International Journal of Sustainable and Green Energy
2026, Vol. 15, No. 2, pp. 75–80
https://doi.org/10.11648/j.ijsge.20261502.11

SciencePG
Science Publishing Group

Research Article

Blue Economy and Renewable Energy: Opportunities and Challenges

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Abstract

This study examines the relationship between the Blue Economy and marine renewable energy, focusing on the opportunities the sector offers and the barriers that continue to slow its adoption. Using a hybrid ecological-developmental framework, the paper maps the environmental, economic, and social dimensions of marine renewables and classifies the structural, financial, and governance obstacles that constrain their wider deployment. Drawing on a systematic review of global case evidence, with particular attention to emerging economies and small island states, the analysis contrasts settings where integration has succeeded with those where institutional and structural constraints persist. The findings show that marine renewables can meaningfully reduce greenhouse gas emissions, diversify national energy portfolios, and strengthen energy security, but that the pace and depth of their adoption depend heavily on context-specific financial and governance conditions rather than on technology alone. The paper closes with evidence-based recommendations for policymakers, financing institutions, and private investors on the design of financing mechanisms, governance structures, and incentive frameworks capable of accelerating an equitable transition to marine renewable energy.

Keywords

Blue Economy, Marine Renewable Energy, Emerging Economies, Policy Implications, Governance, Blue Finance

1. Introduction

Growing pressure to find sustainable development pathways, together with the need to curb climate change, has pushed the Blue Economy toward the center of international policy debate. Championed by institutions such as the World Bank, the concept calls for using ocean resources in ways that support economic growth, improve livelihoods, and create jobs without undermining the health of marine ecosystems. It is closely tied to the United Nations Sustainable Development Goals, particularly SDG 7 on affordable and clean energy and SDG 14 on life below water [15]. Within this agenda, marine renewable energy offshore wind, tidal and wave power, and the newer floating solar technologies is increasingly seen as a technology capable of reshaping the relationship between economic activity and environmental stewardship [3, 7].

The opportunities are considerable: marine renewables can cut dependence on fossil fuels, strengthen energy security, create green jobs, and support coastal livelihoods [11, 13, 18]. Yet their integration into Blue Economy strategies remains held back by high upfront capital costs, technologies that are still immature in some sub-sectors, fragmented regulation, and financing that has not kept pace with ambition. Ecological risks add a further layer of complexity, requiring monitoring

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Received: 2 April 2026; **Accepted:** 14 April 2026; **Published:** 24 July 2026

and adaptive governance that much of the current literature still treats as a separate concern rather than as part of the same policy problem.

This study responds to that gap in three steps. First, it maps the opportunities for using marine renewable energy to strengthen the Blue Economy across environmental, economic, and social dimensions. Second, it identifies and classifies the main barriers to adoption financial, regulatory, and technological. Third, drawing on global case evidence, with particular attention to emerging economies and small island states, it distills lessons from both successful integration and settings where structural and institutional constraints persist. Taken together, these steps are meant to produce a balanced account of what marine renewables can realistically deliver and what stands in the way.

The contribution is threefold. Academically, the paper draws an explicit link between Blue Economy scholarship and the renewable energy transition literature, two bodies of work that are more often reviewed separately than together. Practically, it offers policymakers, financing institutions, and private investors a basis for designing financing mechanisms, governance arrangements, and incentives that can accelerate adoption. Finally, by giving deliberate attention to emerging economies and small island states, it aims to move the discussion beyond the European and East Asian cases that dominate the existing literature.

2. Theoretical and Conceptual Framework

The idea of the Blue Economy has shifted considerably over the past two decades. It began as an extension of traditional maritime industries fisheries, shipping, and coastal tourism in which growth and job creation were the primary concerns, with limited attention to ecological cost. That framing drew criticism for overlooking environmental externalities and for sitting uneasily with long-term sustainability goals. More recent work, including that of international organizations such as the World Bank and the United Nations, instead defines the Blue Economy as the sustainable use of ocean resources for growth, improved livelihoods, and ecosystem preservation together a redefinition that opened the door for renewable energy to become a central part of the discussion [14].

Marine renewables offshore wind, tidal, wave, and floating solar were once treated as peripheral experiments. They are now widely regarded as important to both climate and development goals: offshore wind, in particular, has become cost-competitive with fossil fuel generation in a growing number of markets, and multilateral institutions increasingly highlight its role in addressing energy poverty in coastal and island states [6]. The literature is nonetheless divided. Optimistic accounts stress the pull marine renewables exert on foreign investment, their contribution to energy diversification and innovation, and the jobs they generate.

More cautious accounts point to high capital costs, the immaturity of wave and tidal technologies, and governance gaps in developing countries [4, 8]. This tension between transformative promise and structural limitation runs through much of the field. Two broader theoretical traditions help make sense of this tension. Ecological economics treats the integration of renewables into the Blue Economy as close to a necessity, given the finite regenerative capacity of marine ecosystems.

Development economics, by contrast, frames the same question in terms of efficiency, competitiveness, and innovation. Reconciling the two requires a hybrid framework one particularly suited to emerging economies, where development needs are pressing and ecological vulnerabilities are often acute at the same time. This study adopts such a hybrid ecological-developmental framework, treating the sustainable deployment of marine energy as a problem that has to be evaluated against both biophysical limits and socio-economic need simultaneously, rather than privileging either environmental preservation or economic growth on its own. Technological innovation, policy design, and community engagement are each assessed against both criteria throughout the analysis that follows.

This divergence in perspective, compounded by a marked regional imbalance in the existing scholarship most of it grounded in European and East Asian experience points to a genuine research gap. Technical assessments of marine renewables are plentiful, but integrated analyses connecting these technologies to broader development concerns such as poverty reduction, job creation, and regional equity remain scarce, especially for the socio-economic and institutional context of the Global South. The present study addresses that gap through a comparative, context-sensitive reading of the evidence.

3. Literature Review

Research at the intersection of the Blue Economy and renewable energy has expanded considerably over the past two decades, tracking the rising urgency of climate policy, the global energy transition, and the broader search for sustainable development models. The field draws on engineering, economics, policy studies, and environmental science, and several recurring themes and debates can be traced through it.

Early work in the 1990s and 2000s concentrated on the technical feasibility of marine renewable systems wave, tidal, and offshore wind. Feasibility studies from Northern Europe (Denmark, Germany, the United Kingdom) established the commercial viability of offshore wind fairly early, but largely within an engineering frame that left socio-economic and ecological impacts for later. That early, narrowly technical optimism helped drive the technology forward, while leaving the governance and financing difficulties that would surface later in other regions comparatively unexamined.

By the 2010s the field had broadened. A number of studies emphasized the contribution of marine renewables to energy security [5, 12, 16, 17, 19] while others turned to their potential for green employment and local economic development. Comparative work during the same period looked at synergies between renewable energy and other Blue Economy sectors aquaculture, shipping, coastal tourism including evidence that offshore wind and fisheries can, under the right conditions, coexist within the same coastal space [2, 9]. Cost and risk remain persistent themes throughout this literature. Marine energy infrastructure is capital-intensive and frequently depends on state subsidy or international financing to get built at all [20]. The barriers are more pronounced still in developing regions: work on Sub-Saharan Africa shows that weak governance, thin institutional capacity, and shallow financial markets significantly slow the adoption of marine renewable energy even where the physical resource is abundant, a picture that contrasts sharply with the European experience, where stronger regulatory frameworks and sustained political commitment have supported faster deployment. A separate strand of the literature considers the environmental implications of marine renewables directly. Displacing fossil generation clearly helps reduce greenhouse gas emissions, and offshore wind in particular has one of the lowest lifecycle emissions profiles of any generation technology. But the same projects can alter sediment flows or disturb marine habitats, and the long-term ecological effects of tidal and wave technologies remain comparatively understudied [10]. A separate strand of the literature considers the environmental implications of marine renewables directly. Displacing fossil generation clearly helps reduce greenhouse gas emissions, and offshore wind in particular has one of the lowest lifecycle emissions profiles of any generation technology. But the same projects can alter sediment flows or disturb marine habitats, and the long-term ecological effects of tidal and wave technologies remain comparatively understudied. Adewumi et al. argue for a precautionary approach built around continuous monitoring and adaptive management a position that captures the ongoing tension between clean-energy ambition and ecological stewardship [1].

More recent work has shifted toward the financial and governance side of the Blue Economy. Blue finance mechanisms for channeling public and private capital into ocean-based projects has attracted growing research interest, though critical reviews note that actual flows into marine renewables still lag well behind land-based renewables, exposing a gap between the enthusiasm the concept generates and what is being financed in practice. Without stable policy environments and mechanisms for sharing risk, private capital is likely to stay cautious.

A further gap concerns geographic coverage: emerging economies and small island developing states remain marginal to this literature relative to their exposure to both the opportunities and the risks involved. This imbalance risks encouraging a one-size-fits-all model of renewable integration poorly suited to contexts with distinct socio-economic vulnerabilities, newer institutions, and different ecological sensitivities the gap this study sets out to address by centering those contexts rather than treating them as an afterthought.

Finally, the literature tends to treat opportunities and challenges separately rather than within a single integrated frame: work emphasizing economic opportunity tends to understate ecological risk, and work emphasizing environmental concerns tends to understate developmental benefit. A smaller, interdisciplinary strand has begun to bridge this divide through systems approaches that consider economic, social, and environmental dimensions together, though the integration remains partial. Taken as a whole, the field has moved from narrow technical feasibility studies toward broader debates on sustainability, finance, and governance, but significant gaps remain in understanding the political economy of adoption in developing regions and in building frameworks that reconcile growth with ecological preservation.

4. Methodology

The study is designed to give a systematic account of the opportunities and challenges involved in integrating renewable energy into the Blue Economy. Given the multidimensional nature of the problem spanning environmental, economic, and governance concerns a qualitative research design was adopted, supplemented by quantitative indicators where these were available, so as to combine analytical depth with the ability to situate the findings within observable empirical trends. The evidence base consists mainly of secondary sources: peer-reviewed journal articles drawn from Scopus, Web of Science, and ScienceDirect, complemented by policy reports and working papers from the International Renewable Energy Agency (IRENA), the World Bank, the OECD, and the United Nations Development Programme, along with industry reports from renewable energy associations and government agencies.

Sources were selected purposively. To be included, a study had to (a) be a peer-reviewed article or an authoritative report from an international organization, (b) address the intersection of the Blue Economy and marine renewable energy directly, (c) fall within 2000-2024, so as to capture the evolution of the field, and (d) offer comparative analysis or case evidence from coastal or island states. Particular weight was given to work examining the socio-economic and governance dimensions of adoption in emerging economies, given the gap identified above.

The material was analyzed through deductive thematic content analysis organized around four themes established from the literature review before coding began: (i) economic opportunities investment, employment, energy security; (ii) environmental implications carbon reduction, ecosystem impacts; (iii) technological challenges infrastructure maturity; and (iv) governance and financing mechanisms regulatory frameworks, blue finance. Each source was read and coded against these themes, allowing findings to be compared and contrasted

across contexts and disciplines. Quantitative indicators from IRENA, the World Bank, and national statistical offices installed offshore wind capacity, investment flows into marine energy, and related employment trends were used to give empirical scale to the qualitative discussion, rather than as inputs to any econometric model.

The design has clear limitations. Reliance on secondary sources carries the usual risk that the analysis inherits whatever bias or incompleteness exists in the published record. The literature itself is unevenly distributed, weighted toward European and East Asian cases with stronger infrastructure and governance, which may limit how far the findings generalize to other regions. The absence of primary data collection also means the study cannot capture real-time perspectives from the policymakers, industry actors, and communities directly engaged in Blue Economy initiatives a gap that motivates several of the future-research directions proposed later in the paper. Notwithstanding these limits, systematically reviewing and synthesizing the existing scholarship and policy evidence in this way produces a reasonably holistic account of where renewable energy fits within the Blue Economy, while flagging the gaps particularly around the political economy of adoption in developing regions that remain open.

5. Findings and Discussion

Three points emerge clearly from this review. First, the economic case for marine renewables is well established but conditional. Offshore wind has become a mainstream electricity source in Europe, led by Denmark, Germany, and the United Kingdom, and IRENA's 1.5℃-consistent pathway projects global offshore wind capacity rising from roughly 34 GW in 2020 to around 380 GW by 2030 more than a tenfold increase alongside substantial job creation and investment. China has expanded its own offshore wind sector rapidly enough to overtake several European markets, illustrating that the pace of adoption tracks industrial strategy and policy support as much as it does resource endowment or technology cost. For coastal and island states, the potential extends beyond electricity generation to powering aquaculture, desalination, and port operations, reducing dependence on imported fuel. Even so, the scale of the European and Chinese experience is itself evidence that realizing these gains depends on sustained institutional backing rather than on market forces alone a point that pure market-centered accounts of development tend to underplay.

Second, the environmental picture is genuinely two-sided. Displacing fossil generation clearly supports climate goals, and well-sited projects can coexist with fisheries and marine protected areas, creating synergies between growth and biodiversity protection. But the evidence on sediment disruption and habitat interference is real, and long-term ecological effects of tidal and wave technologies remain thinly studied by comparison with offshore wind. Marine renewables are therefore best understood as both a climate solution and a potential source of localized ecological disruption if governance and monitoring are weak.

Third, the social and institutional picture varies sharply by region. Large-scale projects generate construction and operations jobs and stimulate local research and training, and in small island states, where energy poverty and unemployment are pressing, renewable deployment can support more inclusive growth. Social acceptance, however, is uneven: some coastal communities resist offshore projects over visual impact, disruption to fishing grounds, or distrust of foreign investors, underlining the importance of participatory governance in securing legitimacy and equitable benefit-sharing.

The barriers, in turn, cluster around finance, technology, and governance. Financial constraints are the most frequently cited obstacle: marine energy projects are capital-intensive, and that intensity deters private investment where credit markets are thin, as is often the case in developing economies. Europe has managed to attract investment through feed-in tariffs, auctions, and green bonds; comparable instruments remain underdeveloped elsewhere, and the literature is fairly consistent in calling for blended finance and blue bonds to close the gap without which diffusion is likely to keep favoring wealthier states over vulnerable coastal ones.

Technology adds a further constraint. Offshore wind is commercially proven, but wave and tidal systems remain at demonstration or pilot scale with uncertain cost trajectories, and maintenance in harsh marine conditions raises operating costs and limits how quickly capacity can scale. Governance compounds both problems: effective deployment requires coherent maritime spatial planning and coordination across energy, environment, fisheries, and tourism authorities, and in many countries fragmented institutions and regulatory uncertainty discourage the investment that would otherwise materialize. Evidence from Sub-Saharan Africa and South Asia shows that even strong technical potential can go largely unrealized where governance is weak, in clear contrast to the European Union's integrated maritime policy and clearly stated renewable targets. In industrialized economies, the remaining debate is mostly about optimizing environmental trade-offs and securing public acceptance for technologies that are already commercially viable; in the Global South, the binding constraints are still financial, technological, and institutional. That contrast argues against one-size-fits-all policy prescriptions and for context-specific strategies that address institutional capacity and financing access before technology transfer can do much good a conclusion consistent with the hybrid ecological-developmental framework adopted in this study, which treats sustainable integration as inseparable from the governance and socio-economic realities of each region. Taken together, these findings show that integrating renewable energy into the Blue Economy is simultaneously a source of opportunity and a source of persistent difficulty. Opportunity is most visible where governance, technical capacity, and financing are already strong; difficulty is most acute where institutions are weak and economies are financially constrained. Advancing marine renewables therefore requires new financing models and more inclusive governance as much as it requires better technology.

6. Conclusion and Policy Implications

This study has shown that integrating marine renewable energy into the Blue Economy carries real transformative potential, but that potential is mediated at every turn by structural, financial, and governance conditions specific to each context. By adopting a hybrid ecological-developmental framework and giving deliberate weight to the Global South, the analysis moves past generalized assessments toward a more differentiated account of how sustainable marine energy deployment might actually unfold across different settings.

Three policy priorities follow from this. Governments should commit to comprehensive, cross-sectoral maritime spatial planning that reconciles energy development with fisheries, tourism, and conservation, reducing conflict and giving investors more confidence to commit capital. Financial barriers call for the deployment of blended finance, green and blue bonds, and stronger risk-sharing partnerships capable of mobilizing private capital in capital-constrained regions. And policymakers should move beyond treating this as a purely technological problem: the Blue Economy's promise is tied to broader development goals climate mitigation, poverty reduction, and reducing global inequality so integrating marine renewables into wider, more equitable development strategies is not simply desirable but necessary.

Future research could usefully pursue longitudinal studies of blue-finance mechanisms in small island developing states, empirical work on how integrated maritime spatial planning affects ecosystem health and economic diversification, and closer attention to the social and cultural dimensions of community acceptance for marine energy projects. Comparative, mixed-methods work on the political economy of adoption in under-researched regions would also help close the gaps this review has identified.

Abbreviations

SIDS	Small Island Developing States (SIDS)
IRENA	International Renewable Energy Agency
UNDP	United Nations Development Programme
SDGs	Sustainable Development Goals

Author Contributions

Omar Al-Kasasbeh: Conceptualization, Methodology, Data Curation, Formal Analysis, Writing – original draft, Writing – review & editing, Supervision

Conflicts of Interest

The author declares no conflict of interest.

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