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Blue carbon management integrating socioeconomic and environmental interconnectivity in Southeast Asia: an urgent climate priority

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This perspective article synthesises insights from a 2023 interdisciplinary workshop in Kuching, Malaysia, where 26 experts examined how land use and land cover change (LULCC) impacts Blue Carbon Ecosystems (BCE) in Southeast Asia (SEA) and identified pathways for integrated, science-informed governance. BCE in SEA (mangroves, seagrasses and tidal wetlands) are globally significant carbon sinks, critical to biodiversity and the livelihoods of millions, dependant on them for food, income and coastal protection. Yet rapid development and socio-economically driven LULCC threaten BCE resilience and carbon storage capacity. Blue Carbon initiatives risk falling short if they overlook the socio-ecological interconnectivity of these systems. Advances in remote sensing, sediment carbon accounting and ecosystem modelling have improved BCE monitoring, but key gaps persist. These include understanding cumulative upstream effects of LULCC on BCE carbon dynamics, integrating socio-economic with ecological data for robust scenario modelling and evaluating governance effectiveness and equity over time. We frame BCE as dynamic, interconnected socio-ecological systems and call for the advancement of systems thinking in coastal and climate policy. We underscore the need for transdisciplinary, nested governance models operating across ecological scales and political boundaries and argue for a systems-based management approach that links land-sea processes, addresses upstream-downstream dynamics and balances carbon market incentives with local needs. Recommendations include improved monitoring and carbon accounting; alignment between science and policy; regionally coordinated governance; and diversifying finance to reflect the full value of BCE beyond carbon. Together, these actions chart a path for resilient, science-based, socially inclusive BCE conservation in SEA.

KEYWORDS

blue carbon ecosystems (BCE), land use land cover change (LULCC), source to sea, integrated governance, science-policy alignment

Introduction

Southeast Asia (SEA) is a global hotspot for blue carbon, with over 12 million hectares of mangroves and seagrasses storing an estimated 4778.66 Tg Corg (Thorhaug et al., 2020). These Blue Carbon Ecosystems (BCE) offer powerful nature-based solutions for climate change mitigation and adaptation (Macreadie et al., 2021), whilst simultaneously supporting fisheries and local livelihoods. However, across the region these ecosystems face escalating threats mainly from anthropogenic interventions including land use and land cover change (LULCC) driven by agriculture, aquaculture, infrastructure expansion and other socio-economic pressures (Fauzi et al., 2019; Mao et al., 2023). These changes degrade coastal ecosystems, diminishing provision of key services and disrupting socio-ecological systems (Jamilah et al., 2025). As political and financial interest in blue carbon grows (Howard et al., 2017; Northrop et al., 2020), it is vital that science and policy remain aligned. Importantly, the protection of existing carbon stocks (often ineligible under current crediting schemes) must be prioritised in the avoidance of further greenhouse gas emissions (Osaka et al., 2021; Smale et al., 2018).

The definition of Blue Carbon and what constitutes BCE is not unequivocal (Lovelock and Duarte, 2019). Here, in line with the IPCC (2022), we refer to BCE as coastal vegetated habitats with which the SEA region is replete. BCE provide a wide range of ecosystem services in addition to carbon storage, including coastal protection (Gagarin et al., 2022), tourism (Hamimah et al., 2022), food security (Rudianto et al., 2022) and habitat for a high number of species (McHenry et al., 2021; Nagelkerken et al., 2008) and should be understood as socio-ecological systems (Dencer-Brown et al., 2022) as opposed to simply biological ones.

The rapid pace of LULCC in SEA (Mao et al., 2023) is driven by a complex mix of economic, social and climate factors, which shape both local policies and global market demands (Armitage, 2002). Although commodity-driven deforestation has declined in recent years as production is intensified instead of expanded, 30% of investible mangroves in SEA are under threat from socioeconomic risks (Kwan et al., 2025). Impacts of LULCC on coastal and marine ecosystems remain poorly understood (Tan et al., 2022) but are likely contributing to their degradation and loss of the ecosystem services they provide with negative social and ecological impacts over highly localised to global scales. To maintain vital ecosystem services, preserve biodiversity and continue supporting millions of livelihoods, alongside the global good of mitigating climate change, it is essential that BCE are protected from further LULCC impacts and restored. SEA is a globally important region for carbon sequestration and storage and, as an area experiencing rapid development, is a priority for global support to realise its climate change mitigation potential.

While swift action to combat climate change is essential, the growing financial and political interest in managing these ecosystems must be grounded in sound scientific evidence and not be implemented to the detriment of local communities (both human and ecological).

In 2023, an interdisciplinary workshop in Kuching, Malaysia brought together 26 scientists and practitioners from SEA and beyond to explore how LULCC is compounding stress on BCE, at a time when we need them most. We used a participatory workshop format which combined expert presentations, structured breakout discussions and plenary sessions to identify and synthesis key perspectives. This paper reflects key themes from that dialogue, highlighting how BCE degradation is not solely a local issue, but a regional and global challenge requiring coordinated response. We outline the interconnectivity of BCE, identify critical threats and recommend pathways toward integrated governance and inclusive, long-term solutions.

Blue carbon ecosystems connecting land, sea and society

BCE are highly interconnected with one another and with adjacent coastal systems, a connectivity driven by both their spatial proximity and the continuous movement of water. As components of the land–ocean aquatic continuum (LOAC) (Regnier et al., 2013), BCE mediate the transfer of water, nutrients, carbon, pollutants, pathogens, and organisms between terrestrial and marine environments. These physical, chemical, and biological linkages are fundamental to the ecological functioning, resilience, and carbon storage capacity of BCE. This interconnectivity simultaneously creates diffuse and often difficult-to-define boundaries and exposes BCE to land-based stressors. Their role as biophysical connectors is paralleled by complex socio-economic interdependencies, arising from the diverse ecosystem services they provide.

Ecosystem services provided by BCE are deeply embedded within broader environmental and socio-ecological systems. BCE play a vital role in food security, livelihoods and disaster risk reduction. For example, small-scale fishers, who account for over 90% of the global fish catch (FAO, 2016), rely heavily on mangrove and seagrass habitats (Teh and Pauly, 2018). Recent research in Malaysia further shows that these habitats also support nearshore gleaning, particularly by women, which contributes significantly to household livelihoods and local food access (David et al., 2024). These ecosystems also provide timber, fuelwood, medicinal resources, and tourism value (Ng and Ong, 2022). In addition to their economic and subsistence importance, BCE function as natural infrastructure, buffering coastal communities from storm surges and tsunamis. Crucially, these services depend on the location of BCE at the interface of land and sea—a position that underpins their value, but also exposes them to pressures from both terrestrial and marine environments.

Global connectivity also operates both physically, through ocean currents and the atmosphere and socioeconomically. Globally, SEA's BCE play an outsized role in climate regulation, due to extent, high productivity and carbon burial rates. This makes SEA a region of interest for those seeking to generate carbon credits and offset greenhouse gas emissions. However, global demand for food, energy and raw materials drives pressures that often outweigh local conservation capacity.

These connections are further linked through climate change, a global challenge that attracts international attention and poses significant risks to BCE (Lovelock and Reef, 2020). Sea level rise, increased storm intensity and rising temperatures, could threaten carbon stocks and sequestration rates as well as their ability to provide other ecosystem services. To effectively protect and restore BCE it is essential to consider the interconnectivity from land to ocean and across all facets of the socio-oceanographic system (Popova et al., 2023).

LULCC: direct, indirect and emerging pressures

LULCC is driven by global demand for food and raw materials. Demand for land to produce commodities such as palm oil, rice and shrimps leads to destruction of BCE, whilst land uses such as mining cause pollution which impacts their health.

A study of long-term LULCC change in SEA (Mao et al., 2023) identified huge declines in forest and wetland, with large increases in cropland, grassland and urban area. Whilst a recent literature review (Stankovic et al., 2023) identified blue carbon hotspots in SEA and their potential threats, highlighting the spread of oil palm plantations in Indonesia, aquaculture, cultivated crops and salt ponds in the Philippines, deforestation for aquaculture development in Indonesia and port development in Malaysia. As highly interconnected systems, BCE are impacted by both direct and indirect LULCC.

Direct LULCC includes mangrove conversion for aquaculture or coastal development, resulting in loss of biomass and sediment carbon (Sasmito et al., 2020). In a study of mangrove conversion in SEA from 2000 to 2012, agricultural activities were identified as responsible for 22.64% of the change, aquaculture 5.85%, and infrastructure development 0.69%, with another 16.35% attributed to various human activities associated with population and economic growth (Fauzi et al., 2019). Other uses of mangroves, such as logging or selective harvesting, may have less severe impacts, but alter ecosystem structure and function (Adame et al., 2018).

Indirect LULCC, including upstream deforestation, damming, or urban development, alter sediment supply, freshwater inflow and pollutant loads, affecting BCE health and resilience (Le et al., 2007; Lin et al., 2021). Mangroves deprived of sediment can erode or retreat, while excess nutrients and sediments smother seagrass beds, disrupting trophic dynamics and carbon sequestration (Anh et al., 2021). Emerging threats include energy infrastructure such as hydropower dams (e.g. impacting the Mekong delta, Yoshida et al., 2020) and coal plants, which alter water temperature, sediment dynamics and salinity gradients critical to BCE functioning (Ng and Ong, 2022). Projects to restore BCE, can themselves be seen as LULCC with the potential to displace existing land uses or alter hydrological regimes, highlighting the need for careful planning and monitoring (Tulloch et al., 2021).

LULCC is seen to impact the health (Yap and Al-Mutairi, 2022) and extent (Fauzi et al., 2019) of BCE with knock on effects on ecosystem services, but these impacts are varied, interacting and uncertain (DasGupta and Shaw, 2017; Fortes, 2018a). Most studies of LULCC on BCE in SEA focus on mangroves and only consider direct conversion (Adame et al., 2018; Sasmito et al., 2019; Richards et al., 2020) and not impacts of upstream LULCC. The physical connectivity of BCE to the land through the LOAC means it is imperative that, in addition to considering direct LULCC, we properly consider the potential impacts of indirect LULCC (Jamilah et al., 2025).

LULCC stressors do not occur in isolation and are likely to interact with climate change impacts. Rising sea levels, warmer waters and intensified storm events threaten the stability and sequestration capacity of BCE (Chatting et al., 2022). Interactions among stressors can be synergistic or antagonistic, influencing ecosystem health, carbon sequestration potential and pushing BCE past tipping points beyond which recovery is difficult or impossible. Understanding such feedbacks is critical for avoiding irreversible degradation.

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Barriers to effective BCE management

Irrespective of growing recognition of their importance, BCE remain under protected and underfunded in most SEA countries. Their management is hindered by a range of interrelated informational, institutional and financial barriers that must be addressed to ensure long-term sustainability and equity.

Data gaps

Despite being fundamental to any management of BCE, accurate and comprehensive data on distribution, condition and carbon fluxes remain uneven across the region. The extent of seagrass meadows in particular is often underrepresented in national inventories and international reporting mechanisms (Lee et al., 2025). Whilst the ability to map seagrass remotely has advanced in recent years, the mapping of underwater ecosystems remains challenging (Veettil, 2020).

Carbon stocks in BCE are highly variable due to the influence of multiple biological, chemical and physical factors and their interacting effects (Williamson and Gattuso, 2022). Increased data on the sources of sediment to BCE, the carbon within the sediment and how this might change over time due to LULCC are required. A recent review of blue carbon studies in the Philippines (Corcino et al., 2023) concluded that more research and sustained monitoring of BCE, particularly seagrass meadows, is required. Seagrass meadows have a 76-fold range between the highest and lowest reported carbon burial rates (Williamson and Gattuso, 2022), additionally in many seagrass beds, around 50% of the organic carbon is from non-seagrass sources (Oreska et al., 2018). This information is vital to carbon crediting as carbon from external sources cannot be credited despite large inputs of allochthonous carbon to BCE.

There is uncertainty around how long BCE take to recover following disturbance and similarly, although there is measurement of changes in various carbon pools (biomass, sediment and dead organic matter), over time since regeneration (Azman et al., 2023) studies do not yet include measurement of gas emissions. There is a need for better understanding of methane and nitrous oxide release due to land use change impacts and before, during and after any restoration as the impact of LULCC on sediment carbon and nitrogen dynamics is still unclear (Tan et al., 2022).

Addressing these gaps requires deployment of technologies, such as high-resolution satellite remote sensing and drones (Fakhrurrozi et al., 2023), alongside *in situ* measurement, use of geospatial information systems (GIS) and modelling. Machine learning can be used with data obtained from satellites and drones to automate and improve extent mapping and carbon stock quantification (Pham et al., 2023). These technologies should be deployed alongside capacity-building efforts to train local actors in data collection and interpretation. Regional data-sharing platforms and open-access geospatial databases could enhance transparency, facilitate collaboration and reduce duplication of efforts.

Science-policy disconnect

The disconnect between science, policy and practice has been identified as the most important driver of BCE decline in SEA (Fortes, 2018a). Policymakers may lack the technical capacity or institutional mandates to engage with emerging findings, while researchers may not produce outputs that are readily usable in decision-making contexts (Fortes, 2018a). Many SEA countries, including Indonesia, Malaysia and Philippines (Thu Thuy and Thanh Thuy, 2019) are exploring BCE as a strategy in their Nationally Determined Contributions (NDCs) under the Paris Agreement. It is therefore important that the knowledge gap is bridged to implement science-based policies that ensure reliable carbon storage and align with local socio-economic priorities.

Strengthening science-policy interfaces through the establishment of boundary organisations, policy fellowships and co-production mechanisms is essential. Promoting joint forums where scientists, policymakers and community representatives can regularly interact will enhance mutual understanding, help align research agendas with policy priorities and have the potential to increase conservation success (Aswani et al., 2012). Additionally, embedding scientific advisors within government agencies and offering incentives for applied research can help bridge the divide.

The process of adaptive management is intended to overcome the necessity for decision makers to act with limited or incomplete information. Adaptive management frameworks are responsive, with built-in flexibility, monitoring and review, and should adjust to socio-economic change, such as urbanisation or increased tourism, and climate impacts as well as improved knowledge.

Scale mismatches

Many conservation and restoration efforts operate at local scales yet are affected by regional or global drivers such as upstream deforestation, industrial expansion and international trade. Conversely, national and regional policies may not reflect the ecological heterogeneity and socio-cultural diversity of local BCE contexts. Conservation initiatives, particularly those driven by international donors and Non-Governmental Organisations (NGOs), often prioritise regional or global agendas over local needs. There may be issues around increased monitoring and regulation of marine space, which are seen to exclude local interests and constrain access (Clifton and Foale, 2017). Protecting and restoring BCE as wetlands should ensure multiple benefits are delivered (Canning et al., 2021), but community support is vital to project success (Yusri et al., 2019).

The interconnectivity of BCE and associated marine ecosystems, such as coral reefs and kelp forests is sometimes overlooked as connections can be difficult to manage due to jurisdictional issues (Howard et al., 2017). A change of perspective is required, which considers BCE as components of a larger interdependent system (the LOAC). This is vital to ensuring their continued provision of ecosystem services and maintaining their role in carbon cycling and storage. There is a need for new frameworks to identify, quantify and integrate the ecological and biogeochemical interlinkages between the land and BCE; between the various BCE; and between coastal systems and pathways to carbon storage in the open ocean.

To address this, governance arrangements must support nested approaches where interventions are aligned across multiple levels. Local knowledge systems, customary practices and Indigenous governance structures must be integrated into broader planning frameworks to ensure that interventions are contextually grounded and socially legitimate. The success of blue carbon conservation hinges on the active participation of local communities in decision-making processes and empowering local communities to adopt sustainable practices ensures conservation efforts align with their socio-economic interests, for example by safeguarding livelihoods or creating alternative income streams. A systems approach could be implemented that considers the dynamics between coastal societies and ecosystems as part of interconnected social-ecological systems and links to global processes, whilst simultaneously taking into consideration the rights and needs of local communities.

Carbon market limitations

Whilst voluntary carbon markets offer an opportunity to mobilise private sector funding for blue carbon projects, they alone are unlikely to provide adequate finance, particularly where they fail to integrate broader socio-ecological values, risks and consideration of upstream LULCC impacts (Friess et al., 2022; Howard et al., 2023; Macreadie et al., 2022).

Carbon standards such as the two major, internationally accepted methodologies, the Verified Carbon Standard (Verra) and Plan Vivo (Claes et al., 2022), used to certify projects and facilitate trading are necessarily stringent, making them expensive and difficult to achieve (Wylie et al., 2016). They are also hindered by regulatory and legal uncertainties (Mack et al., 2022; Vanderklift et al., 2019). High transaction costs and complexity of the certification processes can exclude small-scale or community-led projects (Dencer-Brown et al., 2022), whilst volatility in carbon prices and lack of standardised metrics undermine confidence among investors and stakeholders (Vanderklift et al., 2019). It is also acknowledged that there is often a key gap in the integration and application of indigenous and local knowledge in the implementation of blue carbon projects (Macreadie et al., 2022).

A potential solution is to look beyond carbon and incorporate the multiple benefit streams (such as coastal protection, fisheries productivity and cultural heritage) provided by BCE in a form of payment for ecosystem services (PES) (Rakotomahazo et al., 2023; Shilland et al., 2021), which has been effective in protecting and restoring other ecosystems (Charoud et al., 2023).

Governance fragmentation

Maritime SEA comprises 10 countries with varied demographic and economic characteristics. Coastal governance involves a complex network of formal and informal institutions operating across multiple scales (Steenbergen et al., 2019). State governance of BCE is frequently spread across multiple agencies (e.g. environment, fisheries, forestry, planning) each with distinct mandates and limited coordination. To address the complex, interconnected and transboundary issues impacting BCE in a region that has historical been governed through a complex mix of formal, informal, religious and customary law, requires a holistic transboundary governance approach. This necessitates that policies are coherent across economic sectors and levels of governance to achieve balance between preserving ecosystems and meeting the socio-economic needs (access to food and water, health and livelihoods) of their populations. Collaborative efforts among SEA nations, NGOs and international bodies have led to progress in promoting the protection of BCE, for example the Oceanus Conservation Mangrove Restoration Project in the Philippines and the International Climate Initiative (IKI) Seagrass Ecosystem Services Project, which operates over five SEA countries (Miller and Taylor, 2024). Building effective coordination requires institutional reforms, such as establishing inter-ministerial task forces, harmonising policy instruments and developing shared implementation roadmaps. Progress is often slow, as previously noted by PEMSEA members in the Changwon Declaration of 2012, in which they committed to renewing their efforts (Gonzales et al., 2019). Cross-sectoral leadership and political will are critical to advancing coherent, adaptive and forward-looking BCE governance.

Recommendations for integrated system-based solutions

To ensure the long-term viability of BCE in SEA, a transformative shift toward integrated, inclusive and adaptive management is required. We propose five interlinked strategies to operationalise this vision (Figure 1).

Strengthen monitoring and carbon accounting

A robust evidence base is essential for effective BCE protection, restoration and management. Recent studies describe best practice in data collection (Dahl et al., 2025) and highlight the potential for the use of remote sensing in the monitoring, reporting and validation (MRV) of BCE (Malerba et al., 2023). Baseline mapping of extent and condition of BCE should be carried out at national and regional scales, for use in accounting and biodiversity monitoring. Regionally coordinated monitoring frameworks should be developed to track ecosystem health, habitat extent, carbon fluxes and socio-economic benefits, such as impacts on health, education and economic living standards. This would monitor success, assist in understanding the effect of climate change and other anthropogenic impacts, such as LULCC, on these ecosystems and inform future policy and management. Standardised protocols for measuring sediment carbon stock, sequestration rates, gas

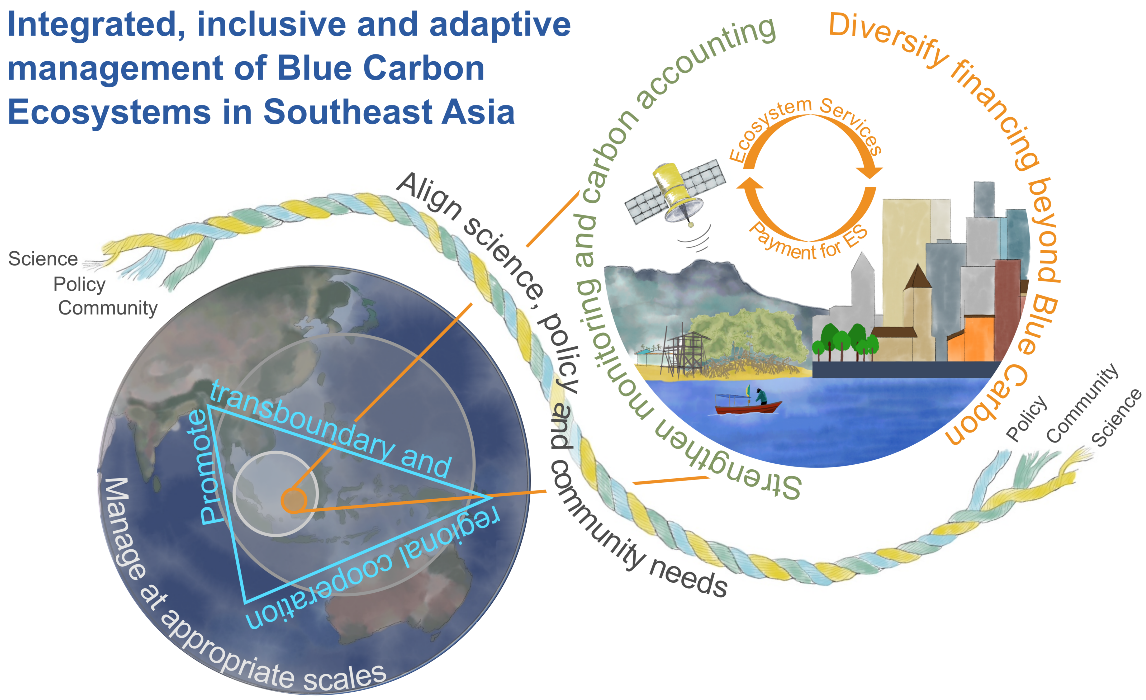

FIGURE 1
Five interlinked recommendations for operationalising integrated, system-based solutions for the management of Blue Carbon Ecosystems in Southeast Asia.

emissions and connectivity across BCE types will improve consistency and comparability (Williamson and Gattuso, 2022). Open-access platforms, such as regional blue carbon observatories, could enhance data accessibility and foster collaboration among governments, NGOs, academia and local communities. Integrating local ecological knowledge and citizen science initiatives will also enrich monitoring efforts and promote local ownership. All of this will go some way towards closing the data gap and could in the long-term reduce the effort and costs for individual projects.

Align science, policy and community needs

Science, policy and local knowledge must be brought into closer alignment through transdisciplinary collaboration and inclusive governance to bridge knowledge gaps and ensure science-based policies are aligned with local socio-economic needs. The science must be relevant, so that in addition to providing data, it can present ideas that can enhance policy. The alignment of scientific research with policy to support MRV will also increase the uptake of blue carbon projects.

Those who are directly reliant on BCE are most vulnerable to degradation and are most likely to be impacted by protection and restoration measures. Codesign, community-based monitoring, participatory planning processes and co-management arrangements can help bridge epistemological divides and ensure legitimacy. An understanding of the local governance context is vital to projects being constrained by socially and politically charged situations (Thomas, 2016). Policies should mandate community representation in decision-making bodies, while also creating enabling environments for grassroots innovation. Tools such as participatory mapping, scenario building and benefit-sharing agreements can facilitate more equitable and durable conservation outcomes. To build trust and accountability, accessible feedback mechanisms and dispute resolution channels should also be institutionalised.

Manage at appropriate scales

Effective BCE governance must reflect the spatial and functional interconnectivity of ecosystems, in addition to addressing global problems whilst maintaining a local focus. Combinatory theories of governance, such as adaptive management have evolved because singular theoretical perspectives are not well suited to understanding and addressing the multiple factors influencing environmental governance (Partelow et al., 2020). Governance approaches that recognise the complex spatial and temporal relationships in the LOAC offer a holistic framework to integrate ecological, hydrological and socio-economic dimensions. Nested governance models, linking local user groups to municipal, national and regional authorities, are needed to coordinate interventions and overcome the issue of terrestrial and aquatic environments coming under the jurisdiction of different authorities. Cross-boundary planning tools, such as marine spatial planning (MSP), should be expanded to incorporate upstream-downstream linkages and cumulative impacts. Scenario planning and adaptive management frameworks will be critical in dealing with uncertainty and responding to shifting climate and development pressures.

Promote transboundary and regional cooperation

Given that SEA encompasses multiple countries with shared marine ecosystems and mutual threats, regional cooperation is essential. Collaboration across borders and jurisdictions is vital to understanding BCE interconnectivity and the implementation of effective restoration and protection. Institutions like ASEAN, PEMSEA and the Coral Triangle Initiative provide platforms for harmonising policies, pooling resources and scaling best practices. In addition to recent calls for co-operation on blue carbon between China and countries of SEA at bi-lateral, sub-regional and trans-regional levels (Zhang, 2025), it has previously been proposed (Fortes, 2018b) that existing regional initiatives should come together to adopt a multi-regional approach to nature-based climate mitigation entitled “The Blue Carbon Triangle”. This could serve as a collaborative initiative for joint monitoring, restoration and capacity building across key BCE-rich countries. Regional centres of excellence, exchange programs and joint training initiatives could foster a common knowledge base and enhance trust among stakeholders. Formalising data sharing agreements and legal instruments for cross-border conservation could further strengthen transboundary coherence.

Diversify financing beyond carbon

A major challenge in protection and restoration of BCE is the need for sufficient finance (Friess et al., 2022). Schemes must be economically viable and yield greater returns as BCE than other potential uses (e.g. conversion to agriculture). Sustainable financing must reflect the multi-dimensional value of BCE. Beyond carbon credits, innovative mechanisms such as biodiversity offsets, blue bonds, climate adaptation finance and insurance-linked instruments should be explored. Blended finance models, combining public, private and philanthropic capital, could help de-risk investments and increase scalability.

Financialising ecosystem services in addition to carbon sequestration can be achieved under PES schemes, which should be designed with robust safeguards to ensure equity, transparency and long-term viability. A study into the viability of PES schemes in the Philippines concluded there were governance and implementation challenges due to the complexities of the coastal zone, but that PES had the potential to overcome these (Thompson et al., 2017). Establishing investment guidelines and Common Asset Trust (CAT) through a set of agreements and polycentrically governed institutions would safeguard BCE as common property by effectively linking finance and governance (Costanza et al., 2021). Aligning these mechanisms with local development goals will enhance synergies and reduce trade-offs between conservation and livelihoods.

Taken together, these strategies offer a roadmap for system-based BCE governance that integrates science, equity and resilience at its core. Building the institutional, financial and social foundations for such a transition will require persistent effort, political leadership and broad-based coalitions across sectors and scales.

Conclusion

Protection and restoration of SEA’s BCE represents a unique opportunity to deliver climate, biodiversity and socio-economic gains, yet these outcomes are not guaranteed. Management of BCE is currently hindered by informational, institutional and financial barriers, which require a transformational shift towards integrated, inclusive, systems-based management.

Our synthesis reveals key knowledge gaps that merit further research, including: understanding the cumulative and indirect effects of upstream LULCC on BCE carbon dynamics; integrating socio-economic and ecological data to better understand the interconnectivity of BCE and improve modelling and scenario analysis; and long-term tracking of governance effectiveness and equality outcomes.

Our vision to ensure the long-term viability of BCE in SEA can be operationalised through five interlinked strategies: strengthening monitoring and carbon accounting through standardised protocols, remote sensing and local participation; aligning science policy and community needs through inclusive governance and co-management; managing BCE at appropriate scales using nested and adaptive governance models; promoting transboundary and regional cooperation to coordinate efforts across shared ecosystems; and diversifying finance mechanisms beyond carbon markets to reflect the full value of BCE. Together these approaches provide a roadmap for resilient, equitable and system-based governance of BCE in the region.

This work contributes to a growing recognition of BCE as interconnected and socio-ecological systems, advancing systems thinking in coastal and climate policy. It underscores the need for transdisciplinary, nested governance models that cross ecological scales and institutional and national boundaries. These insights can inform future studies on adaptive management, transboundary environmental governance and blue carbon financing frameworks.

As SEA continues to urbanise and develop, the region faces a choice: pursue growth at the expense of natural capital or align economic transformation with ecological resilience. The latter pathway offers the possibility of unlocking a sustainable future in which blue carbon ecosystems are valued not only for their carbon, but for their role in sustaining life, livelihoods and planetary health. The urgency of the climate crisis, coupled with the fragility of BCE, demands immediate, inclusive and collaborative action across scales. The region has the scientific capacity, community knowledge and policy momentum to lead globally on blue carbon, but only if efforts move beyond boundaries.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

AB: Conceptualization, Writing – review & editing, Project administration, Visualization, Writing – original draft. SB: Writing – review & editing. JC: Writing – review & editing. FF: Writing – review & editing. AF: Writing – review & editing. SF: Project Administration, Writing – review & editing. EH: Writing – review & editing. MH: Writing – review & editing. MJ: Writing – review & editing. AM: Writing – review & editing. MM: Project administration, Writing – review & editing. JO: Writing – review & editing. TQ: Writing – review & editing. FR: Writing – review & editing. ES: Writing – review & editing. SC: Writing – review & editing. AT: Writing – review & editing. KT: Writing – review & editing. JW: Writing – review & editing. CW: Writing – review & editing. AA: Writing – review & editing. MY: Writing – review & editing. MY: Writing – review & editing. SY: Writing – review & editing. CE: Funding acquisition, Writing – original draft, Project administration, Writing – review & editing.

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Conflict of interest

Author TQ was employed by the company ABS-CBN Lingkod Kapamilya Foundation, Inc.

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