

Role of Ai-Enabled Digital Financial Services in Promoting A Sustainable Blue Economy in Kerala: A Conceptual Framework

R Sreeja

Orcid Id : 0009-5509-183x

Assistant Professor

Monti International Institute of Management Studies

Abstract - Kerala's blue economy spanning marine fisheries, aquaculture, coastal tourism, shipping, and allied livelihoods is a vital source of income and employment for a large coastal population, yet it continues to face challenges of financial exclusion, income volatility, resource overexploitation, and vulnerability to climate and market shocks. Simultaneously, the rapid expansion of digital financial services (DFS), increasingly powered by Artificial Intelligence (AI) for fraud detection, credit scoring, biometric authentication, and personalised financial advisory, is reshaping how individuals and small enterprises access, use, and trust financial systems. While digital finance and AI adoption have been studied extensively in urban and general consumer contexts, and blue economy sustainability has been examined largely through ecological and policy lenses, limited conceptual work exists at the intersection of the two. This paper addresses that gap by proposing a conceptual framework that links AI-enabled digital financial services with sustainable blue economy outcomes in Kerala, mediated by trust and financial inclusion, and moderated by digital literacy, infrastructure, and institutional/policy support. Drawing on the Technology Acceptance Model (TAM), the Diffusion of Innovation (DOI) theory, and financial inclusion literature, the paper develops testable propositions describing how AI-enabled security features build user trust, how trust drives adoption and financial inclusion, and how financial inclusion, in turn, supports sustainable livelihoods and responsible resource use among coastal communities. The paper concludes with theoretical contributions, policy implications for Kerala's fintech and blue economy ecosystem, and directions for future empirical research, situating the discussion within the Sustainable Development Goals (SDG 1, SDG 8, SDG 9, SDG 10, and SDG 14).

Keywords: Blue Economy, Digital Financial Services, Artificial Intelligence, Financial Inclusion, Kerala, Sustainable Development Goals, Coastal Livelihoods

1. INTRODUCTION

The concept of the “blue economy” refers to the sustainable use of ocean and coastal resources for economic growth, improved livelihoods, and employment, while preserving the health of marine ecosystems. For a coastal state such as Kerala, with a coastline exceeding 590 kilometres and a substantial proportion of its population dependent on fisheries, aquaculture, coastal tourism, port operations, and allied trades, the blue economy is not a peripheral sector but a structural component of the state's economic and social fabric. Kerala's blue economy supports the livelihoods of hundreds of thousands of fisherfolk, boat owners, fish vendors, aquaculture farmers, and tourism operators, many of whom operate in informal or semi-formal economic settings characterised by irregular income, seasonal uncertainty, and limited access to formal financial institutions.

At the same time, India has witnessed a rapid transformation in its financial services landscape, driven by the proliferation of digital payment platforms, mobile banking, and Unified Payments Interface (UPI)-based transactions. This transformation has been accelerated by the increasing integration of Artificial Intelligence (AI) into financial services used for real-time fraud detection, biometric authentication, algorithmic credit scoring, personalised financial advisory, and automated risk alerts. These AI-enabled features are positioned as mechanisms to enhance the security, efficiency, and trustworthiness of digital financial services (DFS), thereby encouraging their adoption among historically underserved populations, including those engaged in coastal and marine-based livelihoods.

Despite the parallel growth of these two domains the blue economy and AI-enabled digital finance scholarly and policy attention has rarely examined their intersection in a systematic, conceptual manner. Existing literature on Kerala's blue economy tends to focus on ecological sustainability, fisheries management, and coastal governance, while literature on digital finance and AI adoption is largely oriented toward urban consumers, banking customers, or general retail contexts. There is, therefore, a conceptual gap in understanding how AI-enabled digital financial services can function as an enabler of financial inclusion, income stability, and sustainable resource use specifically within blue economy communities.

This paper responds to that gap by developing a conceptual framework and a set of theoretically grounded propositions that describe the pathways through which AI-enabled digital financial services may contribute to a more inclusive and sustainable blue economy in Kerala. As a conceptual paper, it does not present primary empirical data; rather, it synthesises existing theory and literature to construct a model that can guide future empirical research, policy design, and fintech product development.

1.1 RATIONALE FOR THE STUDY

Three converging trends justify this conceptual inquiry. First, Kerala's blue economy stakeholders, particularly small-scale fisherfolk and coastal micro-entrepreneurs, remain disproportionately underbanked and vulnerable to informal credit systems, income shocks, and exploitative lending practices. Second, the Government of India's Digital India initiative and Reserve Bank of India-led financial inclusion programmes have substantially expanded the infrastructure for digital transactions, yet adoption and trust among coastal and rural populations remain uneven. Third, AI-enabled security and personalisation features are increasingly embedded in mainstream financial applications, but their specific relevance and acceptability among blue economy communities whose risk perceptions, digital literacy levels, and livelihood patterns differ from urban consumers remain conceptually underexplored.

Bringing these three trends together allows this paper to ask:

R1 : How, and under what conditions, can AI-enabled digital financial services contribute to a more inclusive, resilient, and sustainable blue economy in Kerala?

Answering this question conceptually provides a theoretical foundation upon which future empirical, survey-based, or case-study research can be built.

2. OBJECTIVES OF THE PAPER

- To conceptualise the role of AI-enabled digital financial services within Kerala's blue economy ecosystem.
- To develop a theoretical framework linking digital financial services, AI-enabled trust and security, financial inclusion, and sustainable blue economy outcomes.
- To identify the key enablers of, and barriers to, AI-enabled digital finance adoption among blue economy stakeholders in Kerala.
- To propose theoretically grounded research propositions connecting AI-enabled trust, financial inclusion, and SDG-aligned sustainability outcomes.
- To outline policy implications and a future research agenda for AI-enabled digital finance in support of a sustainable blue economy.

3. LITERATURE REVIEW AND THEORETICAL BACKGROUND

3.1 THE BLUE ECONOMY: CONCEPT AND KERALA'S CONTEXT

The blue economy paradigm, popularised in international policy discourse following the Rio+20 Conference (2012) and subsequently embedded in Sustainable Development Goal 14 (Life Below Water), emphasises the sustainable use of ocean and marine resources for economic growth, livelihood improvement, and ecosystem preservation. In the Indian context, the blue economy encompasses fisheries and aquaculture, coastal and marine tourism, shipping and port operations, marine biotechnology, and renewable ocean energy. Kerala, given its extensive coastline, backwater systems, and traditional dependence on fisheries, is

frequently identified as a state with significant blue economy potential, and the Kerala government has articulated policy interest in a “responsible blue economy” that balances resource exploitation with conservation.

However, the sector faces persistent structural challenges: overfishing and declining catch per unit effort, seasonal and weather-related income volatility, limited access to formal credit and insurance, dependence on informal moneylenders (often at exploitative interest rates), and low levels of financial planning or savings among small-scale fishing households. These challenges collectively constrain the resilience and long-term sustainability of coastal livelihoods, suggesting that financial inclusion and access to reliable financial tools are not merely economic conveniences but structural enablers of sustainability itself.

Blue economy policy foundations. Sari and Muslimah's (2020) study of Indonesia's blue economy policy provides a useful policy-level starting point, arguing that when properly implemented, national marine and fisheries strategy can simultaneously deliver food security, economic growth and environmental sustainability, including climate mitigation. Their work frames the blue economy as a national policy integration challenge one requiring coordination across ecological, economic, and social goals rather than treating fisheries sustainability as a standalone environmental issue. This paper is useful for grounding the "sustainability triad" that any blue-economy financing framework must address, but it stops short of examining financial mechanisms as a delivery pathway.

Social equity and inclusion dimensions. Matovu et al. (2024) shift the lens toward social sustainability, using a scoping review from the Global South (including Kerala) to show that marine fishing remains marked by unsustainability issues, including the exclusion of fisherwomen from fisheries value chains and lucrative livelihood opportunities, compounded by socio-cultural bias. This is a critical corrective to purely ecological or financial framings of the blue economy: it demonstrates that "sustainability" is inseparable from equitable participation, and that women's empowerment functions as both an outcome and an enabling condition of transformative blue-economy narratives. For a financing-focused paper, this source signals that access to capital and digital financial tools cannot be assumed to be gender-neutral inclusion has to be designed for, not assumed.

Fintech as a financing mechanism. The two Springer chapters from the *FinTech for Sustainable Finance and a Well-Blue Economy* volume directly bridge finance and the blue economy. Jadhav et al. (2025) note that blue economy sectors sustainable fisheries, renewable marine energy, and eco-tourism require significant, targeted funding to drive innovation, reduce environmental harm, and support economic growth, needs that traditional financing methods have struggled to meet given high risk, uncertain returns, and regulatory complexity. This establishes the "financing gap" rationale that motivates innovative instruments (green bonds, blended finance, fintech-enabled microfinance) as necessary rather than optional. Kaur, Kapur, and Kurucz (2025) extend this by proposing fintech as an active enabler rather than a passive channel, arguing that fintech can eliminate financial gaps, improve monitoring, and enable more efficient management of ocean resources, and they illustrate this with cases such as blockchain-supported Indonesian fisheries and crowdfunded coral-reef restoration. Their chapter's conceptual framework explicitly fusing sustainable marine practice with blockchain, AI, and IoT is one of the closest existing analogues to the framework this paper builds.

Policy and governance layer. Singh's (2026) chapter on transformative policies for blue finance and fintech innovation situates these financing mechanisms within a governance and regulatory context, reinforcing that technology and capital alone are insufficient without supportive policy architecture a theme consistent with the broader blue-finance literature's emphasis on coherent and improved ocean-governance dimensions of the SDGs alongside capital mobilisation (an estimated \$175 billion annually is needed to meet SDG 14 by 2030).

RESEARCH GAP:

The sustainable blue economy rests on three interdependent pillars that existing literature has so far treated somewhat separately: (i) **policy integration** (Sari & Muslimah), (ii) **social equity and inclusion**, particularly of women and marginalised coastal groups (Matovu et al.), and (iii) **innovative, technology-enabled financing** (Jadhav et al.; Kaur, Kapur & Kurucz; Singh). No single source integrates all three into one framework specific to a fintech/AI-enabled financing lens with an explicit equity dimension which is the gap this paper's conceptual framework addresses.

Key additions from this literature :

Policy/governance as a cross-cutting moderator (Singh, 2020), not just infrastructure/literacy

- **Gender/social equity as an explicit mediating condition** (Matovu et al.) financing mechanisms must be evaluated for whether they reach women and marginalised fisherfolk, not just "coastal stakeholders" generically
- **Technology-specific enablers** blockchain (transparency/traceability), AI (risk assessment/monitoring), crowdfunding (small-scale conservation financing) drawn directly from Kaur, Kapur & Kurucz and Jadhav et al.

3.2 DIGITAL FINANCIAL SERVICES AND FINANCIAL INCLUSION

Digital financial services (DFS) encompassing mobile banking, digital wallets, UPI-based payment systems, and app-based microcredit and insurance products have been widely promoted as instruments of financial inclusion, particularly for populations historically excluded from formal banking due to geographic remoteness, low and irregular income, or lack of documentation. The financial inclusion literature broadly identifies three inter-related dimensions of inclusion: access (availability of financial products), usage (frequency and depth of engagement), and quality (affordability, suitability, and safety of the products used).

For coastal and fisheries communities, DFS offer specific potential benefits: enabling faster and safer receipt of payments for catch sold at auction, reducing dependence on cash and the associated risks of theft or loss at sea-adjacent markets, facilitating access to government subsidy transfers and insurance payouts, and creating digital transaction histories that can subsequently support algorithmic credit assessment. At the same time, adoption of DFS among such populations is shaped by factors including digital literacy, network and infrastructure reliability in coastal and island areas, language accessibility, and critically trust in the security and fairness of digital systems.

3.3 ARTIFICIAL INTELLIGENCE IN FINANCIAL SERVICES: SECURITY, TRUST, AND ADOPTION

The integration of AI into financial services has advanced rapidly, particularly in the domains of fraud detection, anomaly-based transaction monitoring, biometric authentication (fingerprint and facial recognition), natural-language chatbots for customer service, and algorithmic credit scoring that uses alternative data sources beyond traditional credit history. These AI-enabled features are theorised to influence user trust and adoption through two primary mechanisms: perceived security (the belief that AI reduces exposure to fraud and unauthorised transactions) and perceived usefulness (the belief that AI-personalised services, such as automated savings nudges or tailored credit offers, provide tangible value).

The Technology Acceptance Model (TAM), originally proposed by Davis (1989), posits that perceived usefulness and perceived ease of use are primary determinants of technology adoption intention. Extensions of TAM in the fintech literature incorporate perceived security and trust as additional antecedents, particularly relevant in financial contexts where the consequences of system failure or fraud are materially significant. Complementing TAM, Rogers' Diffusion of Innovation (DOI) theory identifies relative advantage, compatibility, complexity, trialability, and observability as factors influencing the rate of adoption of an innovation within a social system a framework well suited to explaining differential adoption rates of AI-enabled DFS across heterogeneous coastal communities with varying literacy, infrastructure, and social network characteristics.

For blue economy stakeholders specifically, trust in AI-enabled security features may carry particular weight, given that many transactions involve immediate, often informal, cash-equivalent exchanges (e.g., fish auction payments) where the consequences of fraud or transaction failure directly and immediately affect household income. Conceptually, therefore, AI-enabled trust is positioned in this paper not merely as a determinant of digital finance adoption in general, but as a potentially decisive factor in whether such adoption translates into sustained, meaningful usage among blue economy communities.

3.4 LINKING DIGITAL FINANCE AND AI TO SUSTAINABILITY OUTCOMES

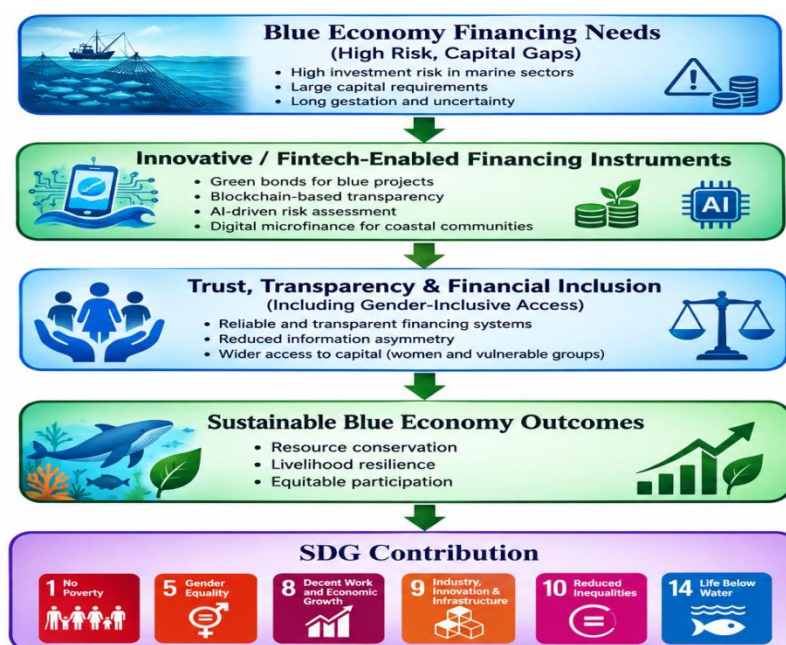
A smaller but growing body of literature connects financial inclusion to sustainability outcomes, arguing that reliable access to savings, credit, and insurance enables households to smooth consumption during income shocks, invest in productive assets, and reduce reliance on unsustainable resource extraction as a coping mechanism (e.g., overfishing during periods of financial distress). Insurance products particularly weather-indexed or catch-based insurance supported by digital and AI-driven underwriting, are theorised to reduce the incentive for short-term, unsustainable resource exploitation by providing an alternative buffer against risk.

This literature suggests a conceptual pathway in which AI-enabled digital financial services, by improving trust and financial inclusion, may indirectly support more sustainable resource-use behaviour among blue economy stakeholders a linkage that has not, to date, been systematically theorised in the Kerala context. This paper's conceptual contribution lies precisely in constructing and articulating this pathway.

3.5 SUSTAINABLE DEVELOPMENT GOALS AS AN INTEGRATING FRAME

The United Nations Sustainable Development Goals provide a coherent frame for integrating the economic, social, and environmental dimensions discussed above. SDG 14 (Life Below Water) is directly relevant to the ecological sustainability of Kerala's marine resources; SDG 8 (Decent Work and Economic Growth) relates to income stability and productive employment for coastal communities; SDG 9 (Industry, Innovation, and Infrastructure) captures the role of AI and fintech innovation and the infrastructure required to support it; SDG 1 (No Poverty) reflects the poverty-reduction potential of improved financial access; and SDG 10 (Reduced Inequalities) addresses the risk that digital and AI-enabled finance may either narrow or widen existing disparities between digitally literate and digitally excluded populations. This paper positions its conceptual framework as a contribution toward operationalising these SDGs jointly, rather than in isolation.

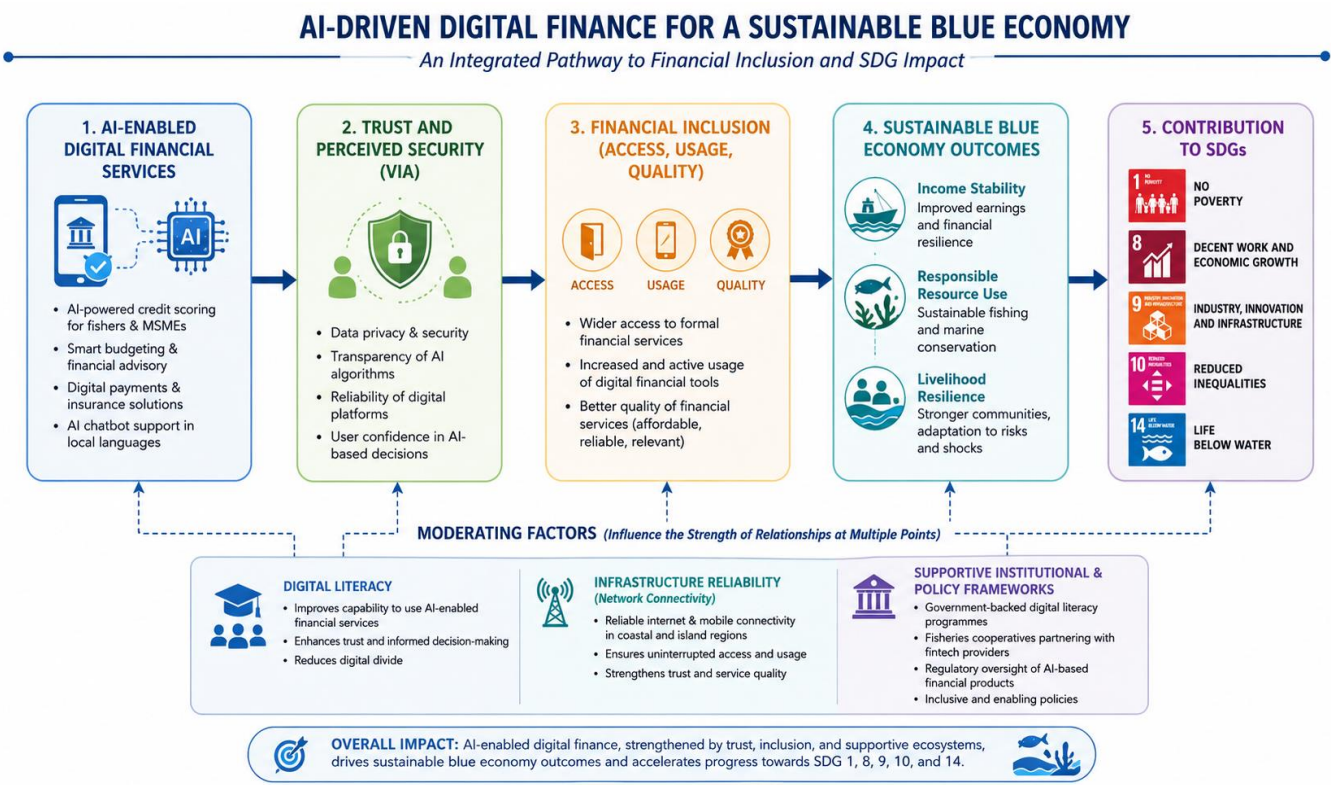
4. PROPOSED CONCEPTUAL FRAMEWORK



Source : Researcher

Building on the theoretical foundations above, this paper proposes an integrated conceptual framework describing the pathway from AI-enabled digital financial services to sustainable blue economy outcomes in Kerala. The framework comprises four sets of constructs: (a) the independent construct AI-enabled digital financial services (encompassing AI-based security, fraud detection, and personalisation features); (b) two mediating constructs trust in digital finance, and financial inclusion (access, usage, and quality); (c) the dependent construct sustainable blue economy outcomes (comprising income stability, responsible resource use, and livelihood resilience); and (d) three moderating conditions digital literacy, infrastructure reliability, and institutional/policy support.

4.1 Framework Pathway



Source : Researcher

4.2 CONSTRUCT DEFINITIONS

Construct	Description
AI-Enabled Digital Financial Services	Digital payment, banking, credit, and insurance platforms incorporating AI-based fraud detection, biometric authentication, automated alerts, and algorithmic personalisation.
Trust and Perceived Security	The degree to which users believe AI-enabled features reduce the risk of fraud, error, or unauthorised transactions, and are fair and reliable.
Financial Inclusion	The extent of access to, usage of, and quality of formal financial products (payments, savings, credit, insurance) among blue economy stakeholders.
Sustainable Blue Economy Outcomes	Income stability, reduced dependence on unsustainable resource extraction, and enhanced resilience of coastal livelihoods.
Moderating Conditions	Digital literacy, infrastructure reliability, and institutional/policy support that strengthen or weaken the above pathway.

5. RESEARCH PROPOSITIONS

Based on the conceptual framework above, the following propositions are advanced to guide future empirical testing:

P1: AI-enabled security features (fraud detection, biometric authentication, automated alerts) are positively associated with users' trust in digital financial services among Kerala's blue economy stakeholders.

P2: Trust in AI-enabled digital financial services mediates the relationship between AI adoption and the extent of financial inclusion (access, usage, and quality) among coastal and fisheries communities.

P3: Financial inclusion is positively associated with income stability and livelihood resilience among blue economy stakeholders.

P4: Financial inclusion, supported by AI-enabled digital finance, is positively associated with more responsible and sustainable resource-use behaviour (e.g., reduced reliance on overfishing as an income-shock coping mechanism).

P5: Digital literacy positively moderates the relationship between AI-enabled digital financial services and trust, such that the relationship is stronger among stakeholders with higher digital literacy.

P6: Infrastructure reliability (network connectivity, device access) positively moderates the relationship between AI-enabled digital financial services and financial inclusion.

P7: Institutional and policy support (e.g., cooperative-fintech partnerships, digital literacy programmes, regulatory safeguards) strengthens the overall pathway from AI-enabled digital finance to sustainable blue economy outcomes.

P8: In the absence of adequate digital literacy and infrastructure, AI-enabled digital financial services may inadvertently widen inequality between digitally included and digitally excluded blue economy stakeholders, contrary to SDG 10 objectives.

6. DISCUSSION AND IMPLICATIONS

6.1 THEORETICAL CONTRIBUTION

This paper contributes to theory by extending established technology-adoption frameworks (TAM and DOI) beyond their conventional application to general consumers or urban banking customers, into the specific and under-theorised context of blue economy livelihoods. It further contributes by explicitly linking financial inclusion literature to sustainability and resource-use literature, proposing that financial inclusion functions not only as an economic outcome in itself but as an intermediate mechanism supporting environmentally sustainable behaviour. In doing so, the paper offers an integrative framework that bridges three previously disconnected literatures: fintech/AI adoption, financial inclusion, and blue economy sustainability.

6.2 PRACTICAL AND MANAGERIAL IMPLICATIONS

For fintech providers and financial institutions, the framework suggests that product design for coastal and fisheries communities should prioritise visible, comprehensible AI-security features (e.g., clear fraud alerts, simple biometric verification) that build trust quickly, rather than complex features that may be perceived as opaque. Financial institutions may also consider co-designing AI-enabled credit and insurance products with fisheries cooperatives, leveraging community trust networks to accelerate adoption.

For technology developers, the framework highlights the importance of designing AI-enabled interfaces that function reliably under conditions of intermittent connectivity and that accommodate varying levels of digital literacy, including through vernacular-language support and simplified user interfaces.

6.3 POLICY IMPLICATIONS

For policymakers, particularly within Kerala's fisheries and digital governance departments, the framework underscores the importance of coordinated investment across three fronts: digital and financial literacy programmes tailored to coastal communities; infrastructure investment to improve network connectivity in coastal and island regions; and regulatory frameworks that ensure AI-based financial products are transparent, fair, and do not disproportionately exclude or disadvantage less digitally literate users. Aligning such policy interventions explicitly with SDG targets particularly SDG 1, 8, 9, 10, and 14 can help position Kerala's blue economy digitalisation efforts within a globally recognised sustainability agenda, potentially unlocking additional development financing and partnership opportunities.

The framework also flags a policy caution embodied in Proposition 8: without deliberate attention to digital literacy and infrastructure gaps, AI-enabled digital finance initiatives risk reinforcing rather than reducing inequality among blue economy stakeholders, an outcome that would run counter to the inclusive intent of the SDGs.

7. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

As a conceptual paper, this study does not present primary empirical data, and the proposed relationships, while theoretically grounded, require empirical validation. Future research should pursue survey-based studies among Kerala's fisherfolk, coastal traders, and marine tourism operators to test the proposed propositions using structural equation modelling or similar techniques capable of assessing mediation and moderation effects. Qualitative case studies of specific fintech interventions in Kerala's coastal districts examining, for instance, cooperative-linked digital credit schemes or AI-based catch-insurance pilots would further enrich understanding of the contextual mechanisms underlying the proposed framework.

Future research could also usefully compare the proposed framework's applicability across different blue economy sub-sectors (capture fisheries versus aquaculture versus coastal tourism), given that income patterns, risk exposure, and digital literacy may vary substantially across these groups. Longitudinal research designs would additionally help establish whether observed associations between financial inclusion and sustainable resource-use behaviour reflect genuine causal influence over time, rather than simple correlation.

8. CONCLUSION

This paper has developed a conceptual framework linking AI-enabled digital financial services to sustainable blue economy outcomes in Kerala, positioning trust and financial inclusion as key mediating mechanisms, and digital literacy, infrastructure, and institutional support as critical moderating conditions. By synthesising technology-adoption theory, financial inclusion literature, and blue economy sustainability perspectives, the paper offers a theoretically grounded foundation for future empirical inquiry into how fintech innovation can support rather than bypass Kerala's coastal and marine-dependent communities. Ultimately, realising the potential of AI-enabled digital finance to advance a genuinely sustainable and inclusive blue economy will depend not merely on technological capability, but on deliberate, coordinated efforts across financial institutions, technology developers, and policymakers to ensure that innovation translates into equitable and sustainable outcomes for all blue economy stakeholders, in keeping with the broader ambitions of the Sustainable Development Goals.

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