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A Literature Study : The Determination of Landing Site for Amphibious Operation

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Abstract— This study aims to identify criteria and methods for determining amphibious operation landing sites, emphasizing the importance of beach characteristics, technological advances, and robust decision-making processes in optimizing site selection for successful operations. The methodology used is a literature study referring to data from five articles, namely Abdurahman et al. (2020), Azhari et al. (2016), Taryono (2022), Setiarso et al. (2018), and Wijatmiko et al. (2021). The analysis shows common themes among these studies, especially the emphasis on environmental and geographic factors such as coastal gradient, wave height, and wind conditions as crucial determinants in site selection. However, the methodological approach of each study varies. Abdurahman et al. (2020) and Azhari et al. (2016) focus on natural factors by applying fuzzy logic systems and meteorological analysis, respectively. Meanwhile, Taryono (2022) and Setiarso et al. (2018) used a decision-making model such as AHP to prioritize coastal characteristics, although they differed in the focus of criteria weights and site ranking. Wijatmiko et al. (2021) combined advanced methods, including NDVI and the Lyzenga algorithm, for detailed analysis of shoreline and seabed features. These findings emphasize the complexity of amphibious operations planning, where a systematic and multi-criteria approach is critical to ensure mission success. The integration of qualitative and quantitative literature review methodologies provides a comprehensive framework for determining optimal landing sites.

Keywords—Criteria; Amphibious Operations; Landing Site; Characteristics Of The Beach.

I. INTRODUCTION

Planning and executing amphibious operations is a crucial component of modern military strategy that requires in-depth analysis and consideration. These operations involve a complex series of activities ranging from determining the optimal landing site to coordination across armed forces to achieve the stated strategic objectives. The success of amphibious operations depends largely on the selection of appropriate landing sites, which must meet a variety of operational and environmental criteria.

In the modern era, the challenges in determining landing sites have increased with technological advances and dynamic environmental changes. The availability of accurate geographic and meteorological data has become critical to ensure that the selected site can support operations effectively. With the advent of new tools and technologies, such as high-resolution satellite imagery, the process of determining landing sites has significantly improved in terms of accuracy and efficiency.

Implementing amphibious operations is a process with various considerations and calculations, especially when determining the landing site. As a critical military strategy, determining the landing site requires an in-depth review of environmental and geographical factors. Determining or selecting a landing site is not only a tactical decision but also includes a review of various coastal characteristics, weather conditions, and terrain suitability to support amphibious operations involving cooperation between the navy, air force, and land to attack enemy shores. For example, in Papua, infrastructure development has enabled the formation of a naval force in Sorong, which plays a vital role in maritime defence in the region (Setiarso et al., 2018).

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Technological advances have introduced new methods for determining landing sites, which increase the accuracy and efficiency of these operations. High-resolution satellite imagery, such as the Pleiades satellite system, has become essential in providing detailed geographic data crucial for military planning (Wijatmiko et al., 2021). This data allows the identification of suitable landing beaches by analyzing variables such as coastal gradient, wave height, and seabed substrate. For example, in coastal sites of Indonesia, which are at high risk of natural disasters such as tsunamis, integrating military resources in disaster mitigation efforts has underscored the importance of accurate geographic information (Abdurahman et al., 2020).

The ability to effectively control amphibious vehicles in these challenging environments highlights the need for accurate and timely data to ensure the safety and success of operations. The decision-making process in selecting a landing site is also very complex. Methods such as the Analytical Hierarchy Process (AHP) and Electre III are used to objectively evaluate various alternative locations, considering various conflicting criteria (Taryono, 2022; Azhari et al., 2016). For example, amphibious operations by the Marine Corps in Indonesia require careful planning, where miscalculations can be fatal (Taryono, 2022). This article, which is a literature study based on five articles (Abdurahman et al., 2020), (Azhari et al., 2016), (Taryono, 2022), (Setiarso et al., 2018), and (Wijatmiko et al., 2021) to find the best criteria and methods in determining amphibious operation landing sites, highlights the importance of coastal characteristics, technological advances, and a robust decision-making process in optimizing landing site selection for successful amphibious operations.

The purpose of this study is to assess the important criteria that influence the selection of amphibious landing sites, such as beach characteristics, meteorological conditions, and other environmental factors. In addition, this study examines the various methodologies used in these studies, including the application of fuzzy logic, statistical techniques, and decision-making methods such as AHP and Electre III. Advanced technologies, such as satellite imagery and seabed analysis algorithms. Through this analysis, this study seeks to propose best practices in amphibious landing site selection, as well as provide useful recommendations for further research and the application of new technologies, in order to improve the accuracy and efficiency in planning and executing amphibious operations.

This research method uses a literature review approach to collect and analyze data from existing literature. This process begins by identifying and collecting various relevant literature sources, including journal articles, books, and other documentation. The data collected includes critical variables such as coastal gradient, wave height, current, and meteorological conditions. Furthermore, this study applies a meta-synthesis method to integrate and summarize the results of the primary studies, resulting in a deeper and more comprehensive understanding of the methodology and criteria used. The methodological analysis was carried out by compiling a narrative review of five primary studies, namely Abdurahman et al. (2020), Azhari et al. (2016), Taryono (2022), Setiarso et al. (2018), and Wijatmiko et al. (2021), to evaluate the criteria and techniques applied in determining amphibious landing sites.

II. Research Method

This study uses a literature review methodology, focusing on literature sources for data collection. Literature review studies are used to collect data or a synthesis of sources related to the topic research from various sources including journals, books, documentation, internet and library (Nursalam 2016). *The first step in making a research plan is to search for literature and collect data through literature sources (Zed, 2014 in Melfianora, 2019).* Literature review is a method of conducting research identification, evaluation and interpretation of all research results relevant to a particular research question, particular topic, or phenomenon of concern (Kitchenham, 2004).

A qualitative approach in the literature review is used for synthesizing (summarizing) descriptive research results qualitative. Method of synthesizing (summarizing) research results This qualitative approach is called meta-synthesis, an integration technique data to obtain new theories or concepts or levels deeper and more comprehensive understanding (Perry & Hammond, 2002). *The literature review research design used is a narrative review. This strategy combines current research theories and techniques. According to Chris (2018), literature reviews require tracing and combining various sources into a coherent framework. This*

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synthesis produces interpretations emphasizing significant problems, patterns, complexities, and discussions. Descriptive qualitative analysis is a data analysis method used in this study to describe, examine, and evaluate data in order to draw informed conclusions.

This literature review synthesizes the methodologies used in five primary studies: Abdurahman et al. (2020), Azhari et al. (2016), Taryono (2022), Setiarso et al. (2018), and Wijatmiko et al. (2021). It focuses on determining the criteria for optimal landing sites for amphibious operations. This study uses qualitative approaches to evaluate various geographic, environmental, and meteorological factors important for selecting amphibious landing sites.

The methodology followed in this study generally begins with identifying and collecting relevant data, including variables such as coastal gradient, wave height, current, and meteorological conditions. For example, Setiarso et al. (2018) conducted a comprehensive site analysis at the Sorong TPI Pier in West Papua, considering the physical and oceanographic characteristics needed to determine the ideal landing site. Similarly, Wijatmiko et al. (2021) studied Bunguran Island, Natuna Islands, where physical features such as coastal slopes and low-lying sites were analyzed to support military amphibious training operations.

In the studies by Abdurahman et al. (2020) and Azhari et al. (2016), advanced quantitative techniques such as fuzzy logic and statistical analysis were used to simulate and evaluate the suitability of various landing sites. Abdurahman et al. (2020) applied a fuzzy membership function system to classify coastal gradients and currents such as vulnerable, ideal, and hazardous, which helps determine the most suitable conditions for amphibious vehicles. Azhari et al. (2016) focused on analyzing meteorological data and converting wind data into wave data, which was then used to determine the best time to conduct amphibious operations in Singkawang, West Kalimantan.

Taryono (2022) emphasized using decision-making models such as the Analytical Hierarchy Process (AHP) and Electre III, which allow for systematic and objective evaluation of various criteria and alternatives for selecting a landing site. These models facilitate the integration of various parameters into a coherent decision-making framework, ensuring that the most critical factors are adequately weighted and considered.

These studies underscore the importance of a multidisciplinary approach that integrates geographic information systems (GIS), remote sensing, and decision support systems to accurately assess and determine the best landing sites for amphibious operations. This methodology ensures that all relevant environmental and operational factors are systematically analyzed to optimize the success of amphibious missions.

III. Results and Discussions

After finding five articles, the author finds some similarities and differences in regards to the findings of criteria for amphibious operations landing site, as follows:

Table 1.1 Literature Study of Articles

Identity of Author	Year Published	Title of Article	Journal Title	Results
Abdurahman, Harsono, G., Prihanto, Y., & Gultom, R. A. G.	2020	Implementation of Support Systems for Determination of Amphibious Vehicle Landing in Disaster Emergency Response Using Fuzzy Takagi Sugeno	Journal of Physics: Conference Series	The system effectively classifies and translates outputs according to the designed rule-based system. Random values were fed into the system for variables such as beach gradient and current velocity during testing. The system could accurately generate percentage and condition values based on these inputs, demonstrating its ability to apply fuzzy logic principles correctly. Successful classification and translation of

				outputs demonstrate that the system is reliable for determining beach gradients and current conditions, as described by the established rule base.
Azhari, F., Sukoco, N. B., & Fatoni, K. I.	2016	Studi Karakteristik Parameter Meteorologi dan Gelombang untuk Operasi Amfibi di Perairan Singkawang Kalimantan Barat	Jurnal Chart Datum, 6(1), 1–9	The study concluded that selecting landing sites for amphibious operations in Singkawang should consider critical meteorological and oceanographic factors. Optimal conditions are found from April to October, when wind speeds and wave heights are lower, making landing operations safer. In addition, attention should be paid to wind direction and speed, especially from December to February, as these factors significantly affect the accuracy of naval and air support and the safety of troop landings.
Taryono	2022	Model Pengambilan Keputusan Pemilihan Pantai Pendaratan dalam Latihan Operasi Amfibi dengan Metode Borda dan Electre III	Jurnal Maritim Indonesia, 10(2), 141–155	The study determined that the most significant criteria for selecting an amphibious landing site were beach type (with a weight of 14%) and foreshore gradient (with a weight of 13%). The least significant criterion was the exit route, with a weight of only 3%. The analysis concluded that Pasieraja Beach 1 was the top choice for a landing site based on these criteria, followed by Pasieraja Beaches 2 and 3, with Batuitam Beach ranked last.
Setiarso, B., Suharyo, O. S., & Susilo, A. K.	2018	Determination of Landing Beach Location for Amphibious Operations on The West Papua Sea with Analytic Hierarchy Process (AHP): Case Study on Sorong Regency	Journal of Defense Resources Management 9, 21-33	The study's results show that the second beach, with a weight value of 0.639, is the most suitable location for amphibious landing operations. The first beach is ranked second with a weight of 0.259, and the third beach is ranked last with a weight of 0.101. These rankings indicate that the second beach is optimal for such operations based on the AHP method.
Wijatmiko, R. D., Amarona, Moh. Q., & Muchsin, F.	2021	Pemilihan Site Alternatif Pantai Pendaratan Amfibi dengan Menggunakan Citra Satelit Pleiades (Studi Kasus Pulau Bunguran-Natuna)	Jurnal Chart Datum, 7(1), 17–36	The study concludes that the selection criteria for landing sites in amphibious operations should prioritize accurate analysis of shoreline gradient, seabed composition, and bathymetry. The study identifies optimal landing sites that meet specific environmental and operational

parameters by integrating methods such as NDVI for shoreline detection and the Lyzenga algorithm for seabed analysis. Ten potential landing sites are evaluated based on these criteria, providing a systematic approach to selecting the most suitable sites for amphibious operations.

The five studies on amphibious landing site selection show fundamental similarities, although each has a different approach and results. One striking similarity among all these studies is the emphasis on environmental and geographic factors as key aspects in selecting an appropriate landing site. For example, the studies by Abdurahman et al. (2020) and Azhari et al. (2016) highlight the importance of natural elements such as coastal gradient, wave height, and wind conditions. Abdurahman et al. apply a fuzzy logic system to classify and assess these variables more precisely, using a rule-based approach to manage complex data. On the other hand, Azhari et al. places a special emphasis on meteorological and oceanographic conditions, such as wind and wave patterns, which directly affect the safety and suitability of a landing site. Both studies demonstrate how environmental factors can influence strategic decisions in amphibious operations but with different methods. While Abdurahman et al. focus on applying fuzzy logic to obtain a more detailed assessment of coastal conditions, Azhari et al. utilize meteorological and oceanographic data analysis to determine the optimal timing and conditions for landing operations. This approach demonstrates the close relationship between a thorough understanding of natural factors and the application of appropriate analytical methods to ensure the success of amphibious operations.

Taryono (2022) and Setiarso et al. (2018) reinforce the importance of beach characteristics in determining landing sites, but they use different methodological approaches. Taryono's study applies decision-making models such as the Analytical Hierarchy Process (AHP) and Electre III to assign weights to various criteria, with a primary focus on beach type and gradient as the most significant factors in site assessment. This method allows for a more structured and systematic evaluation of various criteria by assigning clear weights based on their importance. In contrast, Setiarso et al. (2018) also use AHP but with a slightly different approach, namely by ranking beaches based on their level of suitability through a comprehensive evaluation of various factors. This approach emphasizes a comprehensive assessment and assigns a ranking to each landing site considered. Although both studies emphasize the need for a systematic approach in evaluating landing sites, Taryono focuses more on assigning specific weights to certain criteria, while Setiarso et al. emphasize creating a ranked list of locations based on an evaluation of relevant factors. These differences in approach demonstrate variations in how the analysis is conducted and how the final results may influence strategic decisions in amphibious operations planning.

Wijatmiko et al. (2021) further advance the field by incorporating sophisticated methodologies such as the Normalized Difference Vegetation Index (NDVI) for detecting shoreline features and the Lyzenga algorithm for detailed seafloor composition analysis. Their research highlights the critical importance of precise assessment of various environmental parameters, including coastline gradients, seafloor substrates, and bathymetric profiles. By employing a multi-criteria evaluation framework, Wijatmiko et al. propose a comprehensive and systematic approach to assess and compare multiple potential landing sites for amphibious operations. This study's distinctive contribution lies in its integration of remote sensing technologies and advanced analytical algorithms, which provides a more precise and technology-driven method for site selection. Unlike other approaches, which may rely heavily on traditional methods, Wijatmiko et al.'s use of these advanced tools enhances the accuracy and depth of environmental analysis, ultimately offering a more nuanced and detailed evaluation of potential landing sites.

The differences among the studies lie primarily in their methodological approaches and the specific factors they prioritize. While some studies focus more on qualitative assessments (e.g., Abdurahman et al., 2020), others emphasize quantitative analysis and decision-making models (e.g., Taryono, 2022; Setiarso et al., 2018). This variation in focus highlights the multifaceted nature

of amphibious operation planning, where different environmental factors and methodologies may take precedence depending on the specific context and objectives.

Overall, the studies collectively underscore the critical importance of environmental characteristics in selecting landing sites for amphibious operations. Beach gradients, wave heights, wind conditions, and seafloor composition are consistently identified as key determinants, with the studies emphasizing the need for accurate, systematic, and multi-criteria analysis to ensure mission success. These findings highlight the complexity and importance of integrating qualitative and quantitative from literature studies in approaches to determining optimal landing sites, providing a comprehensive framework for planning and executing amphibious operations.

IV. Conclusion

The conclusions drawn from the five studies on amphibious operation landing site determination underscore several key similarities while showcasing diverse approaches to the problem. Each study emphasizes the critical role of evaluating specific environmental and operational criteria to identify the most suitable landing sites. Key factors consistently highlighted include shoreline gradients, seabed composition, and meteorological conditions, all of which are crucial for ensuring that the landing site fulfills the necessary operational requirements.

The articles employ a range of methodological techniques to assess these criteria. For instance, Abdurahman et al. (2020) and Azhari et al. (2016) utilize fuzzy logic systems and statistical analysis to model and evaluate landing site conditions, illustrating the benefits of these sophisticated methods in handling complex variables. In contrast, Wijatmiko et al. (2021) and Setiarso et al. (2018) incorporate advanced technologies such as the Normalized Difference Vegetation Index (NDVI) for detecting shoreline features and the Lyzenga algorithm for detailed seabed analysis. These remote sensing techniques provide high-precision assessments and highlight the evolving technological landscape in site evaluation. Additionally, Taryono (2022) and Setiarso et al. (2018) apply the Analytical Hierarchy Process (AHP) to systematically prioritize and weigh various criteria, offering a structured framework for decision-making.

Operational considerations emerge as a recurring theme across the studies. They uniformly stress the importance of environmental factors such as meteorological conditions, including wind speed and wave height, which critically influence the safety and effectiveness of landing operations. The characteristics of the beach itself, including its type and gradient, are also consistently identified as vital in assessing site suitability.

In conclusion, the studies collectively advocate for a systematic and multi-faceted approach to site selection, emphasizing the integration of both qualitative and quantitative analyses. By methodically assessing and ranking potential landing sites based on a weighted evaluation of various criteria, the research underscores the importance of ensuring that sites meet both operational and environmental standards. This comprehensive approach not only enhances the precision of site evaluations but also reinforces the importance of a thorough and methodical process in optimizing the selection of landing sites for successful amphibious operations.

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