Design and Stability Analysis of the Galaherang Tourist Vessel Using Maxsurf Software

Muhammad Aqilla Ananta Setia, Arfena Deah Lestari, Mochammad Meddy Danial

Tanjungpura University
email: d1111211022@student.untan.ac.id

Abstract

The safety of river tourism vessels depends on hull geometry, loading conditions, and adequate intact stability, yet vessel-specific numerical evidence for the Galaherang tourist vessel operating on the Kapuas River remains limited. This study evaluates its hull design, hydrostatic properties, and intact stability using Maxsurf Modeler and Maxsurf Stability. A three-dimensional hull model was developed using a length overall of 21 m, beam of 5 m, depth of 3 m, and operational draft of 1.61 m, with an intended capacity of 97 passengers and four crew members. Upright hydrostatic calculations, equilibrium analysis, and large-angle righting-arm (GZ) simulations were performed, and the results were compared with selected IMO and BKI stability reference criteria. At the evaluated loading condition, the vessel had a displacement of 66,280 kg, a block coefficient of 0.494, and a corrected transverse metacentric height (GMt) of 0.957 m, exceeding the IMO reference minimum of 0.15 m. The maximum GZ was 0.523 m at a heel angle of 45.5°, while the reported passenger-crowding and turning simulations produced heel angles of 7.5°–10°. These findings indicate favorable predicted stability under the modeled assumptions and provide preliminary technical guidance for river tourist vessel design. However, comprehensive regulatory compliance and operational safety require further verification and field validation under representative river conditions.

Keywords: Ship Design for tourism, Galaherang Touris Vessel, Vessel Stability, Maxsurf

INTRODUCTION

The development of water-based tourism in Indonesia has increased the demand for safe, efficient, and environmentally appropriate inland waterway transportation. River tourism, in particular, contributes to regional economic development by supporting recreational activities, local businesses, and the utilization of natural tourism resources. The Kapuas River in Pontianak, West Kalimantan, represents an important destination for river-based tourism, where passenger and tourist vessels facilitate recreational journeys and provide opportunities to experience the surrounding river environment [1]. Among these vessels, the Galaherang tourist boat has become a recognizable feature of local river tourism. However, the safe operation of inland passenger vessels remains a critical concern because variations in river currents, water depth, passenger distribution, and operating conditions may influence vessel maneuverability, under-keel clearance, and operational safety [2].

From a naval architectural perspective, vessel design must ensure adequate buoyancy, stability, and operational suitability throughout the intended service conditions. For tourist vessels, stability is particularly important because passenger movements, uneven loading distributions, and changes in the vertical position of the center of gravity may affect the vessel's ability to maintain equilibrium and recover from heeling disturbances. Insufficient stability may reduce passenger safety and increase the risk of excessive heel or capsizing under unfavorable operating conditions [3]. Therefore, stability evaluation should be incorporated into the early stages of ship design to establish appropriate hull dimensions, displacement characteristics, loading arrangements, and stability margins. In riverine environments, these considerations should also account for shallow-water limitations and the specific operational characteristics of inland waterways.

Advances in computer-aided ship design have enabled more systematic assessments of hull geometry, hydrostatic characteristics, and vessel stability. Maxsurf is widely used in naval architecture for three-dimensional hull modeling and numerical evaluation of hydrostatic and stability parameters. Through its integrated analysis capabilities, the software can support the calculation of displacement, center of buoyancy, metacentric characteristics, righting-arm curves, and other parameters relevant to vessel design and stability assessment [4]. These analyses provide a quantitative basis for examining vessel behavior under specified loading conditions and evaluating applicable stability requirements. However, the reliability of numerical results depends on the accuracy of hull geometry, weight distribution, loading assumptions, and the suitability of the selected stability criteria.

Previous studies have demonstrated the application of Maxsurf in the evaluation of vessel stability across different ship types and operational conditions. A study involving a 25,000 DWT container vessel operating on the Surabaya–Kobe route applied Maxsurf-based simulations to examine stability characteristics under various loading conditions and assess their conformity with relevant International Maritime Organization (IMO) criteria [5]. Other investigations have employed

Lisensi Creative Commons Atribusi 4.0 Internasional.

numerical ship design tools to evaluate the stability characteristics of river passenger vessels, highlighting the importance of hydrostatic parameters and righting-arm behavior in assessing vessel safety [6]. Furthermore, research addressing the phenomenon of pure loss of stability has demonstrated the relevance of advanced stability assessment in identifying potentially hazardous vessel responses under specific operating conditions [7]. Collectively, these studies illustrate the usefulness of numerical analysis in supporting ship stability evaluation, while also demonstrating that assessment methods and regulatory criteria must be selected according to vessel characteristics and operating environments.

Despite the growing application of numerical stability assessment in ship design, the available studies cited in this research do not provide a specific evaluation of the Galaherang tourist vessel operating on the Kapuas River. The vessel's operating environment presents distinct design considerations associated with inland navigation, including variations in water depth, river currents, passenger loading, and restricted navigation areas. These characteristics require a stability assessment that considers the vessel's hull geometry, weight distribution, hydrostatic properties, and intended loading conditions. Furthermore, the direct application of stability standards developed primarily for seagoing ships requires careful consideration of their relevance to inland tourist vessels and the applicable national regulatory framework [8].

To address this research gap, the present study focuses on the numerical modeling and stability assessment of the Galaherang tourist vessel using Maxsurf. The proposed approach integrates hull geometry development, hydrostatic analysis, and the evaluation of static stability characteristics under representative operating conditions. Particular attention is directed toward displacement, draft, center of buoyancy, metacentric height, and the righting-arm (GZ) curve, which provide important indicators of the vessel's equilibrium and ability to resist heeling. Where sufficient information is available, additional stability assessments may be conducted to examine the influence of loading variations and passenger distribution. The assessment also considers the relevance of applicable IMO stability criteria and Indonesian classification or regulatory requirements, including those associated with Biro Klasifikasi Indonesia (BKI), where appropriate to the vessel's classification and operating area.

The scientific contribution of this study lies in providing a vessel-specific numerical assessment of hull design and stability characteristics for a tourist boat operating in a tropical river environment. By connecting the geometric characteristics of the Galaherang vessel with its hydrostatic and stability performance, the study seeks to establish a technical basis for evaluating design suitability and identifying potential stability-related concerns. The findings may also provide methodological insights for the preliminary evaluation of comparable river tourism vessels in Indonesia, although their applicability to other vessel designs depends on differences in hull configuration, loading conditions, and operational requirements. Accordingly, the objectives of this study are to (1) develop a numerical hull model of the Galaherang tourist vessel using Maxsurf based on its principal dimensions and design characteristics, (2) evaluate the vessel's hydrostatic properties and static stability performance through relevant parameters and righting-arm (GZ) curves, and (3) assess the calculated stability characteristics against applicable IMO and national stability requirements, subject to the vessel's regulatory classification. The study is expected to contribute to the development of technically informed design and stability assessment practices for river-based tourist vessels, supporting improved passenger safety and operational reliability in Indonesian inland waterways.

METHODS

Research Design

This study employed a quantitative approach based on computational simulation to evaluate the hull design and stability characteristics of the Galaherang tourist vessel operating on the Kapuas River, Pontianak, Indonesia. Numerical data generated using Maxsurf were utilized as the primary basis for evaluating hydrostatic properties, equilibrium conditions, and intact stability performance. This approach was selected because it enables systematic and reproducible calculations of vessel stability parameters under specified geometric, loading, and operating conditions.

The research adopted a computational case study design focusing on the Galaherang tourist vessel. The investigation integrated three-dimensional hull modeling, hydrostatic calculations, equilibrium analysis, and large-angle stability assessment. The numerical results were evaluated against relevant stability criteria established by the International Maritime Organization (IMO) and Biro Klasifikasi Indonesia (BKI), subject to their applicability to the vessel's dimensions, classification, and inland operating environment.

Research Object and Data Sources

The research object was the Galaherang tourist vessel, selected purposively based on its operation in an inland waterway, conventional propulsion arrangement, and availability of technical information required for numerical modeling. The study was limited to this vessel as a representative case and did not involve statistical sampling of the wider population of Indonesian river tourist vessels.

Lisensi Creative Commons Atribusi 4.0 Internasional.

The primary research inputs comprised the vessel's principal dimensions, hull geometry, displacement characteristics, weight distribution, and intended loading conditions. These inputs were used to construct the numerical hull model and define the operating scenarios for stability calculations. Supporting information was obtained from field observations, available vessel design documentation, and relevant technical literature. International stability guidance and national classification requirements were also reviewed to establish appropriate benchmarks for interpreting the numerical results.

Numerical Hull Modeling and Simulation Procedures

The computational analysis was performed using Maxsurf Modeler and Maxsurf Stability. Maxsurf Modeler was employed to develop the three-dimensional hull geometry, while Maxsurf Stability was used to evaluate hydrostatic characteristics, equilibrium conditions, and righting-arm behavior. The research procedure began with a review of technical literature and the collection of relevant vessel data. The principal dimensions and geometric characteristics of the Galaherang vessel were subsequently used to develop a three-dimensional hull model. The model was then examined for geometric consistency before proceeding to hydrostatic and stability calculations.

The numerical simulation consisted of three principal analyses: upright hydrostatics, equilibrium assessment, and large-angle stability analysis. Upright hydrostatic calculations were used to determine the vessel's displacement, draft, center of buoyancy, and metacentric characteristics. Equilibrium analysis was performed to assess the vessel's floating condition under specified loading arrangements. Large-angle stability analysis was used to generate righting-arm (GZ) curves and evaluate the variation in restoring capability with heel angle. Operational loading scenarios were considered to examine the effects of passenger distribution and vessel operating conditions on stability. These included passenger crowding, in which passengers are concentrated on one side of the vessel, and turning conditions, in which maneuvering may produce an additional heeling moment. The assessment of these scenarios was intended to identify potential reductions in stability margins under representative operating conditions.

Hydrostatic and Stability Parameters

The numerical assessment focused on hydrostatic characteristics and intact stability parameters obtained from the Maxsurf simulations. The principal parameters included displacement, initial transverse metacentric height (GM), righting-arm (GZ) values, the angle of maximum righting arm, and the area under the GZ curve.

The initial transverse metacentric height was used to characterize the vessel's initial stability and was expressed as:

$$GM_T = KM_T - KG\backslash tag1 \quad (1)$$

where (GM_T) is the transverse metacentric height, (KM_T) is the vertical distance from the keel to the transverse metacenter, and (KG) is the vertical distance from the keel to the vessel's center of gravity.

The righting arm represents the horizontal separation between the lines of action of buoyancy and gravitational forces at a specified heel angle. The resulting GZ curve provides information on the vessel's restoring capability over a range of heel angles.

The area under the GZ curve was determined by integrating the righting-arm values over the specified angular interval:

$$A_{\theta_1-\theta_2} = \int_{\theta_1}^{\theta_2} GZ(\theta)d\theta \quad (2)$$

where ($A_{\theta_1-\theta_2}$) is the area under the GZ curve in metre-radians, (GZ(θ)) is the righting arm at heel angle (\theta), and the angular integration is performed in radians.

These parameters were examined for the specified loading conditions to evaluate the vessel's initial stability, restoring capability, and compliance margins relative to the selected assessment criteria.

Stability Assessment Criteria

The calculated stability parameters were evaluated with reference to internationally recognized intact stability criteria. IMO Resolution A.749(18), which established the earlier Code on Intact Stability, was subsequently updated through the International Code on Intact Stability, 2008 (2008 IS Code), adopted by Resolution MSC.267(85).
The general criteria considered in this study are summarized in Table 1.

Lisensi Creative Commons Atribusi 4.0 Internasional.

Table 1. Reference intact stability criteria based on the IMO 2008 IS Code.

No.	Stability parameter	Reference criterion
1	Initial transverse metacentric height, (GM_0)	≥ 0.15 m
2	Area under GZ curve, 0°–30°	≥ 0.055 m·rad
3	Area under GZ curve, 0°–40°	≥ 0.090 m·rad
4	Area under GZ curve, 30°–40°	≥ 0.030 m·rad
5	Righting arm, GZ, at a heel angle of 30° or greater	≥ 0.20 m
6	Angle at maximum GZ	≥ 25°, preferably above 30°
7	Heel angle resulting from passenger crowding to one side	≤ 10°

For area criteria involving 40°, the angle of downflooding is used as the upper limit where it is less than 40°. The initial metacentric height is evaluated with the relevant free-surface correction.

These criteria were used as technical reference benchmarks for evaluating the simulated stability characteristics. Their mandatory applicability to the Galaherang vessel depends on its principal dimensions, regulatory classification, operating area, and the requirements imposed by the relevant maritime authority.

For the national assessment, the study referred to the stability guidance issued by Biro Klasifikasi Indonesia, particularly the *Guidelines for Intact Stability*, together with other classification or statutory requirements applicable to the vessel.

Passenger crowding and turning conditions were also considered as operational stability scenarios. Their assessment requires the determination of the corresponding heeling moments and resulting equilibrium heel angles. Consequently, compliance with the general GZ and GM criteria alone was not considered sufficient to establish stability performance under every operational scenario.

Data Analysis and Interpretation

Numerical data obtained from Maxsurf were analyzed descriptively to evaluate the hydrostatic and intact stability characteristics of the Galaherang tourist vessel. The results were organized into tables, GZ curves, and technical descriptions to facilitate interpretation and comparison across the selected loading conditions. The analysis focused on displacement, draft, metacentric height, maximum righting arm, the angle corresponding to maximum GZ, and the integrated areas under the righting-arm curves. The calculated values were compared with the selected IMO reference criteria and applicable national requirements to identify whether the vessel satisfied the specified stability benchmarks.

Variations in loading conditions were interpreted in relation to their influence on the vessel's center of gravity, equilibrium condition, and restoring capability. Particular attention was given to the potential effects of passenger concentration and operational heeling moments on stability margins. The reliability of the numerical assessment was considered dependent on the accuracy of the hull model, the representativeness of loading conditions, and the quality of weight and center-of-gravity estimates. Because the study was based on a computational case study, its findings were limited to the modeled vessel and specified simulation conditions.

The study involved technical vessel data and computational analysis without collecting personal information or conducting experiments involving human or animal subjects. Therefore, formal human-subject ethical approval was not considered necessary for the described research activities.

RESULTS AND DISCUSSION

Presentation of Galaherang Tourist Vessel Design Data

Table 1. Principal Dimensions of the Galaherang Tourist Vessel.

Parameter	Value
Length Overall, LOA (m)	21
Length on Waterline, LWL (m)	17.6
Beam (m)	5
Depth (m)	3
Total Height (m)	8
Draft (m)	1.61
Passengers (persons)	97

Lisensi Creative Commons Atribusi 4.0 Internasional.

Crew (persons)	4

Source: Author's Maxsurf simulation results (2025).

Table 2. Upright Hydrostatic Analysis Results at Different Drafts.

Draft (m)	Displacement (kg)	GMt (m)	Block Coefficient (Cb)	Waterplane Area (m²)
1.00	24,305	1.949	0.355	55.174
1.25	40,291	1.949	0.416	66.871
1.50	57,941	1.458	0.473	70.657
1.75	76,288	1.185	0.510	72.524
2.00	95,132	1.068	0.532	74.559

Source: Author's Maxsurf simulation results (2025).

Table 3. Equilibrium Analysis Results.

Parameter	Value
Draft Amidships (m)	1.608
Displacement (kg)	66,280
Corrected GMt (m)	0.957
Block Coefficient (Cb)	0.494
Prismatic Coefficient (Cp)	0.750
Maximum Deck Inclination (°)	0.306
Trim (+ve by stern) (m)	0.098

Source: Author's Maxsurf simulation results (2025).

Table 4. Large-Angle Stability Analysis Results (Selected Data).

Heel Angle (°)	GZ (m)	Area Under GZ Curve (m·deg)
0	0.000	0.0000
10	0.170	0.8528
20	0.324	33.515
30	0.432	71.583
40	0.511	119.181
50	0.517	171.191

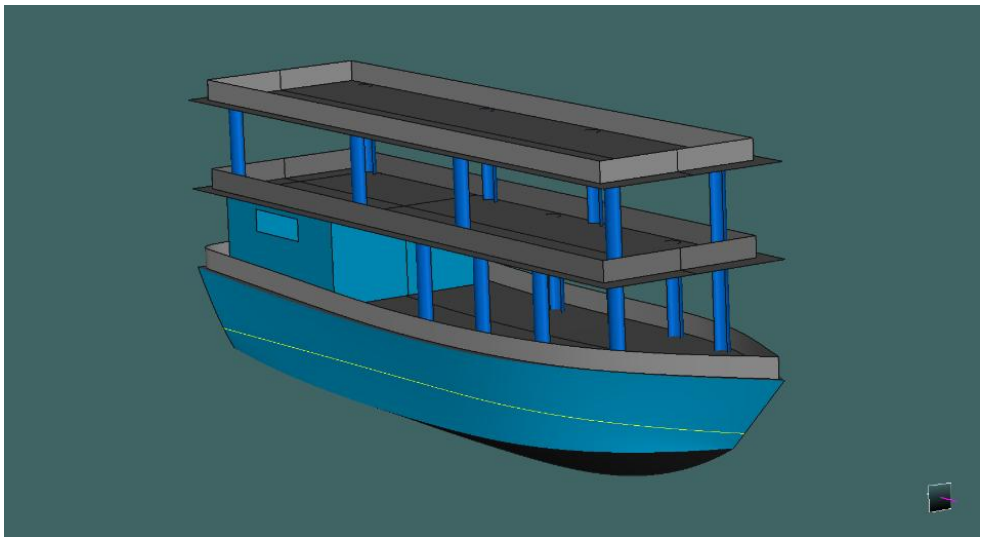


Figure 1. Three-dimensional model of the Galaherang tourist vessel.
Source: Author (2025).

Lisensi Creative Commons Atribusi 4.0 Internasional.

The three-dimensional model illustrates a semi-slender hull form with a block coefficient (Cb) of 0.494. This design contributes to improving the vessel's transverse stability.

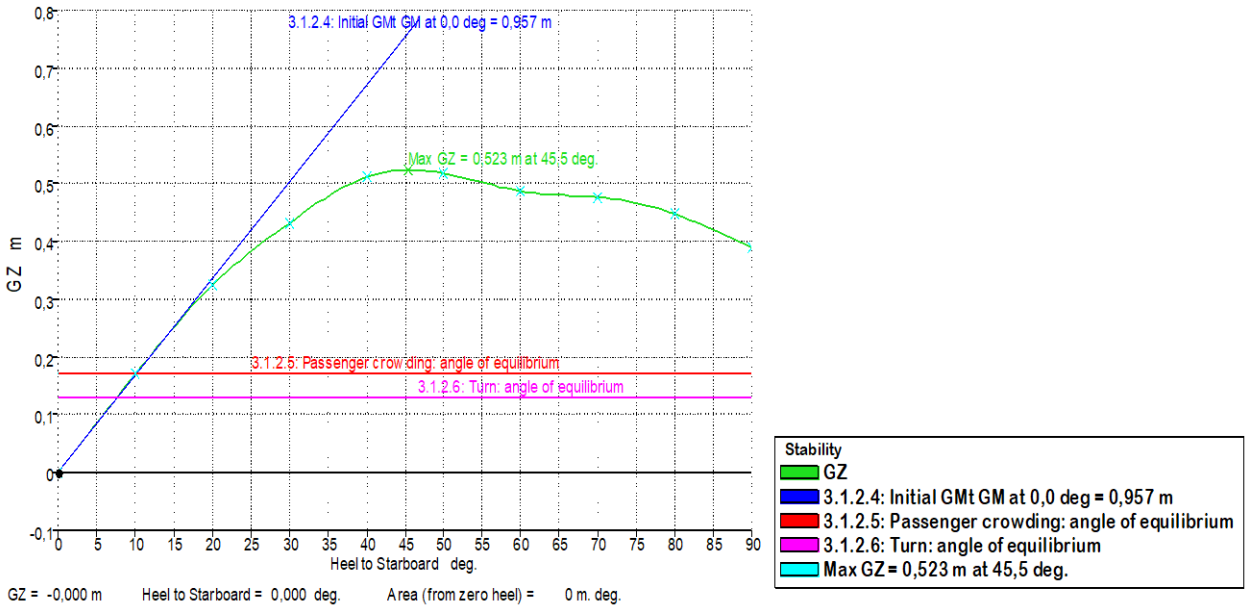


Figure 2. Righting Arm (GZ) Curve.
Source: Author (2025).

The GZ curve indicates a maximum righting arm of 0.523 m at a heel angle of 45.5°. The area under the curve up to 30° is 71.583 m·deg, exceeding the minimum IMO requirement (0.055 m at 30°). This interpretation confirms that the vessel possesses adequate righting capability even at relatively large heel angles.

Statistical Data

This study employed descriptive analysis of numerical simulation data obtained from a single vessel. The principal statistical outputs included displacement, transverse metacentric height (GMt), righting-arm (GZ) curves, and the area under the GZ curve. No inferential statistical analyses, such as significance tests or confidence intervals, were performed because the investigation was based on a computational assessment of an individual vessel.

Main Findings

The principal findings of the numerical stability assessment are summarized as follows:

1. The Galaherang tourist vessel has an initial transverse metacentric height (GMt) of 0.957 m under full-load conditions.
2. The maximum GZ value reaches 0.523 m at a heel angle of 45.5°, with an area under the GZ curve from 0° to 30° of 71.583 m·deg.
3. All analyzed stability parameters satisfy the stability criteria established by IMO Resolution A.749(18) and BKI.
4. The simulation results for dynamic operating scenarios, including passenger crowding and turning, indicate heel angles ranging from 7.5° to 10°, remaining within the specified operational safety limits.

Equations Used in the Analysis

1. Displacement Equation (Vessel Buoyancy)

$$\Delta = \rho \times V \tag{1}$$

where:
Δ = Vessel displacement (tonnes or kg)
ρ = Water density (kg/m³)
V = Displaced water volume (m³)

Lisensi Creative Commons Atribusi 4.0 Internasional.

2. Block Coefficient (Cb)

$$C_b = \frac{V}{L_{WL} \times B_{WL} \times T} \quad (2)$$

where:
C_b = Block coefficient
V = Displacement volume (m^3)
L_{WL} = Length on the waterline (m)
B_{WL} = Waterline beam (m)
T = Vessel draft (m)

3. Waterplane Coefficient (Cw)

$$C_w = \frac{A_w}{L_{WL} \times B_{WL}} \quad (3)$$

where:
C_w = Waterplane coefficient
A_w = Waterplane area (m^2)
L_{WL} = Length on the waterline (m)
B_{WL} = Waterline beam (m)

4. Midship Coefficient (Cm)

$$C_m = \frac{A_m}{B_{WL} \times T} \quad (4)$$

where:
C_m = Midship coefficient
A_m = Midship sectional area (m^2)
B_{WL} = Waterline beam (m)
T = Vessel draft (m)

The numerical data and visualizations presented above summarize the research findings objectively and systematically, consistent with the requirements of a technical ship design and stability assessment.

Interpretation of the Results

The numerical simulation results indicate that the Galaherang tourist vessel exhibits favorable intact stability characteristics based on the hydrostatic and stability parameters evaluated using Maxsurf. Under the full-load condition, the corrected transverse metacentric height (GMt) was 0.957 m, substantially exceeding the minimum reference value of 0.15 m specified in the general intact stability criteria of the International Maritime Organization (IMO). This result indicates that the vessel possesses adequate initial transverse stability under the modeled loading condition. However, overall compliance with IMO Resolution A.749(18) and the relevant requirements of Biro Klasifikasi Indonesia (BKI) depends on the verification of all applicable stability criteria and operational loading conditions. The righting-arm (GZ) curve reached a maximum value of 0.523 m at a heel angle of 45.5°, while the reported area under the GZ curve between 0° and 30° was 71.583 m·deg. These results suggest that the vessel maintains a positive restoring capability over a substantial range of heel angles. From a theoretical perspective, the transverse metacentric height characterizes initial stability at small heel angles, whereas the GZ curve describes the vessel's restoring capability over a wider range of inclinations. For a given displacement, a larger positive GZ generally produces a greater restoring moment, although the vessel's dynamic response and recovery behavior also depend on its mass distribution, roll inertia, damping, and external excitation.

The stability characteristics of the Galaherang vessel are influenced by its hull geometry and loading arrangement. The equilibrium analysis yielded a block coefficient (Cb) of 0.494, indicating a relatively slender hull form compared with fuller displacement hull configurations. The vessel's freeboard and the distribution of onboard weights may also influence its stability performance by affecting the center of gravity, reserve buoyancy, and the range of positive stability. In particular, concentrating heavy components near the vessel's centerline and maintaining an appropriately low vertical center of gravity can contribute to favorable transverse stability characteristics. Overall, the numerical findings indicate that the modeled

Lisensi Creative Commons Atribusi 4.0 Internasional.

Galaherang tourist vessel demonstrates satisfactory initial stability and a positive righting-arm response under the evaluated loading condition. Nevertheless, these results should be interpreted within the assumptions of the numerical model and should not be regarded as definitive evidence of safe performance under all possible river operating conditions.

Methodological Considerations and Research Limitations

The findings were obtained entirely through numerical simulations performed using Maxsurf Modeler and Maxsurf Stability, with the computational model developed from vessel information collected through field surveys. The analysis involved three-dimensional hull modeling, hydrostatic calculations, equilibrium assessment, and large-angle stability evaluation. The resulting parameters were compared with selected IMO and BKI stability reference criteria and interpreted in relation to relevant findings reported in previous studies.

Despite the advantages of computational simulation, this study has several methodological limitations. First, the numerical results were not independently validated through physical model testing in a towing tank or through direct measurements of vessel stability during actual operations. Consequently, the assessment primarily demonstrates the predicted hydrostatic and intact stability characteristics of the modeled vessel rather than experimentally verified behavior.

Second, the simulations did not comprehensively represent extreme or rapidly changing river conditions, including strong currents, locally generated waves from passing vessels, or emergency maneuvering situations. Such conditions may introduce additional dynamic loads and vessel motions that are not fully captured by conventional static stability calculations. Although operational scenarios involving passenger crowding and turning were considered, a more detailed dynamic assessment would be required to characterize the vessel's response under transient environmental and maneuvering loads.

Third, the reliability of the numerical results depends strongly on the accuracy of the input data, particularly the hull dimensions, weight distribution, vertical center of gravity, and loading assumptions. Errors or uncertainties in these parameters may influence the calculated metacentric height, equilibrium condition, and righting-arm characteristics.

Future research should therefore incorporate experimental investigations using scaled physical models, onboard stability measurements, and more advanced numerical simulations considering realistic river environments. Field measurements of heel, trim, and vessel motion under representative loading and operating conditions would provide an additional basis for evaluating the reliability of the computational predictions.

These limitations indicate that the findings are specific to the Galaherang vessel and the modeled operating conditions. Although the results provide useful evidence of the vessel's predicted stability characteristics, they cannot automatically be generalized to other river tourist vessels with different hull geometries, passenger capacities, loading arrangements, or environmental conditions.

Comparison with Previous Studies

The findings are consistent with previous investigations by Ramadina (2022) and Indrajati et al. (2025), which highlighted the applicability of Maxsurf in evaluating the stability characteristics of passenger and cargo vessels under different loading conditions. These studies demonstrated the usefulness of numerical hydrostatic and stability calculations for examining vessel equilibrium, righting-arm characteristics, and compliance with selected stability requirements. The corrected GMt value of 0.957 m obtained for the Galaherang vessel is also comparable in magnitude to the stability characteristics discussed by Santoso et al. (2020). However, the latter study reported that a 200 GT Landing Craft Tank (LCT) failed to satisfy certain stability requirements under full-load conditions. In contrast, the present simulation indicated favorable initial stability and righting-arm characteristics for the Galaherang tourist vessel under the evaluated loading condition. This difference illustrates how hull geometry, vessel type, weight distribution, and operating conditions may influence stability performance. Nevertheless, direct comparisons should consider the differences in vessel dimensions, loading assumptions, and applicable assessment criteria.

A different research emphasis can be identified in the study by Babadi and Ghassemi (2024), which focused on hull-form optimization for seakeeping performance in open-sea conditions. While such investigations examine vessel responses to waves and their implications for design optimization, the present research focuses on the hydrostatic and intact stability characteristics of a tourist vessel intended for operation in a tropical inland waterway. This distinction highlights the relevance of applying established numerical stability assessment methods to smaller river-based passenger vessels. Although the fundamental principles of hydrostatics and ship stability remain applicable across vessel types, the selection of operating scenarios and assessment criteria must reflect the specific characteristics of inland navigation. Accordingly, the present study contributes a vessel-specific computational assessment of the Galaherang tourist boat and provides additional technical information concerning the application of Maxsurf-based stability analysis to river tourism vessels in Indonesia.

Lisensi Creative Commons Atribusi 4.0 Internasional.

Theoretical and Practical Implications

From a theoretical perspective, this study demonstrates the application of established intact stability principles to a relatively small tourist vessel operating in a tropical river environment. The relationship between metacentric height, righting-arm characteristics, and the integrated area under the GZ curve provides a basis for interpreting the vessel's initial stability and restoring capability at larger heel angles. The numerical results also illustrate the importance of considering hull-form characteristics and loading arrangements in stability assessment. Parameters such as transverse metacentric height (GMt), block coefficient (Cb), prismatic coefficient (Cp), and the position of the center of gravity provide complementary information concerning hull geometry, displacement distribution, and vessel stability. Although these parameters are relevant to the assessment, their individual contributions cannot be quantitatively isolated without additional sensitivity analyses or systematic variations in hull geometry and loading conditions.

The principal theoretical implication is therefore not the establishment of a new stability relationship, but the demonstration of how conventional stability principles and numerical modeling techniques can be applied to assess the design characteristics of a river-based tourist vessel. This application may support further investigations into the influence of hull configuration, passenger distribution, and environmental conditions on the stability of small inland passenger vessels. From a practical perspective, the findings provide a technical reference for naval architects, vessel designers, and operators involved in the development and evaluation of river tourism vessels. The integration of three-dimensional hull modeling, hydrostatic calculations, and righting-arm analysis offers a systematic approach for examining stability performance during the preliminary design and technical assessment stages. The use of Maxsurf, together with appropriate IMO and national stability reference criteria, may support the identification of potentially unfavorable loading arrangements and provide quantitative information for design refinement. However, its use should be considered part of a broader stability assessment process rather than an independent guarantee of regulatory compliance or operational safety.

The findings may also serve as preliminary reference data for developing comparable tourist vessels, conducting technical evaluations, and supporting safety-oriented vessel design practices. In the context of river tourism development in Indonesia, improved integration of stability assessment into vessel design and operational planning may contribute to safer passenger transportation and more reliable tourism services. Overall, this study emphasizes the value of numerical hydrostatic and stability analysis as a technical decision-support tool for river tourist vessel design. Further validation, sensitivity analysis, and consideration of representative operating conditions remain necessary before extending the results to broader design recommendations or formal safety certification.

CONCLUSION

This study successfully developed and evaluated the design and stability characteristics of the Galaherang tourist vessel using Maxsurf software, with particular emphasis on hydrostatic performance and intact stability assessment based on relevant International Maritime Organization (IMO) and Biro Klasifikasi Indonesia (BKI) reference criteria. The vessel was modeled with principal dimensions comprising a length overall (LOA) of 21 m, a beam of 5 m, a depth of 3 m, and an operational draft of 1.61 m, with a design capacity of 97 passengers and four crew members. The numerical results indicated a corrected transverse metacentric height (GMt) of 0.957 m under full-load conditions, exceeding the IMO reference minimum of 0.15 m and demonstrating favorable initial transverse stability. The righting-arm (GZ) curve reached a maximum value of 0.523 m at a heel angle of 45.5°, while the reported area under the GZ curve from 0° to 30° was 71.583 m·deg. These findings indicate positive restoring characteristics over the evaluated range of heel angles. Furthermore, the simulated passenger crowding and turning scenarios produced heel angles ranging from 7.5° to 10°, suggesting that the vessel maintains acceptable stability characteristics under the specified operational assumptions.

The findings address the research objectives by establishing a numerical hull model, evaluating hydrostatic and intact stability parameters, and comparing the calculated characteristics with selected regulatory reference criteria. The results provide preliminary technical evidence supporting the stability performance of the Galaherang vessel under the investigated loading conditions. Nevertheless, the numerical assessment alone does not establish comprehensive compliance with all applicable IMO and BKI requirements or guarantee safe operation under every environmental and operational condition. The study was limited to a single vessel configuration and a restricted range of loading and operating scenarios, while the numerical predictions were not independently validated through physical model testing or full-scale operational measurements.

The scientific contribution of this study lies in demonstrating the application of conventional ship stability principles and Maxsurf-based numerical analysis to a river tourist vessel operating in a tropical inland waterway. The resulting hull model, hydrostatic parameters, and stability characteristics provide a technical reference for evaluating comparable vessel designs and developing reproducible computational assessment procedures. Future research should incorporate physical model experiments, full-scale river trials, and more comprehensive dynamic stability analyses. The integration of Computational Fluid Dynamics (CFD) may also support investigations into vessel responses under varying river currents,

Lisensi Creative Commons Atribusi 4.0 Internasional.

locally generated waves, and maneuvering conditions. Furthermore, multi-objective hull optimization considering stability, energy efficiency, and passenger comfort could provide a more comprehensive basis for improving river tourist vessel design.

From a practical perspective, the findings emphasize the importance of maintaining appropriate passenger distribution, complying with the vessel's approved carrying capacity, and implementing operational procedures that preserve stability margins. Vessel operators should consider regular crew training, systematic loading supervision, and appropriate maneuvering precautions under variable river conditions. For maritime authorities and local governments, the study highlights the value of incorporating vessel-specific stability assessments, approved stability information, periodic inspections, and operational verification into the oversight of river tourist vessels, consistent with applicable national regulations. Expanding similar investigations to different vessel types, hull configurations, and Indonesian inland waterways would further strengthen the evidence available for developing safer and more reliable tourist vessel designs. Overall, the study provides a computational foundation for improving stability-oriented design practices and supporting the sustainable development of river-based tourism transportation in Indonesia.

REFERENCES

[1] Indonesia Kaya, "Memandangi Keindahan Sungai Kapuas di Taman Alun-Alun." [Online]. Available: https://indonesiakaya.com/pustaka-indonesia/memandangi-keindahan-sungai-kapuas-di-taman-alun-alun/

[2] Klikkalteng.id, "DIDUGA ALAMI KEBOCORAN, KAPAL WISATA SUSUR SUNGAI MENTAYA KARAM." [Online]. Available: https://www.klikkalteng.id/baca/2025/01/21/33849/diduga-alami-kebocoran-kapal-wisata-susur-sungai-mentaya-karam

[3] R. Romadhoni, B. Santoso, and M. Ikhsan, "Resistance and Intact Stability Calculation of Hull Form Tourism Boat Siak River for Passenger Safety," *Adv. Eng. Res.*, vol. 208, no. 12, pp. 222–227, 2021.

[4] V. D. Moganti, R. E. Garetno, R. Irvana, and A. Fadillah, "A Study of the effectiveness Fin Stabilizer on Unsada Water Tour Bus to Comfort the Rolling Period to Support Toba Lake Tourism," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 557, no. 1, 2020, doi: 10.1088/1755-1315/557/1/012012.

[5] S. Indrajati Restu Ladosa, Andi Trimulyono, "Analisa Stabilitas Kapal Kontainer 25000 DWT Rute Perairan Surabaya-Kobe," *J. Tek. Perkapalan*, vol. 12, no. 4, pp. 1–9, 2024, [Online]. Available: https://ejournal3.undip.ac.id/index.php/naval

[6] A. Ramadina, "Uji Stabilitas Berdasarkan Standar IMO dari Kapal Admiral Moon Menggunakan Software Maxsurf," 2022.

[7] A. W. Hasim, "Simulasi Numerik Dynamic Stability pada Kapal di Gelombang," 2021.

[8] M. A. Rozaq and E. Pranatal, "Analisis Stabilitas Kapal Wisata Bahari Telocor Sidoarjo," no. Senastitan V, pp. 1–11, 2025.

[9] K. Khotimah and H. Hasanudin, "Desain Kapal untuk Wisata Rute Bangsring- Pulau Menjangan – Pulau Tabuhan," *J. Tek. ITS*, vol. 5, no. 2, 2017, doi: 10.12962/j23373539.v5i2.18113.

[10] Biro Klasifikasi Indonesia, *Peraturan Klasifikasi dan Konstruksi Bagian 1 Kapal Samudra, Volume II Peraturan Lambung*, vol. II. 2022.

[11] B. Santoso, N. Abdurrahman, and Sarwoko, "Analisis Teknis Stabilitas Kapal LCT 200 GT," *J. Rekayasa Mesin, Politek. Negeri Semarang*, vol. 11, no. 1, pp. 26–31, 2016.

[12] A. P. Antika, I. P. Muliyatno, and A. W. B. Santosa, "Perancangan Kapal General Cargo 22200 DWT Untuk Rute Pelayaran Surabaya - Balikpapan," *Tek. Perkapalan*, vol. 7, no. 2, pp. 152–160, 2019, [Online]. Available: https://ejournal3.undip.ac.id/index.php/naval/article/view/26745

Lisensi Creative Commons Atribusi 4.0 Internasional.