



Climate Finance to Address Climate Vulnerability and Increase Resilience: A Review

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Abstract

This narrative review synthesises insights from 59 peer-reviewed articles, institutional reports, and empirical field studies published primarily between 2010 and 2025, drawn from databases including Google Scholar, ScienceDirect, Scopus, and Web of Science, as well as institutional repositories such as FAO, IPCC, NOAA, and national bodies like the Department of Fisheries, India. It examines the ecological impacts of climate change, emerging adaptation strategies, and the critical role of climate financial services in enhancing sectoral resilience. The review identifies three dominant thematic clusters: vulnerability assessments, adaptation and climate finance initiatives.

A central focus of the review is on climate financial services, public, private, and blended financing models, which facilitate investments in climate adaptation and mitigation. International Public finance instruments and public finance instruments at the national level in India and Sri Lanka have been studied separately. Private sector tools offer alternative funding avenues but are constrained by high-risk perceptions and limited project bankability. Blended finance mechanisms, such as the Seychelles Blue Bond and the Global Fund for Coral Reefs, demonstrate the potential to de-risk investments and attract private capital toward sustainable blue economy initiatives.

The studies from India and Sri Lanka highlight that concessional credit, parametric insurance, and gen-

der-targeted financial windows can enhance adaptive capacity for small-scale fishers and aquaculture operators. The review underscores that effective fisheries adaptation requires participatory planning, inclusive access to finance, and integration of traditional knowledge with scientific forecasting. These findings provide actionable guidance for policymakers and stakeholders to strengthen sectoral resilience, improve livelihoods, and maintain fisheries productivity under changing environmental conditions.

Keywords: Climate finance, adaptation, fisheries, climate change, vulnerability

Introduction

The impact of climate change on fisheries and the communities that depend on them for livelihoods has become increasingly evident in recent years, with current and projected risks indicating a significant loss of adaptive capacity and the degradation of ecosystem services vital to sustaining their wellbeing (Nurse et al., 2014). These impacts are especially severe for small-scale fishers in vulnerable coastal areas, where fisheries are important for ensuring food and income security, besides being rooted in their cultural identities (Nurse et al., 2014; Barange et al., 2018). Climate change impacts such as extreme weather, sea-level rise, and erosion, coupled with socio-economic challenges like poverty, marginalisation, unstable income, and limited resources, weaken adaptive capacity, discouraging sustainable investment, and limiting their ability to absorb adaptation costs (Giri, 2016).

In the context of climate change, adaptation is an essential strategy shaped by ecological conditions, social dynamics, traditional knowledge, access to technology and financial resources, etc. (Asian

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Development Bank Institute [ADBI], 2022). Galappaththi, Ford, Bennett, and Berkes (2020) have suggested a bottom-up resilience-building exercise that offers equity benefits and opportunities in the areas of nutrition, food security and livelihood.

Climate finance has been proposed as a measure to enhance adaptive capacity and resilience of these communities (Barange et al., 2018). This involves improving their access to capital and financial services through policy initiatives, micro-finance options, and loan guarantee funds, thereby supporting both adaptation measures and the diversification of livelihoods (Mohtar, 2023). This review tries to look at climate finance as an adaptive strategy from the point of view of climate vulnerability of fishing communities. It summarises the initiatives both at the national and global levels that aim to support fishing communities and build resilience against climate change.

The review explores how climate impacts are being experienced on the ground, the strategies communities are using to adapt, and the critical role that climate finance plays in supporting resilience.

Methodology

The methodology for this literature is structured as a Narrative Review Article, designed to build a synthesis of the impacts of climate change on the fisheries sector, adaptive strategies and the available financial services to cope with these effects. The review started with a set of central questions intended to reveal how climate change is transforming fisheries, how communities are responding to

these stresses, and what the contribution of climate financial services is in fostering resilience.

An extensive search of scholarly databases and institutional repositories/websites, such as Google Scholar, Science Direct, Scopus, Web of Science, Food and Agriculture Organisation of the United Nations (FAO), IPCC, NOAA, Government departments (e.g., the Department of Fisheries in India), etc., was conducted. Although publications and reports from before 2010 are included in this review, priority was given to literature published between 2010 and 2025 (Fig. 1), as this period reflects significant policy-relevant developments in climate change research. This era was particularly marked by the release of the IPCC's 5th Assessment Report (2013-14), which emphasised the pressing need for climate finance (IPCC, 2014).

Keyword strings used included "climate change + vulnerability," "adaptation + small-scale fisheries", "climate finance + marine ecosystems", "impact + climate change + fisheries sector", and "climate finance + fisheries sector" as guides for the search. From the initial pool of approximately 120 records, a Critical screening was undertaken by reviewing titles, abstracts, keywords, and executive summaries. At the second stage, peer-reviewed articles and global institution-recognised reports were preferentially selected; opinion pieces, non-empirical papers, and studies without full-text access were excluded (Table 1).

In the final call 59 papers/reports were zeroed in and these were clustered into; (i) climate vulnerability, where the studies primarily defining the ecological,

Table 1. Inclusion and Exclusion criteria for the review

Criteria	Decision
Addresses climate vulnerability, adaptation strategies, or climate finance linked to climate impacts	Included
Empirical studies, theoretical/conceptual analyses, or review articles from peer-reviewed journals/credible reports	Included
Global, regional, or country-specific studies on climate risks/adaptation	Included
Published in English with full text available	Included
Most recent/complete version of a study	Included
Non-scholarly sources (opinion pieces, non-empirical papers) or no full-text access	Excluded
Non-English studies or no accessible full text	Excluded
No clear link to adaptation/vulnerability or climate finance	Excluded
Duplicate publications or earlier versions of the same study	Excluded

economical, or social sensitivity and exposure of fisheries systems to climate hazards; (ii) adaptation and coping strategies where papers detailing on-the-ground responses, coping mechanisms, or policy strategies designed to reduce system harm or maximise opportunities; and (iii) climate finance where papers focused on the instruments, channels, governance, or allocation of capital (public, private, or blended) intended to fund adaptation or mitigation projects (e.g., studies on blue bonds, insurance mechanisms, or development bank lending). This deliberate approach ensures a rigorous, focused, and coherent narrative structure for the subsequent analysis.

Profile of the literature reviewed

The year-wise percentage distribution of the selected articles is given in Fig.1.

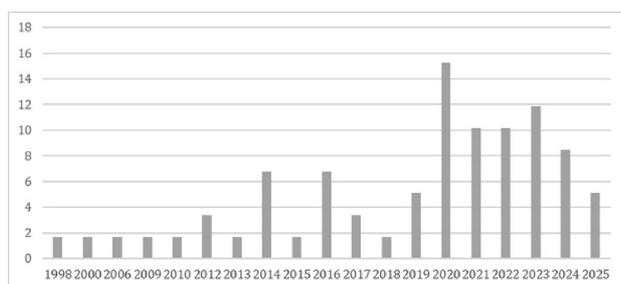


Fig. 1. Year-wise percentage distribution of selected research articles

About 30% of the studies included had a global focus, while 70% were region or country-specific. Chronologically, the literature reflected a growing interest in climate-related fisheries research after the 2015 Paris Agreement. The studies also varied by methodological design, including policies, reports, reviews, case studies, and more. Thematically, the reviewed studies addressed aspects of vulnerability -environmental, social, or institutional, affirming its central role in fisheries under climate stress. Adaptation emerged as a universally acknowledged priority, while climate finance featured prominently in many studies, reflecting its rising relevance, even if unevenly integrated across the literature.

Climate vulnerabilities in the fisheries sector

In climate science, vulnerability is commonly defined as a function of exposure to climatic hazards, sensitivity to those hazards, and adaptive

capacity (Adger, 2006). In the fisheries context, this means examining how environmental changes intersect with social and economic conditions to produce risk. For example, a coastal community's vulnerability will be high if it faces large climate exposures like storms and sea level rise, has high sensitivity, and has low capacity to adapt. Cinner et al. (2012) characterised reef-fishing communities along these lines, finding that even within a single region, some villages were far more exposed and sensitive than others. Vulnerability is not the result of climate alone, but emerges from the interaction of climate hazards and the community.

Climate change, including ocean acidification, rising sea temperatures and extreme weather events, directly affects fishing populations. Sea-level rise and storm surges are drowning coastal habitats. This can permanently erode shorelines, as observed in low-lying atolls (Cinner et al., 2012; Nurse et al., 2014). These environmental changes significantly impact fishing operations and safety, leading to decreased catch yields, shifts in fish distribution, and an increased incidence of natural disasters (Daw, Adger, Brown, & Badjeck, 2009; Weatherdon, Magnan, Rogers, Sumaila, & Cheung, 2016).

Importantly, ecosystem impacts translate into social impacts: fish that fishermen can no longer catch means lost income and food. Studies show that fish populations in tropical areas are shrinking, while some fish are moving toward cooler waters in higher latitudes, which can benefit fisheries in those regions for a short time (Hollowed et al., 2013; Weatherdon et al., 2016; Henderson & Smith, 2022). Thus, the consequences of these disruptions are particularly alarming for tropical fisheries, which could see up to a 40% reduction in potential catch by 2050, drastically affecting food security and economic stability in many coastal regions (Lam et al., 2020).

Not all fishing communities face the same level of threat from climate change. Their vulnerability varies based on ecological, economic, and social factors, underscoring the importance of developing a range of tailored solutions (Koehn et al., 2022). Vulnerability assessments often fail to adequately capture the dynamic interplay between social and ecological components, necessitating the development of integrated frameworks that reflect the true complexity of social-ecological systems (Thompson & Wilson, 2022).

Subsistence and small-scale fishers usually work with extremely limited financial margins, lacking savings, insurance, or adequate access to credit. Any limitations imposed on fishing days, whether temporary or permanent, can substantially undermine the economic stability of fishing communities, as fishing constitutes their principal means of sustenance (Islam, Sallu, Hubacek, & Paavola, 2014; Koehn et al., 2022). It affects not just fishers but also a wide range of related livelihoods along the fish value chains, including those involved in transportation, fish marketing, and processing. It can cause a reduction in the amount they are able to trade, affecting their income and potentially threatening their sustainability (Dudley et al., 2021). The paucity of alternative employment opportunities, combined with barriers such as low education levels, limited skills, and a strong emotional attachment to fishing traditions, further intensifies these vulnerabilities (Colburn et al., 2016). Poorer fishing communities are hit the hardest, especially in countries like Bangladesh and India, where people depend heavily on fishing and have few other ways to earn a living (Cinner et al., 2012; Islam et al., 2014; Umamaheswari et al., 2021). These communities often face both climate risks and social challenges, making it even harder for them to cope.

In coastal Bangladesh, Islam et al. (2014) document that years with extreme heat and rainfall variability saw as much as a 20% drop in traditional dry-fish production, directly reducing incomes. Ksenofontov, Backhaus, and Schaepman-Strub (2017) reported that reduced fish populations are contributing to the decline of traditional food practices and disrupting spiritual connections to fishing grounds in Arctic Yakutia in Russia. Similarly, Koomson, Davies-Vollum, and Raha (2020) observed that Ghanaian fishing households, already facing economic hardship, reported climate-related losses that further strained their livelihoods. Limited infrastructure compounds vulnerability: many rural fishing villages lack refrigerated storage, forcing them to sell catch daily at low prices. In Tamil Nadu, India, Umamaheswari et al. (2021) found that 64% of fishing families endured major losses due to spoilage when unusually high temperatures and heavy rains disrupted drying and storage.

Another significant impact faced by the fisheries sector is the damage to port infrastructure. Sea level rise can cause damaging submersion, requiring costly adaptations that smaller ports may struggle

to afford. Extreme winds lead to port closures, disrupting fishing activities. Fishing communities vulnerable to climate change should prioritise enhancing fisheries management, diversifying income streams, promoting value-added fishery products, and strengthening fisheries-related education (Pinto et al., 2023). Vulnerability is the outcome of intersecting stresses: high exposure to climate hazards and low adaptive capacity. These interrelated impacts highlight the urgent need for proactive marine conservation strategies, adaptive fisheries management, and international collaboration to mitigate the far-reaching consequences of climate change on coastal communities and their economies. There is no single solution that works for all. The most successful approaches to dealing with climate impacts on fisheries are those that combine environmental actions with support for local communities. For example, restoring fish habitats and involving communities in decision-making leads to better outcomes than doing either one alone (Harvey et al., 2025).

Adaptation and mitigation strategies

The fisheries sector has seen the implementation of various adaptation strategies to mitigate the adverse impacts of climate change while striving to ensure long-term ecological sustainability and livelihood security. One of the most prominent strategies is ecosystem-based fisheries management (EBFM), which shifts the focus from single-species management to a holistic ecosystem approach. EBFM incorporates ecological relationships, habitat protection, and climate projections into fisheries planning, thereby promoting the resilience of marine ecosystems under changing environmental conditions (NOAA Fisheries, 2024). Another strategy that works at the grassroots level is community-based adaptation (CBA), which plays a vital role in enhancing adaptive capacity, particularly in small-scale fisheries. CBA approaches empower local communities by integrating traditional ecological knowledge with contemporary adaptation practices. These strategies often involve training in sustainable fishing techniques, livelihood diversification to reduce dependence on marine resources, and local governance mechanisms for managing fish stocks (Ellis, 2000). Such participatory adaptation measures are particularly effective in reinforcing coastal communities' social and ecological resilience.

Furthermore, ecosystem-based and community-based approaches are increasingly recognised as comple-

mentary, with their integration offering a robust pathway for building climate resilience in marine fisheries (Harvey et al., 2025). The vulnerability of fishery-based livelihoods extends beyond climate-related factors. Adaptive capacity will significantly rely on investments in infrastructure at landing sites, as well as the availability of suitable storage facilities and market access (Etongo & Arrisol, 2021). To effectively lessen livelihood vulnerability in coastal fishing communities, interventions must be multifaceted, addressing the interconnected factors of exposure, sensitivity, and adaptive capacity concurrently (Islam et al., 2014). A paradigm shift toward adaptive, inclusive, and ecosystem-conscious fisheries governance through multi-pronged strategies is crucial for safeguarding marine biodiversity and ensuring the sustainability of fisheries in the face of accelerating climate change.

Migration is among the most prevalent coping mechanisms, particularly in coastal regions increasingly threatened by sea-level rise and extreme weather events. Migration can alleviate pressure on dwindling local resources and provide access to safer environments. Still, it also presents significant challenges, including erosion of social cohesion, disruption of cultural ties and economic instability in both origin and destination areas (Scoones, 1998). Livelihood diversification represents another crucial coping mechanism, wherein households integrate farming/fishing with non-agricultural/non-fishing income sources to buffer against climate-related shocks. This strategy enhances resilience by reducing dependence on a single income stream, enabling households to absorb and recover from climate disruptions better. It may include off-farm employment, entrepreneurship, or investments in education and skill development (Adger, 2006). For instance, training programs in Bangladesh have helped fishers learn sewing or vehicle repair, so they can find work on land when catches are low (Scoones, 1998).

Collective enterprises (cooperatives) that bundle assets (boats, gear) also spread risk. Equally important are social networks, which play a vital role in facilitating community coping and resilience during crises. These networks support resource sharing, the dissemination of timely information, and emotional sustenance, helping households manage climate impacts collectively rather than in isolation (Adger, 2006). Localised responses anchored in traditional ecological knowledge enrich

coping capacities at the community level. Communities often draw upon generations of lived experience to interpret environmental signals, implement sustainable practices, and develop context-specific solutions (Kupika, Gandiwa, Nhamo, & Kativu, 2019). Integrating this indigenous knowledge with scientific insights can significantly enhance the relevance and effectiveness of adaptation strategies. Moreover, collective action facilitated through community-based organisations and informal social groups strengthens resilience by fostering cooperation, pooling resources, and implementing adaptation measures that are socially inclusive and locally grounded (Carmen et al., 2022). Collectively, these coping strategies underscore the importance of empowering local communities, enhancing social capital, and recognising the interplay between traditional and modern knowledge systems in climate resilience discourse.

Importantly, most studies stress that adaptation in fisheries must be multifaceted and inclusive. Cinner et al. (2012) introduced a social adaptive capacity index for coral fisheries, and the authors used it to investigate vulnerabilities in five South African countries. Harvey et al. (2025) found that adaptation projects combining ecosystem restoration with community governance (rather than single-strategy projects) yield the strongest long-term resilience. In practice, effective adaptation in fisheries often blends ecological, technological, and social interventions. Finally, adapting fisheries to climate change can also help with other goals, like protecting biodiversity, storing carbon, and supporting ecotourism. Fixing existing problems like overfishing and pollution also helps fish populations deal with climate stress. In fact, combining fisheries work with broader coastal development plans like mangrove tourism or blue carbon projects can bring in more money and support from communities (McIlgorm et al., 2010).

The most commonly identified barriers to effective community-based adaptation include cognitive and behavioural factors; the structure of government and governance; communication challenges and language barriers; inequality, power dynamics, and marginalisation; limitations in resources such as finances, time, human capacity, access to information and technology, and infrastructure; and constraints in physical systems and processes. From this standpoint, supporting effective adaptation and policy development in a broader small-scale fisher-

ies (SSF) context requires a deeper understanding of how various marginalised communities experience climate change and how they respond to it across different scales (Galappaththi et al., 2022). Thus, the studies related to the adaptation of fishing communities to climate challenges are a need of the hour for the effective formulation of policies.

Climate Financial Instruments as an Adaptation Measure

Given the complexity and scale of climate-induced challenges, dedicated climate finance is essential to support adaptation and coping strategies, including ecosystem-based fisheries management and community-based adaptation initiatives. By facilitating access to targeted investments, capacity-building efforts, and climate-smart technologies, climate finance can empower communities to move beyond reactive coping mechanisms toward proactive, long-term resilience while supporting the ecological integrity of marine ecosystems in an era of accelerating climate change.

Climate financial services encompass various mechanisms and instruments designed to support climate change mitigation and adaptation efforts by channelling capital into projects that aim to reduce greenhouse gas emissions and strengthen resilience against climate-related challenges. These financial services are crucial in facilitating investments contributing to environmental sustainability (Mohtar, 2023). A significant share of climate finance is allocated to renewable energy developments, demonstrating its priority in global mitigation strategies. On the other hand, for climate adaptation, these services provide essential funding for initiatives that assist communities and ecosystems in managing climate risks, including coastal protection, disaster risk management, and climate-resilient infrastructure (Dobush et al., 2022). Financial products like climate risk insurance also help vulnerable populations cope with economic losses resulting from climate-related hazards.

Climate finance can be public, private or blended. Public finance is crucial in creating enabling conditions and strategically incentivising private capital to complement public sector resources. There are numerous public initiatives in climate finance aimed at mitigation and adaptation, with a growing focus on the ocean and the blue economy. These national and international initiatives involve gov-

ernments, multilateral development banks, and specialised climate funds.

Meanwhile, private finance includes investments from businesses, financial institutions, and individual investors in climate-related sectors. Mechanisms such as green bonds and blue bonds are instrumental in mobilising funds for environmental and marine conservation projects. However, private sector contributions to sustainable development and the blue economy remain limited, necessitating strategies to incentivise greater investment in natural capital protection (Narula et al., 2023).

To bridge this gap, blended finance strategically combines public and development funds with private sector capital to enhance investment appeal. By reducing financial risks and improving returns, it encourages private investments in climate-related initiatives (Dobush et al., 2022).

International Public Finance Initiatives

Several international funds established under the United Nations Framework Convention on Climate Change (UNFCCC) play a significant role in public climate finance, particularly in supporting climate adaptation and mitigation in developing countries. The Green Climate Fund (GCF) is one of the primary financing mechanisms under the UNFCCC, providing funding through grants for projects that enhance resilience and reduce emissions. GCF is operational in developed, developing, least developed and small island developing states. The GCF has also played a role in financing initiatives like the Global Fund for Coral Reefs and the Subnational Climate Finance Fund (Dobush et al., 2022). Additionally, the Adaptation Fund (AF) established under the Kyoto Protocol and now serving the Paris Agreement, finances climate adaptation projects, particularly in developing countries (ADB, 2022). This fund derives financing from a share of proceeds from the Clean Development Mechanism (CDM) and prioritises projects that enhance ecosystem resilience. Projects funded by the Adaptation Fund have backed ecosystem-related initiatives designed to tackle climate change within fisheries, forestry, wetlands and ecologically sensitive areas such as coral reefs. These efforts have centred on ecosystem-based adaptation to benefit coastal communities (Atteridge & Tenggren, 2019). Other notable climate funds under the UNFCCC include the Least Developed Countries Fund (LDCF) and the Special

Climate Change Fund (SCCF), which are specifically for vulnerable nations (UNFCCC, 2012).

Beyond UNFCCC-led climate funds, Multilateral and Regional Development Banks (MDBS/RDBS) have significantly contributed to public climate finance, particularly in supporting the blue economy and ocean-based climate actions. The World Bank established PROBLUE, a multi-donor trust fund, in 2018 to support sustainable fisheries, aquaculture, and marine conservation while addressing issues like plastic pollution. As of 2024, the initiative had secured commitments totalling \$246.9 million, with \$91.4 million already disbursed (World Bank, 2024). PROBLUE integrates climate considerations by supporting projects that harness the power of natural coastal ecosystems, such as mangroves and coral reefs, for climate adaptation benefits like coastal protection and carbon sequestration. In Bangladesh, PROBLUE has advanced the blue economy by supporting policy reforms in fisheries and aquaculture through the Sustainable Coastal and Marine Fisheries Project. The initiative facilitated the registration and licensing of 15,000 artisanal vessels, improved fisheries management plans, and promoted alternative livelihoods for 40,500 households. The World Bank also supported innovative blue finance mechanisms, such as providing a financial guarantee for Seychelles' sovereign blue bond, which funded sustainable marine initiatives in the country (Benzaken et al., 2024). However, Small Island Developing States like Seychelles continue to face major challenges due to high indebtedness and structural vulnerabilities, compounded by an unequal global financing system that often prioritises creditors' interests over those of borrowers.

The Asian Development Bank (ADB) launched the Action Plan for Healthy Oceans and Sustainable Blue Economies, aiming to invest \$5 billion between 2019 and 2024 through its Oceans Financing Initiative. ADB has also expanded its Green Bond Framework to include Blue Bonds, issuing its first blue bonds to finance sustainable ocean-related projects. Similarly, the European Investment Bank (EIB) introduced the Blue Sustainable Ocean Strategy, committing to €2.5 billion in funding between 2019 and 2023 to support sustainable ocean projects. The EIB is key in mobilising private capital by reducing financial risks in emerging blue economy sectors. The Inter-American Development Bank (IDB) also supports ocean-related projects, focusing

on fisheries management and blue economy development in Latin America and the Caribbean (Thermann, 2023).

In addition to multilateral climate finance, Official Development Assistance (ODA) from developed countries is critical in supporting climate change adaptation and mitigation in developing nations. ODA funding can be instrumental in building adaptive capacity in climate-sensitive sectors such as fisheries. While not all ODA investments in fisheries are explicitly climate-focused, they often enhance resilience and adaptive capacity, making them a crucial component of climate finance. ODA-funded projects can provide necessary technical assistance, infrastructure improvements, and financial resources to help vulnerable communities cope with the challenges posed by climate change (Blasiak & Wabnitz, 2018).

Overall, these financial mechanisms, ranging from UNFCCC climate funds to MDB-led investments and ODA contributions, are vital in strengthening resilience in fisheries and ocean-based economies while supporting global and regional climate action.

National Public Finance Initiatives in India

The Indian government has undertaken several climate financing initiatives for the fisheries sector, integrating sustainability and resilience into its policies and programs. In 2015, the National Adaptation Fund for Climate Change (NAFCC) was launched by the Ministry of Environment, Forest and Climate Change (MoEFCC) with a budget provision of \$42.4 million to provide financial assistance for climate adaptation projects, including coastal livelihood resilience programs for Small Scale fisheries and processing nodes (Oza & Kankariya, 2023). In the same year, the Blue Revolution Scheme (2015-2020) was introduced under the Department of Fisheries, focusing on sustainable fishery development, marine biodiversity conservation, and climate-resilient aquaculture. This scheme also provided financial support for climate-smart fishing technologies and infrastructure.

In 2018, the Fisheries and Aquaculture Infrastructure Development Fund (FIDF) was established to offer low-interest loans for developing modern and climate-adaptive fisheries infrastructure, such as deep-sea fishing, seaweed farming, and climate-smart hatcheries. The fund was initially allocated \$912 million over five years (FY2019–FY2023) and

has since been extended through 31 March 2026 within the approved corpus (Tirumala & Tiwari, 2021). The following year, the Marine Fisheries Regulation and Management (MFRM) Bill (2019) was drafted to regulate deep-sea fishing and protect marine biodiversity from climate-related stressors by implementing climate-adaptive policies for sustainable fisheries management (International Collective in Support of Fishworkers [ICSF], 2021). Additionally, the Coastal Regulation Zone (CRZ) Notification (2019, Revised) introduced new provisions to regulate coastal land use, ensuring that climate-vulnerable fishing communities were protected from rising sea levels and extreme weather events (Ministry of Environment, Forest and Climate Change [MoEFCC], 2019).

In 2020, the government launched the Pradhan Mantri Matsya Sampada Yojana (PMMSY) with an investment of \$2.64 billion, aiming to develop sustainable and climate-resilient fisheries by promoting eco-friendly aquaculture, fish processing, and cold chain logistics (Talawar & Ramateerth, 2023). That same year, the draft National Fisheries Policy emphasised climate-resilient fisheries management and the need for integrated coastal zone management (ICZM) to address climate risks in fisheries (Department of Fisheries [DoF], 2020). Recognising the importance of the blue economy, India introduced the India Blue Economy Mission (2021) to promote sustainable fisheries, marine conservation, and financing adaptation strategies (ADBI, 2022; Ministry of Earth Sciences [MoES], 2025).

Further strengthening fisheries infrastructure, the PM Gati Shakti Initiative (2021) aimed to modernise fisheries logistics by investing in cold chain networks and transport facilities to minimise post-harvest losses caused by climate factors. Additionally, fisheries have been integrated into the National Action Plan on Climate Change (NAPCC) and State Action Plans on Climate Change (SAPCCS), recognising them as a climate-sensitive sector (Brugere & de Young, 2020). These plans support initiatives such as climate risk assessments, adaptive aquaculture practices, and capacity building for fishing communities.

These initiatives highlight India's dedication to integrating climate resilience into the financing and management of fisheries, thereby securing long-term sustainability despite evolving environmental challenges.

National Public Finance Initiatives in Sri Lanka

The major source of climate finance in Sri Lanka is constituted by Government funding and domestic budget allocations. Institutions under the Ministry of Fisheries, such as the Department of Fisheries and Aquaculture Resources (DFAR), Ceylon Fishery Harbours Corporation, National Aquaculture Development Authority (NAQDA), and Ceylon Fisheries Corporation, play a major role in providing and facilitating various climate finance projects. A major initiative put forward by the Department of Fisheries and Aquaculture Resources is the distribution of sustainable fishing gear to 1391 beneficiaries at a cost of \$0.3 million in order to replace harmful gears in lagoons in the year 2018. In addition, there are projects focused on lagoon restoration, improvements in housing and sanitation, enhancements to landing sites, and other infrastructure developments (Senevirathne, De Silva, Esham, & Pupulawaththa, 2023a).

Specialised institutions such as the Agriculture and Agrarian Insurance Board and the National Insurance Trust Fund function as financial intermediaries by offering grants, loans, subsidised programs, insurance coverage, pensions, donations, and microfinance services (Senevirathne et al., 2023a).

Green financing is used as a key strategy to increase climate resilience. Government-backed finance, community-led programs, and donor-funded initiatives have been used to encourage sustainable coastal fisheries management (Senevirathne et al., 2023b). As part of these initiatives, Climate-resilient insurance schemes, green bonds, and microcredit have been launched as they are environmentally friendly technologies (Senevirathne et al., 2023b). At the district level, initiatives include fingerling distribution and stocking programs overseen by the National Aquaculture Development Authority (NAQDA), funded through local sources. In addition, public funds support various Coastal Aquaculture Development and Monitoring Units that aid in the development of inland and coastal aquaculture (Basnayake & De Silva, 2025).

Despite these efforts, major obstacles to advancing climate finance in Sri Lanka remain. These include insufficient and inefficient budget allocation, weak institutional coordination, limited engagement from the private sector, and difficulties in accessing reliable data (Dasandara, Ingirige, Kulatunga, & Fernando, 2023). Table 2 presents a summary of the

Table 2. Overview of public climate finance initiatives in the fisheries sector (Global, India and Sri Lanka)

Year	Initiative / Policy	Implementing Agency	Instrument Type	Key Resilience Outcome
2001	Least Developed Countries Fund (LDCF)	Global Environment Facility (GEF) under UNFCCC	International Grant Fund	Supports climate adaptation in least developed countries, including coastal and fisheries resilience.
2001	Special Climate Change Fund (SCCF)	Global Environment Facility (GEF) under UNFCCC	International Grant Fund	Finances climate adaptation projects in vulnerable developing nations, enhancing ecosystem resilience.
2010	Green Climate Fund (GCF)	UNFCCC	Multilateral Climate Fund (Grants / Concessional Loans)	Finances global climate adaptation and mitigation, including marine and coastal resilience.
2007 / Renewed 2015	Adaptation Fund (AF)	UNFCCC / Kyoto Protocol	International Fund (Share of CDM Proceeds)	Funds ecosystem-based adaptation benefiting fisheries, wetlands, and coral reefs.
2018	PROBLUE – Multi-Donor Trust Fund	World Bank	Multilateral Trust Fund / Grant	Supports sustainable fisheries, aquaculture, and marine conservation integrating climate adaptation.
2018	Seychelles Sovereign Blue Bond	Government of Seychelles & World Bank	Blue Bond / Blended Finance	Funds sustainable fisheries and marine conservation in Small Island Developing States (SIDS).
2019	Action Plan for Healthy Oceans and Sustainable Blue Economies	Asian Development Bank (ADB)	Development Loan / Blue Bond Framework	Invests in sustainable ocean and fisheries projects to build adaptive capacity.
2019	Blue Sustainable Ocean Strategy	European Investment Bank (EIB)	Concessional Finance / Risk-Sharing	Mobilises funds for sustainable ocean projects and reduces financial risks in blue sectors.
2020	Ocean-Based Climate Finance Projects	Inter-American Development Bank (IDB)	Development Loan / Technical Assistance	Supports fisheries management and blue economy projects in Latin America and the Caribbean.
Ongoing	Official Development Assistance (ODA) for Climate Action	Developed Nations	Public Development Assistance	Provides grants and technical support for climate adaptation in fisheries and coastal livelihoods.
2015	National Adaptation Fund for Climate Change (NAFCC)	MoEFCC, India	Public Grant / Adaptation Fund	Enhances coastal livelihood resilience and adaptive capacity of fishing communities.
2015–2020	Blue Revolution Scheme	Department of Fisheries, India	Public Investment Scheme	Promotes sustainable fishery development and climate-resilient aquaculture.
2018	Fisheries and Aquaculture Infrastructure Development Fund (FIDF)	Department of Fisheries, India	Concessional Loan Fund	Develops modern, climate-adaptive fisheries infrastructure (deep-sea fishing, hatcheries, seaweed farming).

2019	Marine Fisheries Regulation and Management (MFRM) Bill	Department of Fisheries, India	Regulatory / Policy Instrument	Introduces climate-adaptive governance and biodiversity safeguards.
2019	Coastal Regulation Zone (CRZ) Notification (Revised)	MoEFCC, India	Regulatory Framework	Protects coastal ecosystems and fishing communities from sea-level rise and erosion.
2020	Pradhan Mantri Matsya Sampada Yojana (PMMSY)	Department of Fisheries, India	Public Scheme / Investment	Promotes sustainable and climate-resilient fisheries through eco-friendly aquaculture and logistics.
2020	Draft National Fisheries Policy	Department of Fisheries, India	Policy / Strategic Framework	Mainstreams climate adaptation into fisheries management and planning.
2021	India Blue Economy Mission	Ministry of Earth Sciences (MoES), India	Programmatic / Policy Initiative	Promotes sustainable fisheries, marine conservation, and financing adaptation strategies.
2021	PM Gati Shakti Initiative	Government of India	Infrastructure Development Program	Strengthens logistics and reduces post-harvest losses due to climate factors.
2018	Sustainable Fishing Gear Distribution Project	DFAR, Sri Lanka	Public Grant / Subsidy Program	Replaces harmful gear with sustainable alternatives to protect ecosystems.
2018	Lagoon Restoration & Infrastructure Development	DFAR, Sri Lanka	Public Infrastructure Investment	Restores lagoons and enhances resilience to floods and salinity intrusion.
2022	Climate-Resilient Insurance & Green Financing Schemes	Agriculture & Agrarian Insurance Board & NITF, Sri Lanka	Insurance / Green Bonds / Microfinance	Provides financial protection and promotes eco-friendly, adaptive fisheries.
2006	Fingerling Distribution & Stocking Programs	NAQDA, Sri Lanka	Public Program / Local Budget	Enhances inland aquaculture and adaptive capacity of rural fishers.

identified public climate finance initiatives at the global level and at the national level in India and Sri Lanka.

Private finance instruments

The growing global focus on the sustainable use of ocean resources for economic growth and the health of ocean ecosystems, known as the blue economy, has led to increasing attention on the need for robust financing mechanisms. While official development assistance (ODA) and public finance have historically played a role, there is a growing necessity to mobilise private capital to address the significant financing gap for ocean conservation and a sustainable blue economy. These instruments are critical for creating new and affordable financing opportunities, particularly for Small Island Developing States (SIDS), which are highly dependent on their ocean

resources. The shift towards leveraging private finance reflects a broader trend from “funding to financing,” where public finance strategically incentivises private capital to complement public sector resources. Private finance instruments are crucial in mobilising capital for ocean conservation and the sustainable use of marine resources. Blue bonds are specialised debt instruments issued by governments, private companies, or financial institutions to fund marine and ocean-based projects that offer environmental, economic, and climate benefits (FAO, 2020). Similarly, while broader in scope, green bonds also finance projects with environmental benefits, some directly related to marine conservation, following the Green Bond Principles for guidance.

Private equity and venture capital provide direct investments in start-ups developing innovative blue

economy technologies, helping drive advancements in sustainable marine industries. Additionally, parametric insurance is emerging as a risk management tool, offering payouts based on predefined triggers, such as hurricane wind speeds, to protect marine ecosystems like coral reefs (The Economist Group Limited, 2020).

Other instruments, such as sustainability-linked loans and bonds, tie interest rates to Environmental, Social and Governance (ESG) targets, shifting conservation risks to impact investors. Traditional bank loans fund blue economy activities but face challenges like high risks and limited profit incentives. Syndicated loans pool multiple lenders for large-scale projects, while project bonds secure funding based on project cash flows. Conservation outcome-based financing links returns to conservation targets, fostering sustainable marine investments. These mechanisms can bridge the climate finance gap, supporting long-term environmental and economic resilience (Narula et al., 2023).

Blended finance approaches

Blended finance is a strategic approach that combines development finance with commercial finance to support sustainable development goals, including those related to the blue economy (MoES, 2025). The primary objective is to mobilise additional private capital by utilising public or philanthropic funds to de-risk investments and enhance their commercial viability, particularly for projects that may not offer immediate high returns or are perceived as riskier. Various initiatives illustrate how blended finance has been effectively employed in the blue economy.

For instance, the Global Fund for Coral Reefs and the Subnational Climate Finance Fund have attracted the Green Climate Fund, demonstrating how public climate finance can potentially draw further private investment. Similarly, the Seychelles Blue Bond incorporated blended finance elements by including guarantees from the World Bank and a non-grant instrument from the Global Environment Facility (GEF). Another innovative financing tool, debt-for-nature swaps, involves restructuring a country's debt in exchange for commitments to invest in conservation activities, freeing up financial resources for ocean-related projects, as demonstrated by the Seychelles debt swap (Benzaken et al., 2024). These mechanisms mitigated risks for investors, making the bond more attractive and lowering

interest rates, enabling Seychelles to raise private capital for marine protection and sustainable fisheries (ADBI, 2022).

Impact investment funds such as the Meloy Fund, which provides debt and equity investments in small fisheries in the Philippines, and the Sustainable Ocean Fund, managed by Althelia, also integrate blended finance principles (Mirova, 2024). These funds leverage Official Development Assistance (ODA) to enhance the commercial viability of sustainable activities while generating both financial returns and positive environmental or social impacts. Additionally, debt-for-nature swaps, like the one undertaken by Seychelles, can incorporate blended finance elements if grant funding is used to compensate investors for potential losses, making the swap more attractive to creditors (Dobush et al., 2022).

These examples highlight the significant role of blended finance in leveraging public and philanthropic capital to reduce investment risks and attract private sector participation in the sustainable blue economy. By structuring investments to improve financial returns and manage risks, blended finance is crucial in bridging the funding gap for ocean conservation and marine-based economic activities.

Challenges and Considerations in Climate Finance

Several cross-cutting issues emerge in climate financing. Primarily, the volume and allocation are as estimated, suggesting that current adaptation funding is many times lower than projected needs, which have been estimated to range between \$70 billion and \$100 billion annually from 2020 (United Nations Environment Programme [UNEP], 2014). Despite an estimated \$174.52 billion per year being required to restore ocean health and achieve SDG 14 (Life Below Water) by 2030, actual investments in ocean initiatives between 2015 and 2019 amounted to just under \$10 billion (Benzaken et al., 2024). This under-allocation reflects the competition among sectors and calls for greater advocacy to raise the profile of fisheries in the climate agenda. The second issue relates to governance and capacity, which critically includes the absence of standardised Monitoring, Reporting, and Verification (MVR) systems. Even where funds exist, recipient agencies may lack experience writing proposals or managing complex financial instruments and standardised

outcome metrics (Galappaththi et al., 2022). The third issue to be addressed is that of equity. There is consensus that finance must flow to the communities most in need. Gender equity and gender responsiveness is crucial. For instance, women often dominate fish processing and trading, but their adaptation needs are overlooked (Gopal, Williams, Porter, & Kusakabe, 2016; Gopal, Hapke, Kusakabe, Rajaratnam, & Williams, 2020; Gopal, Raghavan, Sruthi, Rejula, & Ananthan, 2022). To ensure effectiveness, gender-responsive climate finance must target specific economic mechanisms, such as dedicated credit window, concessional collateral, and capacity building focused on women's entrepreneurship and post-harvest value chains. The motivation to examine 'gender-responsive' climate finance takes into account the differential impacts of climate change. It often magnifies existing societal inequities, including gender disparities. People from different genders face differentiated impacts from climate change that largely arise from entrenched socio-economic structures, which influence the distribution of resources, responsibilities, and power. These differentiated impacts require targeted understanding and interventions, including those related to climate finance, hence the interest in gender-responsive approaches.

Another big problem is that large-scale needs like building strong fishing harbours require more funding than governments or NGOs usually have. Some new funding ideas, like blue bonds and insurance, are helpful, but still too small to make a big difference. Experts say that unless private investors are encouraged to help through risk-reducing measures, most funding will continue to come from limited public sources (Narula et al., 2023). The inability to provide quantified, comparable evidence of returns and impact severity severely compounds this challenge for private capital. How well a country manages these issues also depends on its institutions. Richer countries with strong fisheries rules and monitoring tend to handle climate impacts better. In contrast, many developing countries struggle with weak policies and poor enforcement. Fisheries are often left out of national climate plans, making it harder to get funding or coordinate efforts. Training officials in climate science and improving governance is seen as very important (ADB, 2022).

One of the most notable gaps lies in the limited integration of local and indigenous knowledge

systems into mainstream climate assessments and adaptation planning. Although Indigenous communities possess generations of experiential knowledge that offer context-specific insights into environmental change and resilience, scientific models dominate research agendas (Ford et al., 2015). Future research must prioritise documenting, validating, and meaningfully integrating these knowledge systems to enhance the relevance and effectiveness of adaptation strategies.

Moreover, a substantial proportion of current studies are focused on short-term responses, neglecting the long-term implications and sustainability of adaptation measures. Longitudinal research, supported by robust monitoring and evaluation frameworks (MRV), is vital to assess these interventions' durability, quantify impact metrics, unintended consequences, and adaptive evolution over time (Ani & Robson, 2021).

Additionally, there is a pressing need to enhance communication with public and private investors regarding the potential opportunities within the blue economy and develop robust impact metrics to help effectively mobilise financial resources. Develop robust impact metrics to help effectively mobilise financial resources. Blended finance approaches, which integrate commercial funding with grants from public or philanthropic sources, can play a vital role in de-risking investments and lowering overall funding costs. Public sector guarantees can also help mobilise private capital by instilling confidence and reducing investment risks (Narula et al., 2023). Addressing challenges related to risk, return, scale, and the enabling environment is essential to mobilise private capital for a sustainable ocean future effectively.

Limitations

This review is limited to English-language sources and includes a substantial proportion of grey literature, which may introduce bias. Differences in study designs and indicators prevent direct effect-size comparisons, and rigorous impact evaluations of fisheries finance interventions remain scarce.

To strengthen future research, we propose standard metrics for assessing fisheries finance impact, including post-harvest loss rates, safety days lost, women's earnings and participation, and payout ratios of insurance or financial schemes. Consistent use of these indicators will improve comparability,

accountability, and evidence-based policy-making in the fisheries sector.

Conclusion

This review makes clear that climate change is reshaping fisheries globally, with profound implications for ecosystems and coastal communities. Effective adaptation strategies – from ecosystem-based management and climate-smart aquaculture to livelihood diversification and community co-management do exist and are being tested. However, the success of these strategies often hinges on social, economic and cultural factors. A marine reserve can only sustain fisheries if fishers are involved in its planning and provide alternative incomes when fishing is limited. A flood-resistant harbour benefits communities only if women and men alike have access to its facilities. In practice, building resilience means mainstreaming climate considerations into fisheries policy, finance, and development planning.

Governments and donors should prioritize investments in climate-proof infrastructure (e.g. storm-resilient fish landing sites, refrigerated storage), along with training programs and social safety nets that complement ecological efforts. Innovative finance blue bonds, debt swaps, and blended funds can unlock new resources, but they must be structured to reach vulnerable groups. Crucially, adaptation must be inclusive: stakeholders from fishers to scientists to policy-makers must collaborate. Integrated, participatory approaches that combine traditional knowledge with scientific forecasting yield the best outcomes. As Ford et al. (2015) and Gopal et. al. (2020) emphasise, gender equity and local voices are not optional; they are essential to adaptation success. There is also a need to ensure access and availability of climate finance tools, including digital tools to bridge the gaps and enhance access.

To bridge these acknowledged gaps and accelerate the trajectory toward climate-resilient development within the fisheries sector, this review forwards the following implementable recommendations for policymakers and governing agencies:

- **Develop Concessional Credit Lines:** Design dedicated concessional loan and guarantee facilities through public financial institutions (e.g., FIDF) for critical value chain enhance-

ments, including post-harvest processing and energy-efficient vessel retrofitting.

- **Scale Parametric Micro-Insurance:** Partner with national insurance funds to develop and pilot parametric insurance products for Small-Scale Fishers (SSF) and aquaculture farmers, leveraging transparent environmental triggers for rapid livelihood protection.
- **Implement Gender-Targeted Financial Windows:** Mandate the establishment of gender-targeted credit windows and capacity programs, channelled through established community structures (e.g., Self-Help Groups/Fish Producer Organisations), to finance women's entrepreneurship in processing and marketing directly.

In conclusion, the evidence suggests that climate-resilient fisheries are achievable, but only with concerted, well-funded, and equitable effort. By combining robust science, traditional knowledge, and targeted investments, policy-makers and practitioners can help ensure that fisheries and the millions of people who depend on them remain viable and productive in a changing climate. Without such coordinated action, climate change risks causing severe declines in fishery productivity and undermining food security worldwide. Furthermore, our review confirms that a central challenge in this field is the difficulty in disaggregating 'climate-tagged' finance from general 'sectoral spend', which makes tracking specific climate outcomes difficult.

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References

- Asian Development Bank Institute. (2022). *Blue economy and blue finance: Toward sustainable development and ocean governance* (P. J. Morgan, M. C. Huang, M. Voyer,

- D. Benzaken, & A. Watanabe, Eds.). <https://doi.org/10.56506/HDLZ1912>
- Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268–281. <https://doi.org/10.1016/j.gloenvcha.2006.02.006>
- Ani, C. J., & Robson, B. (2021). Responses of marine ecosystems to climate change impacts and their treatment in biogeochemical ecosystem models. *Marine Pollution Bulletin*, 166, Article 112223. <https://doi.org/10.1016/j.marpolbul.2021.112223>
- Atteridge, A., & Tenggren, S. (2019). *Finance for the adaptation of ecosystems to climate change: A review of the adaptation fund portfolio* (2nd ed.). Stockholm Environment Institute.
- Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (Eds.). (2018). *Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options* (FAO Fisheries and Aquaculture Technical Paper No. 627). Food and Agriculture Organization of the United Nations.
- Basnayake, R., & de Silva, A. (2025). Institutional innovations towards sustainable small-scale fisheries: An assessment of co-management approach in lobster and giant freshwater prawns fisheries, Sri Lanka. *Research on World Agricultural Economy*, 6(1), 624–638. <https://doi.org/10.36956/rwae.v6i1.1547>
- Benzaken, D., Adam, J. P., Viridin, J., & Voyer, M. (2024). From concept to practice: Financing sustainable blue economy in small island developing states, lessons learnt from the Seychelles experience. *Marine Policy*, 163, Article 106072. <https://doi.org/10.1016/j.marpol.2024.106072>
- Blasiak, R., & Wabnitz, C. C. C. (2018). Aligning fisheries aid with international development targets and goals. *Marine Policy*, 88, 86–92. <https://doi.org/10.1016/j.marpol.2017.11.018>
- Brugere, C., & de Young, C. (2020). *Addressing fisheries and aquaculture in National adaptation plans: Supplement to the UNFCCC NAP technical guidelines*. FAO. <https://doi.org/10.4060/ca2215en>
- Carmen, E., Fazey, I., Ross, H., Bedinger, M., Smith, F. M., Prager, K., McClymont, K., & Morrison, D. (2022). Building community resilience in a context of climate change: The role of social capital. *Ambio*, 51, 1371–1387. <https://doi.org/10.1007/s13280-021-01678-9>
- Cinner, J. E., McClanahan, T. R., Graham, N. A. J., Daw, T. M., Maina, J., Stead, S. M., Wamukota, A., Brown, K., & Bodin, Ö. (2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change*, 22(1), 12–20. <https://doi.org/10.1016/j.gloenvcha.2011.09.018>
- Colburn, L. L., Jepson, M., Weng, C., Seara, T., Weiss, J., & Hare, J. A. (2016). Indicators of climate change and social vulnerability in fishing dependent communities along the Eastern and Gulf Coasts of the United States. *Marine Policy*, 74, 323–333. <https://doi.org/10.1016/j.marpol.2016.04.030>
- Dasandara, M., Ingirige, B., Kulatunga, U., & Fernando, T. (2023). Climate financing barriers and strategies: The case of Sri Lanka. *Journal of Financial Management of Property and Construction*, 28(2), 242–259. <https://doi.org/10.1108/JFMPC-12-2021-0069>
- Daw, T. M., Adger, W. N., Brown, K., & Badjeck, M. C. (2009). Climate change and capture fisheries: Potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto, & T. Bahri (Eds.), *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge* (FAO Fisheries and Aquaculture Technical Paper. No. 530) (pp.107-150). FAO.
- Department of Fisheries. (2020). *National Fisheries Policy, 2020*. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India.
- Dobush, B. J., Gallo, N. D., Guerra, M., Guilloux, B., Holland, E., Seabrook, S., & Levin, L. A. (2022). A new way forward for ocean-climate policy as reflected in the UNFCCC Ocean and Climate change dialogue submissions. *Climate Policy*, 22(2), 254–271. <https://doi.org/10.1080/14693062.2021.1990004>
- Dudley, P. N., Rogers, T. L., Morales, M. M., Stoltz, A. D., Sheridan, C. J., Beulke, A. K., Pomeroy, C., & Carr, M. H. (2021). A more comprehensive climate vulnerability assessment framework for fisheries social-ecological systems. *Frontiers in Marine Science*, 8, Article 678099. <https://doi.org/10.3389/fmars.2021.678099>
- Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press.
- Etongo, D., & Arrisol, L. (2020). Vulnerability of fishery-based livelihoods to climate variability and change in a tropical island: Insights from small-scale fisheries in Seychelles. *Discover Sustainability*, 2, Article 48. <https://doi.org/10.1007/s43621-02-00057-4>
- Food and Agricultural Organization of the United Nations. (2020). *FAO's Blue Growth Initiative: Blue finance guidance notes*. <https://openknowledge.fao.org/handle/20.500.14283/ca8740en>
- Ford, J., Maillet, M., Pouliot, V., Meredith, T., Cavanaugh, A., & IHACC Research Team. (2015). Adaptation and indigenous peoples in the United Nations framework convention on climate change. *Climatic Change*, 139, 429–443. <https://doi.org/10.1007/s10584-016-1820-0>
- Galappaththi, E. K., Ford, J. D., Bennett, E. M., & Berkes, F. (2020). Climate change and community fisheries in the Arctic: A case study from Pangnirtung, Canada.

- Journal of Environmental Management*, 250, Article 109534. <https://doi.org/10.1016/j.jenvman.2019.109534>
- Galappaththi, E. K., Susarla, V. B., Loutet, S. J. T., Ichien, S. T., Hyman, A. A., & Ford, J. D. (2021). Climate change adaptation in fisheries. *Fish and Fisheries*, 23(1), 4–21. <https://doi.org/10.1111/faf.12595>
- Giri, S. S. (Ed.) (2016). *Climate change impact on coastal fisheries and aquaculture in South Asia*. SAARC Agriculture Centre.
- Gopal, N., Hapke, H. M., Kusakabe, K., Rajaratnam, S., & Williams, M. J. (2020). Expanding the horizons for women in fisheries and aquaculture. *Gender, Technology and Development*, 24(1), 1–9. <https://doi.org/10.1080/09718524.2020.1736353>
- Gopal, N., Raghavan, R. M., Sruthi, P., Rejula, K., & Ananthan, P. S. (2022). Traditional access rights and methods of fishing in inland water bodies: Are women slowly losing out? A study from Kerala, India. *Gender, Technology and Development*, 26(3), 522–543. <https://doi.org/10.1080/09718524.2022.2120844>
- Gopal, N., Williams, M. J., Porter, M., & Kusakabe, K. (Eds.). (2016). *Gender in aquaculture and fisheries: The long journey to equality* (Special Issue, Vol. 29S). Asian Fisheries Society.
- Harvey, C. J., Clay, P. M., Selden, R., Moore, S. K., Andrews, K. S., deReynier, Y. L., Beaudreau, A. H., Liu, O. R., Norman, K. C., Samhouri, J. F., Bellquist, L., Burden, M., Colburn, L. L., Haltuch, M. A., Harley, A., Kaplan, I. C., Kasperski, S., Klajbor, W., Lewis-Smith, C., Tolimieri, N., Watson, J. L., & Wise, S. (2025). Embracing social-ecological system complexity to promote climate-ready fisheries. *Reviews in Fish Biology and Fisheries*, 35, 633–658. <https://doi.org/10.1007/s11160-025-09926-x>
- Hollowed, A. B., Barange, M., Beamish, R. J., Brander, K., Cochrane, K., Drinkwater, K., Foreman, M. G. G., Hare, J. A., Holt, J., Ito, S. I., Kim, S., King, J. R., Loeng, H., MacKenzie, B. R., Mueter, F. J., Okey, T. A., Peck, M. A., Radchenko, V. I., Rice, J. C., Schirripa, M. J., Yatsu, A., & Yamanaka, Y. (2013). Projected impacts of climate change on marine fish and fisheries. *ICES Journal of Marine Science*, 70(5), 1023–1037. <https://doi.org/10.1093/icesjms/fst081>
- Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. <https://www.ipcc.ch/report/ar5/syr/>
- International Collective in Support of Fishworkers. (2019). *India: Govt set to pass National Marine Fisheries (Regulation and Management) Bill 2019*. <https://icsf.net/newss/india-govt-set-to-pass-national-marine-fisheries-regulation-and-management-bill-2019/>
- Islam, M. M., Sallu, S., Hubacek, K., & Paavola, J. (2014). Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: Insights from coastal Bangladesh. *Regional Environmental Change*, 14(1), 281–294. <https://doi.org/10.1007/s10113-013-0487-6>
- Koehn, L. E., Nelson, L. K., Samhouri, J. F., Norman, K. C., Jacox, M. G., Cullen, A. C., Fiechter, J., Buil, M. P., & Levin, P. S. (2022). Social-ecological vulnerability of fishing communities to climate change: A U.S. West Coast case study. *PLOS One*, 17(8), Article e0272120. <https://doi.org/10.1371/journal.pone.0272120>
- Koomson, D., Davies-Vollum, K. S., & Raha, D. (2020). Characterising the vulnerability of fishing households to climate and environmental change: Insights from Ghana. *Marine Policy*, 120, Article 104142. <https://doi.org/10.1016/j.marpol.2020.104142>
- Ksenofontov, S., Backhaus, N., & Schaeppman-Strub, G. (2017). ‘To fish or not to fish?’: Fishing communities of Arctic Yakutia in the face of environmental change and political transformations. *Polar Record*, 53(3), 289–303. <https://doi.org/10.1017/S0032247417000134>
- Kupika, O. L., Gandiwa, E., Nhamo, G., & Kativu, S. (2019). Local ecological knowledge on climate change and ecosystem based adaptation strategies promote resilience in the middle Zambezi biosphere reserve, Zimbabwe. *Scientifica*, 2019(1), Article 3069254. <https://doi.org/10.1155/2019/3069254>
- Lam, V. W. Y., Allison, E. H., Bell, J. D., Blythe, J., Cheung, W. W. L., Frölicher, T. L., Gasalla, M. A., & Sumaila, U. R. (2020). Climate change, tropical fisheries and prospects for sustainable development. *Nature Reviews Earth & Environment*, 1(5), 440–454. <https://doi.org/10.1038/s43017-020-0071-9>
- McIlgorm, A., Hanna, S., Knapp, G., Le Floc’H, P., Millerd, F., & Pan, M. (2010). How will climate change alter fishery governance? Insights from seven international case studies. *Marine Policy*, 34(1), 170–177. <https://doi.org/10.1016/j.marpol.2009.06.004>
- Ministry of Earth Sciences (MoES). (2025). *Deep ocean mission (DOM)*. Government of India. <https://www.moes.gov.in/schemes/dom>
- Ministry of Environment, Forest and Climate Change. (2019, January 18). *Coastal Regulation Zone Notification, 2019 (G.S.R. 37(E))*. Government of India. <https://crz.elaw.in/crz2019.html>
- Mohtar, R. (2023). *Financing climate action: Equity challenges and practical solutions* (Policy Brief). Policy Centre for the New South.
- Mirova. (2024). *Sustainable Ocean Fund: Impact report 2023*. <https://www.mirova.com/sites/default/files/2024-07/sustainable-ocean-fund-sof-2023-impact-report.pdf>

- NOAA Fisheries. (2024). *Understanding ecosystem-based fisheries management*. <https://www.fisheries.noaa.gov/insight/understanding-ecosystem-based-fisheries-management>
- Narula, K., Spalding, M. J., Thiele, T., Dyer, J., Pouponneau, A., & Chauhan, P. (2023). *Generating finance for the blue economy transition. Task Force 6: Accelerating SDGs—Exploring New Pathways to the 2030 Agenda, India*. <https://t20ind.org/research/generating-finance-for-blue-economy-transition/>
- Nurse, L. A., Mclean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Pelesikoti, N., Tompkins, E., & Webb, A. (2014). Small islands. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Climate Change 2014: Impacts, adaptation, and vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1613–1654). Cambridge University Press.
- Oza, K., & Kankariya, R. A. (2023). Climate finance: G20 and India. *Samshodhak*, 2, 182-190.
- Pinto, M., Albo-Puigserver, M., Bueno-Pardo, J., Monteiro, J. N., Teodósio, M. A., & Leitão, F. (2023). Eco-socio-economic vulnerability assessment of Portuguese fisheries to climate change. *Ecological Economics*, 212, Article 107928. <https://doi.org/10.1016/j.ecolecon.2023.107928>
- Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis* (IDS Working Paper No. 72). Institute of Development Studies.
- Senevirathne, M. M. S. C., de Silva, D. A. M., Esham, M., & Pupulawaththa, C. N. (2023a). Green financing as a measure to build resilience among fisheries communities in Sri Lanka (ICSBE 2023-219). In R. Dissanayake & P. Gajanayake (Eds.), *Proceedings of the 14th International Conference on Sustainable Built Environment (ICSBE) 2023* (pp no. 793–802). Graduate Associate Professionals (Pvt) Ltd.
- Senevirathne, M. M. S. C., de Silva, D. A. M., Esham, M., & Pupulawaththa, C. N. (2023b). Landscape of climate financing for small-scale marine fisheries in Sri Lanka. In *Proceedings of the 2023 conference*. Sabaragamuwa University of Sri Lanka.
- Thermann, A. (2023, May 31). *Progress on ADB action plan for healthy oceans and sustainable blue economy* [Presentation]. Investing in natural capital: Towards sustainability and climate resilience in Sri Lanka. <https://events.development.asia/materials/20230531/investing-natural-capital-towards-sustainability-and-climate-resilience-sri>
- Tirumala, R. D., & Tiwari, P. (2021). *Approaches to strengthening fisheries financing and institutional mechanisms: A cross-country comparison of Cambodia, India, and Indonesia* (ADB Working Paper No. 1289). Asian Development Bank Institute. <https://www.adb.org/publications/approaches-strengthening-fisheries-financing>
- Talawar, D. C., & Ramateerth, S. J. (2023). Pradhan Mantri Matsya Sampada Yojana – A way towards sustainable development. *International Research Journal of Social Sciences*, 12(2), 38–43.
- The Economist Group Limited. (2020). *A sustainable ocean economy in 2030: Opportunities and challenges*.
- United Nations Framework Convention on Climate Change. (2012). *National adaptation plans: Technical guidelines for the national adaptation plan process*. <https://unfccc.int/topics/adaptation-and-resilience/resources/publications/technical-guidelines-for-the-national-adaptation-plan-process>
- United Nations Environment Programme. (2014). *The adaptation gap report 2014: A preliminary assessment*. <https://wedocs.unep.org/items/55b3a330-05af-46c7-8c84-43ec073d9d4d>
- Umamaheswari, T., Sugumar, G., Krishnan, P., Ananthan, P. S., Anand, A., Jeevamani, J. J. J., Mahendra, R. S., Infantina, J. A., & Rao, C. S. (2021). Vulnerability assessment of coastal fishing communities for building resilience and adaptation: Evidences from Tamil Nadu, India. *Environmental Science & Policy*, 123, 114–130. <https://doi.org/10.1016/j.envsci.2021.05.009>
- Weatherdon, L. V., Magnan, A. K., Rogers, A. D., Sumaila, U. R., & Cheung, W. W. L. (2016). Observed and projected impacts of climate change on marine fisheries, aquaculture, coastal tourism, and human health: An update. *Frontiers in Marine Science*, 3, Article 48. <https://doi.org/10.3389/fmars.2016.00048>
- World Bank. (2024). *Problue 2024 Annual Report*. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099605202142527732>