

Ergonomic Study of Passenger Seat Design on Traditional Boats to Enhance Safety

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ABSTRACT: This study evaluates the passenger seat design of traditional boats in Tanjung Luar Tourism Village, East Lombok, using an ergonomic approach to enhance comfort and safety. The Nordic Body Map (NBM) and Rapid Upper Limb Assessment (RULA) methods were employed to assess musculoskeletal complaints and body posture. Data were collected through field observations and questionnaires distributed to 30 respondents. The findings indicate that the current seat design is not ergonomically suitable, leading to physical discomfort, particularly in the back and buttocks. Redesign recommendations include the addition of backrests, seat cushions, and armrests to improve the quality of water transportation in the local tourism sector.

KEYWORDS: Ergonomics, Traditional Boats, Passenger Seat Design, Safety, RULA, NBM.

I. INTRODUCTION

Tourism is a strategic sector that significantly contributes to global economic growth, particularly through job creation and poverty reduction. In Indonesia, the number of tourist visits continues to increase. In February 2024, international tourist arrivals reached 1.14 million—an increase of 20.17% compared to the previous year. Domestic tourism also experienced a sharp rise, with 7.52 million trips, marking a 112.26% increase. In West Nusa Tenggara (NTB) Province, tourist visits grew at an average rate of 25.16% annually between 2013 and 2017, reaching 1.7 million visitors in 2023.

This growth in tourism directly impacts transportation needs, especially inter-island marine transport in coastal areas such as Tanjung Luar Tourism Village in East Lombok. In this area, traditional boats serve as the primary mode of transportation to support marine tourism activities. These boats, typically made of wood, PVC, or metal, offer high stability due to dual pontoons that enhance buoyancy. The vital role of transportation

in connecting Indonesia's diverse communities has been emphasized by Mantoro (2021), who stated that transportation not only facilitates mobility but also shapes social, economic, and governmental infrastructure [1].

However, from the perspective of passenger comfort and safety, particularly in seat design, these traditional boats still present notable limitations. Many of the seats do not meet ergonomic standards, resulting in complaints such as back pain, hip discomfort, and the risk of slipping due to the absence of armrests. Ergonomics, as a discipline that studies human interaction with systems and environments, aims to optimize user comfort, efficiency, and safety [2]. In the context of water transportation, applying ergonomic principles is essential to redesign seats that align with users' body postures and physical needs.

Musculoskeletal disorders—such as neck, back, hip, and knee pain—significantly affect health and productivity. Research by Williams et al. (2018) found that musculoskeletal conditions are not only common complaints but also increase the risk of chronic diseases [3]. Therefore, ergonomic seat designs based on user anthropometric data are necessary to reduce health risks and improve passenger comfort during water travel.

Given these issues, this study aims to analyze and evaluate the passenger seat design on traditional boats in Tanjung Luar Tourism Village using an ergonomic approach. The goal is to propose a redesign that enhances both the comfort and safety of passengers engaging in water-based tourism.

II. RESEARCH METHODOLOGY

This study employed an ergonomic approach to evaluate and redesign the passenger seat configuration on traditional boats. Two primary ergonomic assessment tools were utilized:

the Nordic Body Map (NBM) and the Rapid Upper Limb Assessment (RULA).

The NBM method was applied to identify musculoskeletal complaints reported by users while sitting on traditional boat seats. Respondents were asked to mark areas of discomfort or pain on a body map questionnaire. Data was collected from 30 individuals who had experience using traditional boats in the Tanjung Luar Tourism Village.

The RULA method was employed to analyze the upper body posture of users, focusing on the neck, back, upper arms, lower arms, and wrists. This method evaluates ergonomic risks associated with static postures or repetitive movements that may contribute to musculoskeletal disorders. Observations and postural analyses were conducted directly in the field, with documentation of user positions while seated.

- The tools and materials used in this study included:
- Nordic Body Map questionnaires
 - RULA assessment worksheets
 - Angulus application (for measuring joint angles)
 - Spreadsheet software (for data processing)
 - A camera (for posture documentation)
 - A traditional boat seat (as the study object)
 - Writing instruments and assessment sheets

The RULA assessment produces risk scores ranging from 1 to 7. Higher scores indicate a greater ergonomic risk and suggest that immediate corrective actions are required. Lower scores represent a lesser risk, although they do not entirely eliminate the possibility of musculoskeletal issues.



Figure 1. RULA Assessment Worksheet

III. DISCUSSION

3.1 Nordic Body Map (NBM) Analysis

Based on the Nordic Body Map (NBM) questionnaire distributed to 30 respondents in Tanjung Luar Tourism Village after completing four boat trips, various musculoskeletal complaints were identified among the passengers. Table 1. Recapitulation of NBM Questionnaire Results. The analysis showed that the highest number of complaints was located in the buttocks area. This was primarily due to the absence of seat padding, which caused discomfort during prolonged sitting. Respondents also reported back pain, as the traditional boat seats lacked backrests, forcing passengers to lean directly against the boat's wall. Additional complaints arose in the arms due to the absence of armrests, and in the upper neck because of the lack of proper neck support.

Table 1. Recapitulation of NBM Questionnaire Results

No	Jenis keluhan	Data Kuisisioner Nordic Body Maps Jumlah Responden							
		A		B		C		D	
		TS	%	AS	%	S	%	SS	%
0	sakit/kaku di leher bagian atas	0	0%	8	27%	18	60%	4	13%
1	sakit/kaku di leher bagian bawah	1	3%	7	23%	19	63%	3	10%
2	sakit di bahu kiri	0	0%	10	33%	17	57%	3	10%
3	sakit di bahu kanan	0	0%	6	20%	22	73%	2	7%
4	sakit pada lengan atas kiri	0	0%	11	37%	12	40%	7	23%
5	sakit di punggung	0	0%	6	20%	15	50%	9	30%
6	sakit pada lengan atas kanan	5	17%	11	37%	11	37%	3	10%
7	sakit pada pinggang	0	0%	9	30%	17	57%	4	13%
8	sakit pada bokong	0	0%	3	10%	13	43%	14	47%
9	sakit pada pantat	0	0%	6	20%	13	43%	11	37%
10	sakit pada siku kiri	7	23%	8	27%	14	47%	1	3%
11	sakit pada siku kanan	6	20%	8	27%	16	53%	0	0%
12	sakit pada lengan bawah kiri	5	17%	10	33%	12	40%	3	10%
13	sakit pada lengan bawah kanan	4	13%	8	27%	17	57%	1	3%
14	sakit pada pergelangan tangan kiri	5	17%	10	33%	12	40%	3	10%
15	sakit pada pergelangan tangan kanan	9	30%	6	20%	13	43%	2	7%
16	sakit pada tangan kiri	6	20%	12	40%	6	20%	6	20%
17	sakit pada tangan kanan	2	7%	10	33%	16	53%	2	7%
18	sakit pada paha kiri	10	33%	13	43%	3	10%	4	13%
19	sakit pada paha kanan	11	37%	16	53%	3	10%	0	0%
20	sakit pada lutut kiri	12	40%	15	50%	3	10%	0	0%
21	sakit pada lutut kanan	14	47%	16	53%	0	0%	0	0%
22	sakit pada betis kiri	24	80%	6	20%	0	0%	0	0%
23	sakit pada betis kanan	27	90%	3	10%	0	0%	0	0%
24	sakit pada pergelangan kaki kiri	26	87%	4	13%	0	0%	0	0%
25	sakit pada pergelangan kaki kanan	27	90%	3	10%	0	0%	0	0%
26	sakit pada kaki kiri	19	63%	11	37%	0	0%	0	0%
27	sakit pada kaki kanan	24	80%	6	20%	0	0%	0	0%

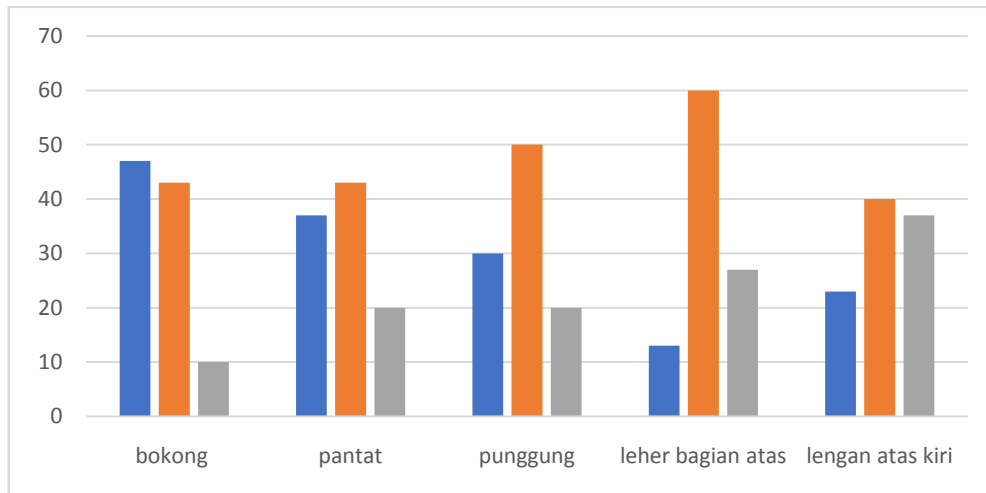


Figure 2. Chart of Respondents' Complaints by Body Part

The graph above illustrates the level of pain reported (severe, moderate, mild) for each body part. Blue bars indicate "severe pain," orange represents "moderate pain," and grey denotes "mild pain." This data strongly supports the need for seat redesign to reduce musculoskeletal complaints.

Respondents scored between 50 and 70, placing them in Action Level 2, which indicates that corrective actions are needed to reduce ergonomic risks associated with the current boat seating. Table 2. Risk Level of Respondents Based on NBM Scores.

Responden	Score	Tingkat Resiko	Responden	Score	Tingkat Resiko
1	61	Sedang	16	62	Sedang
2	58	Sedang	17	62	Sedang
3	55	Sedang	18	64	Sedang
4	53	Sedang	19	59	Sedang
5	55	Sedang	20	61	Sedang
6	54	Sedang	21	62	Sedang
7	53	Sedang	22	65	Sedang
8	55	Sedang	23	62	Sedang
9	55	Sedang	24	61	Sedang
10	54	Sedang	25	65	Sedang
11	57	Sedang	26	57	Sedang
12	63	Sedang	27	63	Sedang
13	66	Sedang	28	62	Sedang
14	59	Sedang	29	65	Sedang
15	62	Sedang	30	63	Sedang

3.2 Rapid Upper Limb Assessment (RULA) Analysis

RULA analysis was conducted to evaluate the posture of a boat seat user while sitting. A

single respondent was used as a representative, and posture angles were measured using the Angulus application. Table 3. Postural Angles While Sitting on the Boat Seat

Body Part (A)	Angle (°)	Body Part (B)	Angle (°)
Upper Arm	21.20°	Neck	19.50°
Lower Arm	73.60°	Trunk	7.20°
Wrist	14.20°	-	-

Group A Assessment

- [1]. Upper Arm angle: 21.20° → score 1
- [2]. Lower Arm angle: 73.60° → score 1
- [3]. Wrist angle: 14.20° → score 2
- [4]. Wrist position (neutral): adjustment score 1
- [5]. Initial total score for Group A: 3

- [6]. Task is infrequent and short-duration → added score: 0
- [7]. No additional load (less than 2 kg) → added score: 0
- [8]. Final Group A score: 3.

Tabel A:		Wrist Posture Score							
Upper Arm	Lower Arm	1		2		3		4	
		Wrist Twist		Wrist Twist		Wrist Twist		Wrist Twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	6	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Group B Assessment

- [1]. Neck angle: 19.50° → score 2
- [2]. Trunk angle: 7.20° → score 2
- [3]. Legs in stable sitting position → score 1
- [4]. Final Group B score: 2.

Table 5. Group B RULA Assessment

Tabel B:	1		2		3		4		5		6	
	Kaki		Kaki		Kaki		Kaki		Kaki		Kaki	
Leher	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	3	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	7	7
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Group C Assessment

The final score from Group A and B resulted in a Group C score of 3, indicating low risk. Nevertheless, a redesign is still recommended to

prevent potential musculoskeletal issues, especially for repetitive or long-term use. Tabel 4. RULA Assessment Worksheet.

Tabel C:	Skor Grup B						
Skor Grup A	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8	5	5	6	7	7	7	7

3.3 Passenger Seat Redesign

Based on the analysis of NBM and RULA data, a redesigned passenger seat was proposed with the following ergonomic improvements:

1. Backrest Addition: To reduce back pain and mitigate the impact of sea waves.
2. Armrest Addition: To help support the upper body and reduce arm fatigue.
3. Seat Cushioning: Installed on the buttocks area to relieve pressure from hard seating surfaces.
4. Reduced Passenger Capacity: From 10 to 8 passengers to provide more space and comfort.
5. Seat Dimensions: Total seat length is 7.3 meters. Each seat is 60 cm long, 40 cm wide, and 60 cm high.

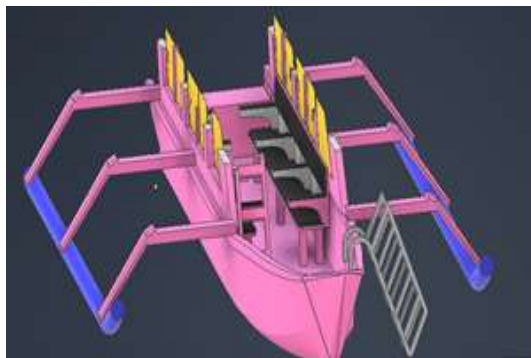


Figure 3. Front View of Redesigned Passenger Seat

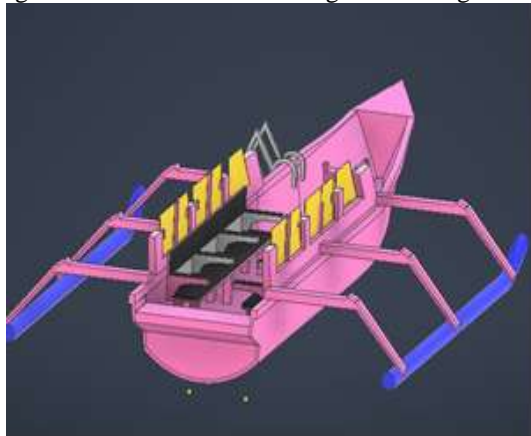


Figure 4. Rear View of Redesigned Passenger Seat

IV. CONCLUSION

Based on the results of this study, several conclusions can be drawn as follows:

1. The analysis using the Nordic Body Map (NBM) method revealed that passengers experienced discomfort in several areas of the body, particularly the back, arms, neck, buttocks, and hips. These findings indicate that the design of traditional boat seats does not support an ergonomic sitting posture, leading to a risk of musculoskeletal disorders. The questionnaire data showed that individual scores ranged from 50 to 70, indicating a moderate risk level that requires corrective action. Therefore, a redesign of the boat seat is necessary to reduce musculoskeletal complaints and improve user comfort and safety.
2. Based on performance testing of solar distillation devices, it was found that the device with a clear glass cover produced the highest volume of distilled water, averaging 988 ml over a 5-hour period. This amount is greater than the volume produced using an acrylic cover (653 ml) and a tinted glass cover (436 ml). These results suggest that the type of cover significantly influences the productivity of distilled water.
3. The efficiency of solar collectors was also affected by the type of cover material used. The collector with a clear glass cover demonstrated the highest efficiency at 22.3%. The acrylic cover yielded an efficiency of 14.7%, while the tinted glass cover had the lowest efficiency at 9.8%. Therefore, using a clear glass cover is recommended to enhance the heating efficiency and output of solar distillation.

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