main criteria of implementation and operation

Implementation and Operation Main Criteria Sub Criteria	Rate of non-adoption of OHS rules by employees	OHS documentation and regulations	Emergency response drills
Rate of non-adoption of OHS rules by employees	(1,1,1)	(5,7,9)	(1/5,1/3,1)
OHS documentation and regulations	(1/9,1/7,1/5)	(1,1,1)	(1/5,1/3,1)
Emergency response drills	(1,3,5)	(1,3,5)	(1,1,1)

Table 17 Clarified matrix for the sub-criteria of the main criterion of implementation and operation

Implementation and Operation Main Criteria Sub Criteria	Rate of non-adoption of OHS rules by employees	OHS documentation and regulations	Emergency response drills
Rate of non-adoption of OHS rules by employees	1,00000	7,00000	0,42222
OHS documentation and regulations	0,14709	1,00000	0,42222
Emergency response drills	3,00000	3,00000	1,00000

CR=0,028<0,10 so the matrix is consistent. The weights of implementation and operation sub-criteria were determined as W= (0,52389, 0,00000, 0,47611). In this case, "*Rate of non-adoption of OHS rules by employees*" sub-criterion has the highest weight rate, while the "*OHS documentation and regulations*" sub-criterion has the lowest weight rate.

The pairwise comparison matrix prepared according to the survey data is given in Table 18 and Table 19.

Table 18 Fuzzy pairwise comparison matrix of sub-criteria of the main criteria of control

Control Main Criteria Sub Criteria	Frequency of OHS audits	Continuous review of OHS audits	Review of accident investigations
Frequency of OHS audits	(1,1,1)	(1/7, 1/5, 1/3)	(1/5,1/3,1)
Continuous review of OHS audits	(3,5,7)	(1,1,1)	(1,3,5)
Review of accident investigations	(1,3,5)	(1/5,1/3,1)	(1,1,1)

Table 19 Clarified matrix for the sub-criteria of the control main criterion

Control Main Criteria Sub Criteria	Frequency of OHS audits	Continuous review of OHS audits	Review of accident investigations
Frequency of OHS audits	1,00000	0,21270	0,42222
Continuous review of OHS audits	5,00000	1,00000	3,00000
Review of accident investigations	3,00000	0,42222	1,00000

CR=0,033<0,10 so the matrix is consistent. The weights of the control sub-criteria are calculated as W= (0,05120, 0,57335, 0,37545). In this framework, the sub-criterion of "*Continuous review of OHS audits*" has the highest weight ratio, while the sub-criterion of "*frequency of OHS audits*" has the lowest weight ratio.

The pairwise comparison matrix prepared according to the survey data is given in Table 20 and Table 21.

Table 20 Fuzzy pairwise comparison matrix of sub-criteria of the main criteria of management review

Management Review Main Criteria Sub Criteria	OHS activity results available at the time of the inspection	Announcement of accident results to employees	The presence of responsible persons at review meetings
OHS activity results available at the time of the inspection	(1,1,1)	(1,3,5)	(3,5,7)
Announcement of accident results to employees	(1/5,1/3,1)	(1,1,1)	(1,3,5)
The presence of responsible persons at review meetings	(1/7,1/5,1/3)	(1/5,1/3,1)	(1,1,1)

Table 21 Clarified matrix for sub-criteria of the main criterion of management review

Management Review Main Criteria Sub Criteria	OHS activity results available at the time of the inspection	Announcement of accident results to employees	The presence of responsible persons at review meetings
OHS activity results available at the time of the inspection	1,00000	3,00000	5,00000
Announcement of accident results to employees	0,42222	1,00000	3,00000
The presence of responsible persons at review meetings	0,21270	0,42222	1,00000

CR=0,033<0,10 so the matrix is consistent. The weights of the management review sub-criteria are calculated as W= (0,57335, 0,37545, 0,05120). In this context, the sub-criterion "*OHS activity results available at the time of the inspection*" has the highest weight rate, while the sub-criterion "*presence of responsible persons at review meetings*" has the lowest weight rate.

6.2 Solution with fuzzy PROMETHEE method

The criteria weights determined by the FAHP method as a result of the calculation of the survey values were used to make the solution with the FPROMETHEE method.

In this study, the fifth type linear/linear preference function was used for all criteria. Among the variables in the preference function, q value is taken as 0 and p value is taken as 0,7 for all criteria. Pairwise comparison of alternatives is made for each criterion according to the selected preference function.

The evaluation of the alternatives according to the main criteria is given in Table 22.

Table 22 Evaluation of alternatives according to main criteria represented by linguistic variables

Main Criteria / Alternatives	Policy	Planning	Implementation and Operation	Control	Management Review
Shipyard1	(0,65; 0,15; 0,15)	(0,80; 0,15; 0,20)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)	(0,50; 0,20; 0,15)
Shipyard2	(0,50; 0,20; 0,15)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)	(0,80; 0,15; 0,20)	(0,50; 0,20; 0,15)
Shipyard3	(0,30; 0,15; 0,20)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)
Shipyard4	(0,15; 0,15; 0,15)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)
Shipyard5	(0,15; 0,15; 0,15)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)

PROMETHEE I produces a partial ranking of alternatives and PROMETHEE II produces a full ranking. The results are shown in Table 23.

Table 23 Superiority values and ranking results

	PROMETHEE I				PROMETHEE II	
	$\Phi^+ (a)$	Ranking	$\Phi^- (a)$	Ranking	Φ_{net}	Final Ranking
T1	0,25	2	0,00	4	0,25	2
T2	0,23	3	0,00	4	0,23	3
T3	0,33	1	0,01	3	0,32	1
T4	0,00	4	0,30	2	-0,30	4
T5	0,00	4	0,50	1	-0,50	5

Table 23 shows the positive, negative and net superiority values. Among the net superiority values, Shipyard3 alternative was found to be superior to the others with a ratio of 0,32. The other alternatives are Shipyard1, Shipyard2, Shipyard4 and Shipyard5 respectively.

FPROMETHEE solutions for sub-criteria:

The sub-criteria weights determined by the FAHP method were used to make a solution with the FPROMETHEE method.

The evaluation of the alternatives according to the sub-criteria of the policy main criterion is given in Table 24.

Table 24 Evaluation of alternatives against the main policy criterion Sub-criteria represented by linguistic variables

Policy Sub Criteria / Alternatives	Senior management support	Simplicity and understandability of the OHS policy	Measuring the initial risk for the development of OHS policy	Employee participation
Shipyard1	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(0,50; 0,20; 0,15)	(1,00; 0,20; 0,00)
Shipyard2	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard3	(0,15; 0,15; 0,15)	(0,65; 0,15; 0,15)	(0,65; 0,15; 0,15)	(1,00; 0,20; 0,00)
Shipyard4	(0,15; 0,15; 0,15)	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)
Shipyard5	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)	(0,50; 0,20; 0,15)

In line with the calculations made, the superiority values of the policy sub-criteria are given in Table 25.

Table 25 Superiority values and ranking results of alternatives for policy sub-criteria

	PROMETHEE I				PROMETHEE II	
	$\Phi^+ (a)$	Ranking	$\Phi^- (a)$	Ranking	Φ_{net}	Final Ranking
T1	0,27	2	0,02	4	0,24	2
T2	0,36	1	0,00	5	0,36	1
T3	0,23	3	0,05	3	0,18	3
T4	0,00	5	0,40	1	-0,40	5
T5	0,01	4	0,39	2	-0,38	4

Table 25 shows the positive, negative and net superiority values for the policy sub-criteria. According to the net superiority values, Shipyard2 alternative is found to be superior to the others with a ratio of 0,36. The other alternatives are Shipyard1, Shipyard3, Shipyard5 and Shipyard4 respectively.

The evaluation of the alternatives according to the sub-criteria of the main planning criterion is given in Table 26.

Table 26 Evaluation of alternatives according to the sub-criteria of the main planning criterion represented by linguistic variables

Planning Sub Criteria / Alternatives	Units use OHS data for development purposes	Financial resources allocated to OHS programs	Announcement of OHS programs
Shipyard1	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard2	(0,65; 0,15; 0,15)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard3	(0,50; 0,20; 0,15)	(0,30; 0,15; 0,20)	(1,00; 0,20; 0,00)
Shipyard4	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)
Shipyard5	(0,15; 0,15; 0,15)	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)

In line with the calculations made, the superiority values of the planning sub-criteria are given in Table 27.

Table 27 Superiority values and ranking results of alternatives for planning sub-criteria

	PROMETHEE I				PROMETHEE II	
	$\Phi^+ (a)$	Ranking	$\Phi^- (a)$	Ranking	Φ_{net}	Final Ranking
T1	0,74	1	0,00	5	0,74	1
T2	0,64	2	0,04	4	0,61	2
T3	0,07	3	0,34	3	-0,27	3
T4	0,00	4	0,51	2	-0,51	4
T5	0,00	4	0,56	1	-0,56	5

Table 27 shows the superiority values for the planning sub-criteria. According to the net superiority values, Shipyard1 alternative is found to be superior to the others with a ratio of 0,74. The other alternatives are Shipyard2, Shipyard3, Shipyard4 and Shipyard5, respectively.

The evaluation of the alternatives according to the sub-criteria of the main criteria of implementation and operation is given in Table 28.

Table 28 Evaluation of alternatives according to the sub-criteria of the main implementation and operation criterion represented by linguistic variables

Implementation and Operation Main Criteria Sub Criteria / Alternatives	Rate of non-adoption of OHS rules by employees	OHS documentation and regulations	Emergency response drills
Shipyard1	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard2	(0,50; 0,20; 0,15)	(0,80; 0,15; 0,20)	(1,00; 0,20; 0,00)
Shipyard3	(0,15; 0,15; 0,15)	(0,50; 0,20; 0,15)	(0,65; 0,15; 0,15)
Shipyard4	(0,15; 0,15; 0,15)	(0,50; 0,20; 0,15)	(0,65; 0,15; 0,15)
Shipyard5	(0,30; 0,15; 0,20)	(0,50; 0,20; 0,15)	(0,65; 0,15; 0,15)

In line with the calculations made, the superiority values for implementation and operation sub-criteria are given in Table 29.

Table 29 Superiority values and ranking results of alternatives for implementation and operation sub-criteria

PROMETHEE I					PROMETHEE II	
	Φ⁺ (*a*)	**Ranking**	**Φ⁻ (*a*)**	**Ranking**	**Φ_{net}**	**Final Ranking**
T1	0,62	1	0,00	4	0,62	1
T2	0,27	2	0,08	3	0,19	2
T3	0,00	3	0,29	1	-0,29	4
T4	0,00	3	0,29	1	-0,29	4
T5	0,00	3	0,23	2	-0,23	3

According to the net superiority values shown in Table 29 for the implementation and operation sub-criteria, Shipyard1 alternative is found to be superior to the others with a ratio of 0,62. The other alternatives are Shipyard2, Shipyard5, Shipyard3 and Shipyard4, respectively.

The evaluation of the alternatives according to the sub-criteria of the control main criterion is given in Table 30.

Table 30 Evaluation of the alternatives according to the sub-criteria of the control main criterion represented by linguistic variables

Control Main Criteria / Sub Criteria / Alternatives	Frequency of OHS audits	Continuous review of OHS audits	Review of accident investigations
Shipyard1	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard2	(0,30; 0,15; 0,20)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard3	(0,65; 0,15; 0,15)	(0,80; 0,15; 0,20)	(0,50; 0,20; 0,15)
Shipyard4	(0,30; 0,15; 0,20)	(0,65; 0,15; 0,15)	(0,30; 0,15; 0,20)
Shipyard5	(0,30; 0,15; 0,20)	(0,30; 0,15; 0,20)	(0,50; 0,20; 0,15)

In line with the calculations made, the superiority values of the control sub-criteria are given in Table 31.

Table 31 Superiority values and ranking results of alternatives for control sub-criteria

PROMETHEE I					PROMETHEE II	
	Φ⁺ (*a*)	**Ranking**	**Φ⁻ (*a*)**	**Ranking**	**Φ_{net}**	**Final Ranking**
T1	0,43	1	0,00	5	0,43	1
T2	0,39	2	0,03	4	0,36	2
T3	0,18	3	0,12	3	0,06	3
T4	0,14	4	0,42	2	-0,28	4
T5	0,09	5	0,67	1	-0,58	5

According to the net superiority values shown for the control sub-criteria in Table 31, Shipyard1 alternative is found to be superior to the others with a ratio of 0,43. The other alternatives are Shipyard2, Shipyard3, Shipyard4 and Shipyard5, respectively.

The evaluation of the alternatives according to the sub-criteria of the main criterion of management review is given in Table 32.

Table 32 Evaluation of the alternatives according to the sub-criteria of the management review main criterion represented by linguistic variables

Management Review Main Criteria Sub Criteria / Alternatives	OHS activity results available at the time of the inspection	Announcement of accident results to employees	The presence of responsible persons at review meetings
Shipyard1	(0,80; 0,15; 0,20)	(0,80; 0,15; 0,20)	(0,80; 0,15; 0,20)
Shipyard2	(0,65; 0,15; 0,15)	(1,00; 0,20; 0,00)	(1,00; 0,20; 0,00)
Shipyard3	(0,30; 0,15; 0,20)	(0,65; 0,15; 0,15)	(0,50; 0,20; 0,15)
Shipyard4	(0,15; 0,15; 0,15)	(0,30; 0,15; 0,20)	(0,15; 0,15; 0,15)
Shipyard5	(0,30; 0,15; 0,20)	(0,15; 0,15; 0,15)	(0,15; 0,15; 0,15)

In line with the calculations made, the superiority values of the management review sub-criteria are given in Table 33.

Table 33 Superiority values and ranking results of alternatives for management review sub-criteria

	PROMETHEE I				PROMETHEE II	
	$\Phi^+(a)$	Ranking	$\Phi^-(a)$	Ranking	Φ_{net}	Final Ranking
T1	0,79	1	0,00	5	0,79	1
T2	0,55	3	0,29	3	0,27	3
T3	0,63	2	0,27	4	0,36	2
T4	0,09	4	0,76	2	-0,66	4
T5	0,01	5	0,77	1	-0,76	5

According to the net superiority values of the management review sub-criteria in Table 33, Shipyard1 alternative is found to be superior to the others with a ratio of 0,79. The other alternatives are Shipyard3, Shipyard2, Shipyard4 and Shipyard5, respectively.

6.3 Evaluation of the results

In the first stage, the weights of the criteria were determined using the FAHP method. Afterwards, the priority ranking of the alternatives was made with FPROMETHEE. In the study conducted with FAHP for the main criteria, the main criterion “Management Review” was found to have a higher weight ratio than the others. When the solution was made with FPROMETHEE, Shipyard3 ranked first in the priority ranking.

7 Conclusions and recommendations

In this study, OHSMS performance in shipyard enterprises was evaluated using FAHP and FPROMETHEE methods. In the research, five main criteria and 16 sub-criteria were selected to evaluate OHSMS performance in shipyard enterprises, and five shipyards operating in Yalova-Altınova Shipyards Region were determined as alternative shipyards.

A questionnaire form was created in such a way that the criteria and alternatives were compared among themselves and evaluated by five experts working as occupational safety experts in Yalova-Altınova Shipyards Region. The survey data were analyzed using Microsoft Office Excel program and the weights of the main and sub-criteria were calculated using the FAHP method. In the calculations, the extended order analysis method used by Chang and triangular fuzzy numbers were used. As a result of the calculations, it was revealed that the main criterion with the highest weight was “management review” with “0.45975”. Management review in the OHSM System is vital for continuous improvement and effectiveness. This review process assesses the organization’s OHS performance and evaluates the effectiveness of existing policies, procedures and practices. Management review allows the business to make important decisions at the strategic level to meet changing requirements and ensures that resources are allocated correctly. It also helps to identify future risks and take precautions when assessing the achievement of OHS objectives. As a result, effective management review at regular intervals allows the business to continuously improve its OHS performance and take the necessary measures to ensure the safety of workers. The most effective sub-criterion of the main criterion “management review” was the OHS activity results available at the time of the review. The OHS activity results available at the time of the review have a critical role to play in objectively assessing the current OHS performance of the organization. These results provide reliable data to measure the actual effectiveness of OHS policies and practices. OHS activity results are an important resource for identifying existing risks, identifying important safety trends and planning future safety strategies. They also play an important role in identifying the corrective actions necessary to ensure the legal compliance of the business and protect the safety of employees. The main criterion "implementation and operation" (0,00556) has the lowest weight. The weight ranking for the main criteria is MR>PL>CO>PO>IO (0,45975>0,36613 >0,11762>0,05094>0,00556). The results of the calculations made in the same way for the sub-criteria; PO main criterion sub-criteria weights are PO4>PO3> PO1>PO2 (0,76126>0,16337>0,04232>0,03305), PL main criterion sub-criteria weights are PL2>PL1>PL3 (0,57335>0,37545>0,05120), IO main criterion sub-criteria weights are IO1>IO3>IO2 (0,52389>0,47611> 0,00000), CO main criterion sub-criteria weights as CO2>CO3>CO1 (0,57335>0,37545>0,05120) and the weights of the sub-criteria of the main criterion MR are MR1>MR2>MR3 (0,57335, 0,37545, 0,05120). Based on these findings, it can be said that the management should be actively involved in the operation for high OHSMS performance in shipyard enterprises. Accordingly, keeping the results of OHS activities available to the management on a continuous basis will enable performance evaluations to be made more effectively.

Criteria weights were entered into Microsoft Office Excel program and FPROMETHEE calculations were used to rank the net alternatives for the main criteria and Shipyard 3 (S3) (Φ_{net} = 0,32) was found to be the best alternative. The net alternative ranking for the main criteria is S3>S1>S2>S4>S5 (0,32>0,25>0,23> –0,30>–0,50). The results of the calculations made in the same way for the sub-criteria; for the PO main criterion sub-criteria, the net alternative ranking is S2>S1>S3>S5>S4 (0,36>0,24>0,18>-0,38>-0,40), for the sub-criteria of the PL main criterion, the net alternative ranking is S1>S2>S3>S4>S5 (0,74>0,61>–0,27> –0,51>–0,56), the net alternative ranking for the sub-criteria of the main criterion IO is S1>S2>S5>S3=S4 (0,62>0,19>-0,23>–0,29=–0,29), the net alternative ranking for the sub-criteria of the CO main criterion is S1>S2>S3>S4>S5 (0,43>0,36>0,06>–0,28>–0,58) and the net alternative ranking for the sub-criteria of the MR main criterion is S1>S3>S2>S4>S5 (0,79>0,36>0,27> –0,66>–0,76). According to the main criteria, the S3 alternative has come to the forefront, but the results of the sub-criteria have particularly emphasized the S1 alternative in terms of net superiority. According to these findings, among the alternative shipyards, S3 is the shipyard with the highest OHSMS performance in terms of main criteria, while S1 is the shipyard with the highest OHSMS performance in terms of alternative criteria.

As a result, in this study, the most important OHSMS performance criteria were tried to be determined and it was aimed to determine the alternative with the best OHSMS performance among the alternatives in line with these criteria and to rank them according to their importance.

When the findings of other studies in the literature are compared with the findings of this study, similar results are observed. Inan et al. (2017) found that among the OHS policy, planning, implementation and operation, control and management review criteria determined for the OHSMS performance comparison of three companies in the packaging sector, planning and management review ranked first in terms of importance. It revealed the importance of planning in OHSMS activities and the importance of senior management's perspective on OHS issues. Azadeh et al. (2012), in the study, power plant OHSMS performance evaluation was conducted. Leadership and commitment, policy and strategic objective, planning, organization/resources and documentation, assessment and risk management, audit and review were identified as OHSMS indicators, and the audit and review indicator was identified as the indicator with the highest efficiency. As can be seen, management-related criteria and indicators come to the forefront in OHSMS performance. According to the literature review, although it is seen that OHSMS performance evaluation, which is the subject of the study, has been carried out in different sectors and using different methods, it is seen that there are not many studies. Although the studies in the literature have been conducted for different sectors, it is seen that criteria or indicators similar to the criteria used in the study (policy, planning, implementation and operation, control, management review) are preferred when evaluating OHSMS performance. When the results of the studies are analyzed, it is seen that "management review" and "planning" are the most effective criteria or indicators.

As a result, it is necessary to establish and maintain OHSMS in order to be preferable in terms of employee health and safety and to be able to perform better in every sense among competing businesses doing the same job in the future. Continuity can be ensured by checking the efficiency of OHSMS by conducting audits at reasonable intervals. In particular, it can be said that the management should take a more active role in the continuity of the system, the system should be constantly reviewed by the management and OHS activity results should be made available in the form of reports. The most important limitation of this study is that the OHSMS performance in shipyard enterprises is selected according to the specified criteria and the alternatives are selected from the shipyards operating in Yalova-Altınova Shipyards Region. Therefore, different criteria and alternatives can be evaluated by different methods for shipyard enterprises. Accordingly, it is suggested that in future studies, OHSMS performance evaluation in shipyard enterprises should be handled with different methods by selecting different criteria and alternatives.

The most important limitation of this study is that the OHSMS performance in shipyard enterprises is evaluated according to the specified criteria and the alternatives are selected from the shipyards operating in Yalova-Altınova Shipyards Region. Therefore, different criteria and alternatives can be evaluated with different methods for shipyard enterprises. Accordingly, in future studies, it is recommended that OHSMS performance evaluation in shipyard enterprises should be handled with different methods by selecting different criteria and alternatives.

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