DIGITAL TRANSFORMATION: LEVERAGING THE DEVELOPMENT OF DIGITAL ECONOMY AND SUSTAINABLE MARINETOURISM IN KHANH HOA PROVINCE

Võ Trọng Thạch[1], Nguyễn Anh Minh[2], Đỗ Thành Nhân[3], Võ Trọng Thành[3]

[1]Viện Nghiên cứu và Ứng dụng Công nghệ Nha Trang, Viện Hàn lâm Khoa học và Công nghệ Việt Nam
[2]Trường UWC Changshu China, No. 88 Kun-Cheng-Hu-Xi Road, Changshu, Jiangsu, China 215500.
[3]Lớp Thạc sĩ điều hành cao cấp Quản lý công (2024-2025), Trường Đại học kinh tế Thành phố Hồ Chí Minh.

Thông tin chung:
Ngày nhận bài:16/06/2024
Ngày phản biện: 20/06/2024
Ngày duyệt đăng: 20/08/2024
**Tác giả chính:*
thach.gpu4rs@gmail.com

Title: *Chuyển đổi số: Động lực phát triển kinh tế số và du lịch biển bền vững cho Khánh Hòa*

Keywords: *Artificial intelligence, digital economy, digital transformation, sustainable marine tourism*

Từ khóa: *Chuyển đổi số, du lịch biển bền vững, kinh tế số, trí tuệ nhân* tạo

TÓM TẮT: *Chuyển đổi số trong cuộc Cách mạng công nghiệp lần thứ tư đang tác động mạnh mẽ đến kinh tế, xã hội, văn hóa và du lịch toàn cầu, thay đổi thói quen con người. Việt Nam cũng không ngoại lệ, đặc biệt là tỉnh Khánh Hòa, cũng hưởng lợi lớn từ tiến bộ này. Các công nghệ số như công nghệ viễn thám, GIS, trí tuệ nhân tạo và xử lý dữ liệu lớn rất quan trọng cho phát triển kinh tế số và du lịch biển bền vững. Bài báo sử dụng phương pháp nghiên cứu tài liệu để phân tích và tổng hợp kết quả của nghiên cứu khoa học, ứng dụng các công nghệ tiên tiến theo dõi nhiệt độ biển, phát hiện ô nhiễm, đánh giá thảm thực vật biển ở vùng biển tỉnh Khánh Hòa, nhằm bảo vệ các hệ sinh thái biển, góp phần phát triển bền vững biển và đại dương. Đặc biệt, đề xuất các giải pháp nhằm thúc đẩy sự phát triển kinh tế số và du lịch biển bền vững tại Khánh Hòa theo đúng tinh thần của Nghị quyết số 09-NQ/TW ngày 28/01/2022 của Bộ Chính trị, phát triển tỉnh Khánh Hoà đến năm 2030, tầm nhìn đến năm 2045.*

ABSTRACT: *Digital transformation in the Fourth Industrial Revolution is significantly affecting the global economy, society, culture, and tourism, changing human habits. Vietnam, especially Khanh Hoa province, has greatly benefited from these advancements. Advanced technologies such as remote sensing, GIS, artificial intelligence, and big data processing are crucial for developing the digital economy and sustainable marine tourism. This article uses document analysis method to analyze and synthesize scientific results, applying advanced technologies to monitor sea temperature, detect pollution, and assess marine vegetation in Khanh Hoa's waters to protect marine ecosystems, contributing to the sustainable development of seas and oceans. Especially, the article also proposes solutions to promote the digital economy and sustainable marine tourism in Khanh Hoa, according to Resolution No. 09-NQ/TW dated January 28, 2022, by the Politburo, aiming for development by 2030 with a vision to 2045.*

1. Introduction

Digital transformation (DT) is revolutionizing industries and global economies. Khanh Hoa boasts the longest coastline in Vietnam, stretching 385 km and encompassing about 200 islands, including the world-renowned Nha Trang Bay and Cam Ranh Bay. This region's rich marine biodiversity creates favorable conditions for numerous economic activities and contributes to a sustainable environment, presenting significant potential for developing the marine economy and sustainable marine tourism (Figure 1). However, to maximize this potential, the province must adopt advanced digital technologies to promote economic development and protect the marine environment.

Figure 1. Hon Noi double beach, Nha Trang (Source: https://vietnamhoinhap.vn)

The digital economy is an economic model based on the use of digital technology to promote sustainable and environmentally friendly economic activities [1-3]. With advantages in geographic location and abundant marine resources, Khanh Hoa can apply digital technologies to optimize resource utilization, minimize environmental impacts, and promote innovation in key industries [4, 5].

Model of sustainable marine tourism: With its long coastline and rich marine landscapes, Khanh Hoa has significant potential for developing sustainable marine tourism [2], (Figure 2). This model focuses on conserving and protecting the marine environment while providing economic and social benefits to local communities.

Figure 2. Trend of sustainable marine economy model *(*Source: *https://mic.gov.vn*)

Principles of sustainable marine tourism include protecting marine ecosystems such as coral reefs, seagrass beds, and mangroves, (Figure 3a and Figure 3a), and optimizing the use of freshwater and energy through advanced technologies. It also involves implementing measures to reduce and manage waste, especially plastic, encouraging tourists to respect local customs and participate in cultural activities, and providing information to raise awareness about the importance of protecting the marine environment.

Figure 3a. Typical marine ecosystem in Khanh Hoa

(Source: *https://tapchinganhang.gov.vn*)

Figure 3b. Coral reef ecosystem in Khanh Hoa

(Source: *https://tapchinganhang.gov.vn*)

Sustainable marine tourism offers numerous benefits, including minimizing negative impacts on the marine environment, creating stable income sources for local communities, and improving the quality of life for local residents. Additionally, it provides tourists with unique and environmentally friendly experiences, contributing to a sustainable economy and society.

Digital technology in marine tourism: Digital technology plays a crucial role in developing sustainable marine tourism in Khanh Hoa by efficiently managing resources, enhancing tourist experiences, and minimizing environmental impacts. Mobile applications provide information on tourist attractions, services, and environmental protection activities, integrating digital maps and weather updates. Online booking systems enable tourists to easily book services, manage visitor numbers, and reduce overcrowding at tourist sites.

Customer relationship management (CRM) systems store information about tourists to support personalized services and enhance their experiences. These systems also enable data analysis to understand tourists' needs and preferences, helping to develop new products and services. Virtual reality (VR) experiences offer virtual travel opportunities to destinations, reducing the environmental impact of physical travel, while augmented reality (AR) guides provide detailed information on tourist sites and marine ecosystems, enhancing educational experiences [6].

Environmental monitoring and protection systems use sensors to measure indicators such as water quality and temperature, ensuring the protection of tourist areas. Surveillance cameras monitor sensitive areas to detect and prevent harmful activities. Social media and digital marketing promote sustainable marine tourism by sharing information and images about destinations and environmental protection activities. They also develop marketing campaigns aimed at attracting environmentally conscious tourists and promoting sustainable marine tourism products and services.

2. Theoretical basis and research methods

2.1. Theoretical basis

2.1.1. Remote sensing and GIS applications

Remote sensing technologies, such as satellites [7-9], unmanned aerial vehicles (UAVs) [10], and Geographic Information Systems (GIS) [11], can be used to manage and monitor Khanh Hoa's marine environment, including mapping submerged aquatic vegetation (seaweed, seagrass) along the central Vietnamese Coast [8, 12] and island resources. Remote sensing provides critical data on environmental factors like water quality, topographic changes, and marine ecosystems, helping managers make informed decisions [13, 14].

These technologies offer valuable tools for monitoring sea surface temperature along the coast, which supports climate change research and marine ecosystem management. These remote sensors can also detect marine pollution, including oil spills and plastic

debris in coastal waters, enabling timely response and mitigation efforts. Additionally, high-resolution images produced by these technologies help map critical coastal habitats such as mangroves, coral reefs, and seagrass beds, thereby supporting conservation and restoration initiatives.

2.1.2. Artificial intelligence and big data analytics

Artificial intelligence (AI) and Big data analytics [15-18], optimize economic activities and marine resource management in Khanh Hoa. AI can predict economic trends and patterns, while Big data provides insights into complex interactions in marine ecosystems, helping optimize activities like fishing, aquaculture, and related industries.

AI algorithms significantly enhance marine research by processing underwater images and videos to identify marine species, thereby reducing the time and effort required for manual identification. Moreover, machine learning models can predict phenomena such as harmful algal blooms, supporting early warning strategies and mitigation efforts. These AI tools are also invaluable for interpreting complex oceanographic datasets, aiding in climate change research, marine ecosystem monitoring, and fisheries management.

2.1.3. Intelligent monitoring systems

Using sensors and Internet of things (IoT) [19, 20] technologies to monitor water environments and the health of marine species optimizes production activities. For example, sensors can measure temperature, salinity, and oxygen levels in water, helping aquaculture farmers adjust farming conditions timely.

2.1.4. Blockchain applications

Blockchain [3, 21] can trace the origin of seafood products, ensuring transparency and enhancing product value. For example, through Blockchain, consumers can access detailed information about the farming and transportation process of products, building trust and increasing brand value.

2.2. Research objectives

This research aims to:

- Evaluate the role of DT in developing the digital economy and sustainable marine tourism in Khanh Hoa.

- Propose specific strategies for applying digital technology in the economic and marine tourism sectors of the province.

2.3. Research methods

The research method employed is the document research method, involving steps such as collecting, classifying, analyzing, synthesizing, and summarizing scientific documents. This approach enables a comprehensive analysis of digital transformation and digital technology applications in the development of the economy and marine tourism in Khanh Hoa.

2.4 Proposals and recommendations

2.4.1. Establishment of the national center for ocean technology

To support research and the application of digital technology in the development of the economy and marine tourism in Khanh Hoa, planning for the establishment of the National Center for Ocean Technology (NCOT) is a crucial step. This center will bring together experts, researchers, and businesses to develop and apply advanced technological solutions to address environmental and economic challenges in the marine sector.

Objectives: The center will focus on researching and developing new technologies, providing training and consultancy to businesses and organizations in the marine economy and sustainable marine tourism sectors.

Functions: The center will act as a bridge between researchers, businesses, and local authorities, promoting public-private partnerships and developing DT projects.

Activities: Organize workshops, training, and events to raise awareness and skills in digital technology; implement applied research projects; develop digital products and services for the economy and marine tourism.

2.4.2. Strategies for developing the digital economy and sustainable marine tourism

a. Developing digital infrastructure

Investing in digital infrastructure is a key factor in supporting DT activities. Khanh Hoa needs to focus on building modern network infrastructure, data centers, and integrated information management systems.

Upgrading and expanding broadband Internet networks is essential to ensure fast and stable connectivity for both coastal and island areas. Building modern data centers is also crucial for storing and managing data related to the marine economy and tourism. Additionally, developing integrated information management systems will support data-driven decision-making, enhancing the efficiency and effectiveness of these sectors.

b. Training and developing human resources

Digital transformation requires highly skilled human resources in technology and management. Khanh Hoa needs to strengthen training programs and skill development for the workforce in marine economy and tourism sectors.

Organizing professional training courses on information technology, data management, and other digital skills for officials and employees in related sectors is crucial. Establishing cooperation programs with international organizations will further enhance local human resource capabilities and skills. Additionally, supporting research and innovation programs will promote the development of new technological solutions in the marine economy and tourism.

c. Encouraging business and community participation

Successful DT requires active participation from businesses and the community. Khanh Hoa needs to create a favorable environment to encourage businesses to invest and apply digital technologies and involve the community in sustainable development initiatives.

d. Developing policies and legal frameworks

Establishing clear policies and legal frameworks is crucial for supporting DT and ensuring sustainable development. The local government needs to develop regulations that promote digital innovation while protecting the marine environment and the interests of local communities.

2.5. Promoting public-private partnerships

Public-private partnerships (PPPs) can play a significant role in leveraging resources and expertise from both the public and private sectors. By fostering collaboration between government agencies, businesses, and non-profit organizations, Khanh Hoa can accelerate DT and sustainable marine tourism initiatives.

2.6. Enhancing international cooperation

International cooperation can provide valuable opportunities for knowledge exchange, technology transfer, and investment in DT and sustainable development. Khanh Hoa should actively seek partnerships with international organizations, universities, and research institutions to benefit from global best practices and innovations.

3. Results and discussion

3.1. Results

Initially, studies conducted in the coastal waters of Khanh Hoa demonstrate significant advances in climate research and marine ecosystem management through the use of remote sensing, satellite imagery, and GIS. These technologies are employed to monitor sea surface temperatures, detect pollution, and assess marine vegetation, such as seaweed and seagrass, thereby supporting conservation efforts [7, 8, 12].

In developed countries, AI significantly enhances marine science [3, 15-19, 21] by identifying species and improving early warning systems for harmful algal blooms. This efficiency ensures timely responses to threats, sustaining marine ecosystems.

Additionally, AI tools and big data analytics enhance climate modeling, biodiversity assessments, and fisheries management. Data centers and integrated information systems in the modern world (such as Cloud Data Centers, Software-Defined Data Centers (SDDC), and AI-Driven Data Centers) enable comprehensive data analysis and informed decision-making in marine research and management [22].

3.2. Discussion

The above results highlight the significant impact of digital technologies on marine research and ecosystem management in Khanh Hoa. Tools like remote sensing, satellite imagery, GIS, AI, and big data analytics have enhanced monitoring, pollution detection, and marine vegetation assessment. They have also improved climate modeling and fisheries management.

Implications: Digital technologies are crucial for advancing marine research and management, supporting sustainable economic growth, and protecting the environment in Khanh Hoa.

Challenges: Key challenges include limited digital infrastructure, a shortage of skilled workers, resistance to change, and data privacy concerns.

Opportunities and future directions:

Digital transformation offers substantial opportunities for sustainable development, enhancing global competitiveness, and ensuring the long-term health of marine ecosystems. Future research should focus on developing tailored digital solutions and fostering public-private partnerships to drive these initiatives.

The establishment of the National Center for Ocean Technology is essential for promoting research, innovation, and the development of digital solutions suited to local needs. Successful digital transformation requires collaboration among government entities, businesses, and the community, coupled with continuous investments in digital infrastructure and innovation. Clear policies and legal frameworks are necessary to support these initiatives and protect local interests, fostering an environment conducive to digital advancements.

Continuous research is vital for developing specific digital solutions in areas like climate modeling, biodiversity assessment, and sustainable fisheries management. By adopting these strategies, Khanh Hoa can achieve balanced economic growth and environmental sustainability. The synergy between advanced technology, collaborative efforts, and strategic investments will enable the province to harness its full potential in the digital age.

4. Conclusion

Digital transformation is crucial for enhancing Khanh Hoa's digital economy and promoting sustainable marine tourism . Leveraging technologies like remote sensing, GIS, AI, and Big data can optimize resource

management and ensure environmental sustainability. These tools are vital for pollution detection, marine habitat monitoring, and environmental impact assessments, thus supporting conservation efforts. Furthermore, blockchain technology improves seafood traceability, and digital marketing strategies attract eco-conscious tourists, boosting sustainable tourism.

The establishment of the National Center for Ocean Technology is essential for driving research, innovation, and the development of digital solutions tailored to local needs. Successful digital transformation requires collaboration among government entities, businesses, and the community, coupled with continuous investments in digital infrastructure and innovation. Clear policies and legal frameworks are necessary to support these initiatives and protect local interests, fostering a conducive environment for digital advancements.

By addressing these key areas, Khanh Hoa can harness the power of digital transformation to leverage sustainable development in its marine economy and tourism sectors, ensuring long-term economic prosperity and environmental health.

References

1. X. Cheng, T. Xue, B. Yang, and B. Ma. (2023). "A digital transformation approach in hospitality and tourism research," *International Journal of Contemporary Hospitality Management*, vol. 35, pp. 2944-2967.
2. R. Nandasena, A. M. Morrison, and J. A. Coca-Stefaniak. (2022). "Transformational tourism – a systematic literature review and research agenda," *Journal of Tourism Futures*, vol. 8, pp. 282-297.
3. I. Tyan, M. I. Yagüe, and A. Guevara-Plaza, (2021). "Blockchain Technology's Potential for Sustainable Tourism," in *Information and Communication Technologies in Tourism 2021*, Cham, pp. 17-29.
4. N. Khanh, M. Thanh, and G. Gim, (2020). "E-Government in Vietnam: Situation, Prospects, Trends, and Challenges," ed, pp. 1915-1934.
5. T. Anh (2021). "*Foundations for Digital Transformation: The Case of Vietnam*. Conference: International Conference on Emerging Challenges: Business Transformation and Circular Economy (ICECH 2021)".
6. T. Milton and C. Philosophers (2023). "Artificial Intelligence in Tourism-A review of Trends Opportunities and Challenges," vol. 1, pp. 01-11, 11/27 2023.
7. V. Trong-Thach, K. Lau, L. M. Liao, and N. Xuan-Vy. (2020). "Satellite image analysis reveals changes in seagrass beds at Van Phong Bay, Vietnam during the last 30 years," *Aquat. Living Resour.*, vol. 33, p. 4.
8. T. N. Khanh Ni, H. C. Tin, V. T. Thach, C. Jamet, and I. Saizen (2020). "Mapping Submerged Aquatic Vegetation along the Central Vietnamese Coast Using Multi-Source Remote Sensing," *ISPRS International Journal of Geo-Information*, vol. 9, p. 395.
9. N. T. T. Huong, T. A. Tuan, V. T. Thach, and H. C. Tin. (2017). "a review of seagrass studies by using satellite remote sensing data in the southeast asia: status and potential," *edirors of the special issue*, vol. 55, pp. 148-154.
10. N. V. Thảo. (2021). "Báo cáo tổng kết đề tài cấp tỉnh "*Nghiên cứu ứng dụng thiết bị không người lái dân dụng cỡ nhỏ trong*

việc đánh giá hiện trạng hệ sinh thái ven biển và đảo Hải Phòng" (đã nghiệm thu)".

11. N. V. Thảo. (2020). "Báo cáo tổng kết đề tài cấp quốc gia thuộc Chương trình Khoa học và Công nghệ vũ trụ giai đoạn 2016-2020. Tên đề tài: "*Nghiên cứu ứng dụng tư liệu viễn thám độ phân giải cao và trung bình, đa thời gian đánh giá tổng hợp tai biến môi trường vùng bờ biển Bắc Trung Bộ*", mã số VT- UD.02/17-20 (đã nghiệm thu)".
12. V. T. Thạch. (2021). " Báo cáo tổng kết đề tài cấp quốc gia thuộc Chương trình Khoa học và Công nghệ vũ trụ giai đoạn 2016-2020. Tên đề tài: "*Nghiên cứu ứng dụng công nghệ viễn thám và công nghệ đồ họa (GPGPU) xây dựng bộ dữ liệu bản đồ thảm thực vật dưới biển, ứng dụng thí điểm tại tỉnh Khánh Hoà*", Mã số VT-UD. 01/17-20 (đã nghiệm thu)".
13. N. H. Huân. (2016). "Báo cáo tổng kết đề tài cấp quốc gia thuộc Chương trình Khoa học và Công nghệ vũ trụ giai đoạn 2012-2015: "*Xây dựng cơ sở dữ liệu số các yếu tố hải dương từ nguồn ảnh VNREDSat-1 và các ảnh viễn thám khác cho khu vực ven biển Ninh Thuận-Bình Thuận phục vụ phát triển kinh tế biển bền vững*". Mã số: VT/UD-07/14-15 (Nghiệm thu)".
14. D. D. Ngoc, H. Loisel, C. Jamet, V. Vantrepotte, L. Duforêt-Gaurier, C. D. Minh. (2019). *et al.*, "Coastal and inland water pixels extraction algorithm (WiPE) from spectral shape analysis and HSV transformation applied to Landsat 8 OLI and Sentinel-2 MSI," *Remote Sensing of Environment,* vol. 223, pp. 208-228, 03/15/ 2019.
15. G. Chen, B. Huang, J. Yang, M. Radenkovic, L. Ge, C. Cao. (2023). *et al.*, "Deep blue artificial intelligence for knowledge discovery of the intermediate ocean," *Front. Mar. Sci.*, vol. 9:1034188.
16. T. Song, C. Pang, B. Hou, G. Xu, J. Xue, H. Sun. (2023). *et al.*, "A review of artificial intelligence in marine science," *Front. Earth Sci.*, vol. 11:1090185.
17. M. Jiang and Z. Zhu. (2022). "The Role of Artificial Intelligence Algorithms in Marine Scientific Research " *Front. Mar. Sci. Sec. Marine Conservation and Sustainability,* vol. 9.
18. M. M. Rathore, S. Shah, D. Shukla, E. Bentafat, and S. Bakiras. (2021)."The Role of AI, Machine Learning, and Big Data in Digital Twinning: A Systematic Literature Review, Challenges, and Opportunities," *IEEE Access,* vol. PP, pp. 1-1, 02/22 2021.
19. I. Durlik, T. Miller, D. Cembrowska-Lech, A. Łobodzińska, E. Złoczowska, and A. Nowak. (2023)."Navigating the Sea of Data: A Comprehensive Review on Data Analysis in Maritime IoT Applications," *Applied Sciences,* vol. 13, p. 9742.
20. V. T. Thạch and N. T. Lộc. (2024). "Giới thiệu về các công nghệ tiên tiến hỗ trợ khám phá biển và đại dương," *Bản tin Khoa học, Công nghệ & Đổi mới sáng tạo, Sở KH&CN Khánh Hòa,* vol. Số 1/2024, pp. 32-37.
21. G. Chiaraluce, D. Bentivoglio, A. Finco, M. Fiore, F. Contò, and A. Galati. (2024). "Exploring the role of blockchain technology in modern high-value food supply chains: global trends and future research directions," *Agricultural and Food Economics,* vol. 12, p. 6, 2024/02/08.
22. A. Mandal and A. R. Ghosh. (2024). "AI-driven surveillance of the health and disease status of ocean organisms: a review," *Aquaculture International,* vol. 32, pp. 887-898, 2024/02/01.