



The Influence of the Management of Navigation Aids and Employee Performance on Maritime Safety

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Abstract

Maritime safety is a fundamental element in supporting secure, efficient, and sustainable sea transportation, particularly in strategic maritime regions such as Makassar. This study aims to analyze the effect of SBNP (Sarana Bantu Navigasi Pelayaran) management and employee performance on maritime safety at the District of Navigation Type A Class I Makassar. The research adopts a quantitative approach using survey data collected from 100 respondents, with instruments measured through a Likert scale. Data analysis was conducted using validity tests, reliability tests, multiple linear regression analysis, partial tests (*t*-test), simultaneous tests (*F*-test), and the coefficient of determination (R^2). The results of the validity and reliability tests confirm that all research instruments are valid and reliable, indicating strong internal consistency. The partial regression analysis reveals that SBNP management does not have a statistically significant effect on maritime safety, suggesting that the mere availability and procedural management of navigational aids are insufficient to directly enhance safety outcomes. In contrast, employee performance shows a positive and highly significant influence on maritime safety, highlighting the critical role of human resources in ensuring the effective operation, maintenance, and responsiveness of navigational systems. Simultaneously, the *F*-test results indicate that SBNP management and employee performance together have a significant effect on maritime safety. Furthermore, the coefficient of determination demonstrates that 94.2% of the variation in maritime safety can be explained by the combined influence of SBNP management and employee performance, while the remaining 5.8% is affected by other factors outside the model.

Introduction

Maritime development plays a crucial role in realizing national progress, as it serves as the backbone supporting various other sectors of life (Ali, 2025; Ayhan, 2023; Nik et al., 2023). Maritime affairs are not just about moving people and goods, but also about opening access, accelerating economic growth, and strengthening connectivity between regions, at the local, regional, and international levels. Therefore, development in this sector needs to be designed comprehensively, efficiently, reliably, and sustainably (Liu et al., 2026; Taloba & Rayan, 2025; Karpavicius et al., 2025). The development of maritime transport across land, sea, and air must be directed in an integrated and interconnected manner to create a robust distribution system capable of providing tangible benefits to the wider community (Juliano et al., 2026; Mostafayi et al., 2026; Vlachogiannis et al., 2026). Through a comprehensive approach that prioritizes the needs of the people, it is hoped that the maritime sector will become a bridge to progress and shared prosperity. Maritime safety is a strategic issue in the management of Indonesia's maritime territory, an archipelagic nation with highly congested shipping traffic (Riyadi &

Erliyani, 2025; Puspitayani, 2025; Hadiningrat et al., 2024). One vital element in maintaining shipping safety is the existence of Navigation Aids (Navigation Aids), which function as direction indicators, hazard markers, and support the smooth flow of maritime traffic. The SBNP (National Navigation Aid System) is not only a physical asset but also part of an integrated navigation system that requires professional management and high standards (Murdo 2021; Laju et al., 2024; Julianto et al., 2025).

The Makassar Class I Type A Navigation District is one of the regions with a significant responsibility in ensuring the optimal functioning of the SBNP. This work area not only serves domestic shipping but also serves as a major international trade route. Therefore, the existence and quality of SBNP management in this region will significantly impact the integrity of the national logistics system and the safety of passing vessels (Dela Ayu Permatasari and Sumartik 2022). Given the vast waters within the Makassar Class I Type A Navigation District's work area and the importance of maritime safety, particularly in the Indonesian Archipelagic Sea Lanes, Navigation Aids are essential for guiding and ensuring the smooth sailing of vessels. They are a vital element supporting the safety and smooth sailing of navigation, especially given the large number of national and international merchant vessels that navigate the Makassar Strait. The Makassar Class I Type A Navigation District plays a strategic role in the management, maintenance, and operation of the SBNP, including lighthouses, beacons, buoys, and the electronic navigation system (VTS). The reliability of these operational facilities is crucial for the success of staff, particularly in the implementation of technical functions in the field. Employee performance in managing the SBNP is a key factor determining the effectiveness and safety of shipping. Competent, disciplined, and professional employees will be able to maintain the reliability of the SBNP, minimize the risk of maritime accidents, and increase the trust of shipping service users. However, challenges in managing the SBNP remain significant, particularly related to uneven human resources in terms of competency and work integrity (Hibatullah Salam et al. 2024). The working area covers 13,260 square miles with a coastline of 1,106 nautical miles, encompassing the provinces of South Sulawesi and West Sulawesi. The northern part borders the Bitung Navigation District, the eastern part borders the Kendari Navigation District in Bone Bay, the southern part borders the Benoa and Kupang Navigation Districts in Selayar, and the western part borders the Surabaya Navigation District, Banjarmasin Navigation District, and Samarinda Navigation District in Makassar Strait. The Makassar Class I Type A Navigation District consists of six installations: the Navigation Aid Installation (SBNP), the Coastal Radio Station Installation (SRQP), the State Vessel Installation, the Marine Observation Laboratory and Workshop Installation, and the Vessel Traffic System (VTS) Installation. According to the 2024 Government Agency Performance Report (LKIP) of the Directorate General of Sea Transportation, Ministry of Transportation, the maritime accident rate in Indonesia remains quite fluctuating. In 2024, 128 maritime accidents were recorded, with the causes of these accidents being attributed to human, natural, and technical factors, including inaccurate positioning, damage, or malfunction of the SBNP. This percentage indicates potential for improvement in SBNP management, particularly in terms of human resources and cross-sector coordination. Based on the comparative data between the realization of performance for the 2020–2024 period and the targets set in the Strategic Plan of the Directorate General of Sea Transportation on the indicator of the ratio of maritime transportation accidents per 10,000 voyages, it shows that the performance achievements obtained tend to fluctuate throughout the period, the realization achievements still do not fully meet the targets set, especially in 2023 and 2024. This is reflected in the performance achievements in 2023 of 86.59% and decreased to 87.5% in 2024.

This is because in 2024 the number of accident realizations (0.90) was actually higher than the target set (0.85), so that the effectiveness of performance achievement is considered to have

decreased, indicating the need to strengthen accident reduction strategies more effectively. This situation underscores the importance of improving maritime safety management, including optimizing Navigational Aids (SBNP), as well as improving employee competency and performance to support the achievement of maritime safety targets. One factor contributing to maritime accidents is the adequacy and reliability of Navigational Aids (SBNP). Based on International Maritime Organization (IMO) standards, the ideal SBNP reliability level is 98% to ensure optimal navigational safety. However, the average reliability of SBNP in the Makassar Class I Navigation District for the 2020–2024 period remains at 97.41%, which does not fully meet these international standards. This situation is a significant concern and underpins the need to improve SBNP management and maintenance to support greater maritime safety. Previous research confirms that successful SBNP management relies heavily on the integration of technical policies and human resource management. Competent and trained human resources significantly contribute to reducing maritime accidents and increasing the operational effectiveness of SBNP. However, the implementation of employee training and certification is still not fully distributed across all navigation districts (Maidita and Amelia 2021). In addition to technical and human resource aspects, external challenges such as extreme weather changes, increasing ship traffic, and developments in navigation technology also influence the complexity of SBNP management. Employees are required to be adaptive and responsive to changes in the work environment, including understanding digital navigation systems that are now beginning to be widely adopted (Nur Kusaeni 2023). This study aims to in-depth identify the factors influencing employee performance in SBNP management, analyze the relationships between relevant variables, and provide data-based recommendations for improving the quality of maritime human resources. Through a quantitative approach and accurate administrative data, the results of this study are expected to provide strategic input for policymakers (Yuliani et al. 2022). The operation of Navigation Aids for Shipping still encounters many abnormalities, which makes the reliability of Navigation Aids for Shipping less than optimal overall and experiences a decline that is very dangerous for navigators in sailing their ships so that the effectiveness of employee task implementation is not only determined by individual factors, but also greatly influenced by the support of available work facilities and infrastructure. Adequate SBNP operational facilities, both in terms of availability, technical feasibility, and sophistication contribute greatly to the speed, accuracy, and quality of employee work results.

On the other hand, the limitations of SBNP operational facilities such as the number of buoys, beacons, and signs are not commensurate with the scope of the work area. Some supporting facilities and infrastructure, especially field equipment (State Ships, Operational Ships, measuring instruments, lifting equipment) are inadequate, lack of routine maintenance, maintenance schedules do not run according to SOP due to budget or logistical limitations. So that employee performance is slow because they have to wait which can have a direct impact on declining performance. These problems indicate inefficiencies and weaknesses in employee performance that have an impact on suboptimal management of SBNP. Efforts to improve employee performance in managing the SBNP will have a direct impact on maritime safety within the Makassar Class I Type A Navigation District. Good employee performance will reduce the risk of accidents, increase public trust among shipping service users, and strengthen the competitiveness of the national maritime sector (Bano, Khatun, and Kumar 2024).

Methods

Research Design

This research uses a quantitative approach with a descriptive design. This approach was chosen to provide a factual picture of conditions in the field while simultaneously exploring the causal

relationships between the variables involved. This design aims to clearly illustrate how employee performance in the management of Navigational Aids contributes to improving maritime safety in the Makassar Class I Type A Navigation District. The research process began with the development of a questionnaire, a data collection instrument designed based on indicators for each variable in the study. All questions in the questionnaire were formulated systematically, referring to the theoretical framework and relevant previous research findings. The questionnaire was then distributed to employees directly involved in the management of the SBNP, ensuring that the results accurately reflect the experiences and perspectives of practitioners in the field.

This research design integrates two main objectives: first, to capture the real-world conditions of SBNP management and its challenges; and second, to examine the relationship between factors such as motivation, human resource competency, organizational culture, leadership, reward and punishment systems, technology, maintenance, government policies, resource availability, and community involvement with employee performance and its impact on maritime safety. Through this analysis, it is hoped to identify the variables that most dominantly influence the effectiveness of SBNP management. After data collection, the analysis was conducted in stages. This began with descriptive analysis to describe the respondent profile and distribution of answers, and then proceeded to inferential analysis using the Partial Least Squares (PLS) method. PLS was chosen as an analytical tool based on its ability to simultaneously examine relationships between variables, while also handling complex research models involving multiple indicators. With PLS, researchers can assess the strength of each independent variable's influence on the dependent variable in the model being constructed. To ensure the instrument used is truly valid and reliable, a reliability test was also conducted using Cronbach's Alpha. An instrument is considered reliable if it achieves a value above 0.70, ensuring reliable measurement results.

Research Location and Timeline

This research was conducted at the Makassar Class I Type A Navigation District, a strategic institution spearheading the management of Navigational Aids in the waters of eastern Indonesia. This location was chosen not only for its vital role in supporting national and international shipping traffic, but also because of the complex challenges faced in maintaining the safety and smoothness of maritime navigation in the region. Its location on a major shipping lane, with high ship traffic, demands a truly effective SBNP management system supported by optimal employee performance. Geographically, the Makassar Class I Type A Navigation District's working area encompasses a highly dense maritime area, where various types of merchant, passenger, and fishing vessels pass through daily. In this area, various types of navigational aids such as beacons, buoys, beacons, and other electronic navigation systems are deployed and regularly maintained. This research also considers the unique characteristics of the work environment, where the interaction between humans, technology, and the environment is a determining factor in the success of SBNP management.

The Makassar Navigation District not only boasts adequate physical infrastructure but is also supported by relatively well-trained and professional human resources. Employees at this institution face various challenges, ranging from budget constraints, technological changes, and the need to adapt to new regulations. This research seeks to capture the real-world dynamics in the field, from operational, managerial, and organizational behavioral perspectives. The research will be conducted over two months, from November to December 2025, with the main activities including questionnaire distribution, in-depth interviews, and participant observation of the SBNP management process in the field. In addition to collecting primary data, researchers will also review internal documents and routine reports. All data

collected will be combined to gain a comprehensive perspective on employee performance, navigation aid management, and its implications for shipping safety in this work area.

Population and Sampling Technique

The population in this study consists of employees working in the Makassar Class I Type A Navigation District and actively involved in the management of the Shipping Navigation Aids (SBNP). This population comprises various levels of positions, ranging from leaders, Division Heads, Section Heads, technical staff, to field staff. Each individual has a distinct contribution and role in the operation, maintenance, and administration of the SBNP, all of which are the backbone of ensuring the smooth and safe operation of shipping in the region. The diverse characteristics of this population are a unique strength. The educational backgrounds of employees generally include marine engineering, maritime management, and applied social sciences. In terms of work experience, some employees have careers in shipping and navigation for more than a decade, while others have only served in the Makassar Navigation District for a few years. The variation in age, length of service, and job specialization reflects the dynamics of the human resources within this institution. As an institution responsible for managing vital national shipping infrastructure, the Makassar Navigation District demands a high level of professionalism from its employees. Therefore, this study focused on respondents who were significantly involved in the strategic and technical processes of SBNP management, such as the inspection and maintenance of lighthouses, beacons, buoys, and navigation document management, with a total population of 100 individuals.

Sampling Technique

The sampling method used was purposive sampling. This technique was chosen considering that not all employees have direct involvement and experience relevant to the research needs. Purposive sampling allows researchers to be more selective in selecting respondents based on criteria relevant to the research objectives. The main criteria used in sample selection include: Active involvement in the operation, maintenance, or supervision of SBNP. Technical and administrative understanding of navigation systems and maritime safety procedures.

By using purposive sampling, researchers hoped to obtain respondents who truly understand the work context and challenges in the field, so that the data collected truly reflects the real situation in SBNP management.

Sample Size

Sugiyono (2020) defines a sample as a subset of a population with similar characteristics and used as a data source in research. When a population is too large to fully study due to time, effort, or financial constraints, researchers can select a sample deemed representative of the entire population. In other words, the sample is selected so that researchers can still obtain an accurate picture without having to examine every individual in the population. Determining the sample size in this study is crucial because researchers cannot utilize all employees as respondents. This is due to limitations in cost, time, resources, effort, and facilities. The sample size for this study was set at 100 employees. This number was carefully considered, taking into account the available population proportion in the Makassar Class I Type A Navigation District, the minimum statistical requirements for validity and reliability tests, and the distribution of employee duties and positions relevant to the research. This number was also determined taking into account the time and resources available during the research. Questionnaires will be distributed directly to respondents from October to November 2025. Throughout the process, researchers will employ a personal approach to ensure all questionnaires are answered correctly and that the data collected is accurate and accountable.

Data Collection Instruments

In this study, data collection instruments were carefully designed to capture the dynamics and realities occurring in the Makassar Class I Type A Navigation District. The main instruments used were a Likert-based questionnaire and administrative documentation, which complemented each other to produce robust, valid, and accountable data. The questionnaire was specifically designed to measure employee perceptions, experiences, and assessments related to the main variables in this study: from employee performance, SBNP management, maritime safety, to factors such as motivation, competence/human resources, organizational culture, leadership, rewards and punishments, and technology adoption. Each statement item was structured based on indicators formulated in the research operational definition. This scale allows researchers to obtain an overview of respondents' level of agreement or disagreement with various aspects of SBNP management and employee performance, while also identifying areas that employees in the field perceive as requiring improvement. The questionnaire was structured concisely and clearly, so that respondents did not feel overwhelmed, while still fully covering all research variables. Before widespread use, the questionnaire was pilot tested on a small number of employees to ensure each item was easily understood and did not lead to multiple interpretations.

Administrative Documentation

In addition to primary data collected through questionnaires, this study also utilized administrative documents as secondary data sources. The documents accessed included employee performance reports, SBNP maintenance and care reports, SBNP reliability reports for the past five years, and internal policies and procedures directly related to maritime safety and the management of Navigational Aids. Analysis of these documents was conducted to strengthen the findings from the questionnaire data, provide broader context for the survey results, and identify trends or policy changes that may impact employee performance. By combining these two data sources, the study was able to provide a more comprehensive picture of the situation on the ground.

Instrument Validity and Reliability Testing

To ensure that the data obtained truly reflects reality and can be academically validated, several instrument testing steps were carried out: The validity of the questionnaire was examined through statistical tests that assessed the relevance, clarity, and coverage of each statement item. Furthermore, construct validity was tested using exploratory factor analysis (EFA) to ensure each indicator was appropriate and adequately represented the measured variable. The internal consistency of the questionnaire was tested using Cronbach's Alpha. A scale is considered reliable if its alpha value is above 0.70. The results of this test will serve as the basis for revising or improving items deemed inconsistent, ensuring the instrument is truly ready for use in the main survey.

Data Collection Techniques

To obtain accurate data and reflect real-world conditions, this study used two main data collection techniques: a questionnaire survey and the collection of administrative documents. These two techniques complement each other so that the research results do not only rely on subjective employee perceptions, but are also supported by factual data from organizational documentation.

The primary technique in this research is a survey using a Likert-scale questionnaire. The questionnaire instrument was carefully designed based on predetermined variables, including SBNP Management, employee performance, and maritime safety. The survey implementation stages included: Items were developed based on operational definitions and indicators of the research variables, with attention to clarity, relevance, and ease of understanding for respondents. The questionnaire was tested for validity and reliability through initial statistical testing (pilot testing) before being widely distributed. The questionnaire was distributed directly to selected employees in the Makassar Class I Type A Navigation District, both face-to-face and using digital media to accommodate respondents' flexibility and accessibility. The researcher ensured that each respondent met the inclusion criteria according to the research needs. The researcher actively monitored the questionnaire completion process, provided explanations for any items that were unclear, and maintained the confidentiality of respondents' answers. The data collection process is scheduled to take place from October to November 2025, allowing sufficient time to ensure optimal participation and maintain the quality of the data obtained. To complement the primary data from the questionnaire, the researcher also collected administrative documents relevant to the research topic. Some of the documents accessed include: Contain quantitative data on employee performance, internal evaluation results, and attendance and discipline data that can be linked to the survey results. This document records detailed maintenance, repair, and installation activities for navigation aids, as well as documentation of incidents that may be related to negligence or operational issues in the field. Includes decrees, standard operating procedures, or government regulations related to SBNP management and maritime safety, which can be analyzed for their contribution to field practices.

Data Analysis Techniques

In this study, data analysis was systematically designed to reveal the relationships between the research variables in a valid, objective, and easily understood manner. The selection of analysis techniques was carried out to ensure that the research hypotheses could be statistically tested and to present results that were relevant to both academic and practical needs in the field of SBNP management and maritime safety. The first stage in data processing is descriptive statistical analysis, which aims to provide an overview of the collected data. Through this analysis, respondent characteristics and the distribution of responses for each variable are presented in the form of frequencies, averages, and percentages. This analysis is important for understanding respondent profiles and response trends regarding employee performance, SBNP management, and other factors such as motivation, organizational culture, and technology utilization. After obtaining an initial overview, the next step is to conduct inferential analysis to test the formulated hypotheses. This analysis uses multiple linear regression to determine the extent to which independent variables, such as SBNP Management and Performance, simultaneously or partially influence Maritime Safety as the dependent variable. The F-test and t-test will be used to assess the significance of the variable's influence, while the coefficient of determination will indicate the extent to which the independent variables contribute to changes in the dependent variable. The entire data analysis process will use SPSS (Statistical Package for the Social Sciences) software. SPSS was chosen for its ability to efficiently manage quantitative data, perform various types of statistical tests, and present easy-to-understand output in tabular form. The use of SPSS also supports the validity of the results, as it is the standard data analysis tool in many social studies.

Data Analysis Steps

Primary data is obtained through questionnaires, while secondary data is taken from administrative documents and internal reports. Each questionnaire response will be assigned a

numeric code to facilitate analysis. The data will also be checked to ensure there are no blank, duplicate, or inconsistent responses. The validity of the questionnaire items is tested through exploratory factor analysis (EFA), while reliability is assessed using Cronbach's Alpha. The questionnaire is considered valid if the questions contain the appropriate loadings for the variables, and reliable if the Alpha value is greater than 0.70. Includes data presentation in tabular form and simple statistical calculations to describe the distribution of each research variable. A multiple linear regression test was applied to determine the effect of the management of Navigational Aids and employee performance on maritime safety. The effect of each independent variable on the dependent variable was tested using a partial t-test, while the effect of the independent variables together was tested using a simultaneous F-test. The testing criteria were based on a significance level of 0.05, where a significance value <0.05 indicates a significant effect, while a significance value >0.05 indicates no significant effect. All analysis results were interpreted in depth, both statistically and substantively, presenting summaries and supporting tables. The researcher also discussed the relationship between the results and the initial hypothesis and drew conclusions to form the basis for recommendations for improving employee performance and management of the SBNP in the Makassar Navigation District.

Results and Discussion

Characteristics of Research Respondents

Characteristics of Respondents Based on Gender

The characteristics of respondents based on gender indicate that the majority of respondents, as presented in the table below, are male.

Table 1. Characteristics of Respondents Based on Gender

No	Gender	Frequency	Percentage
1	Male	70	70%
2	Female	30	30%
	Total	100	100%

Source: Research Results, 2025 (Processed Data)

Based on Table 1 it can be seen that the dominant respondents in this study are male, totaling 70 respondents or 70 percent, while female respondents account for 30 respondents or 30 percent.

Characteristics of Respondents Based on Age

The characteristics of respondents based on age show that the majority of respondents fall within certain age groups, as presented in the table below.

Table 2. Characteristics of Respondents Based on Age

No	Age (Years)	Number	Percentage
1	20–29	13	13%
2	30–39	26	26%
3	40–49	38	38%
4	50–60	23	23%
	Total	100	100%

Source: Research Results, 2025 (Processed Data)

Based on Table 2 the dominant age group of respondents is 40–49 years, with 38 respondents or 38 percent. This is followed by respondents aged 30–39 years, totaling 26 respondents (26%), those aged 50–60 years with 23 respondents (23%), and lastly respondents aged 20–29 years, who represent the smallest group with 13 respondents (13%).

Characteristics of Respondents Based on Highest Educational Attainment

The characteristics of respondents based on their highest level of education indicate that the majority of respondents have completed senior secondary education.

Table 3. Characteristics of Respondents Based on Highest Educational Attainment

No	Education Level	Frequency	Percentage
1	Junior High School / Equivalent	0	0%
2	Senior High School / Vocational	42	42%
3	Diploma (D1, D2, D3)	9	9%
4	Bachelor's Degree (S1)	32	32%
5	Master's Degree (S2)	17	17%
	Total	100	100%

Source: Research Results, 2025 (Processed Data)

Based on Table 3 the respondents in this study are predominantly those with a senior high school or vocational education background, totaling 42 respondents or 42 percent. This is followed by respondents holding a bachelor's degree (S1), amounting to 32 respondents or 32 percent, those with a master's degree (S2) totaling 17 respondents or 17 percent, and diploma holders (D1, D2, D3) with 9 respondents or 9 percent. There were no respondents whose highest educational attainment was junior high school.

Characteristics of Respondents Based on Length of Employment

The characteristics of respondents based on length of employment indicate that most respondents have relatively long work experience.

Table 4. Characteristics of Respondents Based on Length of Employment

No	Length of Employment (Years)	Number of Respondents	Percentage
1	Less than 1 year	6	6%
2	1–2 years	5	5%
3	3–5 years	4	4%
4	More than 5 years	85	85%
	Total	100	100%

Source: Research Results, 2025 (Processed Data)

Based on Table 4 respondents with more than five years of work experience constitute the largest proportion, totaling 85 respondents or 85 percent. This is followed by respondents with less than one year of work experience, accounting for 6 respondents or 6 percent, respondents with one to two years of experience totaling 5 respondents or 5 percent, and lastly respondents with three to five years of experience, totaling 4 respondents or 4 percent of the total sample.

Tabulation of Respondents' Responses

Analysis was conducted on the questionnaire responses to describe respondents' feedback on the research variables. The variable statement regarding Navigation Aids Management (X1) consists of 6 items, Employee Performance (X2) consists of 5 (five) items, and Maritime Safety

(Y) consists of 5 (five) items. The overall average of the analysis of the responses to the research variables is as follows:

The classification of respondents' statements regarding the research variables is as follows:

Lowest Score: $1X = 1$

Highest Score: $1 \times 5 = 5$

Class Interval: $(5-1)/5 = 0.8$

Therefore, the class distribution is:

4.21 – 5.00 = Very High

3.41 – 4.20 = High

2.61 – 3.40 = Fairly High

1.81 – 2.60 = Low

1.00 – 1.80 = Very Low

Table 5. Respondents' Response Tabulation for the SBNP Management Variable

No	Indicator	Frequency of Responses	Score	N	Mean
		SS	S	N	ST
1	SBNP (lighthouses, light buoys, and navigation marks) in this area are positioned appropriately and in accordance with navigational needs.	390	88	0	0
2	Routine maintenance of SBNP is carried out periodically/on a scheduled basis and not only when damage occurs.	315	136	6	2
3	Reports of damaged, disturbed, or non-functioning SBNP are promptly responded to and followed up with repairs by the assigned team.	335	132	0	0
4	The number and types of SBNP available in the working area of the Makassar Type A Class I Navigation District adequately support maritime safety by ensuring safe, accurate, and efficient ship navigation guidance.	295	152	9	0
5	SBNP management procedures (planning, implementation, and supervision) have followed the technical standard operating procedures issued by the Ministry of Transportation.	325	140	0	0
6	Overall, SBNP management in the Makassar Navigation District	395	84	0	0

	supports the creation of safe and smooth navigation.				
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Based on the indicators used in the Navigation Aids (SBNP) management variable, this study measures six main aspects: the accuracy of SBNP placement according to navigation needs, routine and scheduled maintenance, speed of response to damage, the availability of an adequate number and type of SBNP, compliance with Ministry of Transportation SOPs, and the contribution of SBNP management to shipping safety. These six indicators are translated into six statement items in the research instrument. Based on the analysis results in Table 4.11, an overall average score of 4.67 was obtained, indicating that SBNP management in the Makassar Type A Class I Navigation District is in the very good category. The indicator with the highest score is SBNP management supporting shipping safety, as stated in the statement, "In general, SBNP management in the Makassar Navigation District area supports safe and smooth shipping," with a score of 4.79. This reflects respondents' perception that SBNP management has significantly contributed positively to the safety and smoothness of shipping activities. Meanwhile, the indicator for the availability of the number and type of SBNP received the lowest score, at 4.56. Although this is the lowest score, this achievement is still in the very good category, indicating that the SBNP is considered adequate, although there is room for improvement in quantity or quality according to operational needs.

All other indicators showed consistent scores around 4.67, confirming that the placement, maintenance, troubleshooting, and compliance with SOPs have been implemented optimally. These findings demonstrate that SBNP management plays a crucial role in maintaining maritime safety in the Makassar Navigation District's work area. Whenever an abnormality occurs with an SBNP, such as malfunctioning beacons, operational disruptions to beacons and buoys, or theft of vital components like solar panels, officers are immediately assigned to carry out maintenance and distribute necessary repairs. This responsiveness is part of the organization's commitment to ensuring that SBNP, such as lighthouses, beacons, and buoys, continue to function properly as primary guides for ship navigation. This confirms that excellent management of SBNP not only maintains the reliability of navigation facilities, but also has a direct impact on the creation of safe, efficient and sustainable shipping in the Makassar Class I Type A Navigation District area.

Table 6. Respondents' Response Tabulation for the Employee Performance Variable

No	Indicator	Frequency of Responses	Score	N	Mean
		SS	S	N	ST
1	As a member of the Makassar Navigation District employees, I am responsible for ensuring that SBNP functions optimally through maintenance, supervision, reporting, and operational coordination in accordance with regulations, in order to guarantee maritime safety and smooth navigation.	325	124	12	0
2	I strive to respond to every report or disturbance related to SBNP quickly and appropriately.	290	152	12	0
3	I am accustomed to collaborating with team members to complete field tasks.	350	96	18	0

4	I follow work procedures and technical directives in accordance with the regulations applicable in this institution.	295	164	0	0
5	I am committed to maintaining performance and professionalism in every task to support maritime safety.	340	128	0	0

The analysis results, as shown in Table 6 above, indicate that employee performance in the Makassar Class I Type A Navigation District is in the very good category, with an average score of 4.61. This finding indicates that employees are generally capable of carrying out their duties professionally, particularly in terms of maintaining performance quality and work commitment. This is evident from the highest indicator score, namely the statement regarding employee commitment to maintaining professionalism in every task, which achieved an average score of 4.68. This finding demonstrates that values and work ethic are key strengths in employee performance.

However, the indicator with the lowest score was the rapid and appropriate response to SBNP disruptions, which scored 4.54. While this is still considered "very good," this lower score compared to other indicators suggests room for improvement. Based on respondents' observations, some SBNP disruptions cannot be optimally handled because the personnel performing maintenance do not always have the appropriate expertise or certification. This competency mismatch indicates that some employees involved in SBNP maintenance have not received specific training or certification, either at the Basic or Skilled levels. In addition to competency, respondents also assessed that the distribution of maintenance needs is sometimes not timely, particularly when abnormalities or disruptions occur with the SBNP. This situation can cause delays in handling and potentially reduce the effectiveness of navigation services. However, from a supervisory perspective, the inspection process, from ordering to implementing navigation facilities and infrastructure needs, has been carried out well and received adequate attention from the Makassar Class I Navigation District office. Overall, these results indicate that employee performance is already at an excellent level, but capacity building and technical expertise, particularly in SBNP maintenance and troubleshooting, are still needed. Strengthening competency through training and certification, as well as optimizing the distribution process for maintenance needs, will be strategic steps to ensure SBNP reliability and support increased maritime safety in the Makassar Class I Navigation District's working area.

Maritime safety is a crucial element in maritime transportation, ensuring the safe and reliable movement of people and goods. Compliance with safety standards not only protects service users but also supports socio-economic activities that depend on maritime services. The responsibility for maintaining safety is a shared responsibility between the government, operators, and service users through the implementation of regulations and standardized operational practices. And to provide a clearer picture, respondents' statements were analyzed based on the following maritime safety variables.

Table 7. Respondents' Response Tabulation for the Maritime Safety Variable

No	Indicator	Frequency of Responses	Score	N	Mean
		SS	S	N	ST
1	The existence of SBNP plays an important role in ensuring the safety of ship navigation.	410	72	0	0

2	Disturbances or damage to SBNP are handled promptly to avoid potential maritime accidents.	350	120	0	0
3	Good SBNP conditions are able to minimize the risk of maritime accidents such as collisions or groundings.	370	104	0	0
4	The available maritime navigation system provides a sense of safety for shipping service users.	380	92	3	0
5	The frequency of maritime accidents caused by SBNP damage in this area is relatively low.	245	152	30	4

Based on the five main indicators in the Maritime Safety variable the role of the SBNP in safety, rapid response to disturbances, reduced accident risk, a sense of security in navigation, and a low number of SBNP-related accidents this analysis yielded an average score of 4.67, indicating that the maritime safety level in the Makassar Class I Type A Navigation District is in the very good category. The indicator with the highest score was the role of the SBNP in safety, with the statement "The existence of the SBNP plays an important role in ensuring the safety of ship navigation" scoring 4.82. Meanwhile, the maritime accident indicator received the lowest score, at 4.32, with the statement "The frequency of shipping accidents due to SBNP damage in this area is relatively low." Although this score is the lowest, it remains in the very good category, indicating that maritime accidents can be reduced through the functioning of the SBNP. These results indicate the importance of strengthening SBNP management strategies, including improving the adequacy and reliability of navigation facilities such as lighthouses, beacons, and beacon buoys, as a sustainable measure to minimize the risk of maritime accidents.

Instrument Test Results

Validity Test

The validity test calculations in this study were conducted using SPSS version 25 for Windows software. Validity was assessed by determining whether the calculated r value was greater than the tabular r value in a two-sided test with a significance level of 0.05, indicating a significant correlation between each item and the total score. The following are the results of the SPSS calculations:

Table 8. Validity Test Results

Variable	r-count	r-table	Remark
SBNP Management (X1)	0.653	0.195	Valid
	0.563	0.195	Valid
	0.677	0.195	Valid
	0.770	0.195	Valid
	0.576	0.195	Valid
	0.615	0.195	Valid
Employee Performance (X2)	0.701	0.195	Valid
	0.722	0.195	Valid
	0.731	0.195	Valid
	0.728	0.195	Valid

	0.657	0.195	Valid
Maritime Safety (Y)	0.538	0.195	Valid
	0.449	0.195	Valid
	0.639	0.195	Valid
	0.560	0.195	Valid
	0.684	0.195	Valid

Source: Research Results, 2025 (Processed data)

The minimum requirement for validity is if the calculated r is greater than the table r . The table r value used is $N=100$ based on the distribution of statistical table r values at a 5% significance level, which is 0.195. Therefore, if the correlation between items with a score of less than 0.195, the item in the instrument is declared invalid. Based on the calculations in the table above, all statement items are declared valid because they are above the table r , which is 0.195. This means that the measuring instrument used is capable and accurate in measuring the variables studied, namely SBNP Management (X1), Employee Performance (X2), and Maritime Safety (Y).

Reliability Test

Reliability testing is conducted to ensure that researchers obtain a reliable instrument, meaning that the research variables must have a level of consistency and stability. A reliable instrument, when used repeatedly to measure the same thing, will produce the same data or be able to apply consistently. The reliability results can be seen in the calculation results using SPSS as follows:

Table 9. Reliability Test Results

Variable	Cronbach's Alpha	r-table	Remark
SBNP Management (X1)	0.782	0.700	Reliable
Employee Performance (X2)	0.880	0.700	Reliable
Maritime Safety (Y)	0.745	0.700	Reliable

Source: Research Results, 2025 (Processed Data)

Based on the analysis presented in Table 9, it can be concluded that all research constructs demonstrate satisfactory reliability. The SBNP Management variable (X1) shows a Cronbach's alpha value of 0.782, which exceeds the minimum threshold of 0.700, indicating that the items within this instrument have good internal consistency and are reliable for measuring aspects of SBNP management. Similarly, the Employee Performance variable (X2) records a Cronbach's alpha value of 0.880, reflecting a high level of reliability. This indicates that the instrument used to measure employee performance is highly consistent and dependable. Furthermore, the dependent variable, Maritime Safety (Y), achieves a Cronbach's alpha value of 0.745, which also meets the reliability criterion. Although this value is slightly lower than that of X2, it still indicates good internal consistency in measuring maritime safety conditions. Overall, these findings confirm that all measurement instruments used in this study are reliable and suitable for further statistical analysis.

Hypothesis Testing

Multiple Linear Regression Analysis

This section presents the results of the Multiple Linear Regression analysis conducted to test the research hypotheses. The analysis aims to examine the effect of the independent variables SBNP Management and Employee Performance on the dependent variable, Maritime Safety.

Multiple regression analysis is employed to determine the regression equation that predicts the dependent variable based on a combination of the independent variables.

The regression analysis results are presented in two main components:

Partial Significance Test and Regression Coefficients (t-test)

The t-test is used to determine the partial effect of each independent variable (X) on the dependent variable (Y) by examining the significance value. The decision rule states that if the significance value (Sig.) obtained from SPSS is less than 0.05, the independent variable has a significant partial effect on the dependent variable. Conversely, if the significance value is greater than 0.05, the independent variable does not have a significant effect (Ghozali, 2011). The results of the t-test are presented in Table 4.20 below.

Table 10. t-Test Results (Partial Test)

Coefficients^a

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	4.784	1.834	—	2.609	0.011
SBNP Management	0.088	0.140	0.033	0.626	0.533
Employee Performance	1.315	0.075	0.941	17.614	0.000

^a Dependent Variable: Maritime Safety

Based on the partial t-test results, the SBNP Management variable shows a t-value of 0.626 with a significance level of 0.533. Since this significance value is greater than the predetermined threshold ($\alpha = 0.05$), it can be statistically concluded that SBNP management does not have a significant effect on maritime safety. Therefore, the hypothesis stating that SBNP management significantly influences maritime safety is rejected. In contrast, the Employee Performance variable demonstrates a positive and statistically significant effect on maritime safety, as indicated by a t-value of 17.614 and a significance level of 0.000 (< 0.05). Thus, the hypothesis stating that employee performance has a significant effect on maritime safety is accepted.

Simultaneous Significance Test (F-test)

The F-test is used to examine whether all independent variables simultaneously influence the dependent variable. The regression model is considered significant if the F-test significance value is less than 0.05.

Table 11. F-Test Results (Simultaneous Test)

ANOVA^a

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2678.020	2	1339.010	787.699	0.000 ^b
Residual	164.890	97	1.700	—	—
Total	2842.910	99	—	—	—

^a Dependent Variable: Maritime Safety

^b Predictors: (Constant), Employee Performance, SBNP Management

Based on Table 11, the F-test result shows an F-value of 787.699 with a significance level of 0.000 (< 0.05). This indicates that SBNP management and employee performance simultaneously have a significant effect on maritime safety.

Summary of Hypothesis Testing Results

The hypothesis testing results obtained through the partial (t-test) and simultaneous (F-test) analyses can be summarized as follows: 1) The partial t-test result for SBNP Management (X_1) indicates no significant effect on maritime safety, with a t-value of 0.626 and a significance level of 0.533 (> 0.05); therefore, the proposed hypothesis is rejected; 2) The partial t-test result for Employee Performance (X_2) shows a positive and significant effect on maritime safety, with a t-value of 17.614 and a significance level of 0.000 (< 0.05); thus, the hypothesis is accepted; 3) The simultaneous F-test result demonstrates that SBNP management and employee performance jointly have a significant effect on maritime safety, as indicated by an F-value of 787.699 and a significance level of 0.000 (< 0.05); 4) Overall, the findings confirm that maritime safety is the outcome of an integrated interaction between technical aspects and human resource factors, with employee performance emerging as the dominant factor supporting the effectiveness of SBNP management.

Model Fit Test

Model fit is assessed using the coefficient of determination, which explains the extent to which the independent variables collectively account for the variance in the dependent variable.

Table 12. Coefficient of Determination Test Results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.971 ^a	0.942	0.941	1.304

^a Predictors: (Constant), Employee Performance, SBNP Management

Based on Table 12, the multiple regression analysis between SBNP Management (X_1) and Employee Performance (X_2) on Maritime Safety (Y) produces an R value of 0.971. This indicates a very strong simultaneous relationship between the independent variables and the dependent variable, as the R value is close to 1. Furthermore, the R Square (R^2) value of 0.942 indicates that 94.2% of the variation in maritime safety can be explained by variations in employee performance and SBNP management. The remaining 5.8% is influenced by other factors outside the scope of this study, such as work environment, leadership, motivation, or other external variables not examined in this research.

The Influence of SBNP Management on Maritime Safety

The results of the statistical analysis using a partial hypothesis test (t-test) indicate that the significance value for the management of Aids to Navigation is 0.533, which is greater than the significance level (>0.05). This means that SBNP management does not significantly influence maritime safety. This finding indicates that the existence and management of SBNP, although conceptually important, are not directly perceived as determining factors for safety in the empirical context of this study. In other words, SBNP serves as the technical foundation for safety, but its effectiveness depends heavily on how these facilities are utilized in daily operational practice. From a safety systems perspective, maritime safety does not depend on a single element but rather is the result of an integration of technical, human, and organizational aspects.

Theoretically, this finding aligns with safety systems theory, which states that safety is the result of the interaction between technical, human, and organizational elements. Within this framework, aids to navigation are positioned as technical components that provide information and operational support, but do not stand alone in determining the level of safety. Reason (1997) explains that safety failures are more often caused by human factors and organizational system weaknesses than by technical failures, so the role of safety facilities is highly dependent on how these facilities are managed and utilized by humans.

The findings of this study also align with the International Maritime Organization (IMO)'s view, which emphasizes that the presence of safety and navigation facilities does not automatically guarantee shipping safety if not supported by the competence and performance of human resources. In its document, "Human Element, Leadership, and Management," the IMO emphasizes that safety facilities function as enabling factors, while human factors play a key role in ensuring the effectiveness of shipping safety systems (IMO, 2016).

Furthermore, the relatively uniform management of SBNPs, which adhere to applicable operational standards, can lead to limited data variation. This situation makes the contribution of SBNP management to maritime safety variations less visible statistically, although its substantively important role remains. Thus, the results of this study provide an understanding that efforts to improve maritime safety need to focus not only on the availability and management of facilities, but also on improving the quality of human resource performance as the primary actors in the maritime safety system.

The Influence of Employee Performance on Maritime Safety

The results of the statistical analysis using a partial hypothesis test (t-test) yielded very clear findings, proving that the Employee Performance variable has a positive and significant influence on Maritime Safety. This finding not only confirms the acceptability of Hypothesis 2 (H2) of the study but also places crucial academic emphasis on the role of the human factor as a primary determinant in maritime transportation safety operations. The confirmed positive regression coefficient indicates an explicit causal relationship: improving the quality of employee performance, as measured by indicators of responsibility, discipline, response speed, and professionalism, will directly and substantially improve Maritime Safety. This confirms that no matter how sophisticated physical infrastructure, it will not achieve maximum effectiveness without the support of competent and high-performing human resources.

Theoretically, the results of this study align with Bernardin and Russell's Performance Theory, which defines performance as a record of work results resulting from the execution of job functions over a specific time period (Sudrajat et al., 2026; Nendi et al., 2026; Lubis et al., 2026). In the context of the Navigation District, employee performance is reflected in the quality, timeliness, and effectiveness of technical and administrative tasks, from the operation to maintenance of Aids to Navigation, which directly determine the reliability of the navigation system. Optimal employee performance can minimize human error, which is identified in maritime safety literature as a dominant factor causing shipping accidents. This approach is highly relevant to the challenges of managing SBNP, which demands a rapid, accurate response and a focus on continuous improvement (Nurwildani & Padhil, 2025; Darmawan et al., 2026; Elekhtear et al., 2025). Academically, this study makes an important contribution by confirming that Employee Performance is a variable that not only influences internal organizational processes but also directly serves as a strong predictor of external outcomes, such as Maritime Safety. Managerial implications arising from these findings require increased investment focused on Human Resource (HR) development. It is recommended that the

Navigation District implement a certified competency-based training program that specifically targets technical expertise related to the latest SBNP technology.

The Influence of SBNP Management and Employee Performance on Maritime Safety

The F-test results show a calculated F-value of 787.699 with a significance level of 0.000 (<0.05), confirming that the management of Aids to Navigation and employee performance simultaneously have a significant influence on maritime safety. This finding indicates that maritime safety is not determined by a single factor, but rather is the result of an integration of technical and human resource factors. The difference between the results of the simultaneous and partial tests indicates that the influence of each variable becomes significant when analyzed together within an integrated operational system.

Conceptually, the results of this study align with the understanding of maritime safety as a systematic effort to minimize shipping risks through the integration of regulations, technology, and organizational culture (Darijo & Huanxin, 2025; Nugraha & Azisah, 2025; Mišković & Wang, 2025). Within the framework of the International Safety Management (ISM) Code, safety is achieved through the implementation of a management system that encompasses both technical and human resource management aspects simultaneously (Yunia and Muttaqin, 2022). Therefore, reliable SBNP management requires the support of effective employee performance to ensure optimal safety functions (Wanadi et al., 2026; Peng et al., 2025; Safrianto et al., 2025).

These findings are also in line with the Swiss Cheese Model (Reason, 1990) and the High Reliability Organization (HRO) principles (Weick and Sutcliffe, 2007; Onwuzurike et al., 2025), which emphasize that accident risk can be minimized when weaknesses in technical systems and human factors are managed in an integrated manner. The significant simultaneous test results reinforce the argument that integration between technology and human performance is a key prerequisite for creating a reliable and sustainable maritime safety system. The results of this study also indicate that although not all variables have a significant partial effect, the effect becomes significant when analyzed together. This condition indicates that maritime safety is systemic, where the effective management of technical facilities such as SBNP requires optimal employee performance support to significantly contribute to improving maritime safety.

Conclusion

Partial management of navigational aids does not significantly impact maritime safety. Employee performance has been shown to have a positive and significant impact on maritime safety. However, Simultaneous testing results indicate that SBNP management and employee performance simultaneously have a significant impact on maritime safety. This finding indicates that maritime safety is the result of an integrated system of technical and human factors, with employee performance being the dominant factor supporting the effectiveness of navigational aids management.

Recommendations

The Makassar Class I Type A Navigation District is recommended to continue strengthening the SBNP management system by increasing regular supervision, improving maintenance quality, and operational reliability of the SBNP so that it can function optimally as a supporting facility in the maritime safety system. Employees need to continuously improve and prioritize the enhancement of employee competence, discipline, and professionalism through continuous training and objective performance evaluations. Maritime safety policies need to be designed with a systems approach that integrates technical and human factors in a balanced and

sustainable manner. Further research is recommended to develop the research model by including additional variables, such as leadership, organizational culture, navigation technology, and quality management systems, so that it can provide a more comprehensive understanding of the various factors that influence maritime safety.

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