

Green Skills and Digital Competencies for Blue Economy Development: Evidence from the Tran De Coastal Economic Zone, Vietnam

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DOI: <https://doi.org/10.51244/IJRSI.2026.1306000119>

Received: 05 June 2026; Accepted: 09 June 2026; Published: 25 June 2026

ABSTRACT

This study aims to identify the green skills and digital competencies required to support blue economy development in the Tran De Coastal Economic Zone, Soc Trang Province, Vietnam. Grounded in Human Capital Theory, the research employed a three-round Delphi method involving 18 experts from government agencies, economic zone management authorities, logistics and maritime enterprises, digital transformation specialists, and academic institutions. The findings established a competency framework consisting of two key dimensions: green skills and digital competencies. Green skills include environmental awareness, sustainable resource management, green innovation capability, circular economy knowledge, and environmental risk management. Digital competencies comprise digital literacy, data analytics capability, smart logistics management, AI literacy, and digital collaboration and communication. The Delphi results indicate that smart logistics management, environmental awareness, and sustainable resource management are the most critical competencies for supporting blue economy development in the Tran De Coastal Economic Zone. The study highlights that the integration of green skills and digital competencies is essential for developing a future-ready workforce capable of addressing sustainability challenges and technological transformation. The findings provide valuable implications for policymakers, educational institutions, and businesses in designing workforce development strategies, training programs, and human resource policies that support sustainable blue economy growth in Vietnam.

Keywords: Green skills; Digital competencies; Blue economy development; Human resource development; Tran De Coastal Economic Zone; Digital transformation; Sustainable development.

INTRODUCTION

The blue economy has emerged as a strategic development paradigm for coastal nations seeking to simultaneously achieve economic growth, environmental sustainability, and social inclusion. According to the World Bank (2023), the blue economy encompasses the sustainable use of ocean and coastal resources to promote economic development, improve livelihoods, and maintain the health of marine ecosystems. As climate change, environmental degradation, and resource depletion increasingly threaten coastal regions worldwide, governments are placing greater emphasis on developing human capital capable of supporting sustainable maritime industries and green economic transformation. In Vietnam, the sustainable development of the marine economy has been identified as a national strategic priority. Resolution No. 36-NQ/TW on the Strategy for Sustainable Development of Vietnam's Marine Economy to 2030, with a vision toward 2045, sets ambitious goals for marine economic sectors to contribute approximately 10% of national GDP and for the 28 coastal provinces and cities to account for 65-70% of GDP by 2030. This strategy reflects Vietnam's commitment to promoting a sustainable blue economy while strengthening its position as a maritime nation.

Within this context, the Mekong Delta plays a particularly important role due to its extensive coastline, abundant marine resources, and position as one of Vietnam's largest export-producing regions. Nevertheless, the region continues to face significant logistical constraints resulting from the absence of a modern deep-sea gateway port. To overcome this bottleneck, the Tran De Coastal Economic Zone in Soc Trang has been identified as a strategic growth pole for the Mekong Delta. According to Vietnam's seaport development master plan, Tran De Port is expected to become the gateway deep-sea port of the region, capable of receiving vessels of up to 160,000 DWT

and handling between 30 and 35 million tons of cargo annually by 2030. The development of the Tran De Coastal Economic Zone is therefore expected to accelerate regional economic integration, strengthen logistics connectivity, and create new opportunities for blue economy development. However, international experience suggests that the success of coastal economic zones depends not only on physical infrastructure but also on the quality of human resources. Human Capital Theory (Becker, 1964) emphasizes that investments in knowledge, skills, and competencies are essential drivers of productivity and long-term economic growth. In the era of digital transformation and sustainable development, traditional labor skills are increasingly insufficient to meet the demands of emerging maritime industries. Instead, workers are required to possess both digital competencies and green skills to effectively participate in modern port operations, smart logistics systems, sustainable supply chains, and environmentally responsible economic activities.

Digital competencies have become increasingly important as maritime industries adopt automation, artificial intelligence, big data analytics, and smart-port technologies. UNESCO (2018) defines digital competencies as the ability to confidently, critically, and responsibly use digital technologies for learning, working, and participating in society. Meanwhile, green skills refer to the knowledge, abilities, values, and attitudes necessary to support environmentally sustainable economic activities and facilitate the transition toward a green economy (ILO, 2019). Recent studies suggest that these competencies are becoming critical determinants of workforce adaptability and regional competitiveness in emerging economic sectors. Despite the growing importance of green skills and digital competencies, existing research has primarily focused on workforce development, logistics management, maritime education, or coastal economic planning as separate streams of inquiry. In Vietnam, studies have examined shortages in logistics and maritime labor, human resource development for economic zones, and the challenges of digital transformation. However, limited attention has been paid to understanding how green skills and digital competencies contribute to blue economy development, particularly within newly emerging coastal economic zones. More importantly, empirical evidence remains scarce regarding the mechanisms through which these competencies influence sustainable maritime development in developing economies.

This research gap is particularly significant in the case of the Tran De Coastal Economic Zone. As one of Vietnam's most ambitious coastal development projects, Tran De is expected to operate within a highly digitalized, environmentally sensitive, and globally connected economic environment. Consequently, understanding the role of green skills and digital competencies in supporting blue economy development is essential for designing effective human resource strategies and policy interventions.

Against this backdrop, this study investigates the effects of green skills and digital competencies on blue economy development in the Tran De Coastal Economic Zone, Vietnam. By providing empirical evidence from a strategically important coastal development area, the study contributes to the emerging literature on sustainable human capital development and offers practical implications for policymakers, educational institutions, and businesses seeking to prepare the workforce for the future blue economy.

LITERATURE REVIEW AND THEORETICAL FOUNDATION

Blue Economy Development: The concept of the blue economy has gained increasing attention as coastal nations seek to reconcile economic growth with environmental sustainability. Although different definitions exist, most scholars agree that the blue economy refers to the sustainable use of ocean and coastal resources for economic development while maintaining the health of marine ecosystems (World Bank, 2017; OECD, 2016). According to the World Bank (2017), the blue economy encompasses economic activities related to fisheries, aquaculture, maritime transport, coastal tourism, renewable marine energy, and marine ecosystem services. Similarly, the OECD (2016) emphasizes that the future growth of the ocean economy will increasingly depend on innovation, technological advancement, and the quality of human capital. Therefore, workforce capabilities have become a critical component of blue economy development, particularly in coastal economic zones that serve as hubs for maritime logistics and industrial activities (Busemeyer, M. R., Carstensen, M. B., Kemmerling, A., & Tosun, J., 2025).

Recent studies suggest that sustainable blue economy development requires not only infrastructure investment but also a workforce capable of adapting to environmental regulations, technological transformation, and

evolving industry requirements (UNDP, 2022; World Bank, 2023). Consequently, human capital is increasingly recognized as a strategic resource for coastal economic competitiveness.

Green Skills: The transition toward sustainable economic development has generated growing interest in green skills. The International Labour Organization (ILO, 2019) defines green skills as the knowledge, abilities, values, and attitudes needed to support environmentally sustainable economic activities and facilitate the transition toward a low-carbon economy. Pavlova (2018) argues that green skills extend beyond environmental awareness and include problem-solving abilities, sustainable resource management, waste reduction practices, and ecological innovation capabilities.

Likewise, Cedefop (2012) highlights that green skills are becoming increasingly important across all sectors, particularly in industries facing environmental regulations and sustainability requirements. In the context of coastal economic zones, green skills enable workers to implement sustainable practices in logistics, port operations, fisheries, and marine resource management. As environmental sustainability becomes a key pillar of blue economy development, green skills are expected to play a crucial role in enhancing organizational performance and regional sustainability (Grigorescu, A., Munteanu, I., Dumitrica, C. D., & Lincaru, C., 2023).

Digital Competencies: Digital transformation has fundamentally altered labor market requirements worldwide. Digital competencies refer to the knowledge, skills, and attitudes necessary for individuals to effectively use digital technologies in professional and social contexts (UNESCO, 2018). Montanari, S., Agostini, E., & Francesconi, D. (2023) classify digital competencies into several dimensions, including information management, communication, collaboration, critical thinking, creativity, and problem-solving in digital environments. Similarly, the European Commission (2019) emphasizes that digital competencies are essential for workforce adaptability in Industry 4.0 and increasingly automated workplaces.

Within maritime industries, digital technologies such as artificial intelligence, big data analytics, blockchain, and smart-port systems are transforming operational processes. Consequently, employees require advanced digital competencies to manage technological systems, optimize logistics networks, and enhance operational efficiency (Sarkar & Shankar, 2021).

Human Capital Theory: The theoretical foundation of this study is rooted in Human Capital Theory proposed by Becker (1964). The theory argues that investments in education, training, and skill development increase individuals' productivity and contribute to economic growth. According to Becker (1964), knowledge and skills constitute forms of capital that generate economic returns for individuals, organizations, and societies. Schultz (1961) further emphasized that human capital is a primary driver of economic development, particularly in knowledge-intensive industries.

In the context of the blue economy, green skills and digital competencies can be viewed as strategic forms of human capital that enhance workforce productivity, innovation capacity, and adaptability. Consequently, Human Capital Theory provides a suitable framework for explaining how these competencies contribute to blue economy development.

Human Capital Theory Extension in the Blue Economy Context: Human Capital Theory traditionally posits that investments in education, training, knowledge, and skills enhance individual productivity and contribute to economic growth (Becker, 1964; Schultz, 1961). While the theory has been widely applied to explain workforce performance across industries, contemporary economic transformations associated with sustainability transitions and digitalization suggest the need for a broader conceptualization of human capital.

In particular, the emergence of the blue economy requires workers not only to possess occupational and technical expertise but also to develop competencies that enable them to respond effectively to environmental challenges and technological disruptions. In the context of coastal economic zones, green skills and digital competencies represent two complementary dimensions of strategic human capital.

Green skills enable individuals to understand environmental impacts, manage marine resources sustainably, comply with environmental regulations, and contribute to low-carbon and circular economic activities. At the

same time, digital competencies enhance workers' ability to utilize digital technologies, analyze data, operate smart logistics systems, and adapt to technology-driven workplaces.

Rather than functioning independently, these competencies interact to create a new form of human capital that supports both environmental sustainability and technological innovation. This study argues that blue economy development requires an extension of Human Capital Theory from a traditional productivity-oriented perspective toward a sustainability- and technology-oriented perspective. Specifically, green skills contribute to ecological resilience and sustainable resource utilization, while digital competencies facilitate operational efficiency, innovation, and smart decision-making.

The integration of these competencies generates what may be described as “sustainable digital human capital,” a strategic workforce asset capable of supporting the dual transition toward green growth and digital transformation. Consequently, sustainable blue economy development depends not only on investments in infrastructure and technology but also on investments in human capital that simultaneously incorporates environmental responsibility and digital readiness.

Based on this theoretical perspective, the present study proposes that green skills and digital competencies jointly constitute critical drivers of workforce readiness and blue economy development within the Tran De Coastal Economic Zone. This integrated view provides the conceptual foundation for identifying the competencies required to support sustainable maritime development in emerging coastal economic zones.

Green Skills and Blue Economy Development: Several studies have highlighted the importance of green skills in promoting sustainable economic development. According to the ILO (2019), green skills support environmental performance, resource efficiency, and sustainable production systems.

World Bank (2023) argues that the success of blue economy initiatives increasingly depends on workers' ability to implement environmentally responsible practices across maritime industries. Employees equipped with green skills are more capable of supporting sustainable port management, green logistics, marine conservation, and low-carbon operations. Therefore, green skills are expected to positively contribute to blue economy development.

Digital Competencies and Blue Economy Development: Digital competencies have emerged as critical drivers of productivity and innovation in coastal industries. OECD (2024) suggests that digital technologies improve efficiency, connectivity, and decision-making across maritime value chains.

Tyros, S., Andrews, D., & de Serres, A. (2023) further demonstrate that digital readiness is essential for the successful implementation of smart-port and logistics systems. Workers possessing strong digital competencies are better positioned to leverage technological innovations, optimize operations, and enhance competitiveness. Accordingly, digital competencies are expected to positively influence blue economy development.

Research Gap: Although previous studies have examined blue economy development, green skills, and digital competencies separately, limited empirical research has investigated their interrelationships within emerging coastal economic zones. Existing studies largely focus on developed economies or specific maritime industries, while evidence from developing countries remains scarce.

Furthermore, few studies have explored how green skills and digital competencies jointly contribute to blue economy development in newly established coastal economic zones. This gap is particularly evident in Vietnam, where strategic projects such as the Tran De Coastal Economic Zone are expected to operate within highly digitalized and sustainability-oriented environments. Therefore, this study contributes to the literature by empirically examining the effects of green skills and digital competencies on blue economy development in the Tran De Coastal Economic Zone, Vietnam.

Figure 1. Conceptual Framework Linking Green Skills and Digital Competencies to Blue Economy Development through Sustainable Digital Human Capital

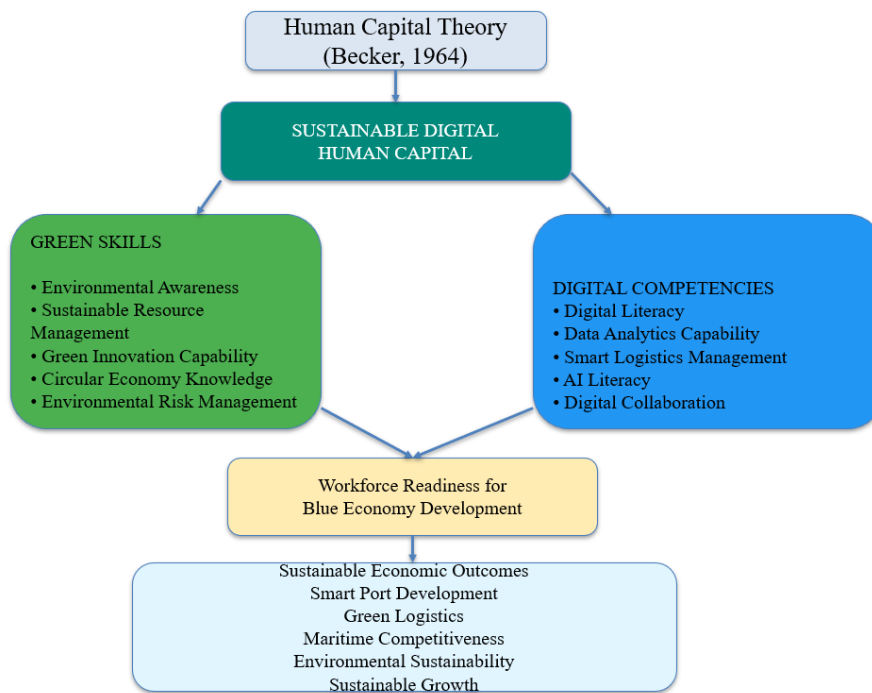


Figure 1 illustrates the proposed conceptual framework of this study. Drawing upon Human Capital Theory, the framework argues that green skills and digital competencies jointly constitute a new form of sustainable digital human capital. Green skills contribute to environmental stewardship, sustainable resource utilization, and ecological resilience, whereas digital competencies enhance technological adaptability, smart logistics operations, and data-driven decision-making. The integration of these competencies strengthens workforce readiness and ultimately supports sustainable blue economy development through improved competitiveness, environmental sustainability, and innovation capacity.

RESEARCH METHODOLOGY

This study employed the Delphi method to identify and establish consensus on the green skills and digital competencies required for blue economy development in the Tran De Coastal Economic Zone, Soc Trang Province, Vietnam. The Delphi method is widely recognized as an effective research approach for investigating emerging issues characterized by limited empirical evidence and a high degree of uncertainty, where expert judgment plays a crucial role in forecasting future trends and requirements (Linstone & Turoff, 2002). Given that the Tran De Coastal Economic Zone is being developed as a strategic hub for logistics, port operations, and marine economic activities in the Mekong Delta, while the future workforce requirements associated with the green and digital transition remain insufficiently understood, the Delphi technique provides an appropriate framework for systematically eliciting and consolidating expert knowledge. The research was conducted through a three-round Delphi process. In the first round, semi-structured interviews were undertaken to explore experts' perspectives on the skills and competencies considered essential for the future workforce in the context of blue economy development. Discussions focused on emerging labor market requirements related to sustainable marine resource management, green logistics, smart port operations, digital technologies, and sustainable development standards. The qualitative data collected during this phase were analyzed using thematic analysis following the approach proposed by Braun and Clarke (2006), enabling the identification of recurring themes and the development of an initial competency framework.

Based on the findings of the first round, the second Delphi round was conducted to assess the importance of each identified skill and competency. Experts were asked to evaluate each item using a five-point Likert scale ranging from 1 ("not important at all") to 5 ("extremely important"). Descriptive statistical measures, including mean scores, median values, and interquartile ranges, were calculated to assess the degree of consensus among participants. Competencies that did not achieve the required level of agreement were retained for further consideration in the subsequent round.

In the third Delphi round, experts were provided with a summary of the previous results and invited to reconsider their evaluations in light of the collective feedback from the panel. A competency was considered to have achieved consensus when it simultaneously satisfied three criteria: a mean score of at least 4.0, an interquartile range not exceeding 1.0, and an agreement level of at least 75 percent. These criteria have been widely adopted in Delphi studies related to strategic planning, workforce forecasting, and competency development (Hsu & Sandford, 2007; Keeney et al., 2011). Applying these thresholds helped ensure the stability, reliability, and credibility of the study’s findings.

The Delphi panel consisted of 18 experts selected through purposive sampling. This panel size was determined based on the recommendations of Okoli and Pawlowski (2004), who suggest that Delphi studies in management and policy research typically involve between 10 and 30 highly qualified experts. The panel included four representatives from government agencies, three representatives from economic zone and port management authorities, four managers from logistics and maritime enterprises, three experts in digital transformation and technology, and four academics and researchers specializing in marine economics, human resource development, and sustainability. All participating experts possessed at least ten years of professional experience or demonstrated expertise through research, consulting, or managerial contributions in fields directly related to marine economy development, logistics, digital transformation, or human resource development.

To enhance the reliability and validity of the research, several methodological safeguards were implemented. First, the anonymity of expert responses minimized the influence of hierarchical relationships and social pressures on the evaluation process. Second, the iterative nature of the Delphi process, combined with structured feedback mechanisms, enabled experts to revise their judgments based on the collective views of the panel, thereby facilitating convergence toward informed consensus. Third, the use of multiple statistical indicators, including mean scores, interquartile ranges, and agreement percentages, provided objective evidence of the consistency and robustness of expert opinions. The outcome of the Delphi process was a validated competency framework comprising the green skills and digital competencies considered critical for supporting blue economy development in the Tran De Coastal Economic Zone. This framework not only reflects current workforce requirements but also captures future competency demands associated with digital transformation and sustainable development. As such, it provides a valuable foundation for policy formulation, curriculum development, workforce planning, and human resource development strategies aimed at supporting the green and digital transition of Vietnam’s coastal economic zones.

RESULTS

Characteristics of the Expert Panel

The Delphi panel consisted of 18 experts representing five stakeholder groups, including government agencies (22.2%), economic zone and port management authorities (16.7%), logistics and maritime enterprises (22.2%), digital transformation specialists (16.7%), and academics and researchers (22.2%) (Table 1). The diversity of the panel ensured a balanced representation of perspectives from policy, industry, technology, and academia. On average, participating experts possessed more than 16 years of professional experience in fields related to maritime economics, logistics, digital transformation, sustainability, and human resource development. Such expertise provides a solid foundation for evaluating future workforce requirements associated with blue economy development in the Tran De Coastal Economic Zone.

Table 1. Characteristics of Delphi Experts

Category	Number	Percentage (%)
Government agencies	4	22.2
Economic zone and port management	3	16.7
Logistics and maritime enterprises	4	22.2
Digital transformation specialists	3	16.7

Category	Number	Percentage (%)
Academics and researchers	4	22.2
Total	18	100.0

Identification of Green Skills and Digital Competencies

The first Delphi round generated a broad range of competencies considered necessary for supporting sustainable blue economy development. Through thematic analysis, these competencies were consolidated into two overarching dimensions: green skills and digital competencies. Within the green-skills dimension, experts consistently emphasized environmental awareness, sustainable resource management, green innovation capability, circular economy knowledge, and environmental risk management. Meanwhile, the digital-competency dimension comprised digital literacy, data analytics capability, smart logistics management, AI literacy, and digital collaboration and communication (Table 2).

The findings indicate that experts perceive future workforce competitiveness as increasingly dependent on the integration of environmental sustainability and digital transformation capabilities. Rather than treating these competencies as separate domains, experts argued that successful blue economy development requires their simultaneous development. In particular, several participants highlighted that the future operation of Tran De Port and related logistics ecosystems will require workers capable of balancing economic efficiency with environmental responsibility.

Table 2. Competency Framework Identified from Round 1

Competency Group	Competency Dimension
Green Skills	Environmental Awareness
Green Skills	Sustainable Resource Management
Green Skills	Green Innovation Capability
Green Skills	Circular Economy Knowledge
Green Skills	Environmental Risk Management
Digital Competencies	Digital Literacy
Digital Competencies	Data Analytics Capability
Digital Competencies	Smart Logistics Management
Digital Competencies	AI Literacy
Digital Competencies	Digital Collaboration and Communication

Assessment of Green Skills

The results of the second Delphi round demonstrate strong consensus regarding the importance of green skills for blue economy development (Table 3). All dimensions achieved mean scores above 4.50, indicating that experts considered them highly important.

Among the identified competencies, Environmental Awareness received the highest evaluation (Mean = 4.83; Median = 5; IQR = 0.50). This result suggests that environmental consciousness constitutes the foundation of sustainable workforce behavior. Experts emphasized that employees working in port operations, logistics, and marine industries must understand the environmental consequences of economic activities and comply with increasingly stringent sustainability standards.

Sustainable Resource Management also received a high level of agreement (Mean = 4.78), reflecting growing concerns regarding marine resource depletion and climate-related challenges. Experts argued that the ability to

utilize resources efficiently while minimizing environmental impacts will become a core competency for future workers.

Although Circular Economy Knowledge obtained the lowest score within the green-skills dimension (Mean = 4.56), it still exceeded the consensus threshold. This finding suggests that while circular-economy principles are increasingly recognized as important, their practical application within local industries remains relatively limited. Consequently, targeted training and capacity-building initiatives will be required to enhance workforce readiness in this area.

Table 3. Importance of Green Skills

Green Skills	Mean	Median	IQR
Environmental Awareness	4.83	5	0.50
Sustainable Resource Management	4.78	5	0.50
Green Innovation Capability	4.61	5	0.75
Circular Economy Knowledge	4.56	5	0.75
Environmental Risk Management	4.72	5	0.50

Assessment of Digital Competencies

The findings also reveal a strong consensus concerning the importance of digital competencies (Table 4). All competencies achieved mean scores greater than 4.50, confirming the central role of digital transformation in future blue economy development. Smart Logistics Management emerged as the highest-rated competency (Mean = 4.89; Median = 5; IQR = 0.25). This result reflects experts’ expectations that Tran De Coastal Economic Zone will evolve into a major logistics and maritime hub for the Mekong Delta. The increasing adoption of smart-port technologies, integrated logistics platforms, and automated operational systems is expected to create substantial demand for digitally skilled workers.

Digital Literacy and Data Analytics Capability also received strong support, with mean scores of 4.72 and 4.67, respectively. Experts noted that data-driven decision-making is becoming increasingly important for optimizing logistics operations, forecasting cargo flows, and enhancing supply-chain efficiency.

AI Literacy recorded the lowest mean score among digital competencies (Mean = 4.50), although it remained above the consensus threshold. This finding may reflect the relatively early stage of AI adoption in local industries. Nevertheless, experts widely acknowledged that AI-related competencies are likely to become increasingly important as maritime and logistics sectors continue their digital transformation.

Table 4. Importance of Digital Competencies

Digital Competencies	Mean	Median	IQR
Digital Literacy	4.72	5	0.50
Data Analytics Capability	4.67	5	0.50
Smart Logistics Management	4.89	5	0.25
AI Literacy	4.50	5	0.75
Digital Collaboration and Communication	4.61	5	0.50

Final Consensus and Competency Framework

The third Delphi round confirmed the stability of expert judgments and resulted in a high degree of consensus across all competencies (Table 5). Agreement levels ranged from 83.3% to 100%, indicating substantial consistency among experts.

Notably, Smart Logistics Management achieved the highest agreement level (100%), underscoring its strategic importance for the future development of Tran De Coastal Economic Zone. Similarly, Environmental Awareness and Sustainable Resource Management achieved agreement levels exceeding 94%, highlighting the critical role of sustainability-oriented competencies in supporting blue economy development.

Taken together, the results suggest that future workforce development strategies should not focus exclusively on either environmental sustainability or digital transformation. Instead, the findings support an integrated competency framework in which green skills and digital competencies jointly contribute to workforce readiness for blue economy development. Such a framework provides a valuable basis for curriculum design, vocational training, talent attraction policies, and long-term human resource planning within the Tran De Coastal Economic Zone and other emerging coastal economic zones in Vietnam.

Table 5. Final Consensus Results

Competency	Mean	Agreement (%)
Environmental Awareness	4.89	94.4
Sustainable Resource Management	4.83	94.4
Green Innovation Capability	4.72	88.9
Circular Economy Knowledge	4.67	83.3
Environmental Risk Management	4.78	88.9
Digital Literacy	4.78	88.9
Data Analytics Capability	4.72	88.9
Smart Logistics Management	4.94	100.0
AI Literacy	4.61	83.3
Digital Collaboration and Communication	4.67	88.9

DISCUSSION

The findings of this study provide important insights into the competencies required for supporting blue economy development in emerging coastal economic zones. Through a three-round Delphi process, the research identified two strategic competency domains—green skills and digital competencies—as critical foundations for workforce development in the Tran De Coastal Economic Zone. The high level of consensus achieved among experts suggests that the future competitiveness of coastal economic zones will increasingly depend on the ability of workers to integrate sustainability-oriented practices with digital technologies. A notable finding is the prominent role of green skills in supporting blue economy development. Among the identified competencies, environmental awareness and sustainable resource management received the highest evaluations from experts, with mean scores of 4.83 and 4.78, respectively. These results indicate that experts view environmental responsibility not merely as a complementary capability but as a fundamental prerequisite for sustainable economic activities in coastal regions. This finding is consistent with the arguments of the International Labour Organization (2019), which emphasizes that green skills are essential for facilitating the transition toward environmentally sustainable production systems. Similarly, Pavlova (2018) argues that the future workforce must possess not only technical expertise but also the ability to incorporate sustainability principles into decision-making processes. In the context of Tran De, where economic growth is expected to be closely linked with maritime logistics, port operations, fisheries, and coastal resource utilization, environmental awareness becomes particularly important for balancing economic development with ecosystem protection.

The study also highlights the growing importance of digital competencies in the blue economy. Smart logistics management emerged as the most important competency, achieving the highest mean score (4.89) and complete expert consensus (100%). This result reflects experts' expectations regarding the future role of Tran De as a strategic logistics and maritime hub for the Mekong Delta. As modern ports increasingly rely on automation,

artificial intelligence, digital platforms, and integrated logistics systems, workforce requirements are shifting from traditional operational skills toward technology-oriented competencies. This finding supports the observations of UNESCO (2018) and OECD (2019), which emphasize that digital competencies are becoming indispensable for labor market participation and organizational competitiveness in the digital era. It also aligns with recent studies suggesting that digital transformation is reshaping employment structures within logistics and maritime industries by increasing demand for data-driven decision-making and technologically skilled workers. Another important contribution of the study lies in demonstrating the complementary relationship between green skills and digital competencies. Rather than viewing these competencies as separate dimensions, experts consistently emphasized that sustainable blue economy development requires their simultaneous integration. This finding extends the Human Capital Theory proposed by Becker (1964) and Schultz (1961), which argues that investments in education, skills, and knowledge contribute to economic productivity and development. In the context of coastal economic zones, the study suggests that human capital should no longer be understood solely in terms of technical or occupational skills. Instead, future workforce development strategies must incorporate both sustainability-oriented competencies and digital capabilities to address the challenges associated with climate change, environmental governance, and technological transformation.

The results further reveal the emergence of a new competency profile for workers in coastal economic zones. Traditionally, workforce development strategies in maritime and logistics sectors have focused on operational efficiency, technical expertise, and industry-specific knowledge. However, the competency framework developed in this study indicates that future workforce readiness will increasingly depend on broader capabilities such as environmental risk management, circular economy knowledge, data analytics, digital collaboration, and AI literacy. This finding reflects global trends identified by the World Bank (2023) and OECD (2023), which emphasize that green transition and digital transformation are fundamentally reshaping skill requirements across economic sectors.

From a theoretical perspective, this study contributes to the emerging literature on blue economy development by integrating concepts from Human Capital Theory, green skills research, and digital competency studies. While previous studies have often examined these topics independently, the present research demonstrates their interconnected role in supporting sustainable coastal development. The study therefore provides a more holistic understanding of the competencies required for the future workforce in coastal economic zones. From a practical perspective, the findings offer valuable implications for policymakers, educational institutions, and businesses. The competency framework developed through the Delphi process can serve as a foundation for designing training programs, revising educational curricula, and developing workforce strategies aligned with the future needs of the blue economy. In particular, the strong emphasis placed on smart logistics management, environmental awareness, and sustainable resource management suggests that future human resource policies should prioritize the integration of digital transformation and sustainability objectives. Such an approach is particularly relevant for the Tran De Coastal Economic Zone, where long-term development success will depend not only on infrastructure investment but also on the availability of a highly skilled workforce capable of supporting both green and digital transitions.

Overall, the study demonstrates that the development of the blue economy requires a new generation of human capital characterized by the integration of green skills and digital competencies. As coastal economic zones increasingly become focal points of economic transformation, workforce development strategies must evolve accordingly to ensure that human resources are capable of supporting sustainable, innovative, and resilient growth.

While Human Capital Theory (Becker, 1964) traditionally emphasizes education, knowledge, and technical skills as determinants of productivity and economic growth, the findings of this study suggest that human capital in the blue economy context should be reconceptualized as a multidimensional construct integrating both sustainability-oriented competencies and digital capabilities. Green skills enable workers to manage environmental risks, promote resource efficiency, and support sustainable maritime practices, whereas digital competencies enhance technological adaptability, data-driven decision-making, and smart logistics operations. The interaction between these competencies creates a new form of “sustainable digital human capital” that is particularly relevant for coastal economic zones undergoing simultaneous green and digital transitions.

Policy and Managerial Implications

The findings of this study provide several important implications for policymakers, educational institutions, and business organizations involved in the development of the Tran De Coastal Economic Zone and other emerging coastal economic zones in Vietnam.

Policy Implications

First, workforce development policies should be repositioned as a strategic pillar of blue economy development. The findings indicate that green skills and digital competencies are no longer supplementary capabilities but have become essential requirements for future workforce competitiveness. Therefore, local and national authorities should integrate competency development objectives into blue economy strategies, coastal economic zone planning, and regional human resource development programs. In particular, policy frameworks should explicitly recognize environmental awareness, sustainable resource management, and smart logistics capabilities as priority competencies for future workforce development.

Second, governments should strengthen investments in education and vocational training systems to support the development of green and digital skills. The emergence of competencies such as smart logistics management, data analytics, AI literacy, and circular economy knowledge suggests that traditional training programs may no longer adequately meet future labor market requirements. Accordingly, vocational institutions, universities, and training centers should be encouraged to modernize curricula and establish interdisciplinary programs that combine maritime economics, logistics, environmental management, and digital technologies.

Third, policymakers should establish stronger collaboration mechanisms among government agencies, educational institutions, and businesses. The competency framework developed in this study highlights the dynamic nature of workforce requirements in the context of digital transformation and sustainable development. Regular consultation platforms and public-private partnerships can help ensure that training programs remain aligned with evolving industry needs and technological developments.

Fourth, targeted policies should be developed to attract and retain highly skilled professionals in coastal economic zones. Given the strategic role of Tran De in Vietnam's maritime development agenda, local authorities should consider implementing incentive schemes related to housing, professional development opportunities, research support, and innovation funding to attract talent in areas such as logistics, digital technologies, environmental management, and maritime economics.

Implications for Educational and Training Institutions

The study suggests that educational institutions should move beyond traditional disciplinary approaches and adopt competency-based training models. Curricula should incorporate sustainability principles, environmental governance, digital literacy, data analytics, artificial intelligence applications, and smart logistics management. In addition, universities and vocational colleges should strengthen experiential learning through internships, industry projects, simulation-based training, and partnerships with enterprises operating in logistics, maritime transport, and port management. Educational institutions should also play a more active role in supporting lifelong learning and workforce reskilling. As technological and environmental requirements continue to evolve, continuous professional development programs will become increasingly important for maintaining workforce competitiveness and adaptability.

Managerial Implications for Businesses

For businesses operating within the Tran De Coastal Economic Zone, the findings highlight the importance of integrating sustainability and digital transformation into human resource management strategies. Organizations should systematically assess workforce competency gaps and develop targeted training initiatives focusing on environmental management, resource efficiency, digital technologies, and smart logistics operations. The strong consensus regarding the importance of smart logistics management suggests that enterprises should accelerate

investments in digital infrastructure and employee training programs related to automation, data analytics, artificial intelligence, and integrated logistics platforms. At the same time, firms should foster organizational cultures that encourage environmental responsibility, innovation, and continuous learning. Furthermore, recruitment and talent management practices should increasingly emphasize green and digital competencies alongside traditional technical qualifications. Organizations capable of attracting and developing employees with these competencies are likely to achieve greater adaptability, innovation capacity, and long-term competitiveness in the evolving blue economy landscape.

Overall, the study suggests that successful blue economy development requires a coordinated effort among policymakers, educational institutions, and businesses. The integration of green skills and digital competencies into workforce development strategies will be essential for ensuring that the Tran De Coastal Economic Zone can achieve sustainable, resilient, and technology-driven growth in the coming decades.

CONCLUSION

This study aimed to identify the green skills and digital competencies required to support blue economy development in the Tran De Coastal Economic Zone, Vietnam. Using a three-round Delphi process involving 18 experts from government agencies, economic zone management authorities, logistics and maritime enterprises, digital transformation specialists, and academic institutions, the research established a competency framework that reflects the emerging workforce requirements associated with sustainable coastal development, digital transformation, and environmental sustainability. The findings reveal that future blue economy development depends not only on physical infrastructure and investment but also on the availability of a workforce capable of responding to the challenges of green transition and technological change. The Delphi process identified two strategic competency domains, namely green skills and digital competencies, comprising ten key competency components. Among these, environmental awareness, sustainable resource management, and smart logistics management were identified as the most critical competencies for supporting the long-term development of the Tran De Coastal Economic Zone. The high level of expert consensus obtained throughout the Delphi process highlights the growing recognition that sustainable maritime development requires the integration of environmental responsibility and technological capability.

From a theoretical perspective, the study contributes to the literature on blue economy development by extending Human Capital Theory to the context of emerging coastal economic zones. While previous studies have often examined sustainability competencies and digital capabilities separately, this research demonstrates their complementary role in supporting workforce readiness for the blue economy. The study therefore provides a more integrated understanding of how green skills and digital competencies jointly contribute to sustainable coastal development.

From a practical perspective, the competency framework developed in this study offers a useful reference for policymakers, educational institutions, and business organizations. The findings suggest that future workforce development strategies should prioritize the integration of sustainability-related competencies and digital capabilities into education, vocational training, recruitment, and human resource development programs. Such efforts will be particularly important for ensuring that the Tran De Coastal Economic Zone possesses the human capital required to achieve its strategic objectives as a regional logistics, maritime, and economic hub.

Despite these contributions, the study has several limitations. First, the findings are based on expert judgments obtained through the Delphi method and do not directly capture the perceptions of employees, students, or enterprises operating within the blue economy ecosystem. Second, the study focuses on a specific coastal economic zone in Vietnam, which may limit the generalizability of the findings to other geographical contexts. Third, the research identifies and prioritizes competencies but does not empirically examine their effects on organizational or regional performance outcomes.

Future research could extend this study by developing quantitative measurement scales for green skills and digital competencies and testing their impacts on workforce readiness, organizational performance, and blue economy development using large-scale survey data. Comparative studies across different coastal economic zones and maritime regions would also provide valuable insights into the contextual factors influencing

competency requirements. Furthermore, future research may explore the role of emerging technologies, including artificial intelligence, digital platforms, and smart-port systems, in shaping workforce development for the next generation of blue economy activities.

Overall, the study demonstrates that the successful development of the blue economy requires a new generation of human capital characterized by the integration of green skills and digital competencies. As Vietnam continues to pursue its sustainable marine development strategy, investing in these competencies will be essential for enhancing workforce adaptability, strengthening regional competitiveness, and ensuring the long-term sustainability of coastal economic development.

ACKNOWLEDGEMENT: This study was conducted as part of the provincial-level research project entitled “Research on Forecasting Labor Demand and Developing Solutions for Attracting and Training Human Resources to Support the Operations of the Tran De Coastal Economic Zone, Soc Trang Province”, led by Associate Professor. Nguyen Xuan Trung.

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