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Safety Assessment of Passengers and Houseboats: A Case Study of Kenyir Lake

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ABSTRACT

Kenyir Lake, located in Terengganu, Malaysia, is the largest man-made lake in mainland Southeast Asia, with an area of more than 200,000 hectares. The problem is that passenger safety is taken lightly during family-like activities. This study has three objectives: first, to identify the elements and sub-elements of passenger safety; second, to rank the elements of passenger safety onboard the houseboat; and lastly, to recommend the best solutions to improve passenger safety onboard the houseboat at Kenyir Lake. In the first stage, the factors that contribute to passenger safety were identified through a literature review, and the collected information was used to form a questionnaire. A field survey was then conducted on houseboats through the distribution of the questionnaire. The data were analyzed using the Analytic Hierarchy Process (AHP) method, literature review, and expert judgement. The analyzed data can be used to recommend onboard improvements to increase the level of passenger safety. The outcomes of this research show that Monitor ranked first, Knowledge ranked second, and Respond ranked third among the passenger safety elements. Recommendations such as monthly safety auditing and inspection, and implementation of a machinery maintenance plan and an emergency response plan, are practical means of securing passenger safety. To conclude, this study emphasizes the importance of the passenger safety elements according to their ranking and proposes relevant solutions for boat tourism sectors and related agencies to carry out.

1. Introduction.

Houseboat is a unique transformation concept of a boat into a residential paradigm. Houseboat can be categorized into two types: perpetually harbored and propelled harbored (Network, 2021). While the non-cruising houseboats are static houseboats where it is anchored, moored, or tied to a dock and immobile as they lack propellers, unable to navigate the water, meanwhile, cruising houseboats come with a sail or engine allowing it to propel in the water. The modified boat is familiar with family during vacation as they provide interesting activities onboard.

Kenyir Lake is the exotic land lies of the Southeast Asia, Malaysia where it becomes the most tourist sports in Terengganu. It is the largest man-made lake in mainland South East Asia with an area of 260,000 hectares (Lake Kenyir, 2015). In local, Kenyir Lake is well known for their houseboat and boat-trip activities. This study was conducted at Kenyir Lake which located in Hulu Terengganu, Terengganu. This place has high frequency of tourists such the activities offered here are boat trips, houseboat, and activities for local fisherman. Referring to a Borneo Post publication titled 'Houseboats the best way to explore Kenyir Lake', about 79 houseboats, 79 speedboats and 53 car topper boats receive license to operate in Kenyir Lake (Mohd Nordin, 2017). However, the man-made lake safety aspect should be analyses because there is safety measure that need to be maintain to avoid recent incident of man overboard or accidents that can harm people.

On passenger ship, there must be a life jacket enough for every person on board ship and life jacket for each child or 10% of the total number of passengers whichever is higher (Anish, 2021). The application and compliance of life-saving equip-

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Table 1: Literature review on elements and sub-elements.

Element	Sub-element	Literatures
Knowledge	Familiarisation with Safety equipment/ Life-Saving Appliances	Passengers who are aware and well-informed are more likely to survive any potentially fatal circumstances that may arise onboard (ICAO, 2018)
	Application of Safety Equipment/ Life Saving Appliances	Passengers' survival rates are improved when they are informed about the correct use of equipment and the actions, they should take in the event of an emergency situation (ICAO, 2018).
	Safety Awareness	Safety awareness was further clustered into three dimensions, which included safety information, vessel condition and rescue equipment (Lau et al., 2021).
Respond	Readiness for Action	The impact of elements such the ship's emergency response procedure, crew members' emergency responses and responsibilities, and an evaluation of the level of security on board on preventing and controlling emergency situations (Cheng & Miao, 2009)
	Safety Equipment/ Life-Saving Appliances Reliability	Accidents occur in inland water due the insufficient safety equipment onboard at Temenggong Lake. (Razak et al., 2020)
Monitor	Accident	Razak et al. (2020) in their study highlights the accidents that are likely to occur on houseboat are man overboard, which is ranked first followed by the risk of children drowning, fire on board and lastly sinking of houseboat.
	Natural Factors	The possibility of bigger floods because water from the dam would be released (Bernama, 2022). Weather conditions such mist, fog, and rainstorms reduce visibility, causing difficulty to navigate or detect hazard in water (Fortey, 2022)
	Safety Equipment/ Life-Saving Appliances maintenance	The life-saving equipment must fulfil particular performance goals set forth by standards and regulations. As conditions become more severe than what is prescribed in the standards, these information gaps will widen, potentially leading to even worse life-saving appliance performance than what is currently measured (Power & Ré, 2015).

Source: Authors.

ment such as personal floatation device has been taken lightly on the passenger boat and houseboat especially when it involving the family-like activities on water. Children drowning risk is highest for passenger boat and man overboard is the highest for houseboat, where most accidents happened on inland water causes from the insufficient safety equipment onboard at Temenggor Lake (Razak et al., 2020).

The water activities associate with drowning cases taking places in local man-made lake. In recent case, a toddler was reported for drowning after fell overboard the houseboat in Kenyir Lake (Bernama, 2021). The State police chief Datuk Rohaimi Md Isa said the three years old victim fell overboard and was unconscious when he was rescued by a houseboat worker 10 minutes later, and the worker tried to resuscitate the toddler but failed. Thus, the study is conducted to identify the elements of passenger safety onboard the houseboat at Kenyir Lake. This study will identify the main elements of passenger safety and houseboat and emphasizing the elements involved onboard.

2. Literature Review.

Table 1 contains the supporting literature on elements and sub-elements of the passenger safety.

2.1. Definition of Life Saving Appliances.

LSA Code which is the International Life - Saving Appliance Code, was adopted by the Maritime safety Committee of the Organization by resolution MSC.48(66), as amended(IMO, 2019). Also, provides more precise technical requirements for the manufacturing, testing, maintenance and record keeping of the life-saving appliances.

According to International Maritime Organization (2019), life-saving appliances used for passenger safety to protect from injuries, casualties and life-threatening situations where vessels must carry appropriate life-saving appliances, such as lifeboats, lifebuoys, life-jackets, life rafts etc., and International Life - Saving Appliances (LSA) Code, 2017 edition.

2.1.1. Lifejacket.

A personal floatation device is a type of safety device that keeps humans afloat in the water in the case of emergency such as falling overboard the vessel. In the United States in 2012, 85 percent of recreational boating-related drowning victims did not wear a life jacket, therefore, lifejacket is compulsory on every vessel (Pitman et al., 2019).

2.1.2. Lifebuoy.

This life saving appliance is designated to be thrown to casualty within the water to provide buoyancy and avoid drowning and located at side port and starboard. It is ring shaped and has a connecting line allowing the casualty to be pulled to the rescue boat. The following specifications are required by SOLAS for each lifebuoy (Shivansh, 2021):

The outer diameter shall not exceed 800mm with inner diameter is 400mm for the least.

Minimum weight is 2.5 kg and able to maintain 14.5 kg of iron afloat in freshwater for 24 hours.

2.2. Safety Requirements on Houseboat in Temenggor Lake.

Table 2: The comparison of safety requirements between US Coast Guard and Temenggor Lake Authority.

Objective	Data Collection	Data Analysis
To identify the elements of the passenger safety.	Secondary data: -Literature review -Article	Quantitative data analysis
To rank the element of the passenger safety onboard the houseboat at Kenyir Lake.	Primary data: -Site survey -Questionnaire -Interview	Hierarchy Structural Model Analytical Hierarchy Process (AHP)
To recommend best solution in improving the passenger safety onboard the houseboat at Kenyir Lake.	Secondary data: -Literature Review Primary data: -Expert judgement	Expert judgement analysis and discussion

Source: Razak et al., 2020.

Razak et al., (2020) stated the passenger boats should at least bring the number of life jacket equal to the capacity of boat according to minimum requirements that has been set up by lake authority. Also, they stated that the minimum requirements for all houseboats are, at least bring 4 units of fire extinguisher, 1 first aid, 2 rescue boat for each houseboat, muster station plan and total number of life jacket based on the total capacity of houseboat in Temenggor Lake.

3. Methodology.

Table 3 shows the research design based on the objective. Each objective has its own data collection and data analysis. The first objective is to identify the element of the passenger safety. So, the data collection used in this objective is primary and secondary data. Data collection is analyzed using the quantitative data analysis. Followed by the second objective, which is to rank the most important elements of the passenger safety on houseboat at Kenyir Lake.

Table 3: Methodology used in conducted research.

Equipment	Us Coast Guard	Temenggor Lake Authority
Life Jacket	Based on total capacity of passenger + 1 lifebuoy (more than 16ft)	Based on total capacity of passenger
First Aid	1 first aid	1 first aid
Fire Extinguisher	1 fire extinguisher	1 fire extinguisher

Source: Authors.

For this objective, the primary data was obtained by using questionnaire, site survey and expert judgement. The questionnaire distributed to the respondents who are the passengers or crew of the houseboat. The respondents received a short briefing regarding the passenger safety and its element. Lastly, the passenger safety element analyzed from the questionnaire by using Hierarch Structural Model and Analytical Hierarchy Process (AHP) software.

The third objective is to recommend the best solutions in improving the passenger safety level onboard the houseboat at Kenyir Lake. The input from the previous objective will be used for further solutions. The expert will give feedbacks and recommendations based on the passenger safety necessity or weaknesses.

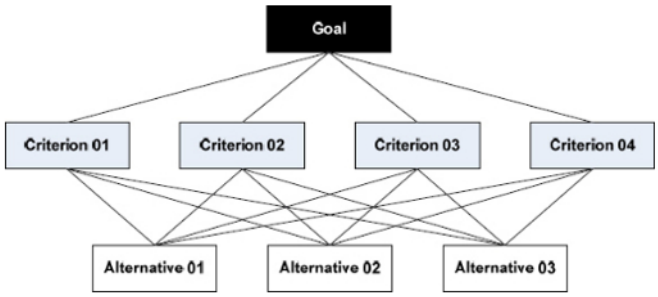
3.1. Data Analysis.

The Analytic hierarchy process (AHP) developed by Saaty in 1987 (R. W. Saaty, 1987) is a tool used to make a decision in multiple criteria. Analytical Hierarchy Process is a system that is acknowledged to produce multiple criteria decisions because this method allows for the formulation of the problem as a hierarchical and the belief in a combination of quantitative qualitative criteria (Hamed Taherdoost, 2017). It was used to compare and rank the identified factors, and provide a numeric scale for the measurement of qualitative and quantitative performance. AHP method contain three steps; First, the problem has to be broken down and structured into a hierarchy of sub problems; Second, the collected data is measured through pairwise comparison of the feature; Finally, the priority weights of factors or items in each level are calculated.

3.1.1. Analytic Hierarchy Process.

The analytic hierarchy process is used to perform multicriteria programming, which is a strategy for making decisions in complicated situations where many variables or criteria are examined in the prioritizing and selection of alternatives or projects (Viana Vargas, 2010). There AHP steps are explained as below:

Figure 1: The example of data analysis from Analytic Hierarchy Process.



Source: Viana Vargas, 2010.

Step 1: The problem is decomposed into a hierarchy goal, criteria, and alternatives. The decision problem is fundamental to be structured in the process of AHP.

Step 2: The data are collected from experts corresponding to the hierarchic structure, in the pairwise comparison of alternatives on a qualitative scale. Experts should rate the comparison as Table 4.

Table 4: The ratio of pair-wise comparison.

Linguistic Meaning	**Numerical Assessment**
High	3
Slightly High	5
Very High	7
Extremely High	9
Intermediate values between two adjacent	2, 4, 6, 8
Equal	1
Low	1/3
Slightly Low	1/5
Very Low	1/7
Extremely Low	1/9
Intermediate values between two adjacent	½, ¼, 1/6, 1/8

Source: Authors.

Step 3: The pairwise comparison of various criteria generated at step 2 are organized into a square matrix. The diagonal elements of the matrix are 1. The criteria in the *i*th row is better than criterion in the *j*th column if the value of element (*i,j*) is more than 1; otherwise, the criterion in the *j*th column is better than in the *i*th row.

Table 5: The pair-wise comparison matrix of main criteria.

	Criteria 1	Criteria 2	Criteria 3
Criteria 1	1	1/3	5
Criteria 2	3	1	7
Criteria 3	1/5	1/7	1

Source: Authors.

Step 4: The principal eigenvalue and the corresponding normalized right eigenvector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalized eigenvector are termed weights with respect to the criteria and ratings with respect to the alternative.

Table 6: Pairwise of Priority Vector.

	Criteria 1	Criteria 2	Criteria 3
Criteria 1	1	1/3	5
Criteria 2	3	1	7
Criteria 3	1/5	1/7	1
Sum	21/5	31/21	13

Source: Authors.

Table 7: Priority Vector.

	Criteria 1	Criteria 2	Criteria 3
Criteria 1	5/21	7/31	5/13
Criteria 2	15/21	21/31	7/13
Criteria 3	1/21	3/31	1/13
SUM	1	1	1

Source: Authors.

Figure 2: The example of the Comparison Matrix.

	STAKEHOLDERS C	FINANCIAL	STRATEGIC	OTHER CRITERIA
Stakeholders C	1	1/5	1/9	1
Financial	5	1	1	5
Strategic	9	1	1	5
Other Criteria	1	1/5	1/5	1
Total (Sum)	16.00	2.40	2.31	12.00
	Results			
Stakeholders C	1/16 = 0.063	0.083	0.048	0.083
Financial	5/16 = 0,313	0.417	0.433	0.417
Strategic	9/16 = 0.563	0.417	0.433	0.417
Other Criteria	1/16 = 0.063	0.083	0.087	0.083

Table 4 – Comparison Matrix for ACME's Group of Criteria after Normalization

Source: Viana Vargas, 2010.

The normalized principal Eigen vector is called as Priority Vector and the sum of all elements in priority vector is 1 since it is normalized. The priority vector shows relative weight among the things that were compared. For example, Criteria 1 is 28.28%, Criteria 2 is 64.34% and Criteria 3 is 7.38%. Most preferable factor is Criteria 2, followed by Criteria 1 and Criteria 3.

W = 1/3 x 0.2381 + 0.2258 + 0.3846 = 0.2828

W = 1/3 x 0.7143 + 0.6774 + 0.5385 = 0.6434

W = 1/3 x 0.0476 + 0.0968 + 0.0769 = 0.0738

Step 5: The consistency of the matrix *n* is evaluated. The consistency index, CI is calculated as

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

Where,

$$\lambda max = \frac{21}{5}(0.28280 + \frac{31}{21}(0.6343) + 0.0738) = 3.0967 \quad (2)$$

Then,

$$CI = \frac{\lambda \max - n}{n-1} = \frac{3.0967 - 3}{2} = 0.0484 \quad (3)$$

Where, λmax is the maximum eigenvalue of the judgement matrix. CI is compared with Random Matrix, RI. The ratio derived, CI/RI is termed as consistency ratio, CR and the value should be less than 0.1. Consistency Ratio Formula is:

$$CR = \frac{CI}{RI} \quad (4)$$

Table 8: The Random Consistency Index.

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

Source: Authors.

Inconsistency is acceptable if the value of Consistency Ratio is smaller or equal to 10%. From the example, CR= CI/RI = 0.0484/0.58 = 8.3% < 10%. Thus, subjective evaluation of the criteria is acceptable.

4. Results and Discussion.

This section discusses the findings of this research. The result of this research analyses and discussed in this chapter. The discussions based on literature review, questionnaire, expert judgement and site view.

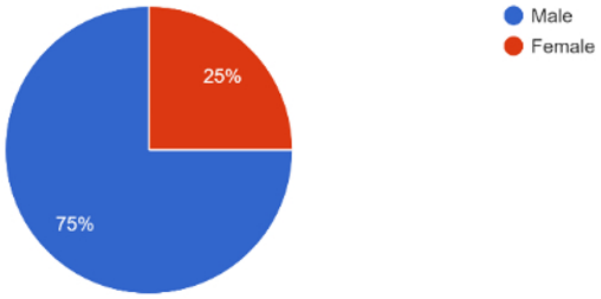
4.1. Demographic Information.

Total of the respondents involved are 20 persons from 10 houseboats at Kenyir Lake. Ten of them are passengers and another ten are houseboat crew, as to avoid any bias in the data collection. The minimum number of samples required to reach a margin of error/CR value of 0.05 is 19 for the questionnaire to be valid (Melillo & Pecchia, 2016). One judge is sufficing for the method if he has both knowledge and practical experience in a particular field, where he can make the judgements alone without having to rely on others who may not be as qualified as him (Saaty & Özdemir, 2014). The respondents have answered the questionnaire and interview had been conducted on them regarding the research study.

4.1.1. Statistic on Gender of the Respondents.

Figure 3 shows the result of the respondent's gender. Mostly, there are male respondents compared female respondents.

Figure 3: Gender of the Respondent.

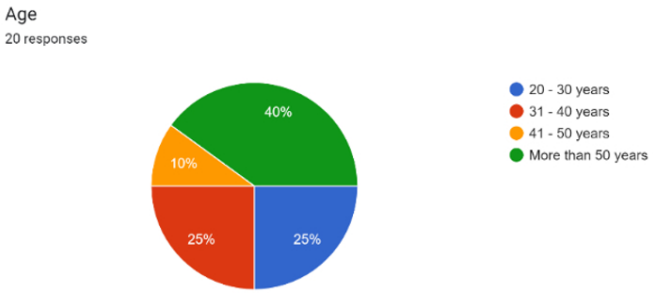


Source: Authors.

4.1.2. Statistic on Age of the Respondents.

Figure 4 shows the result of the respondent's age. Most of them aged more than 50 years old. From the pie chart, 8 of the respondents aged more than 50 years, 5 respondents aged in the range of 31 to 40 years and 5 respondents aged between 41 to 50 years. Only 2 of the respondents aged between 20 to 30 years.

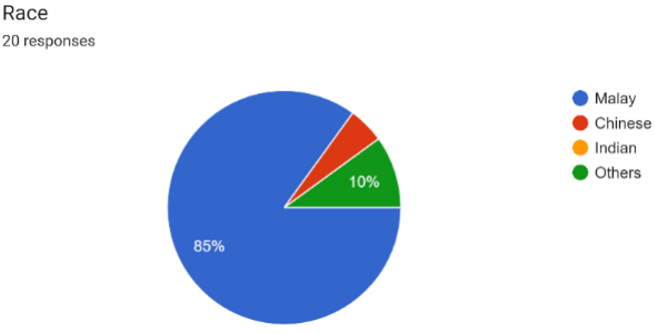
Figure 4: Age of the Respondents.



Source: Authors.

4.1.3. Statistic on Race of the Respondents.

Figure 5: Race of the Respondents.



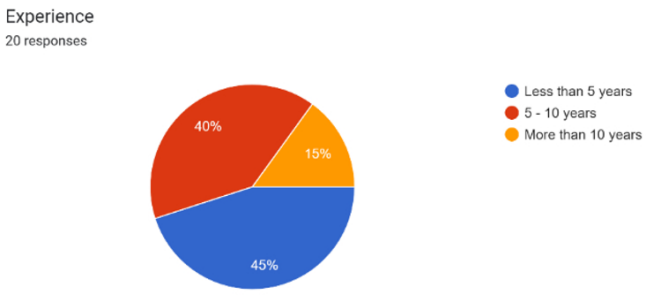
Source: Authors.

Figure 5 shows the result of the respondents' race. Most of them are Malay followed by Others and Chinese.

4.1.4. Statistic on the Houseboating Experience of the Respondents.

Figure 6 shows the result of the years of experience in houseboating among the respondents. The respondents experience are mostly less than 5 years.

Figure 6: Experience of the Respondents.



Source: Authors.

4.2. *Elements of Passenger Safety.*

4.2.1. *Knowledge.*

Knowledge is facts, information, and abilities acquired via education or experience. It is particular the theoretical or practical understanding of a subject. The several sub-criteria of the knowledge are as below:

i. Familiarization with the Safety Equipment's.
ii. Application of Safety Equipment.
iii. Safety Awareness.

4.2.2. *Respond.*

Respond means that knowing what to do and how to respond to regular and irregular disruptions and disturbances either by implementing a prepared set of responses or by adjusting normal function and this is the ability to address the actual. The sub-criteria of the respond are:

i. Readiness for Action.
ii. Safety Equipment Reliability.

4.2.3. *Monitor.*

Monitor is what to look for and how to monitor that which is or can become threat. This element must cover both that which happens in the environment and which happens in the system and its performance. Monitor is the ability to address the critical. The several sub-criteria's the monitor is:

i. Accident
ii. Natural Factors (Weather)
iii. Safety Equipment or Life-Saving Appliances (LSA) Maintenance

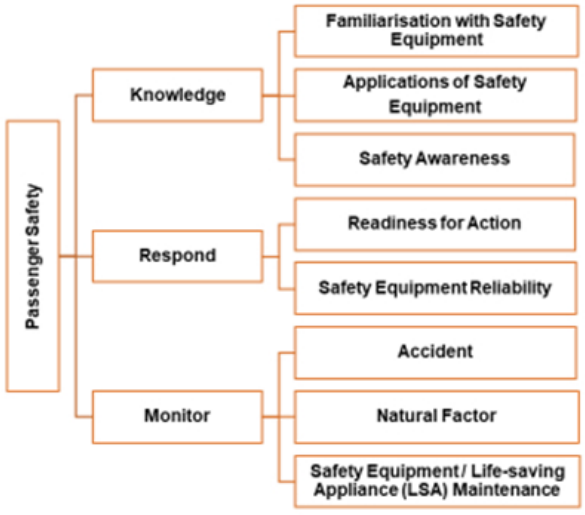
4.3. *Results and Analysis from Questionnaire.*

The results analyzed using Analytic Hierarchy Process (AHP) Software. The result will determine the most important element of the passenger safety.

4.3.1. *Main Element Analysis.*

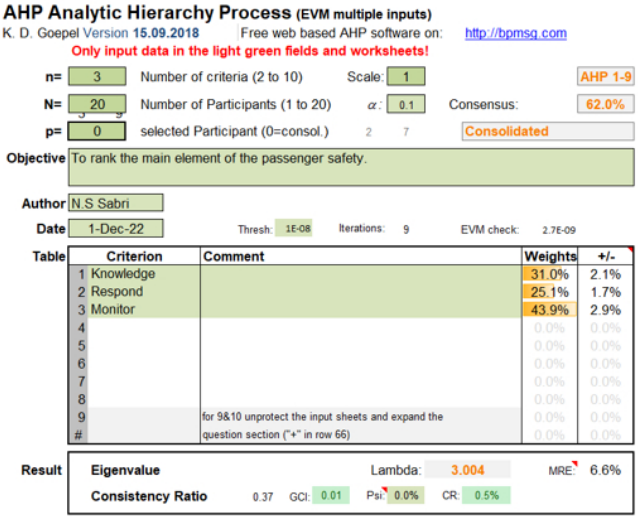
Figure 8 shows the summary of all the 20 respondents on main element of the passenger safety. The value of the Consistency Ratio is 0.5% which is below than 1.0%. Hence, the data is valid. It concludes that Monitor is the most important followed by Knowledge and Respond.

Figure 7: Hierarchy Structural Model.



Source: Authors.

Figure 8: Summary of Main Element of the Passenger Safety.

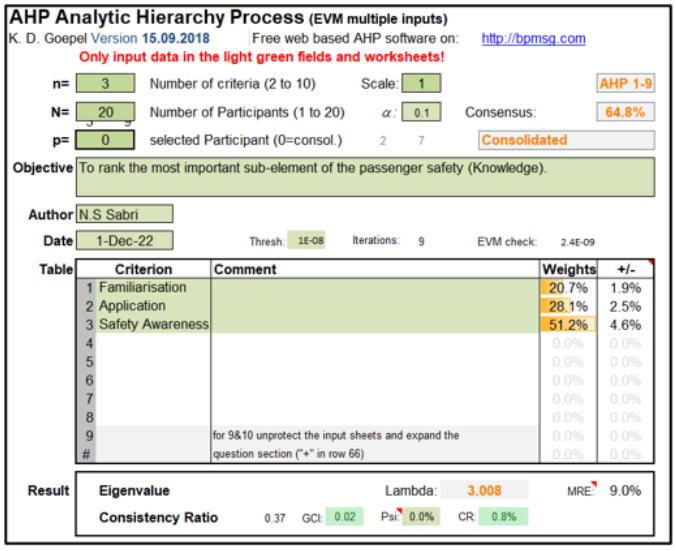


Source: Authors.

4.3.2. *Sub-Criteria of Knowledge Element Analysis.*

Figure 9 shows the summary of all 20 respondents on Knowledge sub-criteria element of the passenger safety. The value of the Consistency Ratio (CR) is 0.8% which is below than 1.0%. Hence, the data is valid. It concludes that Safety Awareness is the most important sub-criteria for the passenger safety under the element of Knowledge, followed by Application of Safety Equipment and Familiarization with Safety Equipment.

Figure 9: Summary on Knowledge Sub-Criteria Element of the Passenger Safety.

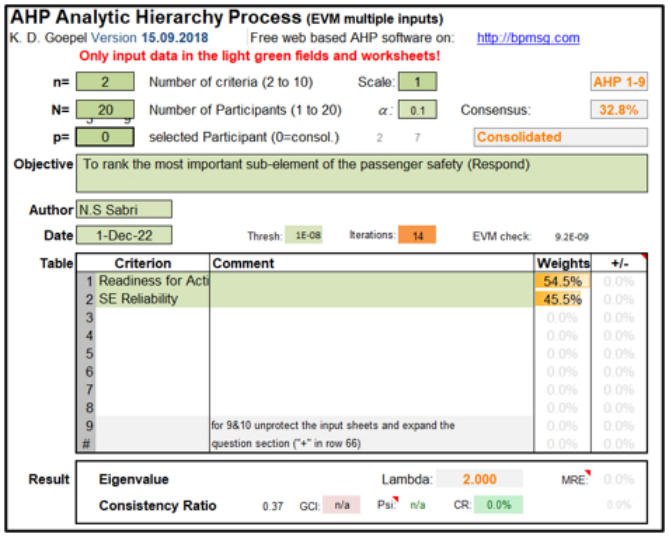


Source: Authors.

4.3.3. Sub-Criteria of Respond Element Analysis.

Figure 10 shows the summary of all the 20 respondents on sub-criteria of the passenger safety. The value of the Consistency Ratio is 0.0% which is below than 1.0%. Hence, the data is valid. It concludes that Readiness for Action is more important compared to Safety Equipment Reliability.

Figure 10: Summary on Respond Sub-Criteria Element of the Passenger Safety.

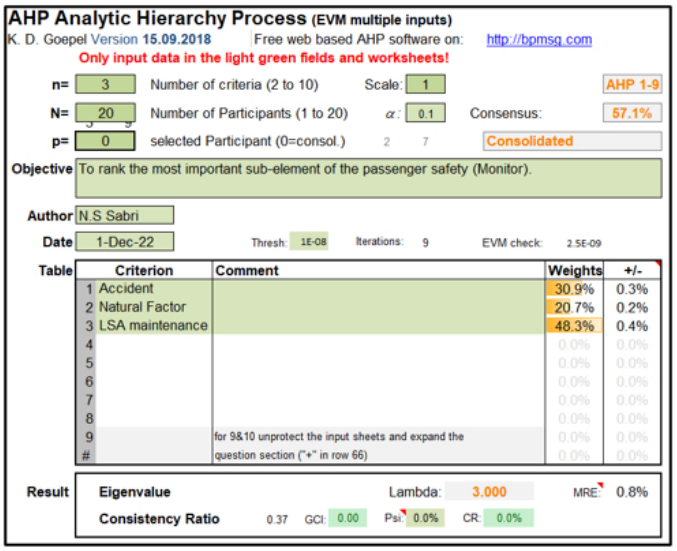


Source: Authors.

4.3.4. Sub-Criteria of Monitor Element Analysis.

Figure 11 shows the summary of all the 20 respondents on sub-criteria of the passenger safety. The value of the Consistency Ratio is 0.0% which is below than 1%. Hence, the data is valid. It concludes that Safety Equipment or Life-Saving Appliances Maintenance is the most important followed by Accident and Natural Factor.

Figure 11: Summary on Monitor Sub-Criteria Element of the Passenger Safety.



Source: Authors.

Table 9: The comparative analysis (Pair Wise Comparison) of the AHP Methods.

Element	Sub-element	Local Weight	Global Weight	Priority Level of Sub-element
Knowledge (0.3100)	Familiarization with Safety Equipment/ LSA	0.2074	0.0643	8
	Application of Safety Equipment/ LSA	0.2854	0.0885	7
	Safety Awareness	0.5071	0.1572	2
Respond (0.2515)	Readiness for Action	0.5451	0.1371	3
	Safety Equipment/ LSA Reliability	0.4549	0.1144	5
Monitor (0.4386)	Accident	0.3091	0.1356	4
	Natural Factor (Weather)	0.2075	0.0910	6
	LSA/ Safety Equipment Maintenance	0.4834	0.2120	1

Source: Authors.

4.3.5. Overall Ranking of Element and Sub-element of Passenger Safety.

From the results shown from the above tables, the rating of each main criteria and sub-criteria are used to calculate or determine the ranking of the most important element of passenger safety. The way to identify the priority level of the element is by using:

Global weight = Main Element Weight x Local Weight**.**

The higher number of Global Weight, the higher - ranking priority level.

Table 10: Normalized Value in Percentage of Main Element.

Main Element	Percentage (%)	Rank
Knowledge	31.00%	2
Respond	25.15%	3
Monitor	43.86%	1

Source: Authors.

Table 11: Normalized Value in Percentage of Sub-element.

Element	Sub-element	Percentage (%)	Rank
Knowledge	Familiarisation with Safety Equipment/ LSA	20.74	8
	Application of Safety Equipment/ LSA	28.54	7
	Safety Awareness	50.71	2
Respond	Readiness for Action	54.51	3
	Safety Equipment Reliability/ LSA	45.49	5
Monitor	Accident	30.91	4
	Natural Factor (Weather)	20.75	6
	LSA/ Safety Equipment Maintenance	48.34	1

Source: Authors.

4.4. Recommendations for passenger safety.

The third objective is to recommend the best solutions in improving passengers' safety onboard the houseboat at Kenyir Lake. Table 12 listed the recommendations. The expert suggestions as following table can be utilized to improve passenger safety, where related agencies can carry out the relevant recommendations onboard the houseboat at Kenyir Lake.

4.5. Limitation.

Limitations of this study are the challenges to collect data due to some passengers and crews reluctant to give cooperation to join the survey and be interviewed. The imbalance number of crews and passengers make the bias present. Furthermore, there is a difficulty to access to literature due to lack of previous studies in houseboat and location of the study which is Kenyir Lake.

5. Conclusion.

To conclude, all of the research objectives of this study has been achieved and reached its conclusion. The research objectives are to identify elements involved in passenger safety, to rank the elements of passenger safety during houseboating at Kenyir Lake and to recommend the best solution to strengthen passenger safety. Based on the results obtained from the questionnaires and interview, the researcher can investigate the most important element for the passenger safety on houseboat at Kenyir Lake. From this research, the researcher identified that respond is the least important in this study because most of the respondents agreed that monitor is more significant to augment passenger safety during houseboating and reduce risk of accident. Houseboat owner and related agencies can utilize the recommendations form the results obtained to secure the passenger safety. Thus, enhancing the boat tourism sectors quality by reducing risks of accident. From the results obtained, they should pay attention on the elements according to its level of importance and execute relevant suggestions.

Acknowledgements.

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Table 12: Recommendations to improve passenger safety.

Element	Sub-element	Recommendation
Knowledge	i. Familiarisation with the Safety Equipment's ii. Application of Safety Equipment iii. Safety Awareness	• Prepare for safety practices during houseboating. • Detail procedures to prepare for and respond to emergency situations. • Safety briefing to passengers. • Experienced and well-prepared crews are required, they should be knowledgeable with their equipment's (Fan et al., 2020) • Emergency escape and evacuation routes must be clear, accessible and muster station symbols are visible (Akindehin et al., 2015)
Respond	i. Readiness for Action ii. Safety Equipment Reliability	• Fast decision and planning • Both crew and passenger should know how to take action if any danger happens there. • Checking for functional of safety equipment before being used. • Standard list of the procedures for training, drills and exercise associated with the ship safety plan. • Emergency and standby equipment are available to maintain essential services.
Monitor	i. Accident ii. Natural Factors iii. Safety Equipment or Life-Saving Appliances (LSA) Maintenance	• Prepare a proper precaution or back up plan according to weather. • Safety audit and inspection monthly. • Proper repair and maintenance for safety equipment according to its expired date. • To implement all the machinery maintenance plan and emergency response plan on board vessel. • Set specific benchmarks for performance that Life Saving Appliances technology should be able to achieve in order for it to be approved for use (Power & Ré, 2015).

Source: Authors.

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