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Legal and Regulatory Frameworks for Blue Carbon Credit Markets

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Abstract. Blue carbon ecosystems — mangroves, seagrasses, and salt marshes — play a critical role in climate change mitigation by sequestering and storing carbon. Blue carbon credit score markets' development allows for restoration and conservation with the promise of economic incentive, but the prison and regulatory systems governing them are still fragmented and dynamic.

This article discusses the legal challenges, opportunities, and governance arrangements that influence blue carbon credit score markets, particularly within the framework of climate version, resilience, and the digital financial system. Critical issues include the standardization of carbon size methods, the role of global agreements such as the Paris Agreement and Article 6 carbon buying and selling frameworks, and the integration of blockchain and AI-driven verification frameworks for increased transparency and fraud avoidance. Furthermore, jurisdictional disputes exist in carbon right definition, especially in coastal regions where land ownership and marine administration interact.

The article discusses national and local policies that could be leading to blue carbon credit schemes, highlighting legal precedents and fiscal mechanisms selling equal advantage-sharing to local communities. In addition, they look at examines digital finance innovations, including tokenized blue carbon credit and decentralized verification frameworks, in enhancing regulatory compliance.

Solidifying legal foundations and embracing generation-driven regulatory solutions can be critical in ensuring the legitimacy, scalability, and long-term effectiveness of blue carbon markets as a climate resilience strategy.

Keywords: Blue Carbon Credits, Climate Adaptation, Regulatory Frameworks, Carbon Markets, Marine Governance, Paris Agreement, Ecosystem-Based Mitigation

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Оригинальная статья

Правовые основы «голубого» углеродного рынка

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Аннотация. Экосистемы с «голубым» углеродом — мангровые заросли, морские водоросли и соленые болота — играют важнейшую роль в смягчении последствий изменения климата, связывая и накапливая углерод. Развитие рынков кредитных рейтингов «Голубой углерод» позволяет осуществлять восстановление и консервацию этих экосистем с предоставлением экономических стимулов, но административная и нормативно-правовая системы, с помощью которых осуществляется управление ими, остаются фрагментированными.

В статье рассматриваются юридические проблемы, возможности и механизмы управления, влияющие на рынки кредитных рейтингов «голубого» углерода, особенно в рамках изменения климата, устойчивости и цифровой финансовой системы. Важнейшие вопросы включают стандартизацию методов определения размера выбросов углерода, роль глобальных соглашений, таких как Парижское соглашение и механизмы купли-продажи углерода по его ст. 6, а также интеграцию блокчейна и систем проверки на основе искусственного интеллекта для повышения прозрачности и предотвращения мошенничества. Кроме того, при определении понятия «углеродные права» существуют юрисдикционные споры, особенно в прибрежных регионах, где взаимодействуют землевладельцы и морская администрация.

В статье обсуждается национальная и местная политика, которая может привести к созданию схем «голубого» углеродного кредитования, освещаются юридические прецеденты и фискальные механизмы, обеспечивающие равное распределение выгод для местных сообществ. Рассматриваются инновации в области цифровых финансов, включая токенизированный «голубой» углеродный кредит и децентрализованные системы проверки, для повышения соответствия нормативным требованиям.

Укрепление правовых основ и внедрение регулятивных решений, ориентированных на будущие поколения, могут иметь решающее значение для обеспечения легитимности, масштабируемости и долгосрочной эффективности рынков «голубого» углерода в качестве стратегии устойчивости к изменению климата.

Ключевые слова: «голубые» углеродные кредиты, адаптация к изменениям климата, нормативно-правовая основа, углеродные рынки, управление морской средой, Парижское соглашение, смягчение последствий на основе экосистемного подхода

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1. Introduction

"Blue" points to the water source; blue carbon is the carbon sequestered in marine and shore ecosystems[1]. Most of the blue carbon is in the seas in the form of dissolved carbon dioxide (CO2) and underwater sediments, stored in shoreline flora, soils, and oceanic creatures from whales to phytoplankton[2]. Blue carbon ecosystems — mangroves, seagrasses, kelp, and tidal marshes — help to mitigate the other emissions[3].

A decade ago, Blue Carbon was coined to refer to the overproportioned contribution vegetated coastal ecosystems make in sequestering carbon on Earth[4]. Today, people worldwide appreciate Blue Carbon's contribution to adaptation as well as to climate change mitigation[5]. Namely by vegetated coastal ecosystems — mangrove forests, tidal marshes, and seagrass meadows — blue carbon is organic carbon stored and accumulated by the ocean and coastal ecosystems[6]. Blue Carbon is appealing around the world because of its potential to help reduce climate change and bring side benefits like coastal resilience and better fishing[7]. By compelling the scientific community to fill the knowledge gaps and uncertainties needed to underpin policy and management responses, the momentum created by these initiatives and conservationists has electrified researchers.

The efficiency of these carbon storage systems, compared to even the terrestrial forests, is partly due to their ability to absorb CO2 faster, the slow decomposing, anaerobic soils providing a favourable environment for storing or 'sequestering' the carbon[8]. Covering about 0.2% of the area of the oceans they account for about 50% of the carbon burial, surviving salinity, temperature changes, tidal flows and storm surges[9]. Even though they have climate mitigation and adaptation capability, these waterlogged environments, which mitigate climate effects and sustain the coastal people, are fast being degraded or being destroyed, primarily by development activities[10]. As attempts to mitigate climate change hazards are growing, concepts such as blue carbon, carbon offsets, credits, and trading dominate the top of the climate change report card[11].

From conservation and private sector businesses to governments and intergovernmental agencies concerned with marine conservation and adaptation and mitigation of climate change, Blue Carbon has attracted attention from many different nonscientific group ac-

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tors[12]. The momentum that these policies and conservation leaders have created has galvanized the scientific field by inspiring it to create uncertainties and knowledge gaps needed for informing policy and management decisions[13].

2. Importance of Blue Carbon for Climate Resilience and Mitigation

Climate change mitigation and adaptation are supported by Blue Carbon Ecosystems (BCEs), which include mangrove forests, and seagrass meadows[14]. These ecosystems are recognized as a natural climate solution worldwide. The UN Sustainable Development Goals (SDGs) have been recognized by nations worldwide as part of the 2030 global agenda. Among the 17[15]. Goals that can be directly tackled include addressing the conservation and protection of coasts, ocean floors (SDG 14) and climate change (1 SGD 13)[16]. SDG 13's objective of enhancing all nations' resilience to climate risks and disasters would be achieved through the restoration efforts of mangroves[17]. Although the document did not cover the socioeconomic background of Blue Carbon mitigation projects using natural ocean systems, it was mostly concerned with Blue Carbon in coastal wetlands form.

Since it is a natural habitat, blue carbon has attracted worldwide interest for its possible ability to offset carbon dioxide emissions. Still, it is somewhat restricted globally since it is applicable only to coasts. Coastal sites have been said to have much more sedimentary carbon—several times greater than those found in many tropical forests as well as most temperate species. The sequestration of carbon by vegetated shore environments is what lowers artificial CO2 emissions[18].

Blue carbon has been internationally recognized for its possibility to offset carbon dioxide releases as a natural habitat[19]. Still, since it only pertains to shorelines, its use is somewhat restricted worldwide. Coastal sites have been noted to contain great quantities of sedimentary carbon that is several folds higher than some temperate as well as most tropical forests[20]. The sequestration of carbon by vegetated shore ecosystems is the reduction of manmade CO2 emissions[21].

Coastal blue carbon ecosystems have been identified as the most effective ocean-based solutions for combating global change, thanks to their exceptional carbon reserves, sequestration levels, and high valuation of other ecological capital[22]. Among the coast vegetative biota are seagrass beds, mangrove forests, salt marshes. These have been lifesavers for humans and their environment for centuries. They have recently made clear to us that they can retain vast amounts of carbon and help reduce climate change».

The ability of blue carbon ecosystems to segregate and store CO2 contributes greatly to their adaptation against climate change, but their future efficiency is uncertain due to this[23]. The blue carbon habitat and its carbon reserves are at risk due to rising sea levels, drought, more frequent and intense hurricanes, altered temperature patterns, precipitation, and coastal heatwaves[24]. Climate-related stressors are linked to ecosystem sensitivity and resilience, which determine the extent to which these systems may be affected by disturbance[25].

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The use of biofuels was deemed detrimental to common food plants, particularly in less developed nations, which put the initial biodiesel on the market at risk[26]. The possibility of producing new biofuels from municipal, lignocellulosic, or agro-industrial waste was presented by the abundance of cellulous energy crops[27].

3. Blue Carbon Policy Objectives

Through international and national response policies to climate change, the value of coastal carbon management in stemming it is still not clearly recognized[28]. Currently unused for the distribution of aid for mitigation projects affecting coastal ecosystems are opportunities for financing opportunities created by climate change for restoration and sustainable use of these biological sites[29].

The Blue Carbon Policy Framework sets forth five Policy Objectives:

As a means of climate change mitigation, Blue Carbon projects completely incorporate into the international policy and financial support of the United Nations Framework Convention on Climate Change (UNFCCC)[30].

Use the voluntary carbon market together with other carbon finance avenues including Blue Carbon projects as a means of mitigating climate change[31].

Set up a Blue Carbon exhibition project network.

Include Blue Carbon projects in other international, regional, and national schemes and policies, including coastal and marine plans and policies, fully integrated[32].

Help to include the carbon value of coastal ecosystems more organically into accounting of ecosystem services[33].

4. Emergence of Blue Carbon Credit Markets as a Financial Mechanism

Natural carbon sinks' carbon trading rests on the idea that science will be able to quantify the carbon stored in these systems and trade it as credits, which the customer will subsequently use to offset emissions[34]. This is also called emissions trading. A particular "standard» including accounting, monitoring, verification, and certification requirements, as well as registration and enforcement mechanisms, certifies carbon credits[35]. These credits are then purchased on the compliance market, where buyers are themselves compelled under a treaty (such as the Kyoto Protocol or the European Union Emissions Trading Scheme) to reduce their emissions, or the voluntary market, where they do so on a voluntary basis with the goal of being more environmentally conscious. Blue carbon markets give us a fresh tool to battle climate change while simultaneously preserving our marine habitats[36]. Within coastal and marine environments including mangroves, seagrass beds, and tidal marshes, blue carbon is stored carbon[37].

The goal and purpose of this research is to give guidelines, observance, and sustainable use of carbon storage of coastal and marine ecosystems (including salt marshes, seagrasses, and mangroves). Along with carbon offsetting, blue carbon credit markets enable governments, businesses, and financial institutions to help pay for restoration and preservation initiatives. Assessing how countries control blue carbon initiatives including property rights, land tenure, and environmental impact assessments. Assessment of carbon credit validation criteria including Verra's Verified Carbon Standard (VCS) and the Gold Standard[38]. The legal environment of regulated carbon markets (such European Emissions

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Trading System) contrasted with that of voluntary carbon markets[39].

5. The Legal Foundations of Blue Carbon Credit Markets

Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD+) and Carbon Dioxide Mitigation (CDM) are examples of carbon market-based mechanisms that operate under the UNFCCC's compliance market[40]. The implementation of carbon offset credits for development projects in developing countries can be facilitated by CDM, which is a country-generated mechanism. REDD+, working in tandem with CDM, broadens the scope of the land use sector to more effectively address issues related to land usage change emissions[41].

International policy processes have been established to achieve better coastal conservation through the development of the International Policy Framework for Blue Carbon Ecosystems[42]. In partnership with governments, the United Nations (UN) agencies and other stakeholders, the Project strives to achieve better global outcomes for coastal ecosystems[43]. The retention of carbon in blue carbon habitats is beneficial for reducing climate change. Similarly, the "United Nations Framework Convention on Climate Change" and "Kyoto Protocol" have been established to identify the same phenomenon[44]. Locally established clean development mechanisms are being created to support the local blue carbon initiative[45].

The blue carbon project, a joint venture between the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO), Conservation International, and the International Union for Conservation of Nature (IUCN), is the first global program designed to combat climate change by conserving and restoring oceans[46]. The initiative is overseen by two working groups, namely the International Blue Scientific Working Group and the International Blue Carbon Policy Working group.

Blue carbon ecosystems have been included in nationally determined contributions (NDCs) to mitigate and adjust to climate change due to their contribution to coastal vulnerability to climate change and extreme weather events[47]. Saltmarshes, seagrasses, and mangroves in the Coral Triangles are particularly sensitive to sea level rise and are also being influenced by environmental change[48].

6. Compliance Market, and the Operationalization of the European Carbon Compliance Market

Carbon pricing is sought after through carbon prices determined by the market through laws or regulations regulating allowances, which are then distributed by national, regional, and international regime[49]. This can be achieved using carbon taxes or cap-and-trade schemes, which will reduce the cost of pollution and modify economic incentives. Over 60 countries have already established NDCs, which are systems designed to meet emission reduction targets set out in the Paris Agreement[50].

Introduced in 2005, the European Union Emissions Trading System (EU ETS) is the top-ranking carbon market globally[51]. Around 11 thousand installations are encompassed by the EU ETS, which covers diverse sectors such as energy-intensive industries and heat/power pro-

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duction[52]. The EU ETS is governed by the cap-and-trade principle[53]. The system imposes a cap or ceiling on the total emissions of greenhouse gases from covered installations. Over time, the cap is reduced to ensure a decrease in overall emissions[54].

Fines are imposed against a company that does not pay any taxes unless it gives up enough allowance to meet its production output each year[55]. When a company lowers its emissions, the excess allowance can be saved for future use or given to whichever business does not have any allowance. When necessary, companies can exchange emission allowances with each other.

Derivative carbon credit, including European Union Area or European Union Actions (EUAs), are traded on spot, forward and future markets under Markets in Financial Instruments Directive (MiFID) II regulations[56]. A portion of the overall allowances is given to operators in the primary market, while other EUAs are designated for financing specific projects related to innovation and transformation. The remainder is auctioned[57].

Some auction platforms host auctions, mainly on the exchange Integrated Coastal Ecosystems (ICE) and Exclusive Economic Zone (EEX)[58]. There are bi-weekly and daily auctions with different numbers offered. To participate in future contract buying and selling auctions, you must either join the registry market as a direct player or hire an intermediary broker/bank. After the European Union (EU) companies start selling and buying the allowances, entities with an EU registry account can do so in the secondary market. Both the parties could sell EUAs and purchase over the counter (OTC) from the registry account.

7. International Climate Agreements

The 2024 Baku UN Climate Conference of Parties (COP) 29 signed the much-awaited global carbon market rules after nearly a decade of negotiations[59]. To ensure the integrity of the carbon market, the participating countries agreed on rules for the creation, trade, and registration of carbon credits under Article 6 of the Paris Agreement, which outlines how countries can reach their climate targets by voluntary cooperation[60]. Article 6.2 of the Agreement has established a rule framework for carbon credit trading between seller and buyer nations to ensure sustainable development and environmental integrity as well as transparency[61]. It is aimed at ensuring the integrity of carbon credit trade through technical examinations as well as open monitoring. In addition, Article 6.4 addresses the establishment of an international carbon market under a supervisory authority that would endorse projects with sound methodologies prior to the issuance of carbon credits[62].

The result of the Conference of Parties (COP) 29 is that an agreed K300 billion climate finance goal for developing nations by 2035 was established, an important step towards addressing global needs[63]. While this is a positive step, the United Nations Commission on Trade and Developments (UNCTAD) analysis indicates that needs for financing from outside the country may rise to K1.46 trillion every year by 2030[64]. To bridge this gap, the 'Baku to Belem Roadmap to K1.3 Trillion' was initiated, laying out a clear path to ramping up ambition in the coming years. Success will depend on turning commitments into action[65].

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8. Voluntary Carbon Market

The voluntary market is a marketplace where individuals and entities can purchase Voluntary Carbon Credit (VCC) to offset carbon emissions, whether they are present or not[66]. It is necessary to implement measures to prevent, reduce, and replace harmful greenhouse gases before they are offset. However, there are emissions that cannot be prevented due to the absence of technology and cost involved[67]. Credits are calculated based on the emissions of one tonne of CO2 (or equivalent Greenhouse Gases (GHG) that have been verified or eliminated[68].

The scheme consists of two carbon emission reduction schemes. The first is a reduction scheme, whereby existing processes are enhanced to reduce the current emissions. Elimination initiatives aim to remove greenhouse gases from the air, utilizing natural methods like forest clearance or technological approaches such as carbon capture and storage[69]. Typically, companies that aim for Net Zero will consider removal projects as they focus on removing greenhouse gases from the atmosphere, while carbon neutral firms will typically choose reduction projects to offset CO2[70].

Verra, American Carbon Registry (ACO), Gold Standard, and Climate Action Reserve are all registries that sell VCC's. VCC's can be obtained from brokers or exchanges like Coastal Biodiversity Learning (CBL) and AirCarbon Exchange (ACX)[71]. Those who have emission reduction targets include corporations, airlines and governments.

The person who holds a VCC must withdraw the credits to make claims for their associated GHG reduction targets[72]. VCC's can be retired by third parties. The registry of a specific carbon offset program specifies the retirement path for individuals. After retiring, a VCC cannot be transferred or sold[73].

9. Legal Complexities in Defining Ownership of Sequestered Carbon in Coastal and Marine Environments

The growing recognition of coastal and marine ecosystems as vital carbon sinks has led to increasing interest in blue carbon markets and conservation finance[74]. However, defining ownership rights over sequestered carbon in these environments presents significant legal complexities[75]. Coastal and marine spaces often involve overlapping jurisdictions, customary rights, national laws, and international treaties, creating uncertainties over who can claim, trade, or benefit from stored carbon[76].

10. Property Rights and Jurisdictional Complexities: Defining Legal Ownership and Control in Blue Carbon Credit Frameworks

10.1. *Property Rights and Jurisdictional Complexities*

One of the primary legal challenges in defining ownership of sequestered carbon is the complex nature of property rights in marine and coastal environments[77]. Unlike terrestrial ecosystems, where land ownership is well-defined, coastal and marine areas involve multiple layers of governance.

10.2. *Public vs. Private Ownership*

In many countries, coastal and marine environments are classified as public commons, meaning they are owned or regulated by the state[78]. This creates uncertainty over whether private entities can claim ownership over the carbon stored in these ecosystems.

Some jurisdictions allow for private ownership of coastal lands, including mangrove forests, raising questions about whether landowners also own the carbon stored in these ecosystems[79].

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In contrast, Indonesia has extensive mangrove ecosystems, but unclear land tenure laws create disputes over whether local communities, private investors, or the government own the carbon benefits.

10.3. *Customary and Indigenous Rights Over Blue Carbon*

In many coastal regions, indigenous communities and traditional users have long-standing rights over marine and coastal areas. Recognizing these rights is crucial in determining ownership of sequestered carbon.

10.4. *Legal Recognition of Indigenous Land Tenure*

Some countries legally recognize indigenous land and resource rights, which may include blue carbon ecosystems.

Challenges arise when governments establish carbon offset projects on customary lands without proper consultation, leading to disputes.

In Papua New Guinea, land tenure laws recognize customary ownership, but carbon trading mechanisms remain unclear, leading to concerns over carbon colonialism (where external actors profit from local resources)[80].

10.5. *Risk of Carbon Rights Dispossession*

Without clear legal frameworks, powerful corporate or government entities may claim carbon sequestration rights, marginalizing local communities.

The risk of "land grabbing» exists, where governments or corporations take control of blue carbon ecosystems under the pretext of conservation or carbon trading.

Example:

In Kenya, some community-led mangrove conservation projects face legal uncertainties over whether local groups can claim carbon credits[81].

11. Reconciling Ecological Protection with Economic Incentives in Blue Carbon Governance

11.1. *Conflicts Between Environmental Laws and Market Mechanisms*

Even when legal ownership is recognized, conflicts between environmental regulations and carbon trading markets create further complexities.

11.2. *Integration of Blue Carbon into Carbon Markets*

Blue carbon is being integrated into cap-and-trade systems and voluntary carbon markets, but most national legal systems lack explicit frameworks for ownership of carbon stored in marine ecosystems.

11.3. *Legal Conflicts Between Conservation and Carbon Markets*

Some environmental laws restrict commercial exploitation of marine ecosystems, leading to legal conflicts when blue carbon is treated as a tradable commodity[82].

Governments may also claim sovereign rights over sequestered carbon to meet national climate targets, preventing private entities from profiting.

Example:

Brazil has strong mangrove protection laws, but there is legal uncertainty over whether carbon credits from mangroves can be sold in international markets[83].

11.4. *Recommendations for Resolving Legal Complexities*

To address these challenges, legal frameworks should:

11.4.1. Clarify Carbon Ownership Rights

Governments must establish clear legal definitions for ownership of sequestered carbon in marine and coastal environments.

11.4.2. Recognize Indigenous and Customary Rights

Strengthen legal protections for local communities and ensure free, prior, and informed consent (FPIC) in blue carbon projects.

11.4.3. Aligning National Laws with Carbon Market Standards

Countries should create legal mechanisms that allow for seamless integration of blue carbon into regulated and voluntary carbon markets.

11.4.4. Developing International Legal Frameworks

The United Nations Convention on the Law of the Sea (UNCLOS) and the United Nations Framework Convention on Climate Change (UNFCCC) should explicitly address carbon sequestration rights in marine environments.

11.4.5. Improve Transparency and Monitoring

Establish legal requirements for reporting, verifying, and ensuring accountability in blue carbon credit transactions.

12. Challenges in Regulating Blue Carbon Markets

12.1. The carbon credits market has been under scrutiny in recent years over the worth of the issued credits, and it has been questioned whether the funds are being utilized properly. The use of tradable permits has limitations because the nature of climate change will vary from one place to the other, so would the nature of emissions/capture, which would complicate the process of calculating carbon offsets. One of the primary difficulties in scaling up blue carbon initiatives is the inherent complexity of working in marine and coastal environments.

12.2. Oceanic ecosystems are more dynamic than land, and it is much more difficult to control and moni-

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tor in terms of conservation and restoration efforts. Furthermore, the science of blue carbon is relatively young when compared to that of forest carbon, and the methods for measuring, reporting, or verifying carbon sequestration in marine ecosystems are still evolving. The wealthy often benefit from dependence, consumption, and concentration of wealth, while a significant portion of the population remains poor.

12.3. It is conceivable that big carbon makers will back individuals who receive inaccurate credits under the facade of this initiative. Instead of decreasing their overall emissions, companies could purchase additional carbon credits to legitimize harmful practices. This is a potential problem. The future is bright in the face of many developing countries participating in blue carbon projects, despite the constraints.

12.4. Standardization and measurement issues pose significant challenges to the credibility and growth of blue carbon credit markets. Inconsistent methodologies, complex ecosystem dynamics, verification costs, and regulatory gaps hinder widespread adoption. However, advances in technology, stronger international cooperation, and improved regulatory oversight can enhance market integrity. A transparent, scientifically robust, and equitable blue carbon credit system is essential for ensuring that marine ecosystems contribute effectively to climate mitigation while benefiting coastal communities.

12.5. Unlike terrestrial carbon markets, which have well-established methodologies (e.g., REDD+ for forests), blue carbon projects operate under multiple, often conflicting accounting standards. Different carbon registries (e.g., Verra, Gold Standard, and American Carbon Registry) use varying criteria for calculating carbon sequestration, leading to inconsistent credit valuations. Some national governments have developed their own methodologies, further complicating alignment with global markets.

12.6. Unlike terrestrial forests, where carbon is stored primarily in above-ground biomass, blue carbon ecosystems store a significant portion of their carbon in below-ground sediments. This presents challenges in Baseline setting: Determining pre-existing carbon levels and expected sequestration rates over time. Variability in sequestration rates: Carbon storage depends on ecosystem type, salinity levels, sediment deposition, and hydrodynamic factors. Duration of sequestration: Some blue carbon ecosystems store carbon for millennia, but disturbances (e.g., coastal erosion, storms, human activity) can release stored carbon back into the atmosphere.

12.7. Some national governments consider blue carbon sequestration as a sovereign resource, making it difficult for private companies or communities to claim ownership and trade carbon credits. Disjointed policies between national and international frameworks create market uncertainty. In developing countries, weak governance and unclear legal definitions of carbon ownership led to disputes over credit revenues.

12.8. Inconsistent methodologies may lead to overestimating carbon sequestration, resulting in low-integrity credits that do not reflect real climate benefits. Some companies may use low-quality blue carbon credits to offset emissions without making real sustainability commitments.

13. Tokenization of Blue Carbon Credits in Digital Finance

Carbon credits guarantee permits to any individual or entity to exhibit a certain level of emission at a global level, including carbon dioxide and other greenhouse gases[84]. Companies earn or buy these carbon credits to adjust their carbon footprint to global sustainability resources. However, the traditional artwork of carbon credit trading does suffer from issues such as fraud, double counting, and lack of liquidity.

The verified environmental initiatives through which regulatory bodies or sustainability projects generate carbon credit include reforestation and renewable energy projects[85]. A carbon credit token is the tangible measure of carbon credit, ensuring its uniqueness and immutability in a blockchain[86]. These tokens are represented in decentralized ledger thus ensuring fraud and double spending risk elimination. Tokenized carbon credits can be traded online for easy blowing or retiring in organized investor markets[87]. With carbon offsetting, tokens are no longer in use anymore since these would be permanently retired[88].

14. Findings

14.1. *Overview of Legal and Regulatory Challenges*

Blue carbon credit markets, which involve carbon sequestration through coastal and marine ecosystems, face complex legal and regulatory hurdles. Unlike terrestrial carbon markets, blue carbon credits require frameworks that address jurisdictional ambiguities, international governance, ownership rights, and compliance with global climate policies.

14.1.1. Key Challenges Identified

14.1.2. Lack of a unified international regulatory framework for blue carbon governance.

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14.1.3. Unclear ownership rights over marine carbon sinks, especially in territorial waters and EEZs.

14.1.4. Complexity in integrating blue carbon credit into national and international carbon markets due to varying standards.

14.1.5. Regulatory inconsistencies across jurisdictions, leading to compliance difficulties for investors and project developers.

14.2. *International Legal and Policy Frameworks Governing Blue Carbon Credits*

Several international agreements and frameworks influence blue carbon markets, but none provide a comprehensive, legally binding system for their governance.

14.2.1. The Paris Agreement and NDCs

Under the Paris Agreement (Article 6), countries can use market mechanisms (e.g., carbon trading) to meet their emission reduction targets.

14.2.2. Some nations include blue carbon ecosystems in their Nationally Determined Contributions (NDCs), but methodologies for accounting remain inconsistent.

14.2.3. The lack of explicit blue carbon recognition under the Paris Agreement creates gaps in credit standardization and validation.

14.3. *UNFCCC*

14.3.1. The UNFCCC provides the foundation for climate-related carbon markets, but it does not have dedicated protocols for blue carbon crediting.

14.3.2. The Carbon Dioxide Mitigation (CDM) under the Kyoto Protocol initially excluded marine ecosystems, limiting their integration into global carbon markets.

14.4. *The CBD*

14.4.1. The CBD supports the protection of marine biodiversity, indirectly influencing blue carbon projects.

14.4.2. However, it does not provide explicit legal guidelines for carbon credit trading from marine and coastal ecosystems.

14.5. *The UNCLOS and Jurisdictional Ambiguities*

14.5.1. The UNCLOS governs marine resource use but does not explicitly regulate carbon sequestration rights in marine areas.

14.5.2. Jurisdictional conflicts arise over who owns the carbon credits from ocean-based sequestration projects, especially in the Exclusive Economic Zones (EEZs) and beyond national waters.

14.6. *Regional and National Regulatory Efforts*

14.6.1. Countries such as Australia, the United States, Indonesia, and the Philippines have started developing national policies for blue carbon projects.

14.6.2. Some nations integrate blue carbon into domestic emissions trading schemes (ETS), but regulatory fragmentation remains an obstacle to scaling international credit markets.

14.7. *Standards and Verification Challenges in Blue Carbon Markets*

Unlike terrestrial carbon credit markets, blue carbon lacks standardized verification methodologies. Several certification bodies are working to bridge this gap:

14.8. *Voluntary Carbon Market Standards*

14.8.1. Verra's VCS: Developed a methodology for mangrove restoration projects, but coverage for seagrass and other marine habitats is still limited.

14.8.2. Gold Standard: Primarily focuses on forestry and land-use projects, but emerging frameworks include marine carbon sequestration.

14.9. *Measurement, Reporting, and Verification (MRV) Gaps*

14.9.1. Complexity in quantifying oceanic carbon sequestration compared to terrestrial ecosystems.

14.9.2. High costs of MRV due to remote locations, lack of standardized protocols, and technological limitations in measuring below-ground carbon storage in wetlands and seagrasses.

14.9.3. Need for internationally recognized MRV frameworks that align with IPCC guidelines to ensure credibility.

14.10. *National Policy Approaches to Blue Carbon Credit Regulation*

Some countries are leading the way in integrating blue carbon into regulatory frameworks, though approaches vary:

14.10.1. Australia

Blue Carbon Methodology under the Emissions Reduction Fund (ERF): Recognizes mangrove and seagrass restoration for generating carbon credits.

Strong research collaboration between government, academia, and conservation groups.

14.10.2. Indonesia & Southeast Asia

Indonesia has legal protections for mangrove forests, which indirectly support blue carbon credit projects.

Partnerships with international organizations (e.g., Blue Carbon Initiative, The Nature Conservancy) are pioneering new methodologies.

14.10.3. European Union

The EU's ETS currently does not recognize blue carbon credits, but policy discussions are ongoing. Some national programs (e.g., Spain, Portugal) are investing in blue carbon research.

14.11. *Emerging Trends in Legal and Regulatory Developments*

14.11.1. Integration of Blue Carbon into Compliance Markets

While blue carbon dominates voluntary markets, efforts are underway to include marine sequestration in regulated carbon trading schemes.

14.11.2. The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) is working to harmonize global carbon credit standards, potentially benefiting blue carbon projects.

14.11.3. Digital Innovations in Blue Carbon Regulation

Blockchain-based registries are being explored to ensure transparency, traceability, and fraud prevention in blue carbon trading.

14.11.4. AI-powered MRV technologies (e.g., satellite monitoring, remote sensing) are improving the accuracy of carbon sequestration data.

14.11.5. Strengthening Legal Definitions of Ownership and Rights

Some nations are working to legally define ownership of sequestered carbon in marine areas, addressing legal ambiguities under UNCLOS.

14.11.6. Public-private partnerships (PPPs) are being promoted to ensure community-based governance models in blue carbon projects.

15. Recommendations

15.1. The UNFCCC should coordinate the development of a global blue carbon accounting framework, like REDD+ for forests. The use of comparable carbon reporting methods in climate reporting frameworks should be encouraged by the Intergovernmental Panel on Climate Change (IPCC) and the High-Level Panel for a Sustainable Ocean Economy.

15.2. Integrate the execution of blue carbon-related commitments and targets in policy processes. Ensuring that countries can achieve climate, biodiversity and sustainable development goals, maximizing utilization of available capacity, harmonize reporting processes, and enhance the implementation of NDC with other relevant frameworks and strategies.

15.3. Incorporate more funding into blue carbon projects within policy frameworks and suggest new sources of financial support. Moreover, nations may collaborate on blue carbon programs and projects that offer multiple co-benefits and can participate in blended finance (both government and private) arrangements.

15.4. Ensure that local communities and Indigenous peoples are involved in the planning, implementation, and monitoring of blue carbon projects.

15.5. Strengthen capacity to facilitate the realization of blue carbon-related commitments and targets and enhance previous efforts in policy processes through capacity strengthening.

16. Conclusion

Blue carbon acts as a key bridging role connecting ocean management and climate change abatement. Blue carbon has an important part in maintaining the good health of marine ecosystems as well as the stimulation of biodiversity while helping abate global climate change through its potent carbon sequestration properties. Global policy mechanisms regarding ocean management and abating climate change have, to a limited extent, included safeguards against blue carbon degradation.

Natural and anthropogenic activities lead to the degradation of coastal ecosystems. Despite its limited benefits, blue carbon is crucial in countering plastic and microplastic that are contributing to climate change. It contributes to the creation of co-benefits, such as development in aquaculture and coastal restoration that has been recognized globally. Moreover, sea grass meadows, coastal marshes and mangroves make up some of the largest carbon sinking ecosystems in the world.

Although blue carbon has not yet been comprehensively incorporated into all applicable dimensions of national and local policymaking, there are several documented best practices that are already in place. Familiarity with these best practices can assist policymakers and project developers in obtaining initial insights while undertaking new carbon-based incentives research.

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