

The Role of Digital Technology in Enhancing Blue Economy Sustainability: Advancing Global Fisheries Management through Innovation and Governance

Antonio Candido¹, Goncalves²

^{1,2} Faculty of Economics, University of Algarve, Portugal-Gambelas

ARTICLE INFO

Article history:

Received May 25, 2025

Revised June 28, 2025

Accepted Juli 30, 2025

Keywords:

Digital Technology;
Blue Economy;
Sustainable Fisheries;
Fisheries Management;
Global Governance.

ABSTRACT

This study examines the role of digital technology in promoting the sustainability of global fisheries within the framework of the blue economy. Traditional approaches to fisheries management often face limitations in data accuracy, traceability, and enforcement, resulting in overfishing and ecosystem degradation. The primary objective of this research is to analyze how digital technologies contribute to enhancing the sustainability of global fisheries within the framework of the blue economy, while also identifying challenges, policy implications, and best practices. The study adopts a qualitative descriptive research design using a literature-based approach. It synthesizes findings from peer-reviewed journals, policy reports, and global case studies to assess the application of digital technologies such as blockchain, artificial intelligence (AI), Internet of Things (IoT), and satellite monitoring in fisheries management. Comparative analysis between traditional practices and digital solutions was conducted to evaluate improvements in efficiency, traceability, and ecological outcomes. The findings show that digital technology enhances fisheries management by enabling real-time monitoring, improving supply chain transparency, reducing illegal, unreported, and unregulated (IUU) fishing, and supporting small-scale fishers through data-driven decision-making. Compared to traditional practices, digital tools provide more reliable, adaptive, and scalable solutions to address overfishing and marine ecosystem degradation. However, barriers such as limited infrastructure, high implementation costs, digital literacy gaps, and governance challenges restrict widespread adoption. This research concludes that digital technology significantly improves sustainability outcomes in fisheries when integrated with supportive policies, international cooperation, and private sector engagement. To maximize impact, multi-stakeholder collaboration and investments in capacity building are essential, particularly in developing regions.

This is an open access article under the [CC BY-NC license](#).



Corresponding Author:

Antonio Candido
Faculty of Economics,
University of Algarve, Portugal-Gambelas,
Estr. da Penha, 8005-139 Faro, Portugal
antoniocandido@ualg.pt

1. INTRODUCTION

The Blue Economy is broadly defined as the sustainable use of ocean resources for economic growth, improved livelihoods, and job creation, while simultaneously ensuring the health of marine ecosystems (Spalding, 2016). It emphasizes a balance between economic development, environmental sustainability, and social equity in ocean-based industries such as fisheries, aquaculture, shipping, tourism, renewable energy, and marine biotechnology. The concept has been strongly endorsed by international organizations such as the World Bank and the United

Nations, particularly as a framework for achieving the Sustainable Development Goals (SDGs), with SDG 14: Life Below Water at its core.

Within this framework, fisheries hold a central position. Fisheries are one of the oldest and most essential ocean-based industries, providing a critical source of food security, nutrition, livelihoods, and trade for millions of people worldwide (Mustafa et al., 2019). According to FAO, fish accounts for nearly 20% of the animal protein intake for about 3 billion people, and fisheries and aquaculture together employ more than 60 million people directly, with hundreds of millions more indirectly dependent on the sector.

However, the sustainability of global fisheries is under threat from overfishing, illegal, unreported, and unregulated (IUU) fishing, habitat destruction, and the impacts of climate change. These challenges undermine both the ecological health of marine environments and the socio-economic stability of communities that rely on fisheries. Here, the Blue Economy approach becomes crucial: it calls for responsible fisheries management, technological innovation, and international cooperation to ensure that fisheries continue to serve as a foundation for both human development and ecological resilience.

Traditional approaches to fisheries management have struggled to address these challenges due to limited data, weak monitoring systems, and governance gaps across international waters (Large et al., 2013). In response, digital technologies have begun to transform how fisheries are monitored, managed, and integrated into the global economy. Tools such as satellite surveillance, Internet of Things (IoT) devices, artificial intelligence (AI), blockchain-based traceability systems, and big data analytics are enabling greater transparency, accuracy, and efficiency in the management of fisheries (Probst, 2020). For instance, blockchain systems allow for end-to-end traceability of seafood products, reducing fraud and ensuring consumer confidence, while AI-driven stock assessment models help predict and prevent overexploitation of marine resources.

The integration of digital solutions aligns with the goals of the United Nations Sustainable Development Goals (SDGs), particularly SDG 14: Life Below Water, which emphasizes the conservation and sustainable use of marine resources. Beyond environmental benefits, digital innovation also holds socio-economic potential by improving the resilience of small-scale fishers, enabling market access through digital platforms, and enhancing the competitiveness of global fisheries in a rapidly evolving blue economy (Nthane et al., 2020).

Over the last decade, a foundational body of work has demonstrated the power of vessel-tracking and remote-sensing data to reveal the spatial and temporal footprint of global commercial fishing. Kroodsma et al. (2018) used billions of Automatic Identification System (AIS) messages to map industrial fishing activity at unprecedented resolution, showing that industrial fleets operate across more than half of the world's ocean and providing a baseline for enforcement and spatial planning. Subsequent Global Fishing Watch studies and commentary have extended these methods with radar and optical satellite data to detect "dark" fleets and to support investigations of illegal, unreported, and unregulated (IUU) fishing, making vessel-tracking one of the most cited advances in evidence-based ocean governance.

A second stream traceability and blockchain in seafood supply chains has grown from pilot projects to multiple systematic reviews that critically assess feasibility, barriers, and impacts. Early pilots by Provenance (Provenance, 2016/2018) and the OpenSC initiative (supported by WWF and partners around 2018–2019) tested blockchain-enabled traceability for tuna and other products, demonstrating how distributed ledgers and QR-code interfaces can link catch information to consumers. More recent academic reviews and empirical studies (e.g., Callinan et al., 2022; ScienceDirect reviews 2021–2023) synthesize these pilots and identify recurrent barriers data capture at point-of-catch, interoperability, cost, governance, and the risk of excluding small-scale fishers while pointing to hybrid blockchain+IoT architectures as promising next steps.

Machine learning (ML) and artificial intelligence (AI) have become a rapidly expanding area of fisheries research, applied from species identification to stock assessment and effort forecasting. Comprehensive reviews (e.g., Kühn et al., 2024 / NOAA repository) document how convolutional neural networks and other ML methods are being used to automate image and acoustic species ID, analyze echosounder and video data, classify fishing behaviours from vessel tracks, and augment classical stock-assessment models. These reviews emphasize both the performance gains ML can provide and important caveats training-data needs, reproducibility, ecological interpretability, and the necessity to couple ML outputs with domain knowledge for management decisions.

A sizeable and socially oriented literature examines digital platforms and mobile apps that empower small-scale fishers by supporting catch reporting, market access, and community management. The ABALOBI suite (documented in case studies and reports from around 2016-2019 and covered in UNESCO/Stanford/press pieces) is frequently cited: research and field reports show ABALOBI's mobile apps and marketplace can increase fisher incomes, improve traceability for small producers, and strengthen co-management by creating locally governed data and market links. Still, evaluations stress the importance of addressing connectivity, long-term financing, and co-design to ensure equity and uptake among marginalized fishing communities.

Aquaculture-focused research highlights a parallel but distinct trajectory of digitalization: sensor networks, real-time water-quality monitoring, automated feeding systems, and robotics are increasingly tested to improve efficiency and reduce environmental impacts. Reviews of aquaculture digitization (2020–2023) and more recent papers on AI-driven aquaculture techniques show potential for improved feed conversion, early disease detection, and labor savings but they also call for context-appropriate designs, attention to scale (small family farms versus industrial operations), and robust cost benefit studies before widescale adoption.

Finally, an emergent cross-cutting literature explores socio-technical integration bringing together IoT, blockchain, ML, and governance frameworks into interoperable “digital ecosystems” for fisheries and aquaculture. Papers proposing intelligent Blockchain–IoT frameworks (e.g., 2021–2023 architectures) and multi-author syntheses argue that technical interoperability, data standards, and governance (data sovereignty, privacy, equitable access) are the linchpins of scaling digital solutions. Critics in this stream warn that technology alone cannot deliver sustainability: institutional capacity, cross-border cooperation, financing models, and inclusive design must accompany technical innovation.

Nevertheless, the adoption of digital technologies in fisheries remains uneven across regions, particularly in developing countries where financial, infrastructural, and digital literacy barriers persist (Tilley & Roscher, 2020). Moreover, questions about governance, equity, and long-term sustainability of technological interventions demand critical examination. This research seeks to explore the role of digital technology in enhancing blue economy sustainability in global fisheries, focusing on its contributions, challenges, and future opportunities for creating a balance between economic growth, environmental protection, and social equity.

2. RESEARCH METHOD

This research employs a qualitative-descriptive approach with elements of comparative analysis to explore the role of digital technology in enhancing the sustainability of the Blue Economy within global fisheries (Okemwa, 2019). The methodological design was chosen to capture the multifaceted nature of the issue, encompassing environmental, economic, and social dimensions, while also accounting for regional variations in technological adoption.

The study began with a comprehensive literature review, drawing upon peer-reviewed journal articles, policy reports, organizational publications from bodies such as the Food and Agriculture Organization (FAO), the World Bank, and Global Fishing Watch, as well as case studies published between 2015 and 2025. This allowed for the identification of key digital technologies including satellite monitoring, Internet of Things (IoT) sensors, blockchain traceability systems, artificial intelligence (AI), big data analytics, and mobile applications and their documented applications in global fisheries management.

To strengthen the analysis, the research applied a comparative case study method (Levi-Faur, 2004). Selected case studies included blockchain-enabled tuna traceability projects in the Pacific, mobile-based fisher empowerment platforms such as ABALOBI in South Africa, and global vessel monitoring initiatives like AIS-based systems and Global Fishing Watch. These cases were chosen for their representativeness in demonstrating both opportunities and challenges across different geographical, economic, and technological contexts.

Data were analyzed using a thematic content analysis approach. Information extracted from literature and case studies was coded into themes such as sustainability outcomes (environmental conservation, resource efficiency, compliance with regulations), socio-economic impacts (livelihood improvements, inclusivity, market access), governance and policy frameworks, and barriers to adoption (infrastructure, digital literacy, and cost). This thematic analysis provided a structured means of evaluating the contributions and limitations of digital technologies to fisheries sustainability (Lakshmi & Corbett, 2020).

In addition, this research incorporated a comparative analysis between traditional fisheries management practices and technology-enhanced practices to assess improvements in transparency, accountability, and ecological resilience. Indicators used for comparison included reductions in illegal, unreported, and unregulated (IUU) fishing, improvements in stock assessment accuracy, traceability of seafood products, and socio-economic benefits to fishing communities (Cooperation & Group, 2008).

While primarily qualitative, the study also relied on secondary statistical data such as global fisheries production, employment figures, and technology adoption rates drawn from international databases to support the discussion with empirical evidence (Barclay et al., 2017).

By combining literature review, case study analysis, thematic coding, and comparative evaluation, the methodology ensured both breadth and depth in understanding how digital technology contributes to Blue Economy sustainability in global fisheries, while also highlighting the conditions under which such innovations succeed or fail.

3. RESULTS AND DISCUSSIONS

Adoption of Digital Technology in Fisheries

The adoption of digital technology in global fisheries has become a transformative force, reshaping how marine resources are monitored, managed, and marketed. As pressures on fish stocks intensify due to overfishing, illegal activities, and climate change, digital solutions have emerged as crucial tools to enhance sustainability, transparency, and efficiency in line with the principles of the Blue Economy. Four technologies blockchain, artificial intelligence (AI), the Internet of Things (IoT), and satellite monitoring have been at the forefront of this transformation.

One of the most significant applications is the use of blockchain technology for traceability. Blockchain enables the creation of transparent, tamper-proof records that track seafood products from the point of catch through processing, distribution, and retail (Cook & Zealand, 2018). For example, blockchain-based pilot projects in the Pacific have been applied to tuna fisheries to ensure that catches are legally sourced and sustainably harvested. This technology not only reduces seafood fraud and strengthens consumer confidence but also supports compliance with international trade regulations and certification schemes. By providing end-to-end visibility, blockchain enhances accountability across the entire value chain and empowers consumers to make informed choices.

Artificial intelligence (AI) has also been increasingly adopted, particularly in improving stock assessments and predicting fish population dynamics. Traditional stock assessment methods often struggle with limited data and complex ecological variables (Cotter et al., 2004). AI models, using machine learning algorithms, can integrate vast datasets from oceanographic conditions, satellite imagery, and catch reports to provide more accurate and timely forecasts of fish abundance and migration patterns. Such predictive analytics improve decision-making in fisheries management by enabling early detection of potential overexploitation and facilitating adaptive management strategies that protect ecosystems while maintaining economic productivity.

The Internet of Things (IoT) has revolutionized the ability to monitor fishing vessels in real time. IoT devices, including GPS trackers, electronic logbooks, and onboard sensors, provide continuous streams of data regarding vessel location, fishing effort, and catch volumes (ASYA, 2020). These devices enhance transparency, support regulatory compliance, and deter illegal, unreported, and unregulated (IUU) fishing. For small-scale fishers, IoT-enabled mobile applications have been particularly impactful, offering digital tools for reporting catches, accessing market information, and improving safety at sea. By bridging data gaps, IoT strengthens both governance and the resilience of coastal communities.

Complementing IoT, satellite monitoring systems have become a critical tool in combating IUU fishing. Using technologies such as Automatic Identification Systems (AIS) and synthetic aperture radar (SAR), satellites can track vessels even in remote or poorly monitored waters (Fournier et al., 2018). Initiatives such as Global Fishing Watch provide open-access platforms that allow governments, researchers, and civil society to analyze vessel movements and detect suspicious patterns. This has significantly improved enforcement capacity, reduced illegal fishing activities in certain regions, and promoted international collaboration in fisheries governance.

Together, these digital innovations illustrate a growing trend toward data-driven fisheries management. By combining blockchain's transparency, AI's predictive power, IoT's real-time monitoring, and satellite surveillance, global fisheries are moving toward greater sustainability, accountability, and efficiency. However, adoption remains uneven across regions, with developing

nations facing challenges related to cost, infrastructure, and digital literacy. Despite these barriers, the steady integration of digital solutions signals a paradigm shift in the governance and sustainability of global fisheries under the Blue Economy framework.

Impact on Sustainability

One of the most significant sustainability outcomes has been the reduction of overfishing through improved monitoring and data-driven decision-making. Artificial intelligence (AI) and big data analytics have provided managers with accurate stock predictions and migration models, allowing for adaptive quotas and more precise management strategies. For instance, AI-assisted forecasting enables fisheries regulators to detect early signs of stock depletion and adjust harvesting levels before serious ecological damage occurs (Chakraborty, 2020). Similarly, digital catch-reporting tools and electronic logbooks ensure that data gaps are minimized, thereby improving the accuracy of stock assessments and reducing the likelihood of overexploitation.

In terms of compliance with fisheries regulations, technologies such as satellite monitoring, Automatic Identification Systems (AIS), and the Internet of Things (IoT) have made it far more difficult for vessels engaged in illegal, unreported, and unregulated (IUU) fishing to operate undetected. Real-time vessel tracking, combined with blockchain-based traceability systems, provides verifiable records of catch origin and movement along the supply chain. This transparency strengthens enforcement and accountability, supporting governments and international organizations in combating IUU fishing a key threat to marine sustainability.

Digital technology also contributes to increased efficiency across the fisheries value chain. IoT-enabled sensors and predictive analytics help vessels optimize routes and reduce fuel consumption, while aquaculture farms use automated feeding systems to minimize waste and maximize productivity (Perakis et al., 2020). These improvements not only reduce operational costs for fishers but also align with broader sustainability objectives by conserving resources and decreasing pressure on marine ecosystems.

A related outcome is the reduction of carbon footprint in the fishing industry. By streamlining operations through optimized navigation, real-time weather and ocean condition monitoring, and efficient harvesting techniques, digital technologies help minimize unnecessary fuel consumption and greenhouse gas emissions. Aquaculture, too, benefits from digital efficiency gains, as precision monitoring of water quality and feed use reduces environmental impacts compared to traditional practices.

Perhaps most importantly, the adoption of digital technology has shown promise in improving livelihoods for fishing communities, particularly small-scale fishers who are often marginalized in global seafood markets (Tilley & Roscher, 2020). Mobile applications and digital marketplaces provide these fishers with direct access to buyers, fair pricing, and real-time market information, reducing dependence on intermediaries. Case studies such as the ABALOB initiative in South Africa have demonstrated that digital platforms can not only enhance income but also strengthen social equity by ensuring greater participation of local communities in fisheries management. Furthermore, improved safety at sea through mobile communication and vessel-tracking systems directly benefits the well-being of fishers and their families.

Taken together, these impacts illustrate that digital technology adoption is more than a technical innovation it represents a paradigm shift in the governance and sustainability of global fisheries. By curbing overfishing, enhancing compliance, improving efficiency, lowering emissions, and uplifting livelihoods, digitalization advances the goals of the Blue Economy, ensuring that ocean resources can continue to support both people and ecosystems for generations to come.

Global Case Studies: Examples of Successful Implementation

The adoption of digital technologies in global fisheries has produced a series of successful case studies that demonstrate the tangible benefits of innovation for sustainability, compliance, and efficiency. One of the most widely recognized examples is the use of blockchain technology for tuna tracking in the Pacific Islands. In this initiative, blockchain is employed to provide transparent and tamper-proof records of the tuna supply chain, from the point of catch to the final consumer market. This system not only ensures that tuna is sourced legally and sustainably but also combats illegal, unreported, and unregulated (IUU) fishing by offering verifiable traceability. As a result, consumers gain confidence in certified products, while fishers receive fairer market access for sustainably caught tuna.

Another important case can be observed in small-scale fisheries across Africa, where mobile applications have been developed to support local communities (Jeffers et al., 2019). These apps allow fishers to access weather forecasts, locate potential fishing zones, and receive real-time

updates on market prices. For example, applications deployed in East African countries have significantly improved the safety and income stability of artisanal fishers, many of whom previously operated under uncertain conditions. By connecting small-scale fishers to broader markets and providing tools for resource management, these mobile technologies help foster inclusive growth while reducing the risk of overexploitation.

In Europe, AI-driven monitoring systems have been integrated into fisheries management practices to ensure sustainable harvesting (Large et al., 2013). Artificial intelligence is used to analyze large datasets from sensors, satellite images, and vessel monitoring systems to predict fish stock levels and assess ecosystem health. Countries such as Norway and Spain have implemented AI-supported quota systems that optimize fishing activities while ensuring compliance with sustainable catch limits. These tools have not only enhanced regulatory enforcement but also improved operational efficiency, reducing both overfishing and fuel consumption.

Together, these global case studies highlight the transformative potential of digital technologies in diverse socio-economic and geographical contexts. From blockchain traceability in the Pacific, to mobile innovations in Africa, and AI-powered monitoring in Europe, the successful applications illustrate that when appropriately implemented, digital solutions can strengthen sustainability, improve livelihoods, and secure the long-term future of the fisheries sector within the framework of the Blue Economy.

Barriers and Challenges

Despite the promising role of digital technology in promoting sustainable fisheries within the blue economy, several barriers and challenges hinder its widespread adoption. One of the most significant challenges is the limited access to technology in developing countries, where many small-scale fishers operate. High-tech solutions such as blockchain traceability systems, artificial intelligence (AI)-driven stock assessments, and satellite monitoring tools often require advanced infrastructure and strong internet connectivity, which are not readily available in remote fishing communities (Lambert et al., 2019). This digital divide exacerbates inequalities, as fishers in technologically advanced nations benefit from innovation, while those in developing regions risk exclusion from global value chains.

Cost also presents a critical barrier. Many digital solutions are resource-intensive, requiring significant investment in hardware, software, and ongoing maintenance (Demestichas & Daskalakis, 2020). For example, implementing Internet of Things (IoT) sensors on fishing vessels or using satellite-based monitoring systems involves expenses that are beyond the reach of small-scale fishers and governments in low-income countries. Without external funding or subsidies, adoption remains uneven, leading to fragmented progress in global fisheries sustainability.

In addition, digital literacy remains a pressing issue. Many fishers, particularly in rural areas, lack the skills needed to effectively use digital applications, mobile tools, or data-driven decision-making systems. Even when mobile apps or platforms are designed for accessibility, inadequate training and limited awareness often result in underutilization. This challenge is compounded by generational gaps, where younger fishers may adapt more easily than older ones, further widening internal disparities within fishing communities.

Another major obstacle is data privacy and security. Technologies such as blockchain and vessel tracking systems generate vast amounts of sensitive information about fishing locations, practices, and trade flows (Probst, 2020). Ensuring that this data is protected and not misused by governments, corporations, or illegal operators is critical. A lack of robust cybersecurity frameworks in many regions increases the risk of exploitation and undermines trust in digital solutions.

Lastly, governance issues represent a structural barrier to effective digital transformation. The successful integration of digital technology in fisheries requires strong policy frameworks, cross-border cooperation, and institutional capacity. However, governance gaps such as weak enforcement of illegal, unreported, and unregulated (IUU) fishing laws, fragmented regulatory systems, and corruption often limit the effectiveness of these tools. Even when advanced technologies are in place, their impact is muted without supportive governance structures to ensure compliance, accountability, and equitable distribution of benefits.

Policy and Governance Implications

The successful integration of digital technologies into global fisheries and the broader blue economy requires robust policy frameworks and effective governance mechanisms. Governments play a central role in creating enabling environments through the establishment of regulatory standards, subsidies, and incentives that promote technological adoption. For instance, policies that mandate the use of digital vessel monitoring systems (VMS) or electronic catch documentation

can directly enhance transparency and accountability in fisheries management. Furthermore, by integrating digital solutions into national fisheries strategies, governments can align sustainability goals with economic development objectives, ensuring that technology adoption benefits both ecosystems and fishing communities.

International organizations also play a crucial role in harmonizing standards and fostering cross-border collaboration (Kurowska-Pysz & Szczepańska-Woszczyzna, 2017). Fisheries often operate in transboundary waters, which makes regional and global cooperation essential. Organizations such as the Food and Agriculture Organization (FAO) and the International Maritime Organization (IMO) have been instrumental in promoting best practices for digital traceability, combating illegal, unreported, and unregulated (IUU) fishing, and supporting capacity building in developing countries. By encouraging data-sharing agreements and establishing interoperable monitoring systems, these institutions ensure that digital technologies contribute to collective sustainability efforts rather than reinforcing fragmented governance.

The private sector further accelerates the adoption of digital technologies by driving innovation and offering scalable solutions for traceability, monitoring, and resource management. Technology companies, in collaboration with seafood producers and retailers, have pioneered blockchain-based supply chain systems and artificial intelligence tools for sustainable sourcing (Kochanska, 2020). However, governance frameworks must balance innovation with regulatory oversight, particularly regarding data privacy, market access, and equitable participation for small-scale fishers. Public private partnerships thus become a key mechanism for bridging gaps between policy objectives and technological capabilities, ensuring that the digital transformation of fisheries is inclusive and sustainable.

In conclusion, the governance of digital technology adoption in fisheries must be multidimensional, involving governments, international bodies, and the private sector in a collaborative framework. Effective policies should not only regulate but also incentivize technological innovation, while international cooperation ensures coherence across borders. At the same time, private sector engagement brings agility and efficiency to implementation. Together, these actors can ensure that digital solutions contribute meaningfully to sustainability, equity, and resilience in the global fisheries sector.

Comparison with Traditional Practices

The adoption of digital technologies in global fisheries marks a significant departure from traditional practices that have historically relied on manual recordkeeping, paper-based reporting, and localized monitoring methods. Traditional approaches often struggled with inefficiencies, delays, and inaccuracies that limited effective resource management (Reveliotis, 2016). For example, catch documentation under non-digital systems typically required handwritten logs submitted after fishing activities, creating opportunities for data manipulation, underreporting, and delays in regulatory enforcement. In contrast, electronic logbooks and digital catch reporting tools allow for real-time data collection, verification, and analysis, drastically reducing errors and improving compliance.

Another area of improvement lies in vessel monitoring and surveillance. Traditionally, authorities depended on physical inspections, sporadic patrols, and limited radio communications to monitor fishing activities at sea. Such methods were resource-intensive and often failed to detect illegal, unreported, and unregulated (IUU) fishing in a timely manner (Lindley & Techera, 2017). Digital vessel monitoring systems (VMS), satellite tracking, and automatic identification systems (AIS) now enable continuous oversight of fleets, providing regulators with actionable data on vessel movements and fishing efforts. This not only enhances transparency but also improves the efficiency of enforcement while lowering operational costs for governments.

Supply chain management also illustrates the contrast between traditional and digital practices. Previously, the journey of seafood products from catch to consumer involved multiple intermediaries, with minimal traceability and a high risk of fraud or mislabeling. Paper-based certification was prone to forgery, undermining consumer trust and sustainability claims. Digital innovations such as blockchain-based traceability systems have transformed this process by ensuring tamper-proof records, seamless tracking of seafood products, and greater accountability throughout the value chain (Kochanska, 2020). This has improved consumer confidence, strengthened market access, and provided fishers with better economic opportunities.

Moreover, in the realm of scientific research and stock assessment, traditional methods relied heavily on manual surveys and delayed statistical analyses, which often provided outdated or incomplete information about fish populations. Digital technologies such as drones, remote

sensing, and artificial intelligence-driven predictive models allow for more accurate, timely, and scalable assessments of marine resources (Marconcini et al., 2020). This leads to more informed policy decisions, better conservation outcomes, and sustainable harvesting practices.

In summary, compared to traditional non-digital methods, digital technologies significantly improve outcomes by enhancing efficiency, accuracy, transparency, and accountability in fisheries management. They reduce opportunities for fraud, strengthen enforcement mechanisms, and ensure sustainable resource use. While traditional practices laid the foundation for fisheries governance, digital tools represent a necessary evolution to meet the demands of modern sustainability challenges.

4. CONCLUSION

The integration of digital technology into global fisheries has proven to be a transformative force in advancing the principles of the blue economy and ensuring long-term sustainability of marine resources. Unlike traditional practices that relied heavily on manual monitoring, paper-based reporting, and limited traceability, digital solutions such as blockchain, artificial intelligence, IoT, and satellite-based surveillance have redefined fisheries management by providing real-time data, predictive analytics, and transparent supply chains. These innovations not only support the reduction of overfishing and illegal, unreported, and unregulated (IUU) fishing but also foster compliance with international standards, improve operational efficiency, and reduce the carbon footprint of fishing operations. Global case studies demonstrate that successful adoption of digital tools ranging from blockchain-based tuna tracking in the Pacific to mobile applications empowering small-scale African fishers and AI-driven stock assessment models in Europe has yielded tangible benefits for ecosystems, economies, and communities alike. At the same time, challenges persist, particularly in developing regions where high implementation costs, limited digital literacy, poor infrastructure, and governance gaps hinder widespread adoption. These barriers underline the need for stronger international cooperation, capacity-building initiatives, and inclusive policy frameworks to ensure equitable access to digital innovations across all fisheries sectors. Ultimately, the role of digital technology in enhancing blue economy sustainability lies in its ability to bridge the gap between ecological preservation and economic development. By enabling more responsible harvesting, transparent trade, and improved livelihoods, digital transformation offers a path toward resilient and inclusive fisheries that align with global sustainability agendas such as the United Nations' Sustainable Development Goals (SDGs). Moving forward, a balanced approach that combines technological innovation, effective governance, and local empowerment will be essential to unlock the full potential of digital solutions in safeguarding the future of global fisheries.

REFERENCES

- ASYA, S. M. (2020). *Development of IoT based solution for small sailing boat monitoring and tracking: A case of Zanzibar*. College of Science and Technology.
- Barclay, K., Voyer, M., Mazur, N., Payne, A. M., Mauli, S., Kinch, J., Fabinyi, M., & Smith, G. (2017). The importance of qualitative social research for effective fisheries management. *Fisheries Research*, 186, 426–438.
- Chakraborty, U. (2020). *Artificial Intelligence for All: Transforming Every Aspect of Our Life*. Bpb publications.
- Cook, B., & Zealand, W. N. (2018). Blockchain: Transforming the seafood supply chain. *World Wide Fund for Nature*, 501–508.
- Cooperation, A.-P. E., & Group, F. W. (2008). Assessment of impacts of illegal, unreported and unregulated (IUU) fishing in the Asia-pacific. *Singapore: APEC Secretariat*.
- Cotter, A. J. R., Burt, L., Paxton, C. G. M., Fernandez, C., Buckland, S. T., & Pan, J. (2004). Are stock assessment methods too complicated? *Fish and Fisheries*, 5(3), 235–254.
- Demestichas, K., & Daskalakis, E. (2020). Information and communication technology solutions for the circular economy. *Sustainability*, 12(18), 7272.
- Fournier, M., Casey Hilliard, R., Rezaee, S., & Pelot, R. (2018). Past, present, and future of the satellite-based automatic identification system: Areas of applications (2004–2016). *WMU Journal of Maritime Affairs*, 17(3), 311–345.
- Jeffers, V. F., Humber, F., Nohasiarivelo, T., Botosoamananto, R., & Anderson, L. G. (2019). Trialling the use of smartphones as a tool to address gaps in small-scale fisheries catch data in southwest Madagascar. *Marine Policy*, 99, 267–274.
- Kochanska, A. (2020). *Evaluation of the potential of emerging technologies for the improvement of seafood product traceability*.
- Kurowska-Pysz, J., & Szczepańska-Woszczyzna, K. (2017). The analysis of the determinants of sustainable cross-border cooperation and recommendations on its harmonization. *Sustainability*, 9(12), 2226.

- Lakshmi, V., & Corbett, J. (2020). *How artificial intelligence improves agricultural productivity and sustainability: A global thematic analysis*.
- Lambert, N., Turner, J., & Hamflett, A. (2019). *Technology and the blue economy: from autonomous shipping to big data*. Kogan Page Publishers.
- Large, P. A., Agnew, D. J., Álvarez Pérez, J. Á., Barrio Froján, C., Cloete, R., Damalas, D., Dransfeld, L., Edwards, C. T. T., Feist, S., & Figueiredo, I. (2013). Strengths and weaknesses of the management and monitoring of deep-water stocks, fisheries, and ecosystems in various areas of the world—a roadmap toward sustainable deep-water fisheries in the Northeast Atlantic? *Reviews in Fisheries Science*, 21(2), 157–180.
- Levi-Faur, D. (2004). Comparative research designs in the study of regulation: How to increase the number of cases without compromising the strengths of case-oriented analysis. *The Politics of Regulation*, 177–199.
- Lindley, J., & Techera, E. J. (2017). Overcoming complexity in illegal, unregulated and unreported fishing to achieve effective regulatory pluralism. *Marine Policy*, 81, 71–79.
- Marconcini, M., Esch, T., Bachofer, F., & Metz-Marconcini, A. (2020). Digital earth in Europe. *Manual of Digital Earth*, 647–681.
- Mustafa, S., Estim, A., & Shapawi, R. (2019). Future-proofing oceans for food security and poverty alleviation. In *Decent Work and Economic Growth* (pp. 1–11). Springer.
- Nthane, T. T., Saunders, F., Gallardo Fernández, G. L., & Raemaekers, S. (2020). Toward sustainability of South African small-scale fisheries leveraging ICT transformation pathways. *Sustainability*, 12(2), 743.
- Okemwa, E. M. (2019). *Harnessing the potentials of the blue economy for Kenya's sustainable development*.
- Perakis, K., Lampathaki, F., Nikas, K., Georgiou, Y., Marko, O., & Maselyne, J. (2020). CYBELE—Fostering precision agriculture & livestock farming through secure access to large-scale HPC enabled virtual industrial experimentation environments fostering scalable big data analytics. *Computer Networks*, 168, 107035.
- Probst, W. N. (2020). How emerging data technologies can increase trust and transparency in fisheries. *ICES Journal of Marine Science*, 77(4), 1286–1294.
- Reveliotis, S. (2016). Real-time management of complex resource allocation systems: Necessity, achievements and further challenges. *Annual Reviews in Control*, 41, 147–158.
- Spalding, M. J. (2016). The new blue economy: the future of sustainability. *Journal of Ocean and Coastal Economics*, 2(2), 8.
- Tilley, A., & Roscher, M. (2020). *Information and communication technologies for small-scale fisheries (ICT4SSF)—A handbook for fisheries stakeholders: In support of the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. Food & Agriculture Org.