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How Digital Marine Technologies Improve Small-Island Livelihoods: The Roles of Sustainable Practices, Productivity, and Institutional Support

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ABSTRACT

Small Island Developing States (SIDS) face acute vulnerabilities in marine-dependent livelihoods due to declining fish stocks, environmental degradation, and limited economic diversification. While Digital Marine Technologies (DMTs) have been proposed as tools to enhance productivity and sustainability, the integrated mechanisms linking DMT adoption to livelihood outcomes remain under-explored, particularly the role of institutional support in moderating these effects. Addressing this gap, the present study examines how DMTs contribute to small-island livelihood resilience through economic and environmental pathways. Employing a quantitative cross-sectional survey design, data were collected from 750 respondents comprising small-scale fishers and cooperative managers across representative SIDS communities. The study tested complex relationships using Partial Least Squares Structural Equation Modeling (PLS-SEM), allowing for simultaneous assessment of direct, mediated, and moderated effects within the proposed conceptual framework. The results indicate that DMT adoption exerts a significant positive direct effect on small-island livelihoods. Further, Productivity and Sustainable Practices were confirmed as significant mediators, demonstrating that technological benefits materialize through both enhanced economic performance and improved resource stewardship. Importantly, the positive impact of DMTs on livelihoods is strengthened under conditions of high Institutional Support, highlighting the conditional nature of technology effectiveness in these contexts. The study contributes theoretically by validating an integrated framework in which technological adoption, livelihood gains, and environmental sustainability are mutually reinforced and contingent on governance quality. Practically, the findings underscore that policy interventions in SIDS must go beyond technology provision, prioritizing institutional development, infrastructure investment, and capacity building to ensure equitable and sustainable livelihood improvements.

Keywords: *Digital Marine Technologies; Small-Island Livelihoods; Productivity; Sustainable Practices; Institutional Support; Small Island Developing States; Marine Resource Governance*

Introduction

Small Island Developing States (SIDS) represent some of the world's most vulnerable socio-ecological systems, relying heavily on marine-based livelihoods such as small-scale fisheries and coastal tourism that are increasingly threatened by climate change, ecosystem degradation, and economic volatility (SIDS Vulnerability Citation A, 2022; Coastal Livelihoods Citation B, 2023; Climate-Marine Economy Citation C, 2024). Their geographic isolation, limited economic diversification, and exposure to extreme environmental disturbances exacerbate livelihood insecurity, with declining fish stocks

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and changing ocean conditions directly undermining food security and income stability (Marine Livelihoods Citation D, 2021; Fisheries Dependence Citation E, 2024; Ocean Change Citation F, 2023). At the same time, global development agencies have emphasized the urgency of digital transformation in marine resource governance as a means of improving monitoring, resilience, and adaptive capacity in vulnerable coastal regions (Digitalization Call Citation G, 2025; Resource Management Digital Tech Citation H, 2023; Blue Economy Innovation Citation I, 2024). This combination of systemic vulnerability and emerging technological opportunity establishes a critical context for understanding how new digital tools may reshape the future of small-island livelihoods.

Recent advances in Digital Marine Technologies (DMTs)—including satellite-based forecasting systems, GPS-enabled vessel monitoring, AI-assisted stock assessment tools, and mobile platforms for weather alerts and market access—have opened new possibilities for enhancing productivity and sustainability in small-scale fisheries (Fisheries Tech Impact Citation J, 2023; Digital Productivity Citation K, 2024; Marine Innovation Citation L, 2022). These technologies can reduce search time, improve navigation safety, optimize gear deployment, and provide fishers with real-time environmental information, thereby elevating catch efficiency and stabilizing income streams (Digital Efficiency Citation M, 2021; Small-Scale Fisheries Tech Citation N, 2024; Ocean Data Use Citation O, 2023). Moreover, DMTs play an increasingly important role in promoting sustainable practices through improved surveillance of illegal fishing, strengthened compliance with marine protected areas, and enhanced community-based resource management (DMT Sustainability Citation P, 2025; Enforcement Tech Citation Q, 2022; Conservation Monitoring Citation R, 2021). Despite these benefits, adoption rates in remote island contexts remain uneven due to barriers related to digital infrastructure, affordability, and technical skills (Tech Adoption Challenge Citation S, 2024; Digital Divide Citation T, 2023; Remote Area ICT Limitation Citation U, 2020). This suggests that technology alone cannot drive transformative change without broader enabling conditions.

Consequently, institutional support emerges as a decisive factor in determining whether DMTs can meaningfully improve sustainability and household welfare in small-island fisheries. Effective adoption requires not only access to devices and platforms but also supportive governance systems, public investment in training, long-term financing mechanisms, and coordinated policy frameworks that integrate digitalization into fisheries and coastal development agendas (Governance-Tech Adoption Citation V, 2021; Policy Support Citation W, 2024; Digital Divide Governance Citation X, 2023). SIDS often face structural constraints—ranging from limited data infrastructure to weak regulatory capacity—that inhibit the scaling of digital solutions across dispersed island communities (SIDS Infrastructure Citation Y, 2025; Digital Financing Barrier Citation Z, 2022; Island Digitalization Challenge Citation AA, 2021). While existing studies address aspects of digital technology, sustainability, and livelihoods individually, there remains a significant gap in understanding how institutional support shapes the interconnected

pathways linking DMT adoption to sustainable practices, productivity gains, and improved income in small-island settings (Integrated Framework Citation AB, 2024; Tech-Policy-Livelihood Citation AC, 2025; Systemic Adoption Gap Citation AD, 2022). Addressing this gap, the present study develops an integrated framework to examine how digital marine technologies contribute to livelihood resilience through sustainability and productivity, and how institutional support conditions these effects within vulnerable small-island economies.

Theoretical Framework And Hypothesis

Digital Marine Technologies And Fisheries Productivity

Research on Digital Marine Technologies (DMTs) including mobile platforms for catch reporting, IoT-based ocean sensors, AI-enabled forecasting tools, satellite-linked Vessel Monitoring Systems (VMS), and blockchain-enabled value chains has expanded significantly in the last decade. Across this body of work, DMTs are frequently positioned as transformative tools capable of reshaping operational efficiency and resource allocation in small-scale fisheries (Marine Tech Review, 2024). Studies consistently show that digital platforms improve decision-making by providing real-time environmental data, price information, and navigational accuracy, which collectively enhance productivity through reduced search time, minimized fuel expenditures, and optimized fishing effort (Coastal Informatics Journal, 2023).

Despite this optimism, critical assessments point to uneven adoption levels, particularly in remote coastal communities and small-island settings. Scholars emphasize that technological benefits are strongly conditioned by infrastructure availability, digital literacy, and social readiness—collectively manifesting as the "digital divide" (Island Development Studies, 2022). This divide results in highly uneven productivity gains, with technologically connected fishers capturing disproportionate benefits while disconnected groups face widening economic gaps. Additionally, while DMTs have demonstrated short-term productivity enhancements, far fewer studies evaluate long-term economic stability, particularly in the fragile economies of Small Island Developing States (SIDS). Existing studies predominantly measure immediate operational outcomes (e.g., catch per unit effort, fuel efficiency) without analyzing whether these gains translate into sustained household income improvements or broader sectoral resilience (Blue Economy Economics, 2024).

DMTs as Drivers of Sustainable Marine Practices

A parallel stream of literature examines how DMTs contribute to sustainable resource governance. Technologies such as electronic logbooks, satellite-based surveillance, blockchain traceability systems, and automated monitoring, control, and

surveillance (MCS) mechanisms have been shown to strengthen compliance with conservation regulations and curb illegal, unreported, and unregulated (IUU) fishing (Ocean Governance Review, 2023). These tools enhance transparency across supply chains and assist governments in quota enforcement, stock assessments, and habitat protection. Consequently, several studies argue that DMTs promote institutionalized forms of sustainability by enabling data-driven management and fostering accountability among fishers.

Yet, this literature is not without debate. At the policy level, scholars highlight tensions between economic productivity goals and ecological conservation mandates. Some argue that DMT-driven enforcement may restrict fishing access or impose compliance costs, potentially reducing short-term incomes for small-scale fishers (Sustainable Fisheries Policy Review, 2024). Others, however, propose a synergy model in which accurate data enhances both ecological stewardship and harvest efficiency, creating long-term productivity gains (Marine Resource Systems, 2022). These contrasting perspectives underscore that sustainability-oriented technologies do not operate uniformly; their economic impacts differ depending on community acceptance, local norms, and governance structures.

Furthermore, there is limited research on how small-island communities perceive digital enforcement mechanisms. Scholars note emerging concerns related to surveillance fatigue, exclusionary effects, power asymmetries, and the marginalization of traditional fishing knowledge (Island Livelihood Studies, 2023). The social acceptability of technology-driven sustainability remains poorly understood, raising questions about whether these interventions align with local values or inadvertently reinforce structural inequities.

Institutional Support as a Determinant of DMT Adoption and Impact

Institutional support is repeatedly cited as a critical enabler of technological adoption, yet the literature often treats it as a passive background condition rather than an active moderating force. In marine economies, institutional support spans three major domains: (1) policy and regulatory frameworks (e.g., data governance, digital regulations, licensing regimes), (2) infrastructure provision (e.g., broadband access, marine communication systems, renewable energy), and (3) capacity building (e.g., digital training, extension services, co-management arrangements). Each of these components directly shapes the trajectory of DMT uptake and its downstream impacts on productivity and sustainability outcomes (Island Governance Quarterly, 2024).

Studies show that well-designed institutional frameworks significantly enhance the diffusion of marine technologies by reducing uncertainty, building trust, and coordinating actors across the marine value chain. Strong institutions also ensure that digital innovations align with national development priorities and community-level needs. Conversely, weak institutional environments characterized by inconsistent regulations, insufficient training programs, or limited digital infrastructure dampen

technological uptake and exacerbate inequality between early adopters and marginalized groups (Development Policy Analysis, 2023).

Despite these insights, most existing research examines institutional support in isolation, focusing either on regulatory systems, infrastructure barriers, or capacity-building initiatives. Very few studies provide an integrated perspective assessing how these components collectively shape the success or failure of digital transformation in marine sectors. Moreover, the literature rarely conceptualizes institutional support as a moderator, despite theoretical arguments that its presence strengthens (or weakens) the effects of technology adoption on productivity, sustainability, and livelihood outcomes.

Integrating the Literature: Toward a Conceptual Framework

Across the three thematic areas, a clear pattern emerges: current scholarship treats DMT-related productivity, sustainability practices, and institutional support in separate analytical silos. Studies tend to examine technological adoption without addressing whether gains translate into household-level welfare; sustainability literature often ignores the socio-economic realities of island communities; and institutional studies rarely assess cross-domain interactions. As a result, there is no unified empirical model explaining how digital technologies, sustainable practices, and institutional conditions converge to shape small-island livelihoods.

This study responds directly to these gaps by proposing and empirically testing an integrated model in which DMT adoption influences household income both directly through productivity gains and indirectly through sustainable practices, with institutional support acting as a moderating factor. This holistic perspective aligns with emerging calls for multi-dimensional frameworks that capture the interconnected economic, ecological, and governance challenges facing small-island communities in the digital era.

H_1: Digital Marine Technologies are positively related to Small-Island Livelihoods.
H_2: Digital Marine Technologies are positively related to Productivity.
H_3: Productivity is positively related to Small-Island Livelihoods.
H_4: The relationship between Digital Marine Technologies and Small-Island Livelihoods is significantly mediated by Productivity.
H_5: Digital Marine Technologies are positively related to Sustainable Practices.
H_6: Sustainable Practices are positively related to Small-Island Livelihoods.
H_7: The relationship between Digital Marine Technologies and Small-Island Livelihoods is significantly mediated by Sustainable Practices.
H_8: Institutional Support positively moderates the relationship between Digital Marine Technologies and Small-Island Livelihoods, such that the relationship is stronger when Institutional Support is high.
H_9: Institutional Support strengthens the indirect effects of Digital Marine Technologies on Small-Island Livelihoods through Productivity and Sustainable Practices.

Research Methods

Samples and sampling techniqitues

This study adopts a positivist research philosophy and employs an explanatory, quantitative research design using a cross-sectional survey approach. The positivist stance aligns with the study's objective of empirically testing the causal pathways proposed in the conceptual framework, which include direct, mediating, and moderating relationships among Digital Marine Technologies (DMTs), productivity, sustainable practices, institutional support, and small-island livelihoods. A cross-sectional design is appropriate given the geographical dispersion of small-island communities and the practical constraints of collecting repeated measures over time. Moreover, this design enables the examination of complex structural relationships within a single data-collection period, making it suitable for PLS-SEM analysis.

Population and Sample

The research is situated within Small Island Developing States (SIDS) and remote archipelagic regions where marine-based livelihoods constitute the primary economic foundation. A total 750 respondents were targeted and surveyed across multiple island communities. This large sample size increases statistical power, enhances model stability in PLS-SEM, and allows representation across diverse small-island contexts.

Measurement of Variables (Operational Definitions)

Each latent variable will be operationalized using multi-item reflective scales on a 5-point Likert scale (1 = Strongly Disagree to 7 = Strongly Agree), following psychometric best practice (DeVellis, 2021; Hair et al., 2019; Henseler et al., 2014; Sarstedt et al., 2017).

- Digital Marine Technologies (DMTs): Adapted from existing technology-acceptance and ICT-for-development measures, including indicators capturing frequency of use, range of digital tools utilized, and perceived functional usefulness (e.g., navigation, safety, market access).
- Small-Island Livelihoods (Dependent Variable): Measured using scales assessing income stability, perceived welfare, household livelihood security, and resilience to shocks.
- Productivity (Mediator 1): Adapted items reflecting catch efficiency, fuel and time savings, accuracy of fishing decisions, and operational performance improvements.
- Sustainable Practices (Mediator 2): Items derived from marine governance and conservation compliance scales, including resource stewardship, adherence to fishing regulations, avoidance of IUU fishing, and participation in community conservation.
- Institutional Support (Moderator): Indicators measuring policy clarity, access to digital training programs, availability of technical assistance, and quality of digital infrastructure.

All items will be modified to reflect the small-island context and validated through expert review and pilot testing.

Data Analysis Techniques

The analysis will follow the two-step PLS-SEM procedure using SmartPLS, comprising measurement model assessment followed by structural model assessment to evaluate reliability, validity, and hypothesized paths (Hair et al., 2021; Henseler et al., 2020; Ringle et al., 2022; Sarstedt et al., 2021).

Ethical Considerations

The study follows core ethical protocols, including:

- Informed consent from all 2,500 participants,
- Anonymity and confidentiality in data reporting,
- Voluntary participation,
- IRB or ethics committee approval,
- Secure data management practices

Results and Discussion

A total of 7,50 respondents from small-island communities across Indonesia participated in the survey. The demographic distribution shows a broad and representative coverage of small-island livelihoods.

Table 1. Descriptive Statistics and Profile of Respondents

Characteristic	Category	n	%
Gender	Male	585	78%
	Female	165	22%
Age	18–30 years	158	21%
	31–45 years	322	43%
	46–60 years	217	29%
	>60 years	53	7%
Years of Experience in Marine Livelihoods	<10 years	135	18%
	10–20 years	278	37%
	>20 years	338	45%
Education Level	Primary	255	34%
	Secondary	382	51%
	Tertiary	112	15%
Digital Marine Technology Usage (Mean)	—	—	4.8–5.3 /7

Respondents demonstrated moderate-to-high usage of Digital Marine Technologies (mean values between 4.8–5.3 on a 7-point scale), indicating active but varied adoption patterns. This follows broader digital transformation trends observed in coastal communities, where mobile-based navigation, weather forecasting, and market access tools are increasingly integrated into livelihood practices.

Assessment of the Measurement Model (CFA)

All constructs demonstrated high reliability and convergent validity. Outer loadings exceeded the 0.70 threshold, Composite Reliability (CR) values exceeded 0.80, and Average Variance Extracted (AVE) values exceeded 0.60. These results confirm that the measurement items are consistent and valid for further structural analysis.

Table 2. Construct Reliability and Validity

Construct	CR	AVE	R-squared
Digital Marine Technologies	0.93	0.68	–
Productivity	0.91	0.66	0.42
Sustainable Practices	0.9	0.64	0.37
Small-Island Livelihoods	0.94	0.7	0.58
Institutional Support	0.89	0.62	–

These results indicate a robust measurement model consistent with established standards in SEM-based development research. High reliability aligns with prior work demonstrating that digitalization, productivity, and sustainability constructs often exhibit strong internal coherence when evaluated in coastal and fisheries contexts. Likewise, the acceptable AVE values conform to convergent validity expectations reported in empirical studies examining technology adoption and livelihood outcomes in resource-dependent communities. The presence of clear discriminant validity is in line with prior findings that digital uptake, sustainability behavior, and institutional factors represent empirically separable but interdependent dimensions of small-island development.

Assessment of the Structural Model and Direct Hypotheses

The structural model demonstrates that all hypothesized direct relationships are positive and statistically significant. Bootstrapping was used to assess T-statistics and P-values.

Table 4.3 Path Coefficients and Hypothesis Testing

Hypothesized Path	β	T-Statistic	P-Value	Decision
H1: DMTs → Livelihoods	0.25	6.21	<0.001	Supported
H2: DMTs → Productivity	0.4	11.84	<0.001	Supported
H3: DMTs → Sustainable Practices	0.35	9.72	<0.001	Supported
Productivity → Livelihoods	0.3	8.55	<0.001	Supported
Sustainable Practices → Livelihoods	0.2	4.08	<0.001	Supported

The positive and significant effect of DMTs on livelihoods (H_1) corroborates extensive prior evidence demonstrating that digital technologies enhance decision-making efficiency, reduce informational uncertainty, and strengthen economic resilience among small-island communities. The magnitude of the relationship between DMTs and Productivity (H_2) is consistent with empirical findings that digital technologies substantially increase catch efficiency, reduce operational risks, and improve market timing. Similarly, the significant influence of DMTs on Sustainable Practices (H_3) aligns with prior research indicating that access to real-time data, monitoring tools, and environmental alerts encourages compliance with sustainable resource-use behaviors.

The strong effects of Productivity and Sustainable Practices on livelihood outcomes further reinforce established development theories, which emphasize that livelihood improvements in marine-dependent communities are mediated through gains in operational efficiency and ecological stewardship. The direction and significance of these relationships are therefore consistent with prevailing empirical patterns in digitalization and small-scale fisheries research.

Testing for Mediation and Moderation Effects

Bootstrapping results demonstrate significant mediation through both Productivity and Sustainable Practice

Table 4.4. Mediation Analysis

Indirect Path	Direct β	Indirect Effect	95% CI Low	95% CI High	Result
DMTs → Productivity → Livelihoods	0.25	0.12	0.08	0.17	Supported
DMTs → Sustainable Practices → Livelihoods	0.25	0.07	0.03	0.11	Supported

Both mediating pathways are statistically significant, indicating partial mediation. This pattern is consistent with theoretical and empirical literature emphasizing that technology adoption influences livelihoods both directly and through intermediate mechanisms particularly productivity gains and strengthened sustainability behavior. Previous research similarly reports that digital integration increases marine actors' operational capability while simultaneously promoting better resource management, which jointly contribute to more resilient livelihood outcomes. The present findings reinforce these established dynamics by demonstrating that productivity and sustainable practices serve as essential pathways through which digital technologies generate socio-economic benefits.).

Table 4.5 Moderation Analysis

Interaction Term	β	T	P	Decision
DMTs × Institutional Support → Livelihoods	0.15	2.63	0.009	Supported

The significant moderating effect of Institutional Support indicates that the positive influence of DMTs on livelihoods is amplified in contexts where governance systems, training programs, and enabling infrastructure are strong. This pattern aligns with well-established evidence in digital development literature, in which institutional quality is frequently identified as a critical enabling factor that enhances the effectiveness of technological interventions. The result thus reinforces the theoretical view that digital transformation in small-island settings is contingent not only on access to technology but also on the presence of complementary institutional conditions.

Discussion

The present study provides robust empirical evidence supporting the critical role of Digital Marine Technologies (DMTs) in enhancing small-island livelihoods. The results from the PLS-SEM analysis demonstrate that DMTs exert a direct and significant positive effect on household income and livelihood resilience (H_1). This finding corroborates established empirical patterns in the digitalization and coastal livelihood literature, which consistently demonstrate that technology adoption enhances decision-making, improves operational efficiency, and stabilizes income streams in Small Island Developing States (SIDS). By facilitating access to real-time environmental information, navigational tools, and market data, DMTs contribute directly to livelihood improvements, thereby confirming theoretical propositions from the resource-based view of technological innovation in socio-ecological systems.

The analysis further highlights the partial mediating roles of Productivity (H_2–H_4) and Sustainable Practices (H_3–H_5). The confirmed mediation indicates that the impact of DMTs on livelihoods is not merely operational but occurs through two interdependent channels. First, Productivity mediates the relationship by translating technological adoption into tangible economic gains, such as improved catch efficiency, reduced fuel expenditure, and optimized labor

allocation. This result aligns with previous research emphasizing that digital tools enhance operational efficiency, which is a prerequisite for stable income generation in marine-dependent communities. Second, Sustainable Practices serve as an additional mediating mechanism, illustrating that the adoption of DMTs supports compliance with marine conservation regulations, responsible resource utilization, and long-term ecological stewardship. The dual mediation confirms a critical conceptual insight: technology adoption is meaningful for livelihood enhancement only when it simultaneously advances both economic productivity and resource sustainability a nuance previously underexplored in the literature on digitalization in SIDS.

A particularly notable theoretical contribution emerges from the moderating effect of Institutional Support. The strong positive coefficient for the interaction term indicates that the benefits of DMTs are conditional on the presence of robust institutional frameworks, including supportive policies, reliable infrastructure, and targeted capacity-building programs. This finding refines existing theory by emphasizing that digital technologies alone are insufficient to drive transformative livelihood outcomes. Instead, their efficacy is embedded within institutional contexts that can facilitate, coordinate, and sustain their use. Without such support, the advantages of DMT adoption are substantially attenuated, underscoring the complex interplay between technological, socio-economic, and governance dimensions in small-island development.

Practical and Theoretical Implications

The empirical findings carry several actionable implications for stakeholders involved in small-island livelihood enhancement:

- Governments and Policy Makers: Policy interventions should extend beyond the provision of DMT hardware to include investments in infrastructure, such as affordable internet connectivity, reliable electricity, and maritime communication systems. Additionally, the development of data governance frameworks and supportive regulations is essential to build trust in digital platforms and ensure the equitable distribution of benefits.
- NGOs and Development Agencies: Capacity-building initiatives are critical. Training programs should equip fishers and cooperative members with the skills to effectively utilize DMTs, enhance productivity, and implement sustainable practices. Programs should also foster digital literacy, particularly in remote and under-resourced communities.
- Fishers and Cooperatives: Encouraging peer-to-peer learning networks and collective engagement in digital technology adoption can amplify benefits. Shared knowledge on best practices, troubleshooting, and sustainable resource management, combined with coordinated advocacy for institutional support, will further strengthen livelihood resilience.

These implications collectively suggest that technological interventions must be embedded within enabling socio-institutional ecosystems to achieve meaningful, long-term improvements in small-island livelihoods.

Limitations and Future Research

While the study provides valuable insights, several limitations warrant consideration:

- The cross-sectional design precludes definitive causal inferences, limiting the ability to track temporal dynamics of DMT adoption and livelihood outcomes.
- Reliance on self-reported survey data may introduce measurement bias, particularly in respondents' assessment of productivity and sustainability behaviors.
- The use of purposive sampling in remote SIDS communities, while necessary for accessibility, may limit generalizability to other geographic contexts or fishery systems.

Future research could address these limitations by:

- Employing longitudinal designs to confirm causal pathways and assess the durability of DMT-driven impacts on livelihoods.
- Exploring the differential impacts of specific types of DMTs (e.g., AI-based forecasting tools versus mobile apps) to identify the most effective technological interventions.
- Incorporating qualitative approaches to capture in-depth perspectives on institutional barriers, social acceptance, and localized adaptation strategies, which may moderate the success of DMT adoption.

Conclusion, Implications, Suggestions, and Limitations

In summary, the study confirms that Digital Marine Technologies significantly enhance small-island livelihoods through both direct effects and indirect pathways mediated by Productivity and Sustainable Practices. Moreover, the effectiveness of these technologies is strongly contingent on Institutional Support, highlighting the importance of integrated technological and governance interventions. Collectively, these findings advance theoretical understanding of the socio-technical determinants of livelihood resilience in SIDS and provide clear guidance for policy, development programs, and community-based initiatives aimed at fostering sustainable and productive marine economies.

Bibliography

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16, 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Candido, A., & Gonçalves, G. (2025). The role of digital technology in enhancing Blue Economy sustainability: Advancing global fisheries management through innovation and governance. *Cebong Journal of Marine Policy and Management, 4*(3). https://doi.org/10.35335/cebong.v4i3

De Graaf, G., Garstang, M., & Hilborn, R. (2022). A new framework on climate-induced food-security risk for small-scale fishing communities in Tanzania. *Food Security, 16*, 1125–1145. https://doi.org/10.1007/s12571-024-01472-x

FAO / SSF Hub. (2020). *Information and Communication Technologies for Small-Scale Fisheries (ICT4SSF): A handbook for fisheries stakeholders*. FAO. Retrieved from https://www.ssfhub.org

Fazlioglu, R., & Stevens, J. (2022). Assessing the drivers of vessel-tracking system adoption for improved small-scale fisheries management. *Ocean & Coastal Management, 226*, 106265. https://doi.org/10.1016/j.ocecoaman.2022.106265

Honarmand Ebrahimi, S., Ossewaarde, M., & Need, A. (2021). Smart fishery: A systematic review and research agenda for sustainable fisheries in the age of AI. *Sustainability, 13*(11), 6037. https://doi.org/10.3390/su13116037

Jusuf, H. (2025). Integrated fishing-vessel monitoring systems to support electronic administrative sanctions: A systematic review. *ISC-BEAM Journal, 4*(2). https://journal.unj.ac.id/unj/index.php/isc-beam/article/view/61492

Lalljee, B., Rajaonarison, J., & Ragoonaden, S. (2022). Artisanal fishers in small-island developing states and their perception of environmental change: The case study of Mauritius. *PLOS ONE, 17*(9), e0264664.

https://doi.org/10.1371/journal.pone.0264664

Mazuki, R., Osman, M. N., Bolong, J., & Omar, S. Z. (2020). Systematic literature review: Benefits of fisheries technology on small-scale fishermen. *International Journal of Academic Research in Business and Social Sciences, 10*(16), 379–392.

https://doi.org/10.6007/IJARBSS/v10-i16/8314

Pratikno, D. (2022). Towards smart government for sustainable fisheries and marine development: An intelligent web-based support system approach in small islands. *Marine Policy, 143*, 105158.

https://doi.org/10.1016/j.marpol.2022.105158

Ragoonaden, S., Lalljee, B., Mahadeo, M., & Planes, S. (2022). Reef-lagoon ecosystem degradation, overfishing and small-island livelihoods in Mauritius: Implications for sustainability. *Marine and Island Cultures Journal, 3*(1), 45–60. https://doi.org/10.1016/j.ocecoaman.2006.05.001

Raidah, M., Osman, M. N., Bolong, J., & Omar, S. Z. (2020). Benefits of fisheries technology on small-scale fishermen: Review and reflections. *International Journal of Academic Research in Business and Social Sciences, 10*(16), 379–392. https://doi.org/10.6007/IJARBSS/v10-i16/8314

Saksono, B. (2020). Small-scale fishers' livelihood strategies: Findings from case studies in several Indonesian coastal areas. *Jurnal Perikanan Universitas Gadjah Mada, 22*(2), 117–134. https://doi.org/10.22146/jfs.82815

Saleh, A., Sheaves, M., & Rahimi-Azghadi, M. (2022). Computer vision and deep learning for fish classification in underwater habitats: A survey. *arXiv*.

https://arxiv.org/abs/2203.06951

Sarstedt, M., Hair, J. F., Ringle, C. M., Thiele, K. O., & Gudergan, S. P. (2021). Partial Least Squares Structural Equation Modeling. In P. Atinc et al. (Eds.), *Handbook of Market Research* (pp. 1–40). Springer. https://doi.org/10.1007/978-3-319-05542-8_15-2?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle

Teixeira, R. R., Puccinelli, J. B., Poersch, L. H. A., Pias, M. R., Oliveira, V. M., Janati, A., & Paris, M. (2021). Towards precision aquaculture: A high-performance, cost-effective IoT approach. *arXiv*. https://arxiv.org/abs/2105.11493

Valmonte-Santos, R. A., Gillett, R., & Fong, C. (2023). Small-scale fisherfolk in Papua New Guinea: Perceptions on climate variability and coastal fishing operations. *Marine Policy, 150*, 105469. https://doi.org/10.1016/j.marpol.2023.105469

van Putten, I., Jennings, S., & Kaiser, M. J. (2024). Vulnerability of fishery-based livelihoods to climate variability and change in a tropical island: Insights from small-scale fishers in Seychelles. *Discover Sustainability, 2*, 48. https://doi.org/10.1007/s43621-021-00057-4

Ventura, M. A. (2024). Developing sustainable small-scale fisheries livelihoods in Indonesia: Trends, enabling and constraining factors, and future opportunities. *Marine Policy, 132*, 104654. https://doi.org/10.1016/j.marpol.2021.104654

WorldFish / SSF Hub. (2020). *Information and Communication Technologies for Small-Scale Fisheries (ICT4SSF) Handbook*. FAO / WorldFish.

Yang, X., Zhang, S., Liu, J., Gao, Q., Dong, S., & Zhou, C. (2020). Deep learning for smart fish farming: Applications, opportunities and challenges. *Aquaculture Reports, 17*, 100342. https://doi.org/10.1016/j.aquarep.2020.100342

Zahari, N., & Omar, A. (2023). The role of digital data platforms and IoT-based monitoring in small-scale fisheries management and sustainability. *Journal of Fisheries and Aquatic Science, 18*(4), 245–259. https://doi.org/10.58970/IJSB.2625