Operations Excellence: Journal of Applied Industrial Engineering, 2025, 17(1): 36-45

ISSN-p: 2085-1431
ISSN-e: 2654-5799

Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort

Rizki Hidayatullah[1*], Fikrihadi Kurnia[2], I Made Suartika[3], Nur Kaliwantoro[4]
[1,4] Department of Mechanical Engineering, Mataram, West Nusa Tenggara, Indonesia
[2,3] Department of Industrial Engineering, Mataram, West Nusa Tenggara, Indonesia
* Corresponding author: rizki.tlh15@gmail.com

ARTICLE INFO

Article history
Submission: 22th November, 2024
Revised: 16th January, 2025
Accepted: 23th Januari, 2025

Keywords:
Boat ladder
Ergonomics
Traveler safety
Quality Function Deployment (QFD)
Marine tourism

https://doi.org/10.22219/oe.2025.v17.i1.129

ABSTRACT

This research aims to redesign an ergonomic tourist boat ladder to improve the comfort and safety of tourists in the context of marine tourism. Tanjung Luar Tourism Village, East Lombok, was chosen as the research location due to the high potential of tourists using boats as a means of transportation to marine tourism destinations. Currently, many tourist boats are not equipped with safe and comfortable stairs, increasing the risk of accidents. The method used in this research is Quality Function Deployment (QFD), which identifies the needs and preferences of tourists through surveys and questionnaires. The research sample consisted of 57 respondents, including tourists, boat crew, and ergonomics experts. The House of Quality (HoQ) results showed that the main needs of tourists include comfortable and safe handrails, anti-slip stair surfaces, and corrosion-resistant stair materials. Based on these needs, three alternative boat ladder designs were developed that consider aspects of safety, durability, and ease of use in marine environmental conditions. Products with ergonomic handrails, stainless steel material, and design flexibility were prioritized in the development. These designs are expected to not only provide a safer and more comfortable solution for users but also contribute to the development of safety standards for tourist boats in Indonesia. This research provides a foundation for the improvement of tourist boat facilities, especially in areas with great potential in marine tourism.

1. Introduction

The tourism sector plays an important role in the global economy, contributing significantly to the world's Gross Domestic Product (GDP). In 2024, the sector is projected to account for approximately 10% of global GDP, valued at USD 11.1 trillion. Furthermore, the sector is expected to create nearly 348 million jobs worldwide, an increase of 13.6 million jobs compared to 2019 (WTTC, 2024). In Indonesia, tourism is also one of the mainstay sectors that continues to grow, especially in the marine tourism segment which is increasingly in demand by domestic and foreign tourists. The tourism industry refers to the performance and growth of this sector in achieving the economic, social, and environmental goals set to increase regional and national foreign exchange. Thus it is very important to be able to improve their performance and achieve a sustainable industry in this sector (Achmad et al., 2023). The potential for marine tourism in West Nusa Tenggara (NTB) is very large, considering

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

that this area has various marine tourism destinations that offer the beauty of the underwater world and activities such as snorkeling and diving.

Tanjung Luar Tourism Village, located in East Lombok Regency, is one of the leading tourist destinations in NTB. This village is known for its beautiful coastal nature and the unique life of the fishing community. In addition, Gili Island, North Sulawesi, which is located around this village is a special attraction for tourists. Based on data from the Central Statistics Agency (BPS) of West Nusa Tenggara, the number of tourists visiting Tanjung Luar Tourism Village in 2024 is projected to reach 320,000 people, with a breakdown of 120,000 foreign tourists and 200,000 domestic tourists (BPS NTB, 2024).

This observation indicates that Tanjung Luar has great potential to continue to be developed as a marine tourism destination. In the development of marine tourism, transportation using tourist boats is an important component that not only facilitates access to various destinations but also becomes part of the tourist attraction itself. However, one of the problems that is often faced is the lack of safe and comfortable boat facilities, especially in the part of the boat ladder used for passengers to get on and off. Many tourist boats in Indonesia, including in popular tourist destinations such as Labuan Bajo, have reportedly not met adequate safety standards (Purnama, 2022). This is certainly a challenge for tourism managers to ensure that the tourist boats used can meet the safety standards required by tourists.

Accidents that occur on boat ladders or steps are often caused by poor ergonomic design, such as the absence of handrails, slippery surfaces, or poor ladder stability. Based on research conducted by the Marine Injury Center (2024), accident on boat ladders often result in serious injuries such as broken bones, bruises, cuts, and even head and neck injuries. An initial observation on July 24, 2024, of 15 tourists showed that they had experienced physical injuries such as sprained ankles or back pain due to unstable and less ergonomic ladder designs. Therefore, improving the design of tourist boat stairs that prioritize ergonomic aspects is very necessary to reduce the risk of accidents and improve tourist safety.In the redesign of boat ladders, ergonomics plays an important role in ensuring that the designed product can be used safely, comfortably, and efficiently. Ergonomics is the science that studies the interaction between humans and work systems, including machines and equipment, to ensure that the use of the equipment can be done with good posture and minimal risk of accidents (Sugiono et al., 2022). One effective method for designing ergonomic-based products is Quality Function Deployment (QFD), which is used to identify consumer needs and translate them into product technical specifications (Hairiyah et al., 2021).

Based on the QFD approach, the redesign of the tourist boat ladder is expected to meet the needs of tourists regarding safety and comfort. The QFD method is an analytical tool that integrates the voice of consumers into a product/service development. The QFD method has been widely applied to improve customer satisfaction not only for services but also for products (Ramayanti et al., 2019). QFD allows product developers to hear the "voice of the consumer" through survey and questionnaire methods, so that every aspect of the design can be adjusted to user preferences. In addition, the use of corrosion-resistant materials such as stainless steel and the implementation of safety features such as handrails and anti-slip surfaces will ensure that the boat ladder can function properly in harsh marine environmental conditions (Sugianto et al., 2020).

As an effort to answer the identified problems, this study aims to redesign ergonomic tourist boat stairs to improve tourist comfort and safety using the Quality Function Deployment (QFD) approach.

By utilizing the QFD method, this study will identify the main needs of tourists and translate them into technical specifications that can be implemented in the design of boat ladders. It is hoped that the results of this study will not only provide safer and more comfortable design solutions, but can also contribute to the development of tourist boat safety standards in Indonesia, especially in the NTB region which has great potential in the marine tourism sector.

2. Methods

This study uses the Quality Function Deployment (QFD) method to redesign an ergonomic tourist boat ladder. QFD is used to identify tourist needs and preferences, then translate them into technical specifications that can be implemented in product design. The study was conducted in Tanjung Luar Tourism Village, East Lombok, West Nusa Tenggara.

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

The sample of this study were tourists who had at least two experiences using a tour boat. Data collection was conducted using open and closed interview methods. Open questionnaires were given to 20 respondents to obtain in-depth insights into the needs of boat ladder users. Then, closed questionnaires were distributed to 57 respondents consisting of tourists, boat crews, and ergonomics experts. The collected data was used to compile the House of Quality (HoQ) matrix. Where in Martia's research (2020) it is said that the form most often used to describe the Quality Function Deployment (QFD) structure is a matrix called the House of Quality (HOQ) because it is considered a product planning matrix that describes customer needs, company targets and evaluation of company products against competitors. Quality Function Deployment (QFD) Process In the redesign of boat ladders, ergonomics plays an important role in ensuring that the designed product can be used safely, comfortably, and efficiently. Ergonomics is a science that studies the interaction between humans and work systems, including machines and equipment, to ensure that the use of the equipment can be done with good posture and minimal risk of accidents (Sugiono et al., 2022). One effective method for designing ergonomic-based products is Quality Function Deployment (QFD), which is used to identify consumer needs and translate them into product technical specifications (Hairiyah et al., 2021; Murgani & Hasibuan, 2022).

The House of Quality (HoQ) Matrix is used to map user needs (voice of customer) with technical solutions that can be applied in stair design. This process includes identifying customer needs, determining technical solutions, and assessing design priorities. Data obtained from the questionnaire are processed with descriptive analysis to assess key attributes such as safety, comfort, and stability of the boat ladder.

3. Results and Discussion

Respondent Demographics

In this study, the respondents used were 57 people. Most of the respondents in this study were in the teenage age group, with a total of 53 people or around 93.0%. of the total respondents. Meanwhile, the adult and elderly groups each consisted of 2 people contributing 3.5%. Based on the location of residence, most respondents came from East Lombok with a total of 21 people or 36.8%, followed by Mataram with 13 respondents (22.8%) and West Lombok with 11 respondents (19.3%). Respondents from other areas, such as Central Lombok and surrounding areas, each contributed 6 people or around 10.5%.

Table 1 Demographic data

Group Data	Category	Quantity	Percent (%)
Age	Teenagers	53	93.0
	Adult	2	3.5
	Elderly	2	3.5
Address	West lombok	11	19.3
	East Lombok	21	36.8
	Central Lombok	6	10.5
	Mataram	13	22.8
	Other	6	10.5
Work	Student	51	89.5
	Fisherman	3	3.5
	Entrepeneur	3	3.5
Experience	2 Times	28	49.1
	3 Times	16	28.1
	More than 3 Times	13	22.8
Gender	Male	26	45.6
	Female	31	54.4

In terms of work, many respondents are students, namely 51 people or 89.5% of the total respondents. The group of respondents who work as fishermen and entrepreneurs each number 3 people, with a percentage of 5.3% each. Based on experience, as many as 28 respondents or around

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

ISSN-p: 2085-1431
ISSN-e: 2654-5799

49.1% have had experience twice in using the facilities related to this research. A total of 16 people (28.1%) had three experiences, and 13 people (22.8%) had more than three experiences.

In terms of gender, the distribution of respondents shows a female dominance with a total of 31 people or 54.4%, while males numbered 26 people or 45.6%. This demographic data overview indicates that many respondents in this study were young people who work as students, with varying experiences in using facilities, and were dominated by female respondents. This data is an important basis for understanding the respondents' perspectives related to the research objects being studied.

House of Quality (HOQ)

House of Quality (HOQ) addresses what the customer needs or expects and how to fulfill those needs and expectations. The House of Quality (HOQ) is created based on the integration of data processing, from determining the level of importance to the interaction of technical responses. Fig. 1 below present the House of Quality (HOQ) matrix.

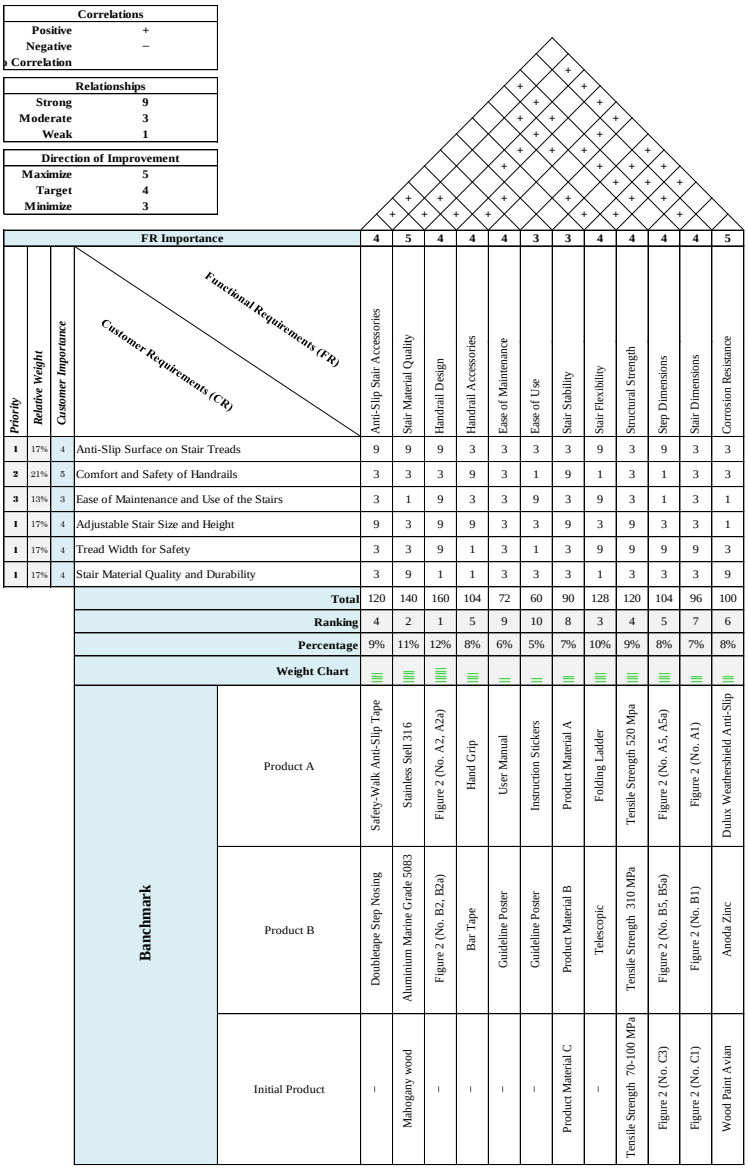


Fig. 1 HOQ of boat ladder product.

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

Customer Requirement (CR)

The first step in HOQ of this research is reflects customer requirements (CR) sorted by priority, according to customer preferences for ladder products. The highest priority requirement is Comfort and Safety of Handrails (21%), indicating that comfortable and safe handrails are the most important aspect. This factor is followed by several requirements with the same weight, namely Anti-Slip Surface on Stairs (17%).

Adjustable Staircase Size and Height (17%), Staircase Width for Safety (17%), and Staircase Material Quality and Durability (17%). Each of these aspects is critical to ensuring the safety and durability of the product, as well as providing size flexibility to suit a variety of user needs.

In addition, Ease of Maintenance and Use of Stairs (13%) is an important need despite having a lower weight. This attribute indicates that customers want stairs that are easy to maintain and operate in their daily lives. By ranking needs based on this priority, the development team can more easily focus their efforts on the factors that most influence customer satisfaction.

Functional Requirements (FR)

The second step in HOQ of this research is focuses on the Functional Requirements (FR) of the ladder product, which are identified to meet the established customer needs. FR is prepared to ensure that the product has features and qualities that meet customer expectations, such as comfort, safety, and durability. One of the main functional requirements is the Anti-Slip Accessory on the Steps, which supports the customer's need for a safe surface to prevent slipping. In addition, the Quality of the Stair Material is also an important requirement to provide long-term product durability and reliability.

Other requirements include Anti-Slip Handrail Design and Handrail Accessories to enhance user comfort and safety, especially when holding onto the ladder. Ease of maintenance and use, represented by the Ease of Maintenance and Ease of Use requirements, are important aspects to meet customer needs for a practical product. In addition, Ladder Stability, Structural Strength and Resistance to Loads, and Seawater Corrosion Resistance add dimensions of safety and durability that are needed, especially in various environmental conditions. Each of these functional requirements is designed to provide a holistic solution to customer needs, ensuring the product can be used safely and comfortably.

CR and FR relationship matrix

The third step in HOQ of this research is shows the relationship matrix between customer requirements (CR) and relevant functional requirements (FR). In this table, each FR is linked to a CR using a relationship assessment value that indicates the extent to which the FR can meet customer needs. The total weight of each FR is calculated based on the priority and importance of the CR to which it is linked. For example, Handrail Design gets the highest weight with a total of 160, indicating the importance of this aspect in meeting the comfort and safety needs of the stair railing.

The FR priorities in this table are also ranked by total weight, with the highest-scoring FRS receiving higher priority in product development. The FR of Anti-Slip Handrail Accessories is the priority with a percentage of 12%, followed by Stair Material Quality in second place (11%), and Handrail Design in third place (10%). This indicates that these features have a major impact on meeting the needs of key customers, especially regarding the safety, durability, and comfort of using stairs.

The percentages listed provide a proportional picture of how each FR contributes to meeting the overall customer needs. Features such as Ease of Use and Ease of Maintenance have lower percentages (5% and 6%) but are still important to ensure that the ladder product is practical and easy to maintain. By understanding this relationship, the development team can determine the focus on the FRS with the highest weight so that the resulting product is in accordance with customer expectations and priorities. The combination of a comprehensive Maintenance Manual and practical usage instruction stickers enhances operational efficiency and safety. The stickers provide clear instructions on how to use the boat ladder, while the maintenance manual outlines procedures and best practices for ensuring optimal performance.

Proposed Boat Ladder Product

The design priorities for boat ladders based on the results of the House of Quality (HoQ) with the method are summarized as seen as in Fig. 2.

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

ISSN-p: 2085-1431
ISSN-e: 2654-5799

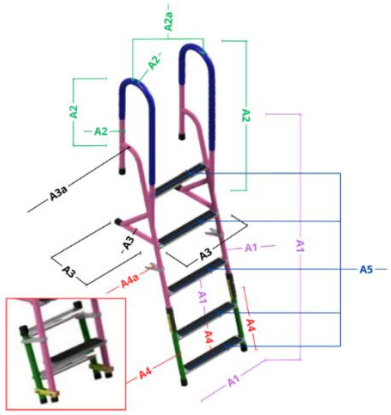
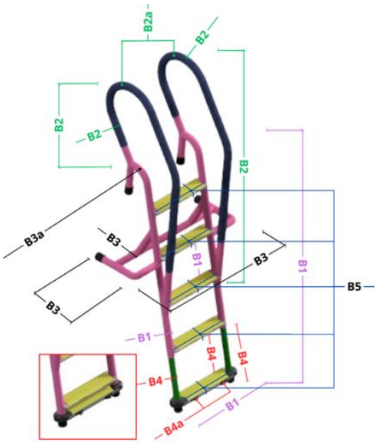
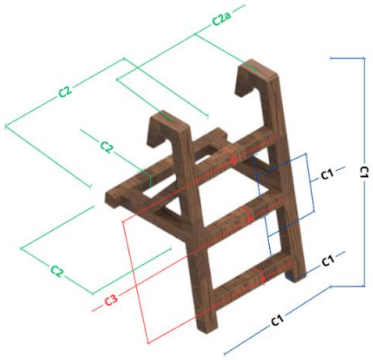
Product A 	Note: A1 = Ladder dimensions (120 cm x 40 cm x Ø3 cm x 2,5 cm) A2 = Handle dimensions (78 cm x 40 cm x 11,8 cm x Ø3 cm) A2a = Hand grip A3 = Support dimensions (25 cm x 40 cm x Ø3 cm) A3a = Ladder hook A4 = Folding mechanism dimensions (30 cm x 23 cm x Ø3 cm) A4a = Folding ladder lock A5 = Step dimensions (40 cm x 6 cm x 2 cm) A5a = Safety-walk anti-slip tape
Product B 	Note: B1 = Ladder dimensions (130 cm x 35 cm x Ø4 cm x 2,5 cm) B2 = Handle dimensions (120 cm x 40 cm x 17 cm x Ø4 cm) B2a = Bar tape B3 = Support dimensions (25 cm x 71 cm x Ø4 cm) B3a = Ladder hook B4 = Folding mechanism dimensions (30 cm x 25 cm x Ø3,4 cm) B4a = Telescopic ladder lock B5 = Step dimensions (35 cm x 8 cm x 2 cm) B5a = Doubletape step nosing
Product C 	Note: C1 = Ladder dimensions (60 cm x 30 cm x 4x4 cm x 25 cm) C2 = Support dimensions (25 cm x 40 cm x 4x4 cm) C2a = Ladder hook C3 = Step dimensions (30 cm x 4x4 cm)

Fig. 2 Proposed boat ladder design.

1. Handrail Design: Product A is ranked highest due to the use of Safety-Walk Anti-Slip Tape made of PVC or textured rubber. This advantage ensures an ergonomic grip and is resistant to seawater and UV rays, supporting durability in harsh marine environments. The dimensions of the tape range from 18-24 mm wide, providing comfort and safety for users. Product B is ranked second with a 2-meter long and 2-3 cm wide Bar Tape, which is elastic and comfortable in humid conditions, although the aesthetics of this material are still inferior to wood. Product C uses Avian

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

Paint coated wood, which is anti-slip but requires regular maintenance to maintain resistance to humidity.

2. Staircase Material Quality: Stainless Steel 316 in Product A is the top priority due to its corrosion resistance, high structural strength, and ability to withstand temperatures up to 870°C with a density of 8.0 g/cm3, making it the most optimal choice for extreme marine conditions. Aluminum 6061 in Product B is second, offering a light weight of around 2.7 g/cm3 and a tensile strength of up to 310 MPa, but is less resistant to high temperatures. Mahogany in Product C has aesthetic appeal, but is susceptible to seawater corrosion and requires ongoing maintenance to maintain its strength in marine environments.
3. Ladder Flexibility: Product B excels in flexibility due to its lightweight 6061 Aluminum telescopic design, which allows for length adjustment from 800 mm to 1300 mm, ideal for limited space on a pleasure boat. Product A has a folding design with a length of 1200 mm, a step width of 250 mm, and a standing height of 600 mm, which is convenient for storage in limited space. Product C, which is made of mahogany, does not have the folding or telescopic flexibility feature, making it less practical for storage on a boat.
4. Anti-Slip Stair Accessories and Structural Strength: Product A is equipped with Safety-Walk Anti-Slip Tape made of PVC or rubber that is resistant to seawater and UV rays. With a tensile strength of around 520 MPa, the Stainless Steel 316 material in Product A provides excellent resistance to load and corrosion. Product Buses Doubletape Step Nosing which enhances safety at the edge of the steps, supporting stability in slippery conditions. The aluminum structure of Product B provides a tensile strength of 310 MPa. Product C relies on anti-slip Avian Paint, which protects the wood from UV rays and moisture, but mahogany only has a tensile strength of around 70-100 MPa and requires more intensive maintenance.
5. Handrail Accessories and Staircase Dimensions: Product A excels in handrail accessories with PVC or rubber Safety-Walk Anti-Slip Tape, offering strong grip and a tape width of 18-24 mm, which is ideal for marine conditions. Product B utilizes a 2-meter long Bar Tape with a width of 2-3 cm, which is elastic and comfortable but requires more maintenance. Product C uses an Avian Paint coating that is anti-slip and UV resistant, but require regular maintenance. In terms of stair dimensions, Product A has a width of 250 mm and a step spacing of 400 mm, providing stable footing; Product B is similar, but with a step spacing of 300 mm for flexibility in tight spaces. Product C in mahogany offers a natural aesthetic, but its dimensions and durability are less than optimal in marine environments.
6. Corrosion Resistance: The corrosion resistance of Products A, B and C is designed to withstand the harsh challenges of the marine environment. Product A uses Dulux Weathershield Anti-Slip, a water-based paint that provides protection against seawater, UV rays and moss growth, suitable for metal surface coatings. Product B utilizes Zinc Anode, a galvanic method that actively protects metal by sacrificing the zinc anode to prevent corrosion, making it highly effective and durable in extreme saltwater exposure. Product C uses Avian Wood Paint, an elastic coating for wood that is water and UV resistant and prevents mold growth, although it requires regular maintenance. Of the three, Zinc Anode on Product B is the most effective in combating severe corrosion, followed by Dulux Weathershield Anti-Slip on Product A which is ideal for moderate exposure, while Avian Wood Paint on Product C is more suitable for wood in humid conditions with minimal salt exposure.
7. Ladder Dimensions: Product A, with a length of 1200 mm and a step width of 250 mm, features a step spacing of 400 mm to provide maximum comfort and stability in marine environments. Product B can be extended to 1300 mm, adding flexibility to use in confined spaces. Product C, with dimensions focused on aesthetics, stands out for less extreme usage environments, such as safer coastal areas.
8. Stability of the Ladder: Product A has the highest stability thanks to its sturdy stainless steel material, which allows it to withstand heavy loads without deformation and is suitable for marine conditions. Product B is lighter but still stable, although not as strong as Product A. Product C made of wood is more vulnerable in marine environments due to the nature of wood that requires special treatment to prevent weathering.
9. Ease of Maintenance and Ease of Use: Products A, B, and C offer unique solutions for easy maintenance and use of boat ladders. Product A provides a structured and illustrated Maintenance Manual, as well as convenient and easily accessible Instructions for Use Stickers, making it

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

efficient for daily maintenance and use. Product B uses an informative Maintenance Manual Poster for procedures such as lubrication, as well as a large, detailed and useful Instructions for Use Poster for understanding the telescopic mechanism. Product C, made of wood, offers a Maintenance Poster for cleaning and refinishing guidance, as well as an Instructions for Use Poster that provides safe steps for using wooden ladders. Of the three, Product A is the most effective and logical choice for boat ladders, as the combination of a comprehensive maintenance manual and convenient Instructions for use stickers supports operational efficiency and safety.

The limitations of this study include several aspects that affect the generalization and application of the results. First, the study sample was limited to tourists who had at least two experiences using the tourist boat ladder in Tanjung Luar Tourism Village, East Lombok. This limits the representativeness of the results to other tourism contexts with different demographic and geographic characteristics. Second, this study relied on a questionnaire collecting user preference data, which has the disadvantage of capturing responses that may be subjective or influenced by individual perceptions of the experience. Third, the application of the Quality Function Deployment (QFD) method focused on specific needs related to the comfort and safety of the boat ladder without considering additional variables such as extreme weather factors or wider material variations. Finally, this study did not include direct testing of the redesigned boat ladder in a real marine environment, so the results cannot fully describe the performance and durability of the material in the long term under harsh sea conditions.

4. Conclusion

This study successfully redesigned the ergonomics-based tourist boat ladder using the Quality Function Deployment (QFD) approach to improve tourist comfort and safety. Based on data from respondents, the main needs of tourists include comfortable and safe handrails, anti-slip ladder surfaces, and corrosion-resistant materials. These needs are accommodated through three design alternatives that prioritize safety, durability, and ease of use in harsh sea conditions.

From the House of Quality (HoQ) analysis, the ladder design with 316 stainless steel material was chosen as the best option because of its resistance to corrosion and its ability to withstand loads in the marine environment. In addition, this ladder is equipped with an ergonomic handle made of anti-slip material to provide additional stability for tourists when getting on and off the boat. The folding or telescopic feature on the ladder also adds flexibility and ease of storage, making it very suitable for use in limited spaces on tourist boats.

The implementation of this boat ladder design is expected to not only improve the comfort and safety of tourists but also contribute to the development of tourist boat safety standards in Indonesia, especially in marine tourism areas such as West Nusa Tenggara. However, the limitations of this study lie in subjective data collection and the absence of direct testing of the ladder in a real marine environment. Further research is recommended to test the performance of the design in real environmental conditions to ensure long-term durability and safety. Thus, this study not only serves as a basis for the development of better tourist boat facilities but also offers important recommendations for improving marine tourism safety standards in general.

References

Achmad, F., Rizaldi, A. S., Sriwana, I. K., & Rumanti, A. A. (2024). Optimizing tourism industry performance strategy selection: an analytical hierarchy process perspective. *Operations Excellence: Journal of Applied Industrial Engineering*, *15*(3), 220. https://doi.org/10.22441/oe.2023.v15.i3.088

Alda, T., & Natasha, C. (2022). Penerapan Metode Nigel Cross Pada Desain Produk Rompi Pemanas. *Talenta Conference Series*, *5*(2), 47–54. https://doi.org/10.32734/ee.v5i2.1545

Anggraini, F. D. P., Aprianti, A., Setyawati, V. A. V., & Hartanto, A. A. (2022). Pembelajaran Statistika Menggunakan Software SPSS untuk Uji Validitas dan Reliabilitas. *Jurnal Basicedu*, *6*(4), 6491–6504. https://doi.org/10.31004/basicedu.v6i4.3206

BPS Nusa Tenggara Barat. (2024). *Jumlah Perjalanan Wisatawan Nusantara Menurut*

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129

Kabupaten/Kota Tujuan - Tabel Statistik - Badan Pusat Statistik Provinsi Nusa Tenggara Barat. https://sultra.bps.go.id/id/statistics-table/2/NjE1IzI=/jumlah-perjalanan-wisatawan-nusantara-menurut-kabupaten-kota-tujuan.html

Erdil, N. O., & Arani, O. M. (2019). Quality function deployment: more than a design tool. *International Journal of Quality and Service Sciences*, *11*(2), 142–166. https://doi.org/10.1108/IJQSS-02-2018-0008

Erdıl, A. (2020). Evaluation Product Development, Product Design for the Furniture-Wood Industry Via Quality Function Deployment and Pareto Analysis. *Sigma Journal of Engineering and Natural Sciences*, *11*(2), 203–217.

Ginting, R., Ishak, A., & Pitaloka, D. (2020). Application of Quality Function Deployment (QFD) Method in Meeting Customer Satisfaction in the Bookshelf Industry. *IOP Conference Series: Materials Science and Engineering*, *1003*(1). https://doi.org/10.1088/1757-899X/1003/1/012005

Hairiyah, N., Kiptiah, M., & Fituwana, B. K. (2021). Penerapan Quality Function Deployment (Qfd) Untuk Peningkatan Kinerja Industri Amplang Berdasarkan Kepuasan Pelanggan. *Agrointek : Jurnal Teknologi Industri Pertanian*, *15*(4), 1099–1113. https://doi.org/10.21107/agrointek.v15i4.10744

Handika, F. S., Nalhadi, A., & Panigara, M. K. (2021). Perancangan Ulang Mesin Las Dengan Metode Quality Function Deployment (Qfd) Di Cv. Prima Mitra Mandiri. *Jurnal InTent*, *4*(2), 147–155.

Ishak, A., Ginting, R., & Siallagan, S. (2024). Application of quality function deployment (QFD) and axiomatic design method for product design: study case compost waste product. *Journal of Achievements in Materials and Manufacturing Engineering*, *122*(1), 31–41. https://doi.org/10.5604/01.3001.0054.4652

Kementrian kesehatan RI. (2024). *Kategori Usia*. https://ayosehat.kemkes.go.id/kategori-usia

Mardhiana, H., Rachmawati, D., Winati, F. D., & Yamani, A. Z. (2022). Implementation of Quality Function Deployment (QFD) for Decision Making in Improving Integrated Academic Information System. *INTENSIF: Jurnal Ilmiah Penelitian Dan Penerapan Teknologi Sistem Informasi*, *6*(1), 92–107. https://doi.org/10.29407/intensif.v6i1.16790

Martia, N. (2020). Usulan perbaikan kualitas pelayanan penerbitan sertifikat tanah dengan pendekatan Quality Function Deployment. *Operations Excellence: Journal of Applied Industrial Engineering*, *12*(2), 228. https://doi.org/10.22441/oe.2020.v12.i2.010

Marine Injury Center. (2024). *Ladder and Stair Accidents and Injuries*. https://www.maritimeinjurycenter.com/accidents-and-injuries/conveyor-belt/

Murgani, R., & Hasibuan, S. (2022). Peningkatan Kualitas Layanan Penyedia Layanan Logistik Berdasarkan Integrasi SERVQUAL dan QFD. *Jurnal Rekayasa Sistem Industri*, *11*(2), 229-242.

Purba, H. H., Sunadi, S., Suhendra, S., & Paulina, E. (2020). The Application of Quality Function Deployment in Car Seat Industry. *ComTech: Computer, Mathematics and Engineering Applications*, *11*(1), 35–42. https://doi.org/10.21512/comtech.v11i1.6329

Purnama, S. (2022). *Kemenparekraf kirim tim peninjau standar kapal wisata di Labuan Bajo - ANTARA News*.

Ramayanti, G., Nalhadi, A., & Pujianto, R. (2019). Pendekatan metode Quality Function Deployment sebagai usulan peningkatan kualitas produk keramik dinding. *Operations Excellence: Journal of Applied Industrial Engineering*, *11*(2), 184. https://doi.org/10.22441/oe.v11.2.2019.028

Setianah, P., Herlina, L., Pamenta, M., & Purba, H. H. (2023). Persebaran Fungsi Kualitas Quality Function Deployment (QFD) di Bidang Manufaktur: Kajian Literatur. *Jurnal Teknologi Dan Manajemen*, *21*(1), 49–58. https://doi.org/10.52330/jtm.v21i1.95

Society China Calssification. (2014). *Guidelines on Application of ICM as Strategy*. http://www.bmb.gov.ph/downloads/TB/TB_2017-14.pdf

Sugianto, A., Yuwono, I. N., & Satriawan, K. (2020). Perancangan Kursi Tangga Menggunakan Metode Quality Function Development. *Jurnal Muara Sains, Teknologi, Kedokteran, Dan Ilmu Kesehatan*, *4*(2), 229–236. https://doi.org/10.4271/870272

Sugiono, S., Pratomo, A., & Willy, S. N. (2022). House-of-Quality Approach for the Design of a Minibus to Transport Visually Impaired and Wheelchair-bound Passengers. *International Journal of Technology*, *13*(1), 69–79.
https://doi.org/10.14716/ijtech.v13i1.4290

Sugiyono, D. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan Tindakan* (2nd ed.). Alfabeta.

SÜRÜCÜ, L., & MASLAKÇI, A. (2020). Validity and Reliability in Quantitative Research. *Business & Management Studies: An International Journal*, *8*(3), 2694–2726.

https://doi.org/10.15295/bmij.v8i3.1540
Wahmuda, F., & Candra, D. M. (2021). Pengembangan Teknologi Pada Desain Alat Transportasi Air Obyek Wisata Kalimas Surabaya. *Prosiding Seminar Teknologi …*, 357–363. https://ejournal.itats.ac.id/stepplan/article/view/1592%0Ahttps://ejournal.itats.ac.id/stepplan/article/viewFile/1592/1335
WTTC. (2024). Travel & Tourism Economic Impact _ World Travel & Tourism Council (WTTC). In *Travel & Tourism Econimc Impact* (pp. 1–58).
https://wttc.org/Research/Economic-Impact%0Awttc.org/Research/Economic-Impact
Zulkarnain, Apriyanti, Y., Aulia, A. D., Pratiwi, W., & Imam, S. (2023). House of Quality sebagai Pengendalian Kualitas Produk pada Kemasan Karton Lipat. *Jurnal PASTI (Penelitian Dan Aplikasi Sistem Dan Teknik Industri)*, *17*(1), 115.
https://doi.org/10.22441/pasti.2023.v17i1.011

Please cite this article as: Hidayatullah, R., Kurnia, F., Suartika, I.M. & Kaliwantoro, N. (2025). Ergonomics-based redesign of tourist boat stairs using a Quality Function Deployment (QFD) to improve traveler security and comfort. *Operations Excellence: Journal of Applied Industrial Engineering*, 17(1), 36-45. doi:http://dx.doi.org/10.22441/oe.2025.v17.i1.129