Machine Learning Research
2026, Vol. 11, No. 2, pp. 143–148
https://doi.org/10.11648/j.mlr.20261102.17

SciencePG
Science Publishing Group

Research Article

Ict-enabled Environmental Sustainability in Coastal Communities: Assessing Digital Governance and Blue Economy Development in Mombasa County, Kenya

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Abstract

Coastal communities face increasing environmental challenges; including habitat degradation, pollution, and climate-related shocks that threaten livelihoods built around the ocean economy. Information and Communication Technologies (ICTs) are increasingly promoted as instruments of environmental governance, yet the extent to which digital governance capacity translates into sustainable blue economy outcomes in African coastal counties remains under-researched. This paper investigates the relationship between ICT-enabled digital governance and environmental sustainability in the context of blue economy development in Mombasa County, Kenya. Grounded in socio-technical systems theory and the public value of information systems perspective, the study adopts an embedded single-case study design combining a cross-sectional household and business survey, key-informant interviews with government and research institutions (NEMA, Mombasa County Government, KMFRI, KWS), and a documentary review of county digital-governance initiatives. The study proposes a Digital Governance Readiness Index (DGRI) integrating four dimensions digital infrastructure, institutional capacity, stakeholder participation, and data-driven decision making, and links these to blue economy outcomes through a conceptual model with six testable propositions. Expected contributions include an evidence-based assessment framework that county governments can use to diagnose governance gaps, a set of policy recommendations for aligning national blue economy strategy with grassroots digital inclusion, and a replicable methodology for other coastal counties. The paper indicates that ICT-enabled sustainability is contingent not merely on technology deployment but on participatory governance structures, inter-agency data sharing, and community digital literacy.

Keywords

Digital Governance, Blue Economy, Environmental Sustainability

1. Introduction

Kenya's coastline, stretching approximately 640 kilometres along the Indian Ocean, hosts ecosystems and livelihoods that are simultaneously among the country's most economically productive and most environmentally vulnerable. Mombasa County-Kenya's second-largest city and principal seaport, anchors a coastal economy in which fisheries, tourism, shipping, port logistics, and small-scale commerce depend directly on the health of marine and coastal ecosystems. Recognising this dependency, Kenya has positioned the blue economy as a pillar of national development, with the Kenya Blue Economy Strategy [10] framing sustainable ocean resource use as a route to inclusive growth.

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Received: 5 October 2026; **Accepted:** 16 October 2026; **Published:** 29 October 2026

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Parallel to this economic agenda, Kenya has made substantial investments in digital governance. The National ICT Policy [11], the Kenya Vision 2030 digitalization pillar, county-level integrated management information systems, and national environmental reporting platforms have created the formal architecture for data-driven environmental decision making. The National Environment Management Authority (NEMA), the Kenya Marine and Fisheries Research Institute (KMFRI), the Kenya Wildlife Service (KWS), and the Mombasa County Government all operate or are developing digital systems for environmental monitoring, licensing, and coastal resource management.

Although digital platforms exist at the institutional level, evidence on whether they reach fishermen, traders, tourism operators, and community organisations, and whether they alter environmental practices remains fragmentary. ICT-for-development (ICT4D) scholarship has long warned that technology investments in developing-country public administration frequently produce 'design-reality gaps' [12]: systems that fail because they ignore institutional capacity, user capabilities, and local contexts. In coastal Kenya, this gap is visible in the discontinuity between sophisticated national platforms and the low levels of digital literacy, connectivity, and participatory engagement observed among resource-dependent communities.

This paper addresses that gap by asking: to what extent, and through what mechanisms, do ICT-enabled digital governance capabilities contribute to environmental sustainability and blue economy development in Mombasa County? The study pursues four objectives:-

1) to assess the state of ICT infrastructure and digital platform use for environmental governance among county institutions;
2) to examine community-level ICT access, digital literacy, and participation in digitally mediated environmental decision making;
3) to evaluate the relationship between digital governance capacity and environmental sustainability outcomes in key blue economy sectors; and
4) to develop a contextualised framework and policy recommendations for ICT-enabled sustainable blue economy governance.

2. Literature Review

2.1. ICTs and Environmental Governance

Environmental governance refers to the set of regulatory processes, mechanisms, and organisations through which environmental outcomes are managed. The integration of ICTs into environmental governance — often termed electronic environmental governance or e-governance for sustainability has been studied across several traditions. In public administration, digital government research has progressed through staged maturity models from cataloguing (online presence) through transaction (service delivery) to connected governance (integrated, cross-agency, participatory decision making) [15, 19]. More recent scholarship emphasises that the highest value of digital government lies not in digitising existing processes but in transforming state-citizen relationships, enabling co-production of public services [14, 16].

In environmental domains specifically, ICTs contribute through remote sensing, geographic information systems (GIS), mobile reporting applications, IoT-based sensor networks, and open data platforms. These tools can lower the cost of environmental monitoring, increase the spatial and temporal resolution of data, and enable community-based monitoring in which citizens generate and share environmental observations. However, the literature consistently shows that technical capability is a necessary but insufficient condition: outcomes depend on institutional arrangements, data quality, interoperability, and the willingness of agencies to act on citizen-generated information [2, 13].

2.2. Digital Governance and Public Value

The public value perspective [7, 17] frames government technology investments as valuable only insofar as they produce outcomes citizens actually experience cleaner environments, responsive services, inclusive decision making. Janowski [14] extends this into 'digital government evolution' models in which technologies progress from supporting internal administration to enabling whole-of-government and governance transformations that engage non-state actors. Empirical work in sub-Saharan Africa shows that most digital government initiatives remain at early maturity stages: websites and social media presence are common, but integrated data exchange, participatory platforms, and data-driven policy making are rare [12, 18, 22].

For environmental governance in Kenya, this maturity question is acute. NEMA operates the Kenya Environmental Information Network and digital licensing systems; KWS runs wildlife and protected-area information systems; KMFRI maintains marine research databases; and the Mombasa County Government has deployed county service delivery platforms and revenue systems. Whether these systems interconnect, and whether communities can access and contribute to them, is largely undocumented in peer-reviewed research.

2.3. The Blue Economy in Kenya and East Africa

The blue economy concept denotes the sustainable use of ocean resources for economic growth, improved livelihoods, and ocean ecosystem health. Scholarship on the blue economy in the Western Indian Ocean region highlights both promise and tension. Proponents emphasise fisheries value chains, maritime transport, coastal tourism, and emerging sectors such as offshore renewables and aquaculture [1, 23]. Critics caution that blue economy discourses can marginalise small-

scale fishers, concentrate benefits in corporate and state actors, and underweight ecological limits unless strong governance arrangements exist [3, 20].

Kenya's policy framework including the National Oceans and Fisheries Policy [9] and the Kenya Blue Economy Strategy [10], and county spatial plans for Mombasa, Kilifi, and Kwale, explicitly links blue economy growth to sustainability. Effective implementation, however, requires information: stock assessments, pollution data, habitat maps, licensing records, and enforcement logs. ICTs are the only realistic mechanism for assembling and sharing such information at the required scale. This makes the blue economy a natural testbed for digital governance research: the sector's sustainability depends on information-intensive governance that technology could dramatically improve if adoption and integration challenges are overcome.

2.4. Community Participation and Digital Inclusion

A central theme in ICT4D research is the risk that digital initiatives deepen existing inequalities. Digital divides in coastal Kenya operate along multiple dimensions: urban-rural connectivity gaps, gendered access to devices and skills, affordability constraints, and linguistic exclusion from platforms delivered only in English or Swahili [8]. Community-based resource management structures, such as Beach Management Units (BMUs) in the fisheries sector offer institutional channels through which digitally mediated participation could be organised, but only if platforms are designed around their operational realities (low-end phones, intermittent connectivity, oral communication norms).

2.5. Research Gap

Three gaps motivate this study. First, there is limited empirical research on digital government maturity in Kenyan county governments generally and in environmental agencies specifically. Second, the blue economy literature in East Africa is predominantly policy-oriented and sectoral; few studies examine the information and governance infrastructure that blue economy sustainability presupposes. Third, no known study has integrated institutional digital governance assessment with community-level participation analysis in a single coastal Kenyan case. This study addresses all three gaps through an integrated, mixed-methods assessment of Mombasa County.

3. Theoretical Framework

The study is anchored in two complementary theories. The first is socio-technical systems theory, which holds that organisational outcomes emerge from the joint optimisation of technology and its social context people, processes, institutions, and culture [4, 21]. Applied here, the theory implies that environmental information systems in Mombasa County will succeed only when technical deployment is matched with institutional capacity building, staff competencies, stakeholder participation, and supportive governance processes. This provides the analytic categories for the institutional assessment.

The second is the public value of information systems perspective, derived from Fountain's [7] work on bureaucracy and the state in the digital age. Fountain argues that technology does not automatically improve government: it must be embedded in networks and norms that enable value creation. Janowski's [14] digital government evolution framework operationalises this by distinguishing stages from digitisation (technology in existing processes) to transformation (new, participatory modes of governance). Together, the two theories yield the paper's central theoretical claim: the sustainability impact of ICT in coastal governance is mediated by the maturity of the socio-technical configuration into which the technology is introduced.

4. Conceptual Framework and Propositions

The study proposes a conceptual model in which four dimensions of digital governance readiness (D1) digital infrastructure, (D2) institutional capacity, (D3) stakeholder participation, and (D4) data-driven decision making jointly influence environmental sustainability outcomes in blue economy sectors, moderated by community digital literacy and by the strength of local resource-management institutions (Figure 1). Environmental sustainability outcomes are operationalised through indicators including adoption of sustainable fishing practices, reported pollution incidents and response times, habitat protection compliance, and perceived ecosystem health by resource users.

The model yields six propositions:

P1: Digital infrastructure availability (connectivity, devices, platforms) is positively associated with institutional environmental monitoring capability in Mombasa County.

P2: Institutional capacity (staff digital skills, budget, leadership) moderates the effect of infrastructure on monitoring capability.

P3: Stakeholder participation in digitally mediated environmental decision making is positively associated with compliance with sustainable resource-use practices.

P4: Data-driven decision making (use of environmental data in policy, licensing, and enforcement) is positively associated with environmental sustainability outcomes.

P5: Community digital literacy moderates the relationship between platform availability and actual community use of environmental information systems.

P6: The strength of local resource-management institutions (e.g., BMUs) moderates the translation of digital governance capacity into sustainability outcomes.

These propositions are tested through the convergent mixed-methods design described below. The Digital Governance Readiness Index (DGRI) is constructed as a composite of D1-D4 measured at both institutional and community levels, enabling comparison across agencies and between government and community perspectives.

5. Methodology

5.1. Research Design

An embedded single-case study design [24] is employed, with Mombasa County as the case and its constituent departments, national agencies (NEMA, KWS, KMFRI), community organisations, households, and businesses as embedded sub-units. A convergent mixed-methods strategy combines a quantitative survey with qualitative interviews and documentary analysis, integrated at the interpretation stage.

5.2. Study Population and Sampling

The study population comprises: (a) environmental and ICT staff of Mombasa County Government; (b) officers of NEMA, KMFRI, and KWS operating in the county; (c) community-based organisations and Beach Management Units; (d) households in coastal sub-counties (Likoni, Mvita, Kisauni, Changamwe, Jomvu, Nyali); and (e) blue economy businesses (fishers, fish traders, tourism operators, port-linked enterprises). Purposive sampling is used for institutional informants (target n = 25 key informants), while households and businesses are sampled using multistage cluster sampling proportionate to sub-county population (target n = 384 households, giving ±5% margin of error at 95% confidence; n = 150 businesses), consistent with Cochran's [25] formula for large populations.

5.3. Data Collection Instruments

1) Structured questionnaire for households and businesses covering ICT access, platform use, environmental practices, participation, and perceptions of ecosystem health (Likert-scale items adapted from validated digital governance and environmental behaviour instruments).
2) Semi-structured interview guide for institutional informants covering platform inventory, data-sharing practices, decision-making use of data, and inter-agency coordination.
3) Documentary review checklist applied to county development plans, NEMA and KMFRI reports, blue economy strategy documents, and platform documentation.
4) Observation protocol for public access points (cyber cafés, county service centres, BMU offices) to verify infrastructure claims.

Ethical clearance will be sought from the university ethics committee and research authorisation from NACOSTI; informed consent will be obtained from all participants, with anonymisation of institutional informants.

5.4. Data Analysis

Quantitative data will be analysed using descriptive statistics, reliability analysis (Cronbach's alpha ≥ 0.7), exploratory factor analysis to validate the DGRI dimensions, and multiple regression to test P1-P4 with sustainability outcomes as the dependent variable. Moderation effects (P5-P6) will be tested using interaction terms. Qualitative interviews will be transcribed and analysed thematically [5] with a codebook derived from the conceptual framework and open codes for emergent themes. Integration occurs through joint displays comparing institutional and community assessments of the same governance functions, following the convergent design protocol [6].

5.5. Validity, Reliability, and Trustworthiness

Instrument validity will be established through expert review and pilot testing in a neighbouring sub-location. Construct validity of the DGRI will be examined via confirmatory factor analysis. Qualitative trustworthiness will be supported through triangulation across data sources, member checking with a subset of informants, and an audit trail of analytic decisions. Instrument reliability will be reported for all multi-item scales.

6. Expected Findings, Contributions, and Policy Implications

Based on the literature and the Kenyan digital government context, the study anticipates a characteristic asymmetry: relatively high digital maturity at the national-agency level (NEMA, KMFRI, KWS) alongside lower integration and participatory capability at county and community levels. This pattern would be consistent with Heeks' [12] design-reality gap thesis and with African digital government maturity assessments more broadly [22]. The moderation analysis (P5, P6) is expected to show that platform availability alone yields little sustainability benefit where digital literacy and local institutional anchoring are weak — echoing socio-technical systems theory's joint-optimisation claim.

The expected empirical and theoretical contributions are threefold. Theoretically, the study extends socio-technical and public-value frameworks to the blue economy domain, demonstrating how governance mediates the technology-sustainability relationship. Methodologically, it offers a validated DGRI instrument and a replicable mixed-methods protocol for assessing digital environmental governance in resource-dependent coastal settings. Practically, it produces an agency-level diagnostic that Mombasa County and national institutions can use to target investments in interoperability, community digital literacy, and participatory platform design.

Policy implications follow directly. First, county governments should prioritise interoperability and data-sharing agree-

ments among NEMA, KMFRI, KWS, and county systems before expanding platform numbers. Second, community-facing platforms should be co-designed with BMUs and CBOs around low-bandwidth, mobile-first, multilingual interfaces, with digital literacy programmes embedded in existing BMU operations. Third, blue economy investment programmes should include a digital governance readiness assessment as a funding criterion, ensuring that economic projects are matched with monitoring and enforcement information capacity. Fourth, gender and youth digital inclusion targets should be explicit in coastal digital governance initiatives, given the demographics of resource-dependent livelihoods.

7. Limitations and Delimitations

The single-case design limits statistical generalisation, though analytic generalisation to comparable coastal counties (Kilifi, Kwale, Lamu) is intended. Cross-sectional survey data cannot establish causality; the qualitative strand mitigates but does not eliminate this limitation. Recall and social desirability biases may affect self-reported environmental practices. Finally, institutional informants may be constrained in discussing system weaknesses; anonymised reporting is used to reduce this risk.

8. Conclusion

This paper has presented the design and conceptual foundations of a study assessing how ICT-enabled digital governance contributes to environmental sustainability and blue economy development in Mombasa County, Kenya. By integrating socio-technical systems theory with the public value perspective, and by combining institutional, household, and business data within a single case, the study addresses a documented gap at the intersection of digital government research and blue economy scholarship in East Africa. The central argument that technology delivers sustainability value only when embedded in participatory, capable, and integrated governance is both theoretically grounded and practically consequential for Kenya's coastal development agenda. The resulting DGRI instrument and policy framework are designed for replication across the Kenyan coast and, with adaptation, across the Western Indian Ocean region.

Abbreviations

BMU	Beach Management Unit
CBO	Community-Based Organization
DGRI	Digital Governance Readiness Index
GIS	Geographic Information System
ICT	Information and Communication Technology
ICT4D	Information and Communication Technologies for Development
IoT	Internet of Things
KMFRI	Kenya Marine and Fisheries Research Institute
KWS	Kenya Wildlife Service
NACOSTI	National Commission for Science, Technology and Innovation
NEMA	National Environment Management Authority

Author Contributions

Joel Sadiki Charo: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Methodology, Project administration

Conflicts of Interest

The authors declare no conflicts of interest.

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