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Bajo Coastal Resilience Through Human Ecology, Mangrove Stewardship, And Blue Carbon Livelihoods

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ABSTRACT: This critical literature review reframes Bajo coastal communities as human-ecological actors in climate adaptation, mangrove stewardship, and emerging blue carbon livelihood governance. Methods: The article synthesizes the provided Scopus-derived literature corpus and the accompanying manuscript, using a thematic critical review rather than a systematic protocol. Evidence was organized around five clusters: Bajo/Sama-Bajau marginality and adaptation, coastal social-ecological systems, small-scale fisheries resilience, mangrove stewardship, and blue carbon governance. Results: The review shows that Bajo resilience is not merely household coping but a relational capability shaped by marine knowledge, mobility, livelihood portfolios, institutional recognition, and access to mangrove benefits. Recent blue carbon literature strengthens the need to move beyond carbon accounting toward community safeguards, benefit sharing, tenure clarity, and plural valuation. Mangrove stewardship emerges as the bridge between ecological restoration, climate adaptation, and livelihood security. Conclusion: For Bajo communities, blue carbon can support resilience only when it is embedded in rights-based human ecology, participatory governance, and locally meaningful livelihood strategies. The article proposes an integrated framework for future empirical research and policy design.

KEYWORDS: Bajo coastal communities, human ecology, climate adaptation, mangrove stewardship, blue carbon, livelihood resilience, social-ecological systems

1. INTRODUCTION

Coastal communities are increasingly exposed to climate stress, biodiversity loss, livelihood insecurity, and the accelerating policy language of the blue economy. For the Bajo or Sama-Bajau, these pressures are not abstract environmental risks; they are experienced through changing fishing grounds, uncertain seasons, conservation rules, market access, settlement vulnerability, and the shifting value of coastal ecosystems. Recent literature on coastal adaptation argues that resilience is produced through interactions among ecological conditions, governance arrangements, local knowledge, and livelihood capabilities rather than through a single technical intervention (Cabana et al., 2023; Dada et al., 2026; Espinoza Córdova et al., 2024; Nair et al., 2026). This review therefore treats Bajo coastal life as a human-ecological system in which people, mangroves, fisheries, institutions, and carbon policies co-produce vulnerability and resilience.

The Bajo are analytically important because their maritime identity, social organization, and livelihood practices have historically been shaped by mobility, fishing, boat-based or stilt-house settlement, and deep familiarity with marine space. Yet contemporary marine conservation and development policy may still treat them as peripheral actors. Evidence from Wakatobi shows that co-management arrangements can fail to recruit Bajau participation when customary practices, social cohesion, and institutional support are not adequately recognized (Ariando & Arunotai, 2022). Studies of Bajo Mola fishers further show that adaptation includes livelihood innovation, aquaculture, product processing, and market strategies rather than simple passive coping (Marlina et al., 2021). Research on Sama Bajo poverty and prosperity also warns that maritime communities are internally differentiated and shaped by market, policy, and resource-access relations (McWilliam et al., 2021).

Mangroves sit at the center of this review because they are simultaneously ecological infrastructure, fish habitat, carbon reservoir, coastal protection system, cultural landscape, and livelihood base. The recent literature has moved from viewing mangroves only as forests or carbon stocks toward conceptualizing them as social-ecological systems whose value depends on local use, community perception, governance, and restoration practice (Buenavista & Purnobasuki, 2023; Cruz Portorreal et al., 2024; Elwin et al., 2024; Quevedo et al., 2025). This shift is crucial for Bajo-focused research because mangrove stewardship cannot be reduced to planting or protection targets. It must be analyzed as a situated practice of care, access, knowledge, and negotiation.

Blue carbon introduces both opportunity and risk. It offers new arguments for conserving mangroves and may attract finance for restoration, coastal protection, and livelihood diversification. However, the literature also shows that blue carbon projects can reproduce inequality if they overlook tenure, benefit sharing, project feasibility, community capacity, or cultural values (Ewane et al., 2025; Huxham et al., 2023; Karpowicz et al., 2024; Nyangoko & Mang'ena, 2026; Thoni & Rummukainen, 2025). For Bajo communities, the relevant question is therefore not whether mangroves store carbon, but whether carboncentered governance strengthens or weakens the social-ecological relations that sustain coastal life.

This article updates and compresses the earlier manuscript for the Journal of Natural Science Research and Review. It develops a critical literature review focused on three questions: how does human ecology reframe Bajo coastal adaptation; how can mangrove stewardship mediate between livelihood resilience and blue carbon policy; and what safeguards are needed so that blue carbon livelihoods do not become a new form of coastal exclusion?

2. MATERIALS AND METHODS

This review uses a critical literature review approach. The source material was limited to the submitted manuscript and the provided Scopus-derived extraction file. No new web-based references were added. The purpose was not to conduct a formal systematic review, but to synthesize conceptual relationships across a curated body of literature relevant to Bajo communities, coastal adaptation, mangrove stewardship, and blue carbon livelihood resilience.

The review process involved four steps. First, the corpus was screened for direct relevance to the article's central argument. Studies were retained when they addressed at least one of five themes: Bajo/Sama-Bajau communities; coastal social-ecological systems; small-scale fisheries adaptation; community-based mangrove governance; or blue carbon policy, finance, and safeguards. Second, the retained studies were grouped into thematic clusters. Third, the reference list was reduced to 50 sources that were consistently cited and directly aligned with the argument. Fourth, the narrative was revised to match journal requirements: a concise title, structured abstract of 150-200 words, clear manuscript sections, embedded tables, ethical declarations, and a focused reference list.

The analysis prioritized recent literature from 2020-2026 while retaining selected older sources when they were central to the Bajo case or the conceptual framing. Citation integrity was checked by aligning each intext citation and table reference with the final reference list. The resulting article is a conceptually integrative review rather than an exhaustive inventory. Its contribution lies in connecting literatures that are often separated: Indigenous maritime communities, fisheries adaptation, mangrove stewardship, and blue carbon governance.

Table 1. Core literature clusters supporting the review

Cluster	Dominant evidence	Human-ecological insight	Use in this article	Ref.
Bajo/Sama-Bajau studies	Marginality in comanagement, livelihood adaptation, ethnic identity, local wisdom, and marine dependence.	Bajo resilience is culturally situated and politically constrained.	Frames Bajo as active but often under-recognized coastal actors.	Ariando & Arunotai, 2022; Marlina et al., 2021; McWilliam et al., 2021; Obie, 2020; Sulaiman et al., 2023
Coastal social-ecological systems	Water quality, governance, adaptation capacity, community perception, and participatory approaches.	Resilience emerges from relations among ecology, livelihoods, and institutions.	Supports the human ecology lens.	Nair et al., 2026; Cabana et al., 2023; Espinoza Córdova et al., 2024; Vasseur, 2021
Fisheries adaptation	Coping, diversification, self-governance, local knowledge, and systemic shocks.	Adaptive capacity depends on assets, social organization, learning, and agency.	Interprets Bajo adaptation as portfolio management under uncertainty.	Gianelli et al., 2021; Frawley et al., 2024; Green et al., 2021; Shah et al., 2025; Salgueiro-Otero et al., 2022
Mangrove stewardship	Community perceptions, restoration practice, governance discourse,	Stewardship links ecological care with livelihood security and identity.	Positions mangroves as everyday governance rather than only carbon stock.	Elwin et al., 2024; Marquez & Olavides, 2024; Song et

	local knowledge, and ecosystem health.			al., 2021; Quevedo et al., 2025
Blue carbon governance	Carbon markets, NDCs, benefit sharing, feasibility, justice, and project safeguards.	Carbon value is negotiated through rights, measurement, standards, and institutions.	Builds the policy safeguards framework for Bajo communities.	Karpowicz et al., 2024; Ewane et al., 2025; Dencer-Brown et al., 2022; Purushotham & Thompson, 2026; Zeng et al., 2021

Synthesis of Table 1. The clusters show that the review is built from converging evidence rather than from a single disciplinary stream. Bajo research supplies the community-specific lens; fisheries literature clarifies adaptation mechanisms; mangrove studies explain stewardship; and blue carbon literature identifies governance risks. Together, they support a human ecology framework that treats resilience as relational, institutional, and ecological.

3. RESULTS

Literature Clusters and Emerging Evidence

The literature clusters in Table 1 show that the article is not built from a single field. Bajo studies explain identity, marginality, and marine livelihood practice; fisheries adaptation literature clarifies how households and communities respond to climate stress; mangrove studies explain stewardship and ecosystem services; and blue carbon governance literature reveals how carbon finance changes coastal value. The human ecology contribution is to hold these streams together. It asks how people and ecosystems mutually shape one another under climate, market, and policy pressure.

The first result is that Bajo adaptation is best understood as relational capability. It is not only the ability to change gear, move fishing grounds, or diversify income. It is the capacity to maintain meaningful relations with the sea, households, markets, customary norms, government agencies, and conservation institutions. The literature on small-scale fisheries shows that adaptive responses are shaped by agency, assets, social organization, and institutional trust (Eurich et al., 2024; Mason et al., 2022; Frawley et al., 2024; Green et al., 2021; Shah et al., 2025). For Bajo communities, these factors are mediated by maritime identity and by unequal recognition in coastal governance (Ariando & Arunotai, 2022; Obie, 2020).

The second result is that mangrove stewardship is a key mediating domain. Mangroves are not external conservation objects; they are part of lived coastal infrastructure. Communities perceive mangrove benefits through provisioning, regulating, cultural, and supporting services (Elwin et al., 2024; Quevedo et al., 2020; Quevedo et al., 2025). Biocultural studies also show that mangrove use in Southeast Asia is embedded in food, medicine, craft, protection, and symbolic relations (Buenavista & Purnobasuki, 2023). Therefore, a review centered on Bajo communities should examine not only whether mangroves are conserved, but who defines their value and who benefits from their protection.

The third result is that blue carbon is a negotiated institutional value. The scientific evidence for mangrove carbon potential is strong, but the social outcomes of blue carbon depend on project design, transaction costs, local participation, tenure recognition, and benefit sharing (Dutta Roy et al., 2024; Karpowicz et al., 2024; Macreadie et al., 2022; Zeng et al., 2021). New literature on carbon markets and NDC integration reinforces that blue carbon is increasingly tied to national and international climate policy, but local communities must not be reduced to project beneficiaries after the main decisions have been made (DencerBrown et al., 2022; Prihatiningtyas et al., 2024; Purushotham & Thompson, 2026; Zhao et al., 2022).

The fourth result is that the regional context matters. Coral Triangle studies show that blue carbon ecosystems are interpreted through community perception, adaptation needs, and coastal development pressure rather than through carbon alone (Alsaaideh et al., 2024). Socio-ecological surveys in mangrove systems also show that conservation outcomes depend on how biodiversity, livelihoods, and governance are connected in particular places (Come et al., 2023). Emerging work on Indigenous stewardship and comanagement further confirms that blue carbon can be governed in ways that recognize local custodianship, but only when institutional authority and local priorities are negotiated together (Costa et al., 2026).

4. DISCUSSION

Reframing Bajo Adaptation Through Human Ecology

Table 2 sharpens the Bajo-specific argument. The Bajo should not be framed only as vulnerable coastal people or as cultural symbols of sea nomadism. They are strategic actors whose adaptation depends on access, recognition, knowledge, and institutional fit. This distinction matters because vulnerability-only narratives tend to invite protective intervention from outside, whereas human ecology asks how existing community capacities can be strengthened without erasing local autonomy.

A human ecology perspective also clarifies why adaptation cannot be separated from identity. The Bajo relationship with the sea is a livelihood relation, but it is also a cultural and spatial relation. Policies that restrict fishing grounds, redefine marine space, or impose conservation zones without meaningful participation may weaken the very knowledge systems that make adaptation possible. The loss of ethnic identity discussed by Obie (2020) and the exclusion from co-management described by Ariando and Arunotai (2022) are therefore not secondary social issues; they are central to resilience.

This does not mean that all local practices are automatically sustainable. The literature requires a balanced interpretation. Local knowledge can support stewardship, but communities may also face poverty, market pressure, resource decline, and limited alternatives (McWilliam et al., 2021; Sulaiman et al., 2023). Human ecology avoids both romanticism and deficit thinking. It analyzes how Bajo households make decisions within changing ecological and political conditions. Under climate stress, this includes fishing mobility, product processing, aquaculture, diversification, and negotiation with conservation authorities (Marlina et al., 2021).

This balanced position is important because coastal communities face simultaneous pressures from climate change, conservation, and blue growth. The concept of triple exposure shows that well-intended conservation or development can add to climate vulnerability when it restricts access or redistributes benefits unevenly (Gill et al., 2023). Indigenous and local perceptions of climate impacts also show that adaptation is not only a technical response but a matter of meaning, loss, attachment, and governance legitimacy (Whitney et al., 2020). For Bajo research, this means social inclusion must be evaluated alongside ecological indicators.

The fisheries adaptation literature further indicates that diversification should be evaluated carefully. Diversification may spread risk, but it can also create new dependency, increase labor burdens, or displace households into less secure work. Studies of adaptive capacity and transformation emphasize that flexibility, learning, trust, and social organization shape whether diversification becomes resilience or maladaptation (Frawley et al., 2024; Green et al., 2021; Salgueiro-Otero et al., 2022; Shah et al., 2025). For Bajo communities, the policy question is therefore not simply how to create alternative livelihoods, but how to expand the capability to choose livelihoods that sustain ecological integrity and cultural continuity.

Mangrove stewardship should be understood as the practical arena where these capabilities are tested. Mangrove restoration can contribute to coastal protection, fisheries, and carbon mitigation, but plantingbased approaches often fail when hydrology, local knowledge, or long-term monitoring are neglected (Ebeler et al., 2026; Marquez & Olavides, 2024). Community definitions of mangrove health may include fish abundance, accessibility, shoreline stability, cultural benefits, and daily use, not only tree density or carbon stock (Elwin et al., 2024). This broader definition is particularly relevant for Bajo settlements because mangroves may function indirectly as nursery habitat, storm buffer, and livelihood support even when households do not harvest mangrove wood intensively.

The recent literature also warns that coastal adaptation and mangrove governance are discursive processes. The shift from conversion to conservation and then to carbon changes whose knowledge counts and how value is allocated (Song et al., 2021). Plural valuation is therefore essential because mangroves are not only carbon reservoirs but also food landscapes, cultural places, coastal protection systems, and livelihood commons (Miller & Tonoto, 2023). Vulnerability-based studies of blue carbon ecosystem services show that conservation can reduce social vulnerability when it strengthens adaptive capacity, institutions, and livelihood options (Quiros et al., 2021). Ecosystem-based adaptation literature similarly emphasizes participatory approaches because climate adaptation is more durable when communities shape the interventions that affect them (Vasseur, 2021). In this sense, the call for social-ecological understanding in fisheries adaptation is equally applicable to mangrove blue carbon governance (Salgueiro-Otero & Ojea, 2020).

Table 2. Bajo and fisheries evidence used to interpret adaptation

Evidence stream	Main contribution	Key risk if ignored	Implication for review	Ref.
Bajau co-management	Shows that participation fails when institutions do not recognize Bajau customary realities.	Co-management becomes procedural inclusion without power.	Treat participation as recognition and influence, not attendance.	Ariando & Arunotai, 2022
Bajo Mola livelihood adaptation	Documents fish processing, aquaculture, and marketoriented adaptation in Wakatobi.	Adaptation is misread as simple coping.	Frame adaptation as livelihood innovation under constraint.	Marlina et al., 2021
Sama Bajo poverty and prosperity	Highlights internal differentiation and uneven access to livelihood opportunities.	The community is treated as homogeneous.	Analyze class, assets, market ties, and household position.	McWilliam et al., 2021
Local wisdom and mangrove preservation	Shows cultural knowledge can contribute to mangrove protection.	Local knowledge is romanticized or ignored.	Use local wisdom as practical governance knowledge.	Sulaiman et al., 2023
Fisheries adaptation reviews	Demonstrate that agency, assets, networks, and external support shape adaptation.	Diversification is assumed to be automatically positive.	Assess whether new livelihoods expand capability or create new risks.	Shah et al., 2025; Salgueiro-Otero et al., 2022

Local and scientific knowledge	Shows that climate adaptation improves when knowledge systems interact.	Policy depends only on external expertise.	Design participatory monitoring and learning platforms.	Gianelli et al., 2021; Whitney et al., 2020

Synthesis of Table 2. The Bajo-related evidence demonstrates why the review should not reduce Bajo communities to a vulnerable population. The studies instead reveal agency under constraint: livelihoods adapt, local wisdom matters, and identity is shaped by policy recognition. This evidence anchors the article in a specific maritime community while allowing lessons to speak to wider coastal social-ecological systems.

5. BLUE CARBON LIVELIHOODS

Opportunities and Limits

Table 3 converts the blue carbon literature into a safeguards agenda. It shows that blue carbon livelihoods cannot be judged only by carbon price, area restored, or credits generated. They must be judged by whether they strengthen rights, ecological care, institutional trust, and livelihood security. This is especially important for Bajo communities because their coastal claims may be socially strong but formally weak. If carbon projects are built on unclear tenure, they can turn climate mitigation into a new form of exclusion.

Recent studies of blue carbon governance emphasize project feasibility and stakeholder readiness. Karpowicz et al. (2024) argue that local communities need support across project development, capacity building, transparency, and partnership. Ewane et al. (2025) show that stakeholders must address prefeasibility issues before expecting mangrove-based carbon markets to deliver benefits. Nyangoko and Mang'ena (2026) similarly show that coastal stakeholders may be willing to engage in mangrove blue carbon projects, but they also identify risks involving carbon-credit knowledge, monitoring, project timelines, benefit sharing, and resource rights. These findings are directly applicable to Bajo communities because participation without understandable rules is not meaningful participation.

Blue carbon is also multi-level governance. Nationally determined contributions, greenhouse gas inventories, carbon standards, and marine spatial planning increasingly shape the value of mangrove ecosystems (Dencer-Brown et al., 2022; Purushotham & Thompson, 2026; Zhao et al., 2022). Indonesiaspecific literature on blue carbon governance and mangrove conservation further suggests that national climate opportunities must be translated into local safeguards if they are to support community well-being (Arifanti et al., 2025; Prihatiningtyas et al., 2024). For Bajo communities, this means policy alignment must work in two directions: local stewardship should inform national climate reporting, and national climate policy should return rights, resources, and recognition to local custodians.

The literature also supports caution. Global analyses identify both potential and limits of mangrove blue carbon mitigation (Zeng et al., 2021). Technical studies on assessment and accounting show that measurement, remote sensing, soil carbon variability, and permanence require careful methods (Dutta Roy et al., 2024; Kelleway et al., 2020; Macreadie et al., 2022). Policy-oriented research highlights risks of abstraction, co-production, and market governance (Thoni & Rummukainen, 2025). Thus, blue carbon should be presented to Bajo communities as one possible component of livelihood resilience, not as a guaranteed income source.

A more defensible approach is to treat blue carbon as a co-benefit of mangrove stewardship. When mangrove restoration improves fish habitat, shoreline protection, food products, and local enterprises, carbon finance may strengthen an already valuable social-ecological system. This interpretation is supported by work on mangrove food products as alternative livelihoods (Lukman et al., 2025), economic valuation of South Sulawesi blue carbon (Malik et al., 2026), and blue carbon as a nature-based climate strategy for mangrove conservation (Hilmi et al., 2025). The Bajo research agenda should therefore prioritize livelihood resilience first and carbon revenue second.

Table 3. Blue carbon safeguards for Bajo-oriented mangrove stewardship

Governance issue	Risk in literature	Required safeguard	Bajo relevance	Ref.
Early engagement	Communities are often consulted after project design.	Participatory mapping, consent, and shared objectives before carbon contracting.	Recognizes Bajo as custodians rather than project recipients.	Karpowicz et al., 2024; Ewane et al., 2025
Benefit sharing	Unclear distribution rules can reduce trust and create conflict.	Transparent agreements, accessible timelines, and public accounting.	Links carbon benefits to household and communal resilience.	Nyangoko & Mang'ena, 2026; Huxham et al., 2023
Rights and access	Carbon projects may restrict resource use where tenure is unresolved.	Tenure assessment and recognition of customary or local use rights.	Prevents blue carbon from becoming coastal enclosure.	Thoni & Rummukainen, 2025; Ariando & Arunotai, 2022
Plural valuation	Carbon metrics can overshadow food, culture, protection, and identity.	Value mangroves as carbon, fisheries habitat, cultural landscape, and commons.	Keeps blue carbon aligned with lived human ecology.	Miller & Tonoto, 2023; Buenavista & Purnobasuki, 2023

Policy alignment	Local stewardship may be disconnected from NDCs and inventories.	Connect local monitoring to district planning and national climate reporting.	Turns stewardship into recognized climate contribution.	Dencer-Brown et al., 2022; Prihatiningtyas et al., 2024; Zhao et al., 2022
Feasibility and permanence	Carbon benefits face market, measurement, and permanence constraints.	Conservative finance design, long-term monitoring, and risk disclosure.	Avoids overpromising carbon income to coastal households.	Zeng et al., 2021; Dutta Roy et al., 2024; Macreadie et al., 2022

Synthesis of Table 3. The safeguard table translates the blue carbon literature into design principles. It shows that carbon projects become socially meaningful only when they are linked to early engagement, rights, benefit sharing, plural valuation, policy alignment, and transparent risk communication. These conditions are especially important for Bajo communities whose tenure and institutional recognition may be fragile.

6. INTEGRATED FRAMEWORK FOR BAJO HUMAN-ECOLOGICAL RESILIENCE

The synthesis of the three tables leads to an integrated framework: climate stress and policy change affect Bajo communities through ecological disruption, livelihood uncertainty, and institutional marginality; Bajo adaptive capacity is shaped by mobility, knowledge, assets, social organization, and recognition; mangrove stewardship mediates between ecological protection and livelihood security; and blue carbon becomes beneficial only when it is governed through safeguards, plural valuation, and fair benefit sharing.

This framework differs from carbon-centered conservation. A carbon-centered approach begins with the carbon asset and then asks how communities can participate. A human ecology approach begins with the social-ecological system and asks how carbon finance can support existing relations of care, use, and responsibility. The difference is not semantic. It changes research design, indicators, and policy priorities. Carbon-centered research measures hectares, biomass, credits, and abatement costs. Human-ecological research also measures access, trust, cultural continuity, food security, institutional recognition, and distribution of benefits.

For future empirical research, the framework implies a mixed-methods design. Household surveys should document livelihood portfolios, fishing effort, income sources, perceived climate impacts, mangrove dependence, adaptation strategies, and willingness to participate in restoration or carbon projects. Participatory mapping should identify fishing grounds, mangrove use areas, erosion zones, cultural spaces, and conflict points. Key informant interviews should examine district planning, carbon policy, conservation rules, and customary institutions. Ecological assessment should include mangrove structure, condition, regeneration, and local indicators of ecosystem health. Such a design would allow Bajo communities to be analyzed as both knowledge holders and governance actors.

The framework also suggests practical policy outputs: a Bajo human ecology profile, a mangrove stewardship typology, a livelihood resilience index, and a blue carbon safeguards checklist. These outputs would help bridge academic review and applied policy. They would also prevent the review from becoming only descriptive. The article's main contribution is to show that Bajo coastal resilience requires an alignment of climate adaptation, ecosystem stewardship, and justice-oriented carbon governance.

7. CONCLUSIONS

This critical review has argued that Bajo coastal communities should be understood through a human ecology perspective that integrates climate adaptation, mangrove stewardship, and blue carbon livelihood resilience. The reviewed literature shows that resilience is not only an ecological condition or an economic outcome. It is a relational capability shaped by marine knowledge, household strategies, social organization, institutional recognition, and access to ecosystem benefits.

Mangrove stewardship is the central bridge in this framework. It connects coastal protection, fisheries support, carbon sequestration, cultural value, and livelihood security. However, stewardship must not be treated as unpaid community labor for external conservation goals. It requires rights, capacity, participation, monitoring support, and fair benefit sharing. Blue carbon can contribute to Bajo resilience only if it is embedded in these safeguards.

The article therefore recommends a shift from carbon-centered conservation toward justice-oriented human ecology. For Bajo communities, the goal is not merely to insert local people into blue carbon projects. The goal is to design coastal climate action around lived realities, ecological knowledge, cultural resilience, and locally meaningful livelihoods. Future research should test this framework empirically in Bajo settlements by combining household-level livelihood analysis, participatory mangrove mapping, governance assessment, and blue carbon feasibility analysis.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability Statement

The data supporting this review consist of the literature extraction files and bibliographic records used by the authors. The compiled data are available from the corresponding author upon reasonable request.

Research Ethics

This article is a literature review and does not involve new human participants, animal subjects, or fieldbased data collection. Ethical approval and informed consent were therefore not required.

Author Contributions

Rustam Anwar: conceptualization, literature synthesis, original draft, and revision. Hasim: supervision and theoretical direction. Dewi Wahyuni K. Baderan: environmental science review and mangrove ecology input. Abdul Hafidz Olii: coastal and fisheries interpretation. Mahludin H. Baruwadi: livelihood and socioeconomic interpretation. All authors reviewed and approved the manuscript.

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