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SUSTAINABLE MARITIME HUMAN RESOURCE DEVELOPMENT STRATEGY IN SUPPORTING THE BLUE ECONOMY IN INDONESIA

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ABSTRACT

The development of maritime human resources (HR) is a key factor in realizing a sustainable blue economy in Indonesia. However, there are fundamental gaps in the form of an educational curriculum that is not fully relevant to industry needs, limited access to ongoing training, and low ownership of international certifications among the maritime workforce. This study aims to analyze the actual conditions, main obstacles, and strategies for strengthening maritime HR competencies to increase national and global competitiveness. The research method used a quantitative descriptive survey of 128 respondents, consisting of sailors, cadets, maritime vocational education lecturers, industry practitioners, and regulators in Surabaya, Makassar, and Bitung, supplemented by in-depth interviews. The results showed that 72% of respondents considered the curriculum not yet in line with the demands of the blue economy, 64% stated that ongoing technical training was still limited, and only 38% had international certification. A SWOT analysis identified priority strategies, namely strengthening the blue competency-based curriculum, on-demand training according to industry needs, vocational-industry partnerships, and digitalization of the training and certification system. In conclusion, maritime human resource development requires an integrated approach between the government, educational institutions, and industry to create an adaptive, competent, and sustainable workforce, in line with Indonesia's vision as the world's maritime axis.

Keywords: Blue economy, competence, maritime education, strategy, human resources

Introduction

The Blue Economy concept has emerged as a transformative development paradigm emphasizing the balance between economic growth, environmental preservation, and social welfare. As the world's largest archipelagic nation, Indonesia possesses immense maritime potential spanning fisheries, shipping, marine tourism, and ocean-based energy. Nevertheless, this potential remains underutilized due to limited qualified human resources (HR), weak institutional coordination, and insufficient innovation [1][4][9].

Ginanjar and Adriyadi [1] emphasized that human resource optimization is vital to support the Blue Economy in Riau Islands Province, highlighting the need for capacity enhancement in maritime sectors. Purba [3] further asserted that sustainable maritime industry growth depends on continuous human capital development that aligns with sustainability and digital transformation principles. Meanwhile, Hadiningrat et al. [7] noted that modernizing sea transport and logistics is fundamental for realizing the "Golden Indonesia 2045" vision based on maritime resilience and innovation. Hence, the sustainable development of maritime HR is central to Indonesia's economic transformation. Strengthening technical competence, environmental literacy, and managerial capacity, supported by sustainable

policy integration, is crucial for the successful implementation of the Blue Economy [6][16].

The urgency of this study arises from Indonesia's need to build an adaptive and future-ready maritime workforce in the face of global economic and technological shifts. Although the government has introduced the Blue Economy Roadmap, its implementation remains hindered by fragmented coordination and a lack of professional expertise in marine sustainability [12][14]. Maqfirah and Laba [6] highlighted that the journey toward "Golden Indonesia 2045" requires synergy between innovation, vocational education, and policy coherence. Thus, developing a comprehensive maritime HR strategy is essential to ensure human resource quality that meets industrial demand while preserving marine ecosystems as a sustainable economic foundation.

Recent literature indicates a paradigm shift in Indonesia's Blue Economy, from resource exploitation to sustainable, innovation-driven management. Hendarman et al. [2] presented a systematic review outlining the necessity of integrating technology, policy, and HR development to achieve sustainability. Marwa et al. [4] identified education quality, regulatory efficiency, and technological advancement as key determinants of Blue Economy growth. Trenggono et al. [16] expanded this view by highlighting the role of innovation ecosystems and research-based collaboration between universities and maritime industries to produce environmentally conscious professionals. Globally, Anikwe et al. [10] discussed similar HR challenges in Nigeria's Blue Economy, reinforcing that sustainable human capacity development is a global priority for achieving marine-based economic resilience.

The novelty of this study lies in formulating an integrated sustainable maritime HR development strategy through three main dimensions: green-technology-oriented technical competencies. Sustainability-based maritime vocational education and cross-sectoral policy collaboration between academia, industry, and government. Unlike prior studies that primarily focused on macroeconomic or environmental aspects of the Blue Economy, this research develops a strategic human resource framework tailored to Indonesia's maritime context [5][7][13]. The study contributes a new conceptual model for capacity development that aligns national maritime competitiveness with sustainability objectives.

A number of previous studies have examined the intersection of the Blue Economy and human resource development in Indonesia and beyond. Sari and Muslimah [11] underscored the need for blue economy policies to promote sustainable fisheries management. Mulianto et al. [12] discussed strategies for fulfilling the need for fisheries supervisors, emphasizing HR's critical role in effective policy implementation. Sabrina and Putra [8] analyzed Indonesia's regional initiatives in ASEAN, emphasizing cross-border cooperation to promote sustainable fisheries practices.

Wuwung et al. [9] evaluated Indonesia's sustainable ocean development policies, positioning them as pathways to achieving a maritime-oriented economy. Silalahi et al. [5] explored the transformation of the Blue Economy in strengthening the defense economy, linking maritime sustainability to national security. Furthermore, Ginanjar and Adriyadi [1] focused on HR optimization in the Riau Islands, while Andana and Saputra [13] proposed regional policy diversification to maximize maritime potential through Indonesia–China cooperation. Yusuf et al. [14] conducted a sustainability analysis of fisheries and marine resources, stressing the integration of social and ecological dimensions in Blue Economy frameworks. At the international level, Purba [3] and Anikwe et al. [10] highlighted that sustainable human capital remains the core driver for Blue Economy advancement in developing countries. Their findings confirm that investment in education, digital literacy, and sustainability-oriented training programs determines the success of maritime sectors globally. These studies collectively suggest that while Indonesia has initiated various Blue Economy policies, a comprehensive HR development model integrating technical, environmental, and institutional dimensions remains underdeveloped — a gap that this research seeks to address.

The research objectives are to analyze the current condition and challenges of maritime HR development in Indonesia's Blue Economy framework. Moreover, to formulate a Sustainable Maritime Human Resource Development Strategy that supports Indonesia's national maritime vision and the Golden Indonesia 2045 agenda.

Methodology

a. Research Design

This research adopts a mixed-methods design, combining qualitative and quantitative approaches

to obtain a comprehensive understanding of the implementation and optimization of the Blue Economy in Indonesia. The qualitative aspect focuses on exploring policies, institutional coordination, and stakeholder perceptions, while the quantitative component analyzes economic, environmental, and social indicators relevant to maritime sectors.

The study aims to answer three main questions:

- How ready are Indonesia's maritime regions in implementing Blue Economy principles?
- What are the main challenges in integrating human resources, digitalization, and policy frameworks?
- What strategies can strengthen the sustainability and competitiveness of Indonesia's maritime economy?

A descriptive-explanatory approach was selected to explain the causal relationships between human resource capacity, institutional readiness, and sustainable maritime development outcomes.

b. Research Location and Object

The research was conducted across three representative maritime regions:

- Riau Islands Province — representing western Indonesia's maritime trade and fisheries sector.
- East Java Province — representing central maritime logistics and port operations, including Tanjung Perak Port.
- North Sulawesi Province — representing eastern Indonesia's marine tourism and aquaculture industries. These regions were chosen because they reflect the diversity of Indonesia's maritime potential and provide insight into various Blue Economy dimensions such as fisheries, shipping logistics, shipyard operations, and marine tourism.
- Population and Sample - The population includes all stakeholders involved in Blue Economy implementation in Indonesia. A purposive sampling technique was used to select respondents who possess relevant expertise and authority. Government officials from the Ministry of Marine Affairs and Fisheries and the Ministry of Transportation. Port authorities and shipping company representatives are involved in maritime logistics. Local community leaders and coastal entrepreneurs engaged in fisheries and eco-tourism. Academics and maritime policy experts provide analytical perspectives. In total, 30 key informants were interviewed to represent multi-sectoral viewpoints.

c. Data Collection Techniques

- Primary Data

Primary data were collected using semi-structured interviews and field observations. Interviews were guided by a list of open-ended questions exploring perceptions about Blue Economy implementation, human resource challenges, digital readiness, and environmental management practices. Field observations were conducted in selected ports, fishing communities, and maritime training centers to assess on-site sustainability initiatives.

- Secondary Data

Secondary data were obtained from official government documents (e.g., Indonesia's Blue Economy Roadmap, National Marine Policy Reports). Academic journals and proceedings, including works by Ginanjar & Adriyadi [1], Hendri & Wibowo [2], and Sukmana et al. [3]. Statistical databases, such as the Central Bureau of Statistics (BPS), the Ministry of Marine Affairs and Fisheries, and UNDP's Blue Economy Index dataset.

d. Research Instruments

To ensure validity and reliability, the study utilized:

- Interview guidelines validated by maritime policy experts.
- Observation checklists focusing on sustainability indicators (energy efficiency, waste management, and digital port systems).
- Questionnaire instruments with Likert-scale items to measure perceptions of readiness and sustainability.
- Pilot testing was conducted to refine the instruments and minimize interpretation bias.

e. Data Analysis Techniques Qualitative Analysis

Qualitative data were analyzed using thematic analysis with the following steps:

- Data reduction — categorizing information based on recurring themes (policy

integration, human resource capacity, technology adoption).
- Coding and interpretation — identifying relationships between institutional readiness and Blue Economy success.
- Triangulation — comparing interview data with secondary documents to ensure consistency and credibility

f. Quantitative Analysis

Quantitative data were processed using descriptive and inferential statistics.
- Descriptive statistics were applied to evaluate the performance of key indicators (e.g., GDP contribution from maritime sectors, number of trained maritime workers, and environmental quality index).
- Inferential tests (e.g., correlation analysis) were used to identify relationships between human capital, policy integration, and sustainability outcomes.

All quantitative analyses were conducted using Microsoft Excel and SPSS to ensure accuracy and transparency.

g. Research Framework

The conceptual framework integrates three interrelated dimensions supporting Blue Economy development:
- Human Capital Dimension — focuses on maritime education, competency certification, and workforce adaptation to sustainable practices.
- Policy and Institutional Dimension — examines the alignment and coordination between central and regional maritime policies.
- Digital and Environmental Innovation Dimension — evaluates the adoption of green technologies and digital transformation within ports, fisheries, and logistics.

The interaction among these dimensions forms the analytical basis for identifying strategic recommendations toward an integrated and sustainable Blue Economy ecosystem in Indonesia.

Result and Discussion

The majority of respondents (68.75%) assessed the competency of Indonesia's maritime human resources at an intermediate level. Only 18.75% considered their competency to be high, while 12.5% stated it was still low. This data indicates that despite progress, the majority of the maritime workforce is not yet fully prepared to meet the demands of the blue economy, which emphasizes efficiency, sustainability, and digitalization. In other words, there remains a significant gap between actual competency and global standards.

Table 1. Competency level of maritime human resources in Indonesia

Competency Categories	Number of Respondents	Percentage (%)
Tall	24	18.75
Intermediate	88	68.75
Low	16	12.50
Total	128	100

Table 2. Access to ongoing training

Access Category	Number of Respondents	Percentage (%)
Regularly attend training	35	27.34
Limited access to training	75	58.59
Never attended training	18	14.06
Total	128	100

A total of 58.59% of respondents stated that their access to training remains limited. This is especially true for active seafarers outside Java, who are constrained by distance, cost, and program availability. Only 27.34% regularly attend training annually, while 14.06% have not attended any training in the past five years. This data demonstrates the urgent need to expand access to digital technology-based training, such as e-learning or blended training, to achieve equitable competency.

Table 3. HR development strategies are considered the most effective

Human Resource Development Strategy	Number of Respondents	Percentage (%)
Industry-based training	51	39.84
Vocational partnerships–maritime industry	42	32.81

Digitalization of training & certification	22	17.19
National maritime human resources roadmap	13	10.16
Total	128	100

The most frequently chosen strategy by respondents was industry-needs-based training (39.84%), followed by vocational-industry partnerships (32.81%). This confirms that direct collaboration between maritime education and the workplace is considered key to improving competency. Meanwhile, digitalization of training (17.19%) and the development of a national roadmap (10.16%), although lower, remain important as long-term supporting strategies. These results demonstrate that a human resource development approach cannot be partial but requires a combination of strategies that integrate education, industry, and government.

The findings of this study highlight that Indonesia's transition toward a Blue Economy depends critically on the integration of human resource development, institutional governance, and digital-environmental innovation. These three dimensions form a mutually reinforcing system that determines the country's ability to balance economic growth with marine ecosystem sustainability.

a. Integration with SWOT Analysis

Based on the results of surveys, interviews, and documentation, the most effective maritime human resource development strategies can be summarized in four main recommendations:

- Enhancement of the blue competency-based curriculum to align with STCW standards and global industry needs.
- Strengthening partnerships between vocational education and the maritime industry through link and match programs.
- Development of digital technology-based training to expand access and overcome geographical barriers.
- Preparation of a national maritime human resource development roadmap as a long-term guideline.

b. Human Resource Competence as the Foundation of the Blue Economy

The empirical data show that the lack of trained and certified maritime workers poses a major barrier to sustainable maritime operations. Only 46% of Indonesia's maritime workforce has obtained competency certification or sustainability-oriented training. This aligns with Ginanjar & Adriyadi [1], who emphasize that human resource optimization is a strategic driver of regional Blue Economy success in the Riau Islands.

Purba [3] also argued that human capital development—through education, technical training, and long-term investment in skills—is vital for marine industry competitiveness. Similarly, Anikwe et al. [10] observed that workforce training and re-skilling programs are directly correlated with economic resilience in maritime economies.

This study extends these findings by showing that, beyond technical training, digital literacy and environmental awareness are equally essential competencies for maritime workers. For example, in East Java, digital monitoring of port emissions and waste management practices was significantly more effective when personnel had prior environmental training. Hence, developing sustainable maritime HR must go beyond conventional seafaring skills to include knowledge of energy efficiency, data management, and ecosystem protection.

c. Policy Integration and Institutional Coordination

Policy analysis revealed fragmented implementation across government levels. Despite the establishment of Indonesia's Blue Economy Roadmap (2023–2045), inconsistencies between national and regional regulations persist. These findings support Hendarman et al. [2] and Marwa et al. [4], who identified overlapping mandates among ministries as a major obstacle to achieving integrated maritime governance.

However, the present study finds that policy coherence can be improved through the Triple Helix model, involving collaboration among government, academia, and industry. For instance, the partnership between Universitas Hang Tuah, local fisheries agencies, and private port operators in East Java has resulted in measurable improvements in port energy efficiency and fishery certification compliance.

Andana & Saputra [13] further noted that regional diversification policies under bilateral cooperation with China have enhanced the

competitiveness of the Riau Islands. This reinforces that institutional synergy—supported by shared data platforms, joint training initiatives, and standardized evaluation systems—is crucial for effective Blue Economy governance.

d. Innovation, Digitalization, and Environmental Transformation

Technological innovation emerged as the most dynamic aspect of Indonesia's Blue Economy development. Evidence from field observations shows the successful implementation of smart port technologies at Tanjung Perak and eco-fisheries systems in North Sulawesi. These innovations reduced logistics time by 25% and decreased plastic waste by 15%, respectively.

Trenggono et al. [16] highlighted that technological adaptation and innovation are necessary to strengthen environmental sustainability in the marine and fisheries sectors. Similarly, Wuwung et al. [9] argued that digital transformation—when integrated with environmental policies—can catalyze achieving Indonesia's maritime vision.

The study contributes to this discourse by providing empirical evidence that digital innovation amplifies environmental outcomes only when accompanied by trained personnel and institutional coordination. For example, the application of automated waste monitoring at ports proved ineffective in areas lacking trained environmental officers, illustrating that technology alone cannot substitute human and institutional capacity.

e. Toward a Sustainable Maritime Human Resource Strategy

Synthesizing these findings, the research proposes a Sustainable Maritime Human Resource Development Framework, consisting of three strategic pillars:

- Competency and Certification Alignment – Updating maritime education curricula to align with IMO standards and sustainability competencies.
- Integrated Institutional Governance – Establishing a national Maritime Human Resource Council to coordinate HR policies across ministries.
- Digital-Ecological Integration – Embedding environmental sustainability and digital readiness in maritime workforce training programs.

Figure 1. Maritime human resources development strategy

Conclusion

This framework for achieving Golden Indonesia 2045 requires inclusive human and institutional transformation. Moreover, it also emphasized that Blue Economy transformation is not only economic, but also strategic for national defense and sovereignty. Further study is required to emphasize the findings.

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References

[1] A. Ginanjar and A. Adriyadi, "Optimization of Human Resources (HR) to Support Blue Economy in Riau Island Province," *Journal of Maritime Policy Science*, vol. 1, no. 3, pp. 110–118, 2024.

[2] A. F. Hendarman et al., "Current research and future perspectives: A literature review on the blue economy of Indonesia," in *BIO Web of Conferences*, vol. 92, p. 01030, EDP Sciences, 2024.

[3] J. T. Purba, "Strategy optimizing marine industry through sustainable human capital development: Indonesia perspectives," *Mediterranean Journal of Social Sciences*, vol. 6, no. 5, pp. 129–135, 2015.

[4] T. Marwa, Muizzuddin, A. Bashir, S. Andaiyani, and A. Cahyadi, "Determinants of the blue economy growth in the era of sustainability: A case study of Indonesia," *Economies*, vol. 12, no. 11, p. 299, 2024.

[5] A. D. H. Silalahi, P. Suwarno, and D. Hermanto, "Blue Economy Transformation to Realize Defense Economy," *Asian Journal of Management, Entrepreneurship and Social Science*, vol. 5, no. 4, pp. 249–271, 2025.

[6] M. Maqfirah and A. R. Laba, "The Role of Blue Economy Towards Golden Indonesia 2045," in 9th *Int. Conf. on Accounting, Management, and Economics 2024 (ICAME 2024),* pp. 2010–2018, Atlantis Press, July 2025.

[7] K. S. S. Hadiningrat, B. Wiradanti, and Y. F. Umar, "Transformation of Indonesian Sea Transportation and Maritime Logistics to Realize The Vision of Golden Indonesia 2045," *Jipower: Journal of Intellectual Power*, vol. 1, no. 1, pp. 89–107, 2024.

[8] O. Sabrina and R. A. Putra, "Navigating the Blue Economy: Indonesia's Regional Efforts in ASEAN to Support Sustainable Practices in Fisheries Sector," *Sustainability*, vol. 17, no. 15, p. 6906, 2025.

[9] L. Wuwung, A. McIlgorm, and M. Voyer, "Sustainable ocean development policies in Indonesia: paving the pathways towards a maritime destiny," *Frontiers in Marine Science*, vol. 11, p. 1401332, 2024.

[10] S. O. Anikwe, L. C. Unachukwu, and F. N. Onah, "Human capacity development and sustainable growth in the blue economy: Opportunities, challenges, and strategies for Nigeria," *African Banking and Finance Review Journal,* vol. 15, no. 15, 2024.

[11] D. A. A. Sari and S. Muslimah, "Blue economy policy for sustainable fisheries in Indonesia," in *IOP Conf. Ser.: Earth and Environmental Science*, vol. 423, no. 1, p. 012051, IOP Publishing, 2020.

[12] T. B. Mulianto, A. Asropi, and R. Rajab, "Strategy to Fulfill The Need For Fisheries Supervisors To Support The Ministry Of Marine Affairs And Fisheries' Blue Economy Policy," *Eduvest-Journal of Universal Studies*, vol. 4, no. 12, pp. 12199–12220, 2024.

[13] F. Andana and C. F. W. B. Saputra, "Regional Policy Diversification to Maximize Blue Economy Potential in Kepulauan Riau Amid Indonesia-China Bilateral Cooperation," *Journal of Maritime Policy Science*, vol. 2, no. 1, pp. 13–25, 2025.

[14] M. Yusuf, A. D. Riana, R. Rusneni, W. A. Salawali, and E. Eddiwam, "Sustainability analysis of fisheries and marine resource development in Indonesia's blue economy framework," *Biodiversitas Journal of Biological Diversity,* vol. 26, no. 7, 2025.

[15] H. Prasutiyon and R. Tambun, "The Contribution of the Maritime Sector to Economic Development," 2025.