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Interim report

# Analysis of selected Blue Carbon projects in the voluntary carbon market

## Opportunities and risks of current carbon crediting methodologies

**by:**

Dr. Tim Jennerjahn

ZMT, Bremen

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On behalf of the German Environment Agency

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**Abstract: Analysis of selected Blue Carbon projects in the voluntary carbon market**

Coastal ecosystems such as mangroves, tidal marshes, and seagrass meadows are experiencing widespread degradation, threatening biodiversity, livelihoods, and their significant potential to mitigate climate change. While interest in restoring these ecosystems has grown—particularly due to their carbon sequestration capacity—such efforts often face high costs and limited financial returns. In this context, "Blue Carbon" projects have emerged as a mechanism to mobilise private finance through voluntary carbon markets by generating tradable carbon credits from ecosystem conservation and restoration activities. This paper critically examines the opportunities, the risks, and the drivers for success associated with Blue Carbon projects, with a focus on whether the crediting methodologies and thus the projects themselves face integrity risks.

This report attempts a systematic assessment of the specific risks and opportunities which may arise when using carbon crediting mechanisms to raise funding for the protection and restoration of coastal ecosystems. The assessment draws on empirical evidence from a small sample of seven projects registered with carbon crediting programmes in the voluntary carbon market. The sample represents about one third of all registered Blue Carbon projects at the time of writing. It is skewed towards mangrove conservation and mangrove restoration projects, as there are currently no registered seagrass or tidal marsh restoration projects. Inputs for the assessment were project design documents and monitoring reports as well as other documentation made available through the registries of the carbon crediting programmes under which the projects are registered. The assessment also considered rules of carbon crediting programmes applying to all project types, where relevant. Finally, peer-reviewed literature as well as grey literature was used to contextualise the observations from the project sample and inform the analysis.

The report shows that integrity risks are a major challenge for the effectiveness of BC projects These risks relate to all core dimensions of crediting – additionality, quantification, permanence, safeguards and double counting. The analysis of the project sample shows that there is evidence that risks also materialize in concrete projects on the ground. It however also highlights that existing projects – despite inherent uncertainties in available quantification methodologies – have made project design choices, which very likely lead to conservative estimates of carbon removals. This especially applies to mangrove restoration projects, offering important lessons for development of future projects.

Certain integrity risks such as avoided emissions and removals being not permanent remain even under conservative quantification approaches. This means that caution should be applied when using resulting carbon credits for meeting mitigation targets. Improving liability mechanisms and ensuring continuous monitoring are crucial to addressing these concerns.

Finally, by committing to measure changes in key carbon pools such as biomass and soil carbon regularly and by making this data readily available to the scientific community, Blue Carbon projects could directly help reduce uncertainties in quantifying carbon stocks in coastal ecosystems. For example, if the more than 50 projects currently under development collectively agreed to annually collect field data using statistically robust measurement techniques, this could significantly advance availability of global data. Carbon crediting programmes and public agencies could support these efforts by creating a platform that connects individual projects, fosters peer-to-peer learning, and builds communities of practice to support measurement efforts and facilitate data exchange between projects and the scientific community.

**Kurzbeschreibung: Analyse ausgewählter Blue Carbon Projekte im freiwilligen Kohlenstoffmarkt**

Küstenökosysteme wie Mangrovenwälder, Salzwiesen und Seegraswiesen sind zunehmend von Degradierung betroffen. Dadurch sind nicht nur Biodiversität und Lebensgrundlagen gefährdet, sondern auch das erhebliche Potenzial dieser Ökosysteme zur Abschwächung des Klimawandels. Obwohl das Interesse an der Wiederherstellung dieser Ökosysteme – insbesondere aufgrund ihrer Fähigkeit zur Kohlenstoffbindung – gewachsen ist, stehen entsprechende Maßnahmen häufig vor hohen Kosten und begrenzten finanziellen Erträgen. Vor diesem Hintergrund sind „Blue Carbon"-Projekte entstanden, die durch den freiwilligen Kohlenstoffmarkt privates Kapital für den Schutz und die Wiederherstellung von Küstenökosystemen mobilisieren sollen. Durch handelbare Kohlenstoffzertifikate bieten sie einen marktbasierten Finanzierungsansatz. Dieses Papier untersucht kritisch die Potenziale, Risiken und Erfolgsfaktoren dieser Projekte im Hinblick darauf, ob die verwendeten Zertifizierungsmethoden und somit auch die Projekte Risiken in Bezug auf die Umweltintegrität haben.

Hierzu unternimmt der Bericht den Versuch einer systematischen Einordnung der spezifischen Risiken und Chancen, die mit der Nutzung von handelbaren Emissionsgutschriften zur Finanzierung des Schutzes und der Wiederherstellung von Küstenökosystemen verbunden sind. Die Untersuchung stützt sich auf empirische Daten aus einer kleinen Stichprobe von sieben Projekten, die bei Kohlenstoffprogrammen im freiwilligen Kohlenstoffmarkt registriert sind. Diese Stichprobe repräsentiert etwa ein Drittel aller zum Zeitpunkt der Erstellung des Berichts registrierten Blue-Carbon-Projekte. Da es zum Zeitpunkt der Erstellung keine registrierten Projekte zur Wiederherstellung von Seegras oder Gezeitenmarschen gibt, dominieren Mangroven-Projekte die Stichprobe. Für die Analyse wurden Projektdesign-Dokumente und Monitoringberichte sowie andere Dokumente genutzt, die in den Projektdatenbanken der Kohlenstoffprogramme verfügbar sind. Die Analyse berücksichtigt auch die Regelwerke der Kohlenstoffprogramme, unter welchen die Projekte registriert sind, sofern relevant. Schließlich wurden sowohl wissenschaftliche Literatur als auch Graue Literatur verwendet, um die Erkenntnisse aus der Analyse der Beispielprojekte zu kontextualisieren.

Der Bericht zeigt, dass Integritätsrisiken eine wesentliche Herausforderung für die Wirksamkeit von Blue Carbon Projekten darstellen. Diese Risiken betreffen alle Kernaspekte von Emissionsgutschriften, darunter Zusätzlichkeit, Quantifizierung, Permanenz, Umwelt- und Sozialstandards sowie Doppelzählung. Die Analyse der untersuchten Projekte zeigt, dass es Hinweise darauf gibt, dass diese Risiken auch in konkreten Projekten vor Ort eintreten. Sie hebt jedoch auch hervor, dass einige Projekte – trotz der Unsicherheiten in den verfügbaren Quantifizierungsmethoden – Quantifizierungsansätze gewählt haben, welche tendenziell zu konservativen Abschätzungen der Kohlenstoffbindung führen. Dies gilt insbesondere für Wiederherstellungsprojekte von Mangrovenwäldern, deren Ausgestaltung wegweisend für zukünftige Projekte sein kann.

Bestimmte Integritätsrisiken, wie das Risiko der Nicht-Permanenz, bleiben selbst bei der Verwendung von konservativen Quantifizierungsansätzen bestehen. Das bedeutet, dass Vorsicht geboten ist, wenn die resultierenden Emissionsgutschriften zur Erreichung von Minderungszielen verwendet werden sollen. Eine kontinuierliche Verbesserung der bestehenden Haftungsmechanismen und die Gewährleistung einer kontinuierlichen Überwachung sind hierbei entscheidend, um diese Bedenken adäquat anzugehen.

Blue-Carbon-Projekte können ferner direkt dazu beitragen, Unsicherheiten bei der Quantifizierung von Kohlenstoffbeständen in Küstenökosystemen zu verringern. So könnten sie sich zum Beispiel verpflichten, regelmäßig Veränderungen in wichtigen Kohlenstoffpools wie Biomasse und Böden zu messen und diese Daten der Wissenschaft zur Verfügung zu stellen. Wenn sich beispielsweise die mehr als 50 Projekte, die sich derzeit in Entwicklung befinden,

kollektiv darauf einigen würden, jährlich Feldmessdaten unter Verwendung statistisch robuster Messmethoden zu sammeln, könnte dies die Verfügbarkeit globaler Zeitreihen zu Kohlenstoffspeicherpotentialen erheblich voranbringen. Kohlenstoffprogramme und öffentliche Institutionen könnten diese Bemühungen unterstützen, indem sie Möglichkeiten für Projekte schaffen sich zu vernetzen, um gemeinsames Lernen und den Austausch von Daten zwischen Projekten und der Wissenschaft zu erleichtern.

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## List of abbreviations

| | |
|---|---|
| **ACES** | Association for Coastal Ecosystem Services |
| **ACR** | ACR – formerly known as American Carbon Registry |
| **AFOLU** | Agriculture, Forestry, and Other Land Uses |
| **BAU** | Business-as-usual |
| **BC** | Blue Carbon |
| **BCE** | Blue Carbon Ecosystem |
| **C** | Carbon |
| **CAR** | Climate Action Reserve |
| **CBD** | Convention on Biological Diversity |
| **CCBS** | Climate, Community and Biodiversity Standard |
| **CCQI** | Carbon Credit Quality Initiative |
| **$CH_4$** | Methane |
| **$CO_2$** | Carbon dioxide |
| **$CO_2e$** | Carbon dioxide equivalents |
| **CDM** | Clean Development Mechanism |
| **CP** | Carbon pool |
| **CRT** | Climate Reserve Ton |
| **DBH** | Tree diameter at breast height |
| **DMI** | Integrated Management District |
| **DRMI** | Regional Integrated Management District |
| **ERR** | Emission reduction and removal |
| **ES** | Emission source |
| **FIAL** | Fund for Local Environmental Initiatives |
| **FPIC** | Free, prior, and informed consent |
| **GHG** | Greenhouse gas |
| **Ha** | Hectares |
| **IBAP** | Institute for Biodiversity and Protected Areas |
| **IC-VCM** | Integrity Council for the Voluntary Carbon Market |
| **IFC** | International Finance Corporation |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IUCN** | International Union for the Conservation of Nature |
| **KFS** | Kenyan Forest Service |
| **KMFRI** | Kenya Marine and Fisheries Research Institute |
| **MPCO** | Mikoko Pamoja Community Organisation |
| **MX** | Mexico |
| **MXN** | Mexican Pesos |
| **$N_2O$** | Nitrous oxide |

| | |
|---|---|
| **ACES** | Association for Coastal Ecosystem Services |
| **NDC** | Nationally Determined Contributions (in Paris-Agreement) |
| **NDVI** | Normalized difference vegetation index |
| **NNL** | National Natural Landmark |
| **NPRT** | Non-permanence Risk Tool |
| **OIMP** | Other international mitigation purposes |
| **PDD** | Project Design Document |
| **PES** | Payment for environmental services |
| **PRN** | Regional Natural Park |
| **PV** | Plan Vivo |
| **PVC** | Plan Vivo Certificate |
| **REDD+** | Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries |
| **SDG** | Sustainable Development Goal |
| **SDVISta** | Sustainable Development Verified Impact Standard |
| **SOC** | Soil Organic Carbon |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **USD** | US-Dollar |
| **VCM** | Voluntary Carbon Market |
| **VCR** | Virginia Coastal Reserve |
| **VCS** | Verified Carbon Standard |
| **VCU** | Verified Carbon Unit |

## Zusammenfassung

Küstenökosysteme speichern Kohlenstoff vor allem in Mangrovenwäldern, Seegraswiesen und Salzmarschen. Obwohl einige von ihnen einen gewissen Schutz genießen, sind die globalen Kohlenstoffbestände in diesen Ökosystemen in den letzten Jahrzehnten zurückgegangen. Bei Mangrovenwäldern sind die Hauptursachen für diesen Verlust der gestiegene Landnutzungs-Druck durch Flächenbedarfe von Reisanbau und Aquakultur. Die Nutzung von Mangrovenhabitaten für die Brennholzgewinnung und die Subsistenzwirtschaft spielen nur eine untergeordnete Rolle.

Durch Emissionsgutschriften kann der Kohlenstoffspeicherfunktion von Küstenökosystemen ein ökonomischer Wert beigemessen werden. Dadurch sind sie eine potenzielle Finanzierungsquelle für Aktivitäten, die darauf abzielen, degradierte Küstenlebensräume wiederherzustellen oder bestehende vor weiterer Degradierung zu schützen.

Im Gegensatz zu anderen Finanzierungsformen, wie Unterstützung durch Philanthropie oder Entwicklungszusammenarbeit, bringt die Verwendung von Emissionsgutschriften als Finanzierungsmechanismus jedoch eine entscheidende Verantwortung mit sich. Wenn sie zur Kompensation eingesetzt werden, erlaubt jede ausgegebene Gutschrift eine entsprechende Tonne $CO_2$-Emissionen an anderer Stelle. Deshalb ist die Umweltintegrität der Gutschrift von entscheidender Bedeutung. Wenn Gutschriften ohne Gewährleistung von Zusätzlichkeit, Permanenz und konservativer Kohlenstoffbilanzierung ausgegeben werden, kann dies zu einem Nettoanstieg der globalen Emissionen führen. Im Resultat könnte die Gesellschaft neue Maßnahmen zum Schutz und zur Wiederherstellung von Küstenökosystemen mit höheren $CO_2$-Konzentrationen in der Atmosphäre subventionieren – ein kontraproduktives Ergebnis. Dies unterstreicht die Notwendigkeit strenger Zertifizierungsregeln, robuster Methoden und wirkungsvoller Aufsichtsmechanismen, um sicherzustellen, dass Emissionsgutschriften Klimaschutz wirklich unterstützen und nicht untergraben.

Es gibt viele verschiedene Projekttypen, unter denen Blue-Carbon-Projekte eine relativ neue Erweiterung des Projektportfolios von Kohlenstoffprogrammen auf dem freiwilligen Kohlenstoffmarkt darstellen. Derzeit spielen sie eine untergeordnete Rolle, was sich in einer vergleichsweise geringen Anzahl von ausgeschütteten Emissionsgutschriften widerspiegelt. Dies könnte sich in Zukunft ändern, da das Interesse an dieser Art von Projekten zunimmt und sich derzeit mehr als 50 Projekte in der Entwicklung befinden.

Dieser Bericht versucht eine systematische Bewertung der spezifischen Risiken und Chancen, die bei der Nutzung von Emissionsgutschriften zur Finanzierung des Schutzes und der Wiederherstellung von Küstenökosystemen entstehen können. Ein besonderer Schwerpunkt liegt auf der Wirksamkeit von Aktivitäten bei der Verbesserung der Kohlenstoffspeicherung und der Reduzierung von Emissionen. Die Bewertung stützt sich auf empirische Daten aus einer kleinen Stichprobe von sieben Projekten, die unter Kohlenstoffprogrammen auf dem freiwilligen Kohlenstoffmarkt registriert sind. Die Stichprobe umfasst etwa ein Drittel aller zum Zeitpunkt der Erstellung dieses Berichts registrierten Blue-Carbon-Projekte. Sie ist auf Projekte zum Schutz und zur Wiederherstellung von Mangrovenwäldern ausgerichtet, da derzeit keine Projekte zur Wiederherstellung von Seegraswiesen oder Salzmarschen registriert sind. Als Grundlage für die Bewertung dienten Projektdokumente (PDDs) und Monitoring-Berichte sowie weitere Unterlagen, die über die Projektdatenbanken der Kohlenstoffprogramme, unter denen die Projekte registriert sind, zugänglich gemacht wurden. Bei der Bewertung wurden gegebenenfalls auch die für alle Projektarten geltenden Regeln der Programme berücksichtigt. Schließlich wurde peer-reviewte sowie graue Literatur herangezogen, um die Erkenntnisse aus der Projektstichprobe zu kontextualisieren.

Die wichtigsten Ergebnisse und Schlussfolgerungen zu den folgenden Dimensionen waren:

- **Zusätzlichkeit**: Projektaktivitäten wie die Wiederaufforstung von Mangroven, die Durchführung von Patrouillen zum Schutz von bestehenden Mangrovenwäldern und die Durchführung von Schulungsprogramme zur Schaffung alternativer Lebensgrundlagen für die lokale Bevölkerung verursachen Kosten, generieren jedoch keine Einnahmen für die Projektverantwortlichen. Alle Projekte in der Stichprobe zeigten deutlich, dass finanzielle Anreize für die Umsetzung der Klimaschutzmaßnahmen notwendig waren. Weniger klar war jedoch, ob die Einnahmen aus Emissionsgutschriften die einzige verfügbare Finanzierungsquelle waren und welche Rolle sie für die allgemeine finanzielle Tragfähigkeit der Projekte spielten. In mehreren Fällen hatten die für die Projekte zuständigen Stellen zuvor Gelder aus der Entwicklungszusammenarbeit oder philanthropische Zuwendungen für ähnliche Aktivitäten, einschließlich der Projektvorbereitung, erhalten. Die Projektdokumente enthielten jedoch nur begrenzte Informationen über die Projektkosten und die Rolle anderer Finanzierungsquellen, sodass eine vollständige Bewertung der Risiken für Nicht-Zusätzlichkeit nicht möglich war. Eine damit zusammenhängende Beobachtung aus der Projektstichprobe ist, dass die Einreichung der PDDs bei dem jeweiligen Kohlenstoffprogramm in allen Fällen erst nach Beginn der Wiederaufforstungs- oder Schutzmaßnahmen erfolgte. Es ist gängige Praxis von Kohlenstoffprogrammen, eine Registrierung auch nach Beginn der Klimaschutzmaßnahmen zuzulassen, da die Vorbereitung der für die Registrierung erforderlichen Analysen und Unterlagen mehrere Jahre dauern kann. Wenn Projekte jedoch über einen langen Zeitraum ohne Einnahmen aus Emissionsgutschriften erfolgreich umgesetzt werden können, wird es zunehmend schwieriger nachzuvollziehen, ob die Aussicht auf eine Finanzierung durch Emissionsgutschriften ein entscheidender Faktor für die Initiierung des Projekts war. In einem Extremfall wurden die PDDs erst neun Jahre nach Beginn der Projektaktivitäten eingereicht.

  Die Bewertung ergab auch, dass Projektentwickelnde derzeit bevorzugt Blue-Carbon-Projekte in Gebieten mit Schutzstatus umsetzen, wie z. B. Nationalparks. Diese Überschneidung zwischen Projektstandorten und Schutzgebieten birgt gewisse Risiken der Nicht-Zusätzlichkeit, da bestimmte Aktivitäten, von denen im Referenzszenario ausgegangen wird – wie z. B. die Abholzung von Mangroven – bereits durch Schutzgebietsvorschriften verboten sind. In Fällen, in denen diese Vorschriften nicht durchgesetzt werden, sind die Risiken der Nicht-Zusätzlichkeit jedoch möglicherweise gering. Darüber hinaus deutet die bevorzugte Ansiedlung von Projekten in Schutzgebieten darauf hin, dass die aktuellen Blue-Carbon-Projekte noch keinen wesentlichen Beitrag zu globalen Zielen wie der 30x30-Initiative des Übereinkommens über die biologische Vielfalt (CBD) leisten, die darauf abzielt, das globale Netzwerk von Schutzgebieten zu erweitern. Es ist jedoch wichtig zu beachten, dass diese Schlussfolgerung auf einer kleinen Stichprobe von Early-Mover-Projekten basiert und zukünftige Projekte diesen Trend möglicherweise verändern werden. Projektentwickelnde können zudem legitime Gründe dafür haben, sich auf Schutzgebiete zu konzentrieren, da diese Standorte oft weniger Konfliktpotenzial mit lokalen Gemeinschaften bergen, da bereits Landnutzungsbeschränkungen bestehen und keine neuen eingeführt werden müssen.

  Insgesamt gibt es trotz dieser Bedenken keine Hinweise aus der Projektstichprobe, die darauf hindeuten, dass die Risiken der Nicht-Zusätzlichkeit für Blue-Carbon-Projekte ausgeprägter sind als für andere Projekttypen. Die Hauptrisiken für einzelne Projekte ergeben sich aus ihrer Überschneidung mit Schutzgebieten und der potenziellen Verfügbarkeit alternativer Einnahmequellen. Während diese Bedenken hinsichtlich der

Integrität bestehen, gibt es zwei wichtige Maßnahmen, die Kohlenstoffprogramme umsetzen können, um die Risiken der Nicht-Zusätzlichkeit weiter zu verringern. Erstens sollten sie von den Projektentwickelnden eine öffentlich zugängliche, umfassende Investitionsanalyse verlangen, einschließlich einer detaillierten Aufschlüsselung der Kosten und einer klaren Unterscheidung zwischen Einnahmen aus Emissionsgutschriften und anderen Finanzierungsquellen. Zweitens sollten Projektentwickelnde eine Absichtserklärung einreichen, sobald sie sich für die Durchführung des Projekts entschieden haben. Dies könnte dazu beitragen, Unsicherheiten in Fällen zu verringern, in denen die Projektdokumente erst nach Beginn der Klimaschutzmaßnahmen eingereicht werden. Ein Projekt in der Stichprobe hat solche Informationen bereits auf freiwilliger Basis eingereicht.

- **Quantifizierung**: Die Quantifizierung der Kohlenstoffspeicher in Küstenökosystemen ist komplex, und die Ergebnisse sind mit großen Unsicherheiten behaftet. Küstenökosysteme weisen eine hohe räumliche und zeitliche Variabilität in der Kohlenstoffdynamik auf, was die Entwicklung standardisierter Messverfahren zur Kohlenstoffquantifizierung erschwert. Die wichtigsten Kohlenstoffspeicher sind ober- und unterirdische Biomasse sowie organischer Kohlenstoff im Boden, während die wichtigsten Emissionsquellen die mikrobielle Methanproduktion und die Nutzung fossiler Brennstoffe für die Projektdurchführung sind. Quantifizierungsmethoden berücksichtigen alle relevanten Kohlenstoffspeicher und Emissionsquellen innerhalb der Treibhausgasbilanzgrenze. Sie erlauben jedoch den Ausschluss bestimmter kleinerer Emissionsquellen, was zu einer Überschätzung der Emissionsminderungen oder -einspeicherung führen könnte, wenn auch wahrscheinlich nicht in erheblichem Umfang.
- Die Ansätze zur Bestimmung von Entwaldungsraten im Referenzszenario in Mangroven-*Schutzprojekten* sind mit erheblichen Überschätzungsrisiken verbunden. Die Quantifizierungsmethode VM0007 lässt erhebliche Flexibilität bei der Auswahl der Referenzgebiete und -zeiträume zu. Ein Projekt in der Stichprobe geht beispielsweise im Referenzszenario davon aus, dass es zu einem Verlust von 67 % der bestehenden Mangroven-Kohlenstoffvorräte kommen wird. Angesichts der Tatsache, dass das Projekt in einem Schutzgebiet durchgeführt wird, könnte dies eine sehr starke Annahme sein. Im Gegensatz dazu sind Mangroven-*Renaturierungsprojekte* weniger von systemischen Unsicherheiten im Referenzszenario betroffen, da Mangrovenhabitate in vielen Fällen ohne die Projektmaßnahmen degradierte Flächen bleiben würden. Einzelne Projekte könnten jedoch die Kohlenstoffbindung überschätzen, wenn sie nicht die Möglichkeit berücksichtigen, dass die Renaturierung auch durch alternative Finanzierungsquellen im Referenzszenario erfolgt wäre. Dieses Risiko ist besonders relevant in Gebieten, in denen in der Vergangenheit bereits erfolgreiche Mangroven-Wiederaufforstungsmaßnahmen durchgeführt wurden. Zur Vermeidung dieser Unsicherheiten sollten Projektentwickelnde dazu verpflichtet werden, in solchen Fällen Abzüge für die angerechnete Projektfläche vorzunehmen und die Emissionswirkung der Aktivitäten konservativ abzuschätzen.
- Die Messung der Auswirkungen von Projektmaßnahmen auf Veränderungen der Kohlenstoffspeicher zwischen Referenz- und Projektszenario ist von Natur aus mit Unsicherheiten behaftet. Das Fehlen langfristiger Daten zu Kohlenstoffströmen, insbesondere in wiederhergestellten Ökosystemen und für Nicht-Mangroven-Lebensräume wie Seegraswiesen und Salzmarschen, erschwert die Abschätzung dieser Veränderungen. Bei der Biomasse resultieren die größten Unsicherheiten aus der Auswahl geeigneter allometrischer Gleichungen, der Anzahl der zur Erstellung dieser Gleichungen verwendeten Bäume in der Stichprobe sowie aus der Lage und Platzierung der Stichprobenflächen für die nachträgliche Messung der Kohlenstoffentnahmen. Die Kohlenstoffschätzungen in allen

sieben in diesem Bericht betrachteten Projekten sind von diesen Unsicherheiten betroffen. Ob diese eher zu einer Über- oder Unterschätzung der Minderungs- oder Entnahmemenge in der Projektstichprobe führen, konnte für die Stichprobe nicht abschließend bewertet werden. Organischer Kohlenstoff in Böden sind bei weitem der größte Speicher in Blue-Carbon-Ökosystemen und gleichzeitig der am schwierigsten zu überwachende. Die Erhebung der erforderlichen Daten erfordert spezielles Fachwissen und den Zugang zu speziellen Laborgeräten. Die Messung ist zudem mit hohen Kosten verbunden, weshalb Erhebungen im Projektgebiet selten durchgeführt werden und wenn nur auf wenigen Proben basieren. Die Quantifizierung des Kohlenstoffs im Boden ist daher nach wie vor mit großer Unsicherheit behaftet und könnte zu einer Überschätzung der Entnahmewirkung führen, wenn Projekte Daten verwenden, die nicht repräsentativ für das gesamte Projektgebiet sind, oder wenn stattdessen verwendete Standardwerte die tatsächlichen Raten der Kohlenstoffakkumulation im Boden überschätzen. Ein weiteres Problem ist, dass einzelne Methoden Projektentwickelnden die Wahl geben, flexibel zwischen verschiedenen Messansätzen zu wählen, was zu adverser Selektion führen kann. Eine weitere Ursache für die Unsicherheit in der Quantifizierung der Entnahmemengen ist der Umgang mit Methanemissionen durch Mikroben. Keines der Beispielprojekte berücksichtigt diese Emissionen, was zwar den Anforderungen der jeweiligen Quantifizierungsmethoden entspricht, aber zu Unsicherheiten über die netto-Entnahmemenge führt. Die Bedeutung von Methanemissionen in Mangrovenprojekten wird derzeit noch weiter erforscht. Im Einklang mit dem Vorsorgeprinzip sollten Kohlenstoffprogramme Erkenntnisse dieser Forschung bei der Weiterentwicklung ihrer Methoden berücksichtigen.

- **Nicht-Permanenz**: Nicht-Permanenz ist ein weiteres Risiko bei Blue-Carbon-Projekten, da Küstenökosysteme sensible auf menschliche und natürliche Störungen reagieren. Im Gegensatz zu technischen Lösungen zur Kohlenstoffentnahme hängt die Permanenz der Kohlenstoffbindung von der Aufrechterhaltung der ökologischen Integrität des Projektgebiets ab. Faktoren wie extreme Wetterereignisse, Anstieg des Meeresspiegels, Erosion, Verschmutzung und Landnutzungsdruck bergen jedoch ein ständiges Risiko, dass durch Projektaktivitäten erzielte Entnahmemengen wieder freigesetzt werden. Kohlenstoffprogramme erfordern zwar den Aufbau von Pufferreserven oder Risikodiskontierungen, um solchen Unsicherheiten Rechnung zu tragen, doch variieren die Angemessenheit und Transparenz dieser Maßnahmen. Die meisten Blue-Carbon-Projekte haben eine Laufzeit von 20 bis 40 Jahren und der Fortbestand der Speicher wird nach Projektende nicht bei allen Kohlenstoffprogrammen nachgehalten. Für einen Ausgleich von $CO_2$ Emissionen wäre jedoch eine Entnahme von 100 Jahren oder länger erforderlich. Außerdem verfügt keines der Kohlenstoffprogramme über Haftungsmechanismen, die greifen, falls das Programm eingestellt wird. Diese Herausforderungen stellen Risiken für die Integrität von Emissionsgutschriften aus Blue-Carbon-Projekten dar, insbesondere wenn diese für den vermeintlichen Ausgleich von Emissionen verwendet werden. Um diese Risiken zu minimieren, sollten strengere Haftungsmechanismen und ein kontinuierliches Monitoring eingeführt werden, um sicherzustellen, dass die geltend gemachten Minderungsmengen im Laufe der Zeit nicht verloren gehen. Dennoch lassen sich Nicht-Permanenz-Risiken bei Blue-Carbon-Projekten nie vollständig vermeiden. Diese Erkenntnis gilt nicht nur für Blue-Carbon-Projekte, sondern für alle Projekte, die die Kohlenstoffspeicherfunktion von Ökosystemen monetarisieren.

- **Umwelt- und Sozialstandards, Regeln zur fairen Verteilung der Nutzen und Beitrag** zu den SDG-Zielen: Küstenökosysteme sind reich an biologischer Vielfalt und sehr anfällig für Umweltbelastungen. Darüber hinaus leben etwa 15 % der Weltbevölkerung innerhalb von

10 Kilometern Entfernung zur Küste. Dazu gehören oft lokale Gemeinschaften, deren Lebensunterhalt und Existenz von Küstenökosystemen abhängt. Wie alle anderen Projektaktivitäten in diesen Ökosystemen, sollten auch Blue-Carbon-Projekte keine negativen Auswirkungen auf die Umwelt, oder die lokalen Gemeinschaften haben, die von diesen Ökosystemen abhängig sind. Wirksame Umwelt- und Sozialstandards sind ein wichtiges Instrument, um sicherzustellen, dass Projekte integrative Planungsprozesse befolgen und Umweltmanagementpläne aufstellen, mit Hilfe derer negative Auswirkungen vermieden, minimiert und kompensiert werden. Alle Kohlenstoffprogramme, unter denen die Stichprobenprojekte registriert sind, verfügen über Umwelt- und Sozialstandards. Darüber hinaus haben viele von ihnen im Zuge der Angleichung an die Core Carbon Principles des Integrity Council for the Voluntary Carbon Market (ICVCM) kürzlich ihre Umwelt- und Sozialstandards verbessert. Diese gelten jedoch nicht für die Stichprobenprojekte, die vor diesen Aktualisierungen registriert wurden. Zwei Projekte der Stichprobe enthielten in ihrer Projektdokumentation eine Beschreibung detaillierter Systeme zur Verteilung der Einnahmen aus den Emissionsgutschriften. Dazu gehörten Governance-Strukturen, die die direkte Beteiligung der lokalen Gemeinschaften an der Projektsteuerung sowie Vereinbarungen zur Verteilung der Einnahmen aus der Monetarisierung von Emissionsgutschriften an die lokalen Gemeinschaften umfassen. Ein Projekt legte einen Mindestanteil von 60 % der Einnahmen fest, die an die lokalen Gemeinschaften gehen sollen. Blue-Carbon-Projekte haben potenziell hohe Zusatznutzen, die der biologischen Vielfalt und den Lebensgrundlagen der lokalen Bevölkerung zugutekommen, z. B. durch die Schaffung von Arbeitsplätzen im Bereich der Verwaltung und Überwachung der Projektaktivitäten oder durch das Angebot von Schulungen, zur Unternehmensgründung z.B. im Ökotourismus. Im Rahmen dieses Berichtes wurden jedoch keine Befragungen durchgeführt, um unabhängig zu verifizieren, ob die in den Projektdokumenten beschriebenen Vereinbarungen über die Verteilung der Einnahmen tatsächlich umgesetzt werden und gut funktionieren. Zur Beantwortung dieser Frage braucht es weitere empirische Untersuchungen. Insgesamt erscheint es aufgrund der Tatsache, dass lokale Gemeinschaften in empfindlichen Ökosystemen leben, wichtig auf deren Bedürfnisse bei der Projektplanung und -umsetzung angemessen einzubinden. Bislang sind keine Berichte bekannt, wonach Blue-Carbon-Projekte zu negativen Auswirkungen auf die Umwelt oder zu Konflikten über die Landnutzung geführt haben. Bisher sind allersing auch nur eine geringe Anzahl von Projekten durchgeführt worden, die sich alle in Schutzgebieten mit bestehenden Schutzregelungen durchgeführt werden und somit möglicherweise weniger Konfliktpotenzial bergen. Es wird daher wichtig sein weiterhin zu verfolgen, wie die sich zurzeit in Planung befindlichen Projekte mit den Anforderungen an Umwelt- und Sozialstandards umgehen.

- **Doppelzählung**: Die Risiken indirekter Überschneidungen zwischen Blue-Carbon Projekten und anderen durch Emissionsgutschriften finanzierte Projekte wie z.B. effiziente Kochöfen werden in keinem der in dieser Studie untersuchten Projekte berücksichtigt. Darüber hinaus bestehen potenzielle Risiken einer doppelten Anrechnung, wenn Länder in ihren Nationally Determined Contributions Blue Carbon -Aktivitäten berücksichtigen. Derzeit haben die Kohlenstoffprogramme Climate Action Reserve und Verified Carbon Standard (VCS) Regeln, um eine potenzielle doppelte Anrechnung zu vermeiden, indem vom Projektland entsprechende Anpassungen verlangt werden, während es bei Plan Vivo keine solchen Regeln gibt. Ohne Regeln besteht die Gefahr, dass Emissionsgutschriften aus Blue-Carbon-Projekten die nationalen Klimaschutzbemühungen untergraben, anstatt sie zu ergänzen.

Zusammenfassend zeigt der Bericht, dass bei der Verwendung von Emissionsgutschriften als Finanzierungsmechanismus für neue Maßnahmen zur Erhaltung und Wiederherstellung von Küstenökosystemen erhebliche Integritätsrisiken bestehen. Diese Risiken betreffen alle Kernaspekte der Anrechnung – Zusätzlichkeit, Quantifizierung, Permanenz, Umwelt- und Sozialstandards und Doppelzählung. Die in diesem Bericht vorgenommene stichprobenhafte Untersuchung von bestehenden Projekten zeigt, dass diese Risiken wesentlich sind.

Die stichprobenhaft angeschauten Projekte verdeutlichen jedoch auch, dass es Gestaltungsmöglichkeiten gibt, die sehr wahrscheinlich zu konservativen Schätzungen der Kohlenstoffbindung in Mangroven-Renaturierungsprojekten führen. Ein konkreter Ansatz besteht darin auf die Anrechnung der Kohlenstoffbestände in organischen Böden zu verzichten, bis es robustere Methoden gibt, um die Auswirkungen der Mangroven-Wiederaufforstung auf diesen Kohlenstoffspeicher zu messen. Dies verringert zwar die möglichen Einnahmen aus Emissionsgutschriften, die Einnahmen aus der Monetarisierung der Erhöhung der Speicher über die leichter messbare Biomasse sind dennoch erheblich. Es wären jedoch weitere Einblicke in die Investitionsmodelle erforderlich, um festzustellen, ob die so verringerten Einnahmen ausreichen, um die Kosten für die Wiederaufforstung von Mangrovengebieten vollständig zu decken. Unter einer hier untersuchten Quantifizierungsmethode ist die Anrechnung von Kohlenstoff in organischen Böden nicht zulässig. Dies könnte darauf hindeuten, dass Mangroven-Wiederaufforstungsprojekte auch eine die Berücksichtigung dieses Kohlenstoffspeichers finanziell tragfähig sein könnten.

In der Zwischenzeit könnten Blue-Carbon-Projekte direkt dazu beitragen, Unsicherheiten bei der Quantifizierung des Kohlenstoffs in organischen Böden zu verringern, wenn sie sich dazu verpflichten würden, Veränderungen im Kohlenstoffspeicher des Bodens regelmäßig zu messen und diese Daten der Wissenschaft zur Verfügung zu stellen. Wenn sich beispielsweise die mehr als fünfzig derzeit in der Entwicklung befindlichen Projekte gemeinsam darauf einigen würden, im Projektgebiet regelmäßig Stichproben mit statistisch robusten Messverfahren zu erheben, könnte dies die Erstellung einer zuverlässigen globalen Datenbank zum Kohlenstoffgehalt im Boden erheblich vorantreiben. Angesichts der Tatsache, dass die Anrechnungszeiträume für diese Projekte zwischen 20 und 60 Jahren liegen, könnte eine solche Datenbank aussagekräftige Zeitreihen generieren, die sowohl für die Projektentwicklung als auch für ein besseres Verständnis der Dynamik von Kohlenstoffströmen in diesen Ökosystemen von Nutzen wären. Kohlenstoffprogramme und öffentliche Organisationen könnten diese Bemühungen unterstützen, indem sie z.B. eine Plattform schaffen, die einzelne Projekte vernetzt, und Austausch zwischen Projektbeteiligten fördert.

Eine verstärkte Zusammenarbeit zwischen Wissenschaft und Projektentwickelnden kann zur Lösung der identifizierten Probleme beitragen und auch die akademische Forschung vorantreiben wodurch die stärkere Verknüpfung zwischen Methodenentwicklung und praktischer Anwendung eine Win-Win-Situation entstehen würde. Eine engere Einbindung von Wissenschaftler*innen in die Projektentwicklung würde dazu beitragen, dass wissenschaftliche Methoden korrekt angewendet und die Kapazitäten der Mitarbeiter*innen vor Ort gestärkt werden. Dies würde beiden Seiten zugutekommen: Die Projekte würden über eine wesentlich robustere Datenbasis verfügen, und die akademische Wissenschaft hätte die Möglichkeit, Zeitreihendaten zu erheben, die zum wissenschaftlichen Fortschritt beitragen könnten.

Selbst wenn Projekte konzeptionelle Entscheidungen treffen, die eine konservative Quantifizierung anstreben, bleiben bestimmte Integritätsrisiken bestehen, wie beispielsweise das Risiko der Nicht-Permanenz. Das bedeutet, dass bei der Verwendung der aus Blue Carbon-Projekten resultierenden Emissionsgutschriften für die Kompensation Vorsicht geboten ist. Stärkere Haftungsmechanismen und ein kontinuierliches Monitoring sind von entscheidender

Bedeutung. In Ermangelung strengerer Vorschriften durch Kohlenstoffprogramme könnten Projekte diese Bedenken einseitig ausräumen, indem sie sich freiwillig bereit erklären, die Projektgebiete bis zu 100 Jahre nach Projektende zu überwachen und alle während dieses Zeitraums auftretenden Reversibilitätsereignisse zu kompensieren. Alternativ könnten Emissionsgutschriften aus Blue-Carbon-Projekten als temporäre Gutschriften mit zeitlich begrenzter Gültigkeit ausgegeben werden, verbunden mit der Auflage der Kohlenstoffprogramme, diese nach Ablauf ihrer Gültigkeit durch dauerhafte Klimaschutzmaßnahmen zu ersetzen. Auch hier könnte ein intensiverer Dialog zwischen Projektentwickler*innen, Kohlenstoffprogrammen und Kaufinteressenten von Emissionsgutschriften aus Blue-Carbon-Projekten hilfreich sein. In einem Markt, der zunehmend mehr Sicherheit hinsichtlich der Umweltintegrität einfordert, könnten fehlende Vorkehrungen zum Nachweis von Permanenz im Laufe der Zeit zu einem Wettbewerbsnachteil werden. Weitere Dialoge zwischen Marktakteuren und Wissenschaft zur Ausgestaltung besser institutioneller Regelungen für den Umgang mit Permanenz-Risiken von Projekten in Küstenökosystemen sind notwendig.

Eine Nutzung von Emissionsgutschriften im Kontext von freiwilligen Klimabeiträgen könnte ein alternatives Finanzierungsmodell für Blue Carbon-Projekte sein, da in diesem auf die Nutzung zur Kompensation verzichtet wird. Die Auswirkungen der Risiken bezüglich der Permanenz und Überschätzung der Minderungswirkung sind in diesem Modell geringer, während gleichzeitig sinnvolle Projekte zum Erhalt und Wiederherstellung von Küstenökosystemen gefördert werden.

## Summary

Coastal ecosystems store carbon primarily in mangrove forests, seagrass meadows and tidal marshes. Despite some of them benefitting from a certain degree of protection, global carbon stocks in these ecosystems have declined over recent decades. For mangrove forests, the primary drivers of this loss include land-use pressures through rice cultivation and aquaculture, minor drivers are the use of the habitat for fuelwood collection and subsistence farming.

Carbon credits offer an opportunity to attach an economic value to the carbon storage function which coastal ecosystem provide. As such, they offer a potential source of funding for activities aimed at restoring degraded coastal habitats or safeguarding existing ones from further degradation.

However, unlike other forms of financing, such as philanthropic contributions or development assistance, the use of carbon credits as a funding mechanism introduces a critical responsibility. If used to meet climate mitigation targets, each credit issued permits a corresponding tonne of $CO_2$ emissions elsewhere, making the environmental integrity of the credit essential. If credits are issued without ensuring additionality, permanence, and conservative carbon accounting, the result may be a net increase in global emissions. In effect, society could be subsidising new coastal ecosystem protection and restoration efforts with higher levels of atmospheric $CO_2$ – a counterproductive outcome. This emphasises the need for stringent safeguards, robust methodologies, and strong oversight mechanisms to ensure that carbon crediting genuinely supports climate mitigation rather than undermining it.

There are many different project types, with Blue Carbon projects being a more recent addition to the portfolios of carbon crediting programmes in the voluntary carbon market. They currently play a small role, reflected by a comparatively low number of issuances. This may change in the future, as the level of interest in the project type picks up and a pipeline of more than 50 projects is currently under development.

This report attempted a systematic assessment of the specific risks and opportunities, which may arise when using carbon crediting mechanisms to finance the protection and restoration of coastal ecosystems, with a particular focus on their effectiveness in enhancing carbon storage and reducing emissions. The assessment draws on empirical evidence from a small sample of seven projects registered with carbon crediting programmes in the voluntary carbon markets. The sample represents about one third of all registered Blue Carbon projects at the time of writing. It is skewed towards mangrove conservation and mangrove restoration projects, as there are currently no registered seagrass or tidal marsh restoration projects. Inputs for the assessment were project design documents and monitoring reports as well as other documentation made available through the registries of the carbon crediting programmes under which the projects are registered. The assessment also considered rules of carbon crediting programmes applying to all project types, where relevant. Finally, peer-reviewed literature as well as grey literature was used to contextualise the observations from the project sample and inform the analysis.

Main findings and conclusions regarding the following dimensions were:

- **Additionality**: Project activities like mangrove replanting, forest patrols, and training programmes to create alternative economic livelihoods for local populations incur costs but do not generate income for project owners. All projects in the sample clearly demonstrated that financial incentives were necessary to implement the mitigation activities. However, it was less clear whether revenues from carbon credits were the only available funding source and what role they played for the overall financial viability of the projects. In several cases,

agencies managing the sample projects had previously received development assistance or philanthropic contributions for similar activities, including project preparation. However, project design documents provided limited information about project costs and the role of other funding sources, preventing a full evaluation of the materiality of associated non-additionality risks. A related observation from the project sample for all cases is that submission of PDDs to the respective carbon crediting programme took place only *after* the replanting or conservation activities had already begun. It is common practice in carbon markets to allow registration after the start of mitigation activities as preparing the necessary analysis and documentation for registration can take several years. However, if projects operate for a long time without receiving carbon credit revenues, it becomes increasingly difficult to determine whether the prospect of carbon financing was a decisive factor in initiating the project. In one extreme instance, project developers submitted their PDDs nine years after project activities had commenced.

The assessment also found that project developers currently prefer to implement Blue Carbon projects in areas that already hold some form of protected status, such as national parks. This overlap between project sites and protected areas introduces some risks of non-additionality, as certain activities assumed to occur in the baseline scenario – such as mangrove logging—are already prohibited under protected area regulations. Risks might however be low in cases where these restrictions are not enforced. Moreover, the preference for locating projects within protected areas suggests that current Blue Carbon projects may not yet contribute meaningfully to global targets like the Convention on Biological Diversity’s (CBD) 30x30 initiative, which aims to expand the global network of protected areas. Yet, it is important to note that this finding is based on a small sample of early-mover projects, and future projects may shift this trend. Project developers may also have legitimate reasons for focusing on protected areas, as these locations often present fewer risks of conflict with local communities, given that land-use restrictions are already in place and do not need to be newly introduced.

Overall, and despite these concerns, there is no evidence from the project sample to suggest that non-additionality risks for Blue Carbon projects are more pronounced than for other types of projects. The main risks for individual projects arise from their intersection with protected areas and the potential availability of alternative revenue streams. While these integrity concerns exist, there are two key measures that carbon crediting programmes can implement to further reduce non-additionality risks. First, they should require project developers to publicly disclose a comprehensive financial analysis, including a detailed breakdown of costs and a clear distinction between carbon market revenues and other funding sources. This information could also help guide the scaling-up of similar projects. Second, carbon crediting programmes should require project developers to submit a notification of intent as soon as they decide to proceed with the project. This could help reduce uncertainties in cases where project documentation is submitted after the mitigation activities have already begun. One project in the sample already provided such information on a voluntary basis.

- **Quantification:** Quantifying carbon benefits in coastal ecosystems is complex, and results are inherently associated with uncertainties. Coastal ecosystems exhibit high spatial and temporal variability in carbon dynamics, making it challenging to develop standardized measurement approaches for carbon quantification methodologies. The main carbon pools are above- and belowground biomass as well as soil organic carbon, while key emission sources are microbial methane production and fossil fuel use. Quantification methodologies include all relevant carbon pools and emission sources in the greenhouse gas assessment boundary. However, they allow the exclusion of certain minor emission sources, which could lead to overestimation of emission reductions or removals, though likely not substantial.

Potentially substantial overestimating risks are associated with the approaches to estimating baseline deforestation rates in mangrove *conservation* projects as the respective methodology offering registration for this subtype provides project developers with considerable flexibility in selecting reference areas and periods. One project in the sample, for example, assumes that baseline deforestation would result in the loss of 67% of mangrove carbon stocks by the end of the project crediting period. Considering that the project takes place in a protected area, this may be a very aggressive assumption. In contrast, mangrove *restoration* projects are less affected by systemic baseline uncertainty as in many cases mangrove habitat would remain degraded lands without the project interventions. However, individual projects may overestimate carbon removals if they fail to account for the possibility that restoration might have occurred through alternative funding sources under the baseline scenario. This risk is particularly relevant in areas with a history of successful mangrove restoration activities. Addressing this matter would be relatively straightforward. For example, by requiring project developers to apply conservative deductions to the credited project area in such contexts.

Measuring the effect of project activities on changes in carbon pools occurring between baseline and project scenario is inherently uncertain. The lack of long-term data on carbon fluxes, especially in restored ecosystems and for non-mangrove habitats like seagrasses and saltmarshes, makes the estimation of these changes challenging. For biomass, the main uncertainties result from the selection of appropriate allometric equations, the number of sample trees used to construct these equations, as well as location and placement of sample plot design for ex-post measurements of removals. Carbon estimates in all sample projects are affected by these uncertainties. Whether these are more likely to lead to over- or underestimation of emission reductions or removals in the project sample was inconclusive for projects in the sample. Organic soils are by far the largest carbon pool of Blue Carbon ecosystems and at the same time the most difficult to monitor. Obtaining necessary data requires specialised expertise and access to laboratory equipment. Measurement is further associated with high costs and therefore field data are scarce and based on few samples. Soil carbon quantification remains highly uncertain and could lead to overestimation if projects use field-data which are not representative of the full project area or if refined scientific research finds that default values overestimate soil accumulation rates. For other projects, adverse selection due to the flexibility in the VCS methodology could therefore become an issue. A further cause of uncertainty is the accounting for methane emissions from microbes. None of the sample projects currently accounts for methane emissions which is consistent with the requirements of the respective quantification methodologies. In line with the precautionary principle, carbon crediting programmes should closely monitor emerging scientific evidence on methane emissions from mangrove replanting and be prepared to adjust methodologies accordingly.

- **Non-permanence:** Non-permanence is a further critical concern in Blue Carbon projects due to the inherent vulnerability of coastal ecosystems to both human and natural disturbances. Unlike engineered carbon removal solutions, durability of carbon sequestration depends on maintaining ecological integrity of the project area. However, factors such as extreme weather events, sea level rise, erosion, pollution, and land-use pressures pose ongoing risks of carbon reversals—that is, the release of previously sequestered carbon back into the atmosphere. While carbon crediting programmes require buffer reserves or risk discounting to account for such uncertainties, the adequacy and transparency of these measures vary. Most Blue Carbon projects have a duration of 20-40 years and therefore do not qualify for permanent removals, which would require maintaining carbon stocks in these ecosystems for 100 years or more. Additionally, in the case of the VCS, monitoring by the project developer may cease after the end of the crediting period. Also, none of the crediting programmes seems to have liability mechanisms in place in case the programme ceased its operations. These challenges can undermine the integrity of Blue Carbon credits, particularly if these were used for offsetting claims. There is a need for stronger liability mechanisms, and continuous monitoring to ensure that claimed mitigation benefits are not lost over time. Yet, reversal risks can never be fully avoided for Blue Carbon projects. This is a finding that applies not only to Blue Carbon projects but all projects that monetize the carbon storage function from ecosystems.

- **Safeguards, benefit-sharing and contribution to SDG goals:** Coastal ecosystems are rich in biodiversity and highly vulnerable to environmental stressors. Further, about 15% of the global population live within 10 kilometres of the coastline. Often this includes local communities which depend on coastal ecosystems for livelihoods and subsistence. Like any other project activity in these ecosystems, Blue Carbon projects should not negatively affect the environment they operate in or the local communities relying on these ecosystems. Stringent environmental and social safeguards (E&S safeguards) are a key instrument to ensure that projects follow inclusive design processes and include effective environmental management plans which avoid, minimize and compensate for any negative impacts. All carbon crediting programmes under which the sample projects are registered have E&S safeguards. Further, in the process of aligning with core carbon principles of the Integrity Council for the Voluntary Carbon Markets (IC-VCM) many recently improved their E&S safeguard provisions. These, however, do not apply to the sample projects, which have received registration before these updates. Two projects in the sample included a description of elaborate benefit-sharing systems in their project documentation. These included project governance structures which include direct involvement of local communities in project steering as well as arrangements for distributing revenues from monetization of carbon credits to local communities. One project set a minimum floor of 60% of revenues to go to local communities. Blue Carbon projects potentially have high co-benefits which benefit biodiversity and the livelihoods of the local population, e.g. by creating job opportunities in the management and monitoring of the project activities, or offering trainings for local communities, which empower them to establish their own sustainable businesses like ecotourism. This report, however, did not involve interviews or field visits to validate if the arrangements and benefits described in the project design documents work well or materialize on the ground. Answering this question would benefit from further empirical research. Overall, because of their location in vulnerable ecosystems which are home to local communities, exerting utmost precaution in project design and implementation appears to be appropriate. To date there are no known reports of Blue Carbon projects being involved in negatively impacting the environment or lead to conflict over land use. This finding is, however, based on a very small number of projects, which all take place in already protected areas with existing protection regimes which might offer less potential for conflict. For the more than 50 projects in the pipeline close monitoring will be required to ensure that they comply with all safeguards.

- **Double counting:** Risks of potential indirect overlaps between BC projects and other mitigation projects are not addressed by any programme considered in this study. Additionally, potential risks for double claiming exist if a national NDC covers BC activities. Currently, CAR and the VCS have rules in place to avoid potential double claiming by requiring the host country to apply corresponding adjustments while rules are lacking for Plan Vivo. Without such rules, there is a danger that Blue Carbon credits could undermine rather than complement national mitigation efforts.

In conclusion, the report shows that integrity risks are material when using carbon credits as a funding mechanism for new measures to conserve and restore coastal ecosystems. These risks relate to all core dimensions of crediting – additionality, quantification, permanence, safeguards and double counting. The project sample shows that there is evidence that risks also materialize in concrete projects on the ground.

The sample projects, however, also highlight the availability of design choices which very likely lead to conservative estimates of carbon removals in mangrove restoration projects. A straightforward approach seems to be to forego accounting of soil organic carbon stocks until there are more robust ways to measure the effect of mangrove replanting on this carbon pool. Revenues from monetizing biomass carbon stocks may still be significant, although further insight into cost data would be needed to determine if they are sufficient to fully cover restoration costs. One methodology already does not allow to account for soil carbon, suggesting that this might be a financially viable model for some mangrove restoration projects.

In the meantime, Blue Carbon projects could directly help to reduce uncertainties in quantifying soil organic carbon if they would commit to regularly measuring changes in the soil carbon pool and making these data available to the scientific community. For example, if the more than fifty projects currently under development collectively agreed to periodically collect field data using statistically robust measurement techniques, it could significantly advance the creation of a reliable global database on soil carbon accumulation rates. Given that crediting periods for these projects range from 20 to 60 years, such a database could generate meaningful time series that would inform both project development and a better understanding of carbon flux dynamics in these ecosystems. Carbon crediting programmes and public agencies could support these efforts by creating a platform that connects individual projects, fosters peer-to-peer learning, and builds communities of practice to support measurement efforts and facilitate data exchange between projects and the scientific community.

Close cooperation between scientists and project developers would contribute significantly to solving the identified problems and also advance academic research, creating a win-win situation. The knowledge required to develop carbon quantification methods is produced and made available by academic science. Until now, that has been the end of their job. Blue carbon project developers and implementers apply this knowledge and carry out the necessary activities for quantifying GHG fluxes. Closer involvement of scientists in project development would help to ensure that scientific methodologies are correctly applied and capacities of field staff strengthened It would further benefit both sides: The projects would have a much more robust data base, and academic science would have the opportunity to acquire time series data that contribute to scientific progress.

Even if projects use design choices which approach quantification conservatively, certain integrity risks such as the non-permanence risks of avoided emissions and removals remain. This means that caution should be applied when using resulting carbon credits for meeting mitigation targets. Stronger liability mechanisms and continuous monitoring are crucial. In the absence of stronger rules by carbon crediting programmes, projects could unilaterally address these concerns by voluntarily agreeing to monitor project areas for up to 100 years after the end of the crediting period and to compensate any reversals that occur during this period. Alternatively, credits from Blue Carbon projects could be issued as temporary credits with a limited validity, accompanied by requirements from the crediting programmes to replace these credits with permanent mitigation activities upon their expiry. Again, here more dialogue between project developers, carbon crediting programmes and interested buyers of Blue Carbon credits could be useful. In a market that moves towards credits which provide more reassurance of environmental integrity, inability to demonstrate sufficient arrangements to demonstrate permanence might become an impediment over time to sell carbon credits from Blue Carbon projects. This might point to the need to open a space for all actors in the market to explore how institutional arrangements could be created that effectively monitor and compensate for any reversals in coastal ecosystems.

Finally, conserving or restoring coastal ecosystems could also be a viable project type for companies shifting away from traditional carbon offsets. Instead of using offsets to meet emission reduction targets, these companies could contribute directly to global climate protection efforts through ecosystem-based initiatives such as coastal ecosystem conservation and restoration efforts.

# 1 Introduction

Coastal ecosystems worldwide are experiencing significant degradation, impacting biodiversity, livelihoods and climate resilience. They are under threat from pollution, ocean acidification, habitat modification through human activities, invasive species, overharvesting as well as coastal erosion. Human exploitation has led to the depletion of over 90% of important species and the destruction of more than 65% of seagrass and wetland habitats in estuarine and coastal regions worldwide over the past centuries (Lotze et al. 2006). The International Union for the Conservation of Nature (IUCN) reports that half of the world's mangroves are currently under threat due to human activity, sea level rise and extreme climate events (IUCN 2024).

Due to the large potential of coastal ecosystems to sequester carbon from the atmosphere (see Reise et al. 2024), public interest in these ecosystems has been increasing in recent years. Yet, while some recovery has been observed in coastal ecosystems over the past decades, full restoration of their structures and functions remains unachieved. Substantial costs involved in restoration projects necessitate significant investment and as the immediate economic returns can be limited, securing funds and encouraging participation in these activities has proven to be challenging (e.g. Shusheng et al. 2023). In response, the integration of coastal ecosystems into carbon markets—so-called "Blue Carbon" projects—has been proposed as a funding strategy. These projects aim to generate so called carbon credits by conserving or restoring carbon-rich coastal habitats, theoretically linking ecological protection with market-based climate mitigation.

This paper critically examines the chances, risks, and potential success factors of Blue Carbon projects within voluntary carbon markets. While such projects are often promoted as "win-win" solutions, their actual implementation reveals a wide range of practical and technical challenges. In particular, concerns exist regarding the robustness of carbon accounting methods, the permanence and additionality of mitigation impacts, the adequacy of social safeguards, and the risk of overreliance on market-based mechanisms as a strategy to achieve climate mitigation.

Section 2 outlines the variety of Blue Carbon interventions being implemented or proposed across mangrove forests, tidal marshes, and seagrass meadows. It reviews their ecological roles and vulnerability to anthropogenic pressures, and discusses the interventions aimed at either protecting existing carbon stocks or enhancing carbon sequestration. Additionally, this section provides an overview of the current landscape of Blue Carbon projects in the voluntary carbon market, including a classification of relevant carbon crediting programmes and methodologies. Despite a growing number of initiatives, Blue Carbon projects still represent a small fraction of market activity, and adoption has been hindered by methodological, institutional, and financial obstacles.

Section 3 builds the core of the paper providing a detailed assessment of seven selected Blue Carbon projects, chosen to represent different geographies, methodologies, and governance models. Each project is characterised and analysed according to criteria including ecosystem type, carbon quantification approach, land tenure, community involvement, and financial arrangements. The characterisation (chapter 3.2) reveals significant variation in project design and implementation, as well as recurrent weaknesses in transparency, benefit-sharing, and cost documentation. Section 3.4 provides an analysis of the selected projects along five key issues for the effectiveness and integrity of Blue Carbon projects: ensuring additionality, accurately quantifying climate benefits, addressing non-permanence, managing environmental and social impacts, and avoiding double counting. Drawing on current project documentation and international standards, the paper evaluates how the selected projects and methodologies perform against these criteria. The conclusion summarises the identified challenges as well as opportunities associated with Blue Carbon projects and discusses possible ways forward.

# 2 Landscape of Blue Carbon projects

## 2.1 Overview of activities that enhance carbon storage in coastal ecosystems

The possible activities aiming at protecting or increasing carbon sequestration and storage in coastal ecosystems are manifold and differ depending on the coastal ecosystem type as well as their site condition and previous management regime.

There are numerous anthropogenic pressures impairing the integrity of coastal wetlands that cause loss of ecosystem services like carbon sequestration and habitat for marine species. For example, expanding rice cultivation and shrimp aquaculture is a key human driver for mangrove deforestation (Hagger et al. 2022). Also, changes in connectivity affecting hydrology and sediment dynamics, contamination and pollution and high nutrient inputs can lead to the destruction or degradation of the coastal ecosystem. Human activities are either:

- *directly* affecting the coastal ecosystem by activities involving land reclamation, construction of aquaculture ponds, salt extraction, expanding of agriculture land, construction of ports and marinas as well as logging; or
- *indirectly* affecting the coastal ecosystem by damming and discharge of effluents from agriculture, urban and industrial areas upstream of the concerned coastal ecosystem (Newton et al. 2020).

Hence, interventions to protect and enhance carbon sequestration in coastal ecosystems need to address both, direct and indirect, pressures disturbing the coastal ecosystem at hand. For example, successful seagrass restoration very much depends on the water quality, hence causes of eutrophication need to be addressed to support the regrowth or reestablishment of seagrass beds (van Katwijk et al. 2016). Additionally, given the high spatial and temporal variability of coastal ecosystems, the impact of human activities on carbon varies accordingly (Mason et al. 2024).

The term 'Blue Carbon' (BC) was first coined in 2009 (Nelleman et al. 2009).[1] It was originally intended to highlight the important role of the oceans as a carbon sink for anthropogenic emissions. However, at the time, the term was not clearly defined. A more pragmatic approach in defining the term examined the potential application of 'Blue Carbon' as a ‘management tool’ in climate change mitigation (Laffoley und Grimsditch 2009). It puts a focus on coastal ecosystems because of their high carbon storage potential and the fact that management activities, e.g., through planting or restoration of hydrology, appear to be suitable to influence it.

Because of the multifaceted nature and its overall relevance for society on a global scale, the scientific discourse expanded from the natural sciences into economics, policy and legislation. From this discourse, mangrove forests, tidal marshes and seagrass beds emerged as those coastal ecosystems that meet the majority of criteria which account for long-term removal and storage of $CO_2$ on the one hand, and for the practicality of management activities on the other hand (Lovelock und Duarte 2019). These three ecosystems are considered the "established solutions" which current debates are centred upon.[2]

[1] An in-depth discussion on the definition and criteria of BC and BC measures is presented in Reise et al. (2024).

[2] Enhancing the storage of carbon in these ecosystems can be considered ‘Nature-based Solutions’ as they are locally appropriate, adaptive actions to protect, sustainably manage or restore natural or modified ecosystems to address targeted societal challenge(s) - such as climate change mitigation -, while simultaneously enhancing human well-being and providing biodiversity benefits (Reise et al. 2022).

In the following, examples of specific Blue Carbon activities in the three defined coastal ecosystems are given. Their aim is to either protect the carbon storage and/or to enhance the sequestration of carbon in those ecosystems.

**Mangrove forests**

Blue Carbon activities in mangrove ecosystems primarily aim to protect existing carbon stocks and enhance carbon sequestration within coastal habitats. These activities include the conservation of intact mangrove forests to prevent carbon loss from deforestation, the restoration of degraded mangrove areas through hydrological reconnection and the replanting, and application of sustainable management practices that maintain ecosystem function and resilience (López-Portillo et al. 2017; Alongi 2014). Additionally, policies such as the establishment of protected areas and the integration of mangroves into national climate strategies support long-term carbon storage.

**Tidal marshes (or saltmarshes)**

Tidal marsh restoration often focuses on reestablishing the hydrological regime by removing barriers and opening dikes seasonally to allow for regular flooding of the marsh area. This is important for the establishment of natural vegetation at the site as well as for carbon fluxes. The recovery of the tidal regime increases the salinity of the site which reduces methane emissions substantially (Kroeger et al. 2017). Likewise, regular flooding of the tidal marshes causes sediment inflow, which is kept on site by the vegetation and slowly elevates the tidal marsh as well as its allochthonous carbon storage (van den Hoven et al. 2022). Other restoration measures involve the planting, fertilization, and sediment addition. According to a data review by Mason et al. (2023), restoration measures involving the reestablishment of the tidal regime and sediment alteration show higher carbon storage.

Most saltmarsh restoration projects were conducted in Europe and the United States of America. Existing research frequently compares natural and restored saltmarshes across a broad temporal spectrum, ranging from immediately post-restoration to over two decades—and in some cases, several decades—after intervention. It was found that restored saltmarshes can attain soil carbon stock levels comparable to those of natural systems within approximately 20 years in certain contexts, though some may require up to 100 years to reach similar levels (e.g., Burden et al. 2019; Santini et al. 2019). In another case it was demonstrated that plant biomass and $CO_2$ uptake were 50-100 % higher in marshes restored 5-10 years ago than in their natural counterpart (Wang et al. 2021). These findings provided important data to support developing Blue Carbon projects.

**Seagrass meadows**

The global decline of seagrass and the need for seagrass conservation are long known (Waycott et al. 2009; Unsworth et al. 2022; Unsworth und Cullen 2010). Yet, seagrass restoration is challenging because of the dynamic and stressful environment seagrass often grows in. Prior to planting it is important to remove existing threats, for example, reduced water quality and eutrophication, dredging, and construction activities. To restore seagrass meadows, it can be necessary to plant seagrasses or spread seeds which is labour-intense as it requires divers. In addition to the site conditions, the success of these measures depends largely on the size of the area and the time frame (Duarte et al. 2013). Large-scale trials have higher success rates, indicating the need for a critical level to ensure successful recovery (van Katwijk et al. 2016). Carbon stocks of seagrass meadows and their major drivers have been determined in many locations worldwide (e.g., Röhr et al. 2018; Thorhaug et al. 2020; Kennedy et al. 2022). However, little is known on carbon stocks and fluxes in restored seagrass ecosystems. Generally, a dense seagrass vegetation cover is positively correlated with autochthonous carbon sequestration and on sites where terrestrial carbon can flow, the allochthonous carbon sequestration can be maximised (Duarte et al. 2013).

Large-scale restoration of seagrasses was conducted along the Midwestern Atlantic coast of the United States of America since 1999. Monitoring of the activities and their impacts was conducted for an array of ecosystem services including the biogeochemical cycling of carbon and nitrogen. The sediment carbon stock increased exponentially with meadow expansion over two decades (Orth et al. 2020), demonstrating the effectiveness of seagrass restoration for carbon sequestration.

**Relevant activities which address indirect anthropogenic pressures**

Indirect interventions are those conducted mainly upstream, but sometimes also downstream, of the concerned coastal ecosystem. These include the return of freshwater supply, including its dissolved and particulate substances, through the removal of dams, barrages and weirs in rivers. Another intervention is the decrease or avoidance of input of effluent discharges from agriculture and urban and industrial areas. In certain cases, a construction of breakwaters downstream of a wetland may also be a suitable intervention. Similarly, prohibiting nutrient inflow from rivers close to agricultural lands can prevent eutrophication of coastal waters.

Table 1 displays the current best estimates of the global distribution of the three major Blue Carbon ecosystems and their carbon stocks.

**Table 1: Global distribution of Blue Carbon ecosystems and their carbon stocks**

| Ecosystem | Area ($km^2$) | Global C stock (Tg C) | Global C stock (Tg $CO_2$e) |
|---|---|---|---|
| Tidal marshes | 54,951[a] – 90,800[b] | 862 – 1350[g] | 3,161 – 4,950 |
| Mangrove forest | 137,760[c] – 147,359[d] | 1,230[h] – 3,900[i] (biomass)<br>1900[k] – 8400[l] (soil)<br>3130 – 12,300 (total) | 4,510 – 14,300<br>6,967 – 30,800<br>11,477 – 45,100 |
| Seagrass bed | 160,387[e] – 316,284[f] | 76 – 151[m] (biomass)<br>3,760[g] – 8,400[m] (soil) | 279 – 554<br>13,787 – 30,800 |

Data sources: a – Mcowen et al. 2017; b – Murray et al. 2022; c – Giri et al. 2011; d – Bunting et al. 2022; e – McKenzie et al. 2020; f – UNEP-WCMC 2021; g – Macreadie et al. 2021; h – Hamilton und Friess 2018, I – Simard et al. 2019; k – Ouyang und Lee 2020; l – Kauffman et al. 2020; m – Fourqurean et al. 2012.

## 2.2 Overview of projects registered with carbon crediting programmes on the voluntary carbon market

There are four carbon crediting programmes that offer registration for BC projects on voluntary carbon markets. These are the Climate Action Reserve, the Gold Standard for the Global Goals, Plan Vivo and the Verified Carbon Standard (VCS). All of them are well known programmes in the Voluntary Carbon Market (VCM) and offer registration for several other project types as well. In addition, BC projects were eligible for registration under the Clean Development Mechanism (CDM) until 31.12.2020. Compared with other project types, the number of registered BC projects is low, and transactions currently comprise less than one percent of overall VCM transactions. The slow adoption of BC projects in the voluntary carbon market reflects the challenges to quantify the mitigation impact of BC projects, with more comprehensive quantification methodologies becoming available only recently. However, interest in these types of projects is increasing, particularly within the financial sector, where major banks and asset managers are beginning to develop dedicated investment vehicles for BC initiatives (see Friess et al. 2022).

Currently, there are at least 55 projects in the project pipelines of the above-mentioned carbon crediting programmes (see Table 2). Most of these projects apply for registration under the VCS, which is also the largest carbon crediting programme on the voluntary carbon markets when considering the amount of credits issued.

**Table 2: Number of BC projects registered and under development**

| Programme | Registered | In project pipelines |
|---|---|---|
| Clean Development Mechanism | 1 | 0 |
| Climate Action Reserve | 2 | NE* |
| Gold Standard | 0 | 0 |
| Plan Vivo | 3 | 8 |
| Verified Carbon Standard | 11 | 47 |
| **Total** | **17** | **55** |

Sources: Registries of carbon crediting programmes. Information as of 30th September, 2024. *The registry does not allow to filter for the project type “mangrove restoration”. Hence, no information could be retrieved on the number of projects in the pipeline.

For registration, project developers must estimate the impact of their projects on emission reductions and removals by applying a quantification methodology that is eligible under the respective carbon crediting programme. Currently, about half of the registered projects have applied the CDM methodology AR-AM0014 - the first methodology made available under the CDM for BC projects as early as 2011. All but one project using this methodology are, however, registered with the VCS, which allowed its application until August 2022, when Verra replaced it with its own quantification methodology, VM0033 (see Table 3 below for an overview of available quantification methodologies).

Starting in 2011, the VCS also offered registration for BC projects that quantified their emission reduction and removal impact through the application of its REDD+ methodology VM0007. Four years later in 2015, the VCS also started offering registration for projects using its methodology for wetland restoration activities – VM0033. With a project pipeline of 29 projects, the methodology for wetland restoration (VM0033) is poised to become the most important methodology for quantifying BC projects. Another important programme for BC projects is the Plan Vivo Standard, which started registering BC projects in 2014 and currently has a pipeline of eight projects under development. Its quantification methodology uses elements of AR-AC0014. The Climate Action Reserve offers registration for BC projects in Mexico, Panama and Guatemala. Projects must apply the Mexico, Panama, or Guatemala Forest Protocol respectively.

The market uptake of the Gold Standard Methodology for Sustainable Management of Mangroves is yet to be determined as it has been only released in August 2024. The same applies for the Panama and Guatemala Forest Protocols, whose respective first versions were released in 2024. Both are eligible methodologies for certification under the Climate Action Reserve.

# 3 Analysis of selected Blue Carbon projects

## 3.1 Selection of project sample

For constructing our project sample, we filtered the respective registries of the Climate Action Reserve, Plan Vivo and Verified Carbon Standard (VCS) for BC projects. We did not consider the registry of the Gold Standard as its BC quantification methodology was published only in August 2024. We also did not consider the CDM registry, because no new project can be registered under the CDM anymore. An overview of the number of registered projects and those still in project pipelines for each carbon crediting programme can be found in Table 3 below.

**Table 3: Quantification methodologies eligible under carbon crediting programmes**

| Methodology | Release year of first version | Eligible under | Projects registered | In project pipelines |
|---|---|---|---|---|
| AR-AM0014 | 2011 | CDM, VCS | 9 | 6 |
| GS Sustainable Management of Mangroves | 2024 | Gold Standard | 0 | 0 |
| Plan Vivo Standard | 2014 | Plan Vivo | 3 | 8 |
| Mexico Forest Protocol | 2013 | Climate Action Reserve | 2 | NE* |
| Panama Forest Protocol | 2024 | Climate Action Reserve | 0 | 0 |
| Guatemala Forest Protocol | 2024 | Climate Action Reserve | 0 | 0 |
| VM0007 | 2011 | VCS | 2 | 12 |
| VM0033 | 2015 | VCS | 1 | 29 |
| **Total** | | | **17** | **55** |

Sources: Registries of carbon crediting programmes. Information as of 30 September 2024. *The registry does not allow to filter for the project type mangrove restoration. Hence, no information could be retrieved on the number of projects in the pipeline.

When selecting projects for the sample we applied the following four groups to draw from to ensure representativeness of the sample:

- Blue Carbon ecosystems (mangroves, seagrass meadows, salt marshes)
- United Nations regions (Africa, America, Asia, Europe, Oceania)
- Carbon crediting programme (Climate Action Reserve, Plan Vivo, VCS)
- Quantification methodologies (AR-AM0014, Mexico Forest Protocol, Plan Vivo Standard, VM0007, VM0033)

All registered BC projects that we identified in the registries of the three selected carbon crediting programmes take place in mangrove ecosystems. We did not identify any saltmarsh projects and there is currently only one project being developed applying measures to enhance carbon storage in seagrass meadows. This is because the knowledge regarding carbon fluxes is not as advanced for seagrass meadows and tidal marshes (synonymous saltmarshes) as for mangrove forests.[3]

To ensure that we have at least two ecosystems represented in our sample we added this project although it has a different status (under development) than the other projects (registered). The current focus of project developers on mangrove projects reflects that the carbon flows in these ecosystems are better understood than for the other two project types. Therefore there is better data and knowledge on mangrove carbon flows which project developers can utilize to quantify the climate change mitigation and removal impact of their projects (Duarte de Paula Costa, Micheli und Macreadie 2022).

All mangrove projects registered with major carbon crediting programmes are implemented in developing countries, taking place in each of the following UN (sub-)regions: Africa, Asia as well as Latin America with the Caribbean. In constructing our sample, we ensured that we include at least one project for each of these three regions to ensure regional balance.

We further made sure that we included at least one project for each of the four quantification methodologies with active registrations (AR-ACM0014; Mexico Forest Protocol; VM0007 and VM0033) in our project sample.

Finally, we excluded projects for which no sufficient documentation is available. The final sample consists of seven projects and covering about one third of all registered Blue Carbon projects in the voluntary carbon markets at the time of writing. An overview of the project sample is provided in Table 4, which provides information on key characteristics of the projects such as location, current status, project area and land ownership. It highlights the differences between BCP and the potential impact these differences may have on essential crediting aspects, such as additionality, permanence, leakage, monitoring, reporting, and verification, stakeholder engagement, legal clarity, and ultimately the projects' overall credibility, scalability, and success in mitigating carbon emissions.

[3] However, there are numerous research and restoration projects running which are aiming at closing the data and knowledge gap and/or exploring opportunities for Blue Carbon in restoration projects for seagrass meadows and tidal marshes.

**Table 4: Overview of project sample**

| Project | Úrsulo Galván (no. 1) | Vida Manglar (no. 2) | Guinea-Bissau (no. 3) | Mikoko Pamoja (no. 4) | Delta Blue Carbon-1 (no. 5) | Zhanjiang MAP (no. 6) | VCR Seagrass Restoration (no. 7) |
|---|---|---|---|---|---|---|---|
| Country | Mexico | Colombia | Guinea-Bissau | Kenya | Pakistan | China | USA |
| Ecosystem | Mangroves | Mangroves | Mangroves | Mangroves | Mangroves | Mangroves | Seagrass |
| Status | Registered | Registered | Registered | Registered | Registered | Registered | Pipeline |
| Approach | Project | Grouped project | Project | Project | Project | Project | Project |
| Carbon crediting programme Project ID | CAR 1429 | VCS-CCB 2290 | VCS 2324 | Plan Vivo PV_2014_012 | VCS-CCB 2250 | VCS 2343 | VCS 2360 |
| Quantification methodology | MX Forest | VM0007 | VM0007 | PV Standard | VM0033 | AR-AM0014 | VM0033 |
| Crediting period (years) | 30 | 30 | 20 | 20 | 60 | 40 | 30 |
| Start of crediting period (year) | 2018 | 2015 | 2011 | 2012 | 2015 | 2015 | 2015 |
| Year of initial verification | 2022 | 2021 | 2020 | 2018 | 2022 | 2020 | NA |
| Project area (ha) | 930 | 7,561 | 136,265 | 117 | 350,000 | 380 | 66,452 |
| Land ownership | Public | Public | Public | Public | Public | Public | Public |
| Consideration of C leakage | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Non-permanence risk buffer | 7.7 % | 7.1 % | 10 % | 15 % | 10 % | 10 % | NA |
| Est. annual issuances (t $CO_2$e) | 1,600* | 31,310 | 90,330 | 2,500 | 2,407,629 | 4,020 | 1,349 |
| Total issuances (t $CO_2$e) to date | 5,851 | 59,363 | 302,043 | 18,052 | 4,802,658 | 5,880 | NA |
| Retirements (t $CO_2$e) to date | NA | 57,639 | 108,990 | 17,488 | 2,761,170 | 326 | NA |

Sources Project Design Documents. All information valid as of 30 September 2024. Text in *italics* highlights that data source only partially applies. CAR = Climate Action Reserve, VCS= Verified Carbon Standard VCS-CCB = Verified Carbon Standard combined with Climate, Community and Biodiversity Standards. *Issuances in 2019 and 2020.

## 3.2 Information sources considered for the assessment

For the assessment we considered available information in the project databases of the respective carbon crediting programme as well as peer-reviewed and grey literature. A main source of information for each project was the project design document (PDD) which contains the additionality demonstration and ex-ante estimation of the emission impact of the project. Where available, we also consulted verification and monitoring reports provided by projects. Table 5 below contains the document title and version of each PDD considered for the assessment. Where reference is made to PDDs throughout the report, we use a shorthand citation format (e.g. PDD project no. 1) to enhance readability.

**Table 5 Project Design Documents of the project sample**

| Project | Document title | Reference |
|---|---|---|
| Úrsulo Galván (no. 1) | Reporte de Proyecto, Version 1.5 – 13 March 2022 | (CAR 2022) |
| Vida Manglar (no. 2) | Blue Carbon Project Gulf of Morrosquillo "Vida Manglar", Version 3.0 – 7 April 2021 | (VCS 2021a) |
| Guinea-Bissau (no. 3) | Community Based Avoided Deforestation Project in Guinea-Bissau, Version 01.13 – 13 October 2020 | (VCS 2020a) |
| Mikoko Pamoja (no. 4) | Plan Vivo Project Design Document (PDD) Mikoko Pamoja Mangrove conservation for community benefit – 2020 revision | (Plan Vivo 2020) |
| 5 Delta Blue Carbon-1 (no. 5) | Delta Blue Carbon -1 The Indus Delta Mangrove Restoration Project Phase 1, Version 4 – 11 August 2021 | (VCS 2021b) |
| Zhanjiang MAP (no. 6) | Zhanjiang Mangrove Afforestation project, Version 01.1 – 8 September 2020 | (VCS 2020b) |
| VCR Seagrass Restoration (no. 7) | Virginia Coast Reserve Seagrass Restoration Project, Version 1.0 – 14 December 2021 | (VCS 2021c) |

## 3.3 Main characteristics of projects selected for the project sample

The following sections briefly summarise the main characteristics of the projects in the project sample.

### 3.3.1 Project subtypes and activities

Six out of the seven projects take place in mangrove ecosystems while the location of one project is within a seagrass ecosystem.

It is useful to further subcategorise the six projects conducted in mangrove ecosystems, using the type of project activity to better distinguish the mitigation impact associated with the respective project activities.

Three projects plant new mangrove forests on previously degraded mangrove habitat. We label these as *mangrove restoration* projects for the purpose of this report. A common term, which is used by carbon crediting programmes to label this subtype of mangrove Blue Carbon projects.

The main objective of the three remaining projects in the sample is to conserve existing mangrove habitats, thus labelled as *mangrove conservation* projects for this report. This subtype of mangrove Blue Carbon projects follows a similar logic as REDD+ projects in terrestrial forests. Mangrove habitats in these project areas are subject to deforestation. Deforestation is usually caused by multiple local agents. They use mangrove wood for fuel or convert mangrove habitat for other land use purposes such as cattle ranching or shrimp farming. To address drivers of deforestation, this project subtype often combines different activities, including improving agricultural practices, providing alternative livelihoods to local communities, instituting patrols (see Table 6).

For *mangrove restoration* projects, the main mitigation impact is the removal of $CO_2$ from the atmosphere. For *mangrove conservation* projects, the impact is the avoidance of emissions that would occur if the mangrove ecosystem in the project area would be deforested. This differentiation is important for the analysis of the quantification approaches as well as additionality, non-permanence risks as well as environmental co-benefits, which are presented later in the report.

The sole project which is taking place in the seagrass ecosystem is a seagrass *restoration project*. It follows the same logic as mangrove restoration projects, with the main difference being that it focusses on a different type of plant - seagrass.

Carbon market methodologies often use more aggregated labels that do not distinguish between mangrove and seagrass projects. For example, all restoration projects taking place in wetlands run under the label of "Wetland restoration" while methodologies use the label "Wetland conservation" for conservation projects.

**Table 6: Project subtypes and activities implemented by projects in the project sample**

| Project | Project subtype | Main activities |
|---|---|---|
| Úrsulo Galván (no. 1) | Mangrove restoration | Mangrove restoration through mangrove planting and removal of impediments for natural growth |
| Vida Manglar (no. 2) | Mangrove conservation | Identification, prioritization, and execution of actions for the proper management of mangroves, the strengthening of local governance and monitoring, and the promotion of alternative productive activities.<br>Practices that prevent the degradation or drainage of wetlands associated with mangroves in the context of changes in land use resulting from deforestation. |
| Guinea-Bissau (no. 3) | Mangrove conservation (Project also implements REDD+ activities in terrestrial forests) | Application of a community-based management approach in conjunction with an innovative micro-finance mechanism for small-scale socio-economic investments with conservation goals |
| Mikoko Pamoja (no. 4) | Mangrove restoration<br>Mangrove conservation | Agreement on and policing of clear boundaries for protected, no-take areas. Enhanced community education and awareness.<br><br>Tree planting and protection |
| 5 Delta Blue Carbon-1 (no. 5) | Mangrove restoration | Mangrove restoration through mangrove planting and human-assisted natural regeneration |
| Zhanjiang MAP (no. 6) | Mangrove restoration | Mangrove restoration through mangrove planting |

| Project | Project subtype | Main activities |
|---|---|---|
| VCR Seagrass Restoration (no. 7) | Seagrass restoration | Restoration of a seagrass ecosystem through direct seeding |

Source: PDDs projects no. 1-7.

### 3.3.2 State of the ecosystems before the start of the project interventions

Depending on the project subtype (see section above), the state of the ecosystem before the start of the intervention is either mangrove forest (mangrove conservation) or barren or degraded land (mangrove restoration). Projects aim to protect or plant a diverse set of different mangrove species (see Table 7). This diversity reflects that projects take place in different geographical regions. The type of mangrove species that can be found in each of the project areas depends on several factors such as e.g. the region of the project or the salinity of the project area.

**Table 7: State of ecosystems before project interventions**

| Project | State of the ecosystem | Species |
|---|---|---|
| Úrsulo Galván (no. 1) | Mangrove forest | Rhizophora mangle (red mangrove), Avicennia germinans (black mangrove), Laguncularia racemose (white mangrove) |
| Vida Manglar (no. 2) | Mangrove forest | Rhizophora mangle (red mangrove), laguncularia racemose (white mangrove), conocarpus erecta (button mangrove), pelliciera rhizophorae (tea mangrove), avicennia germinans (black mangrove) |
| Guinea-Bissau (no. 3) | Mangrove forest | Avicennia germinans (black mangrove) and rhizophora mangle (red mangrove) |
| Mikoko Pamoja (no. 4) | Mangrove forest / Deforested beach area | Rhizophora mucronate (loop-root mangrove), Sonneratia alba (apple mangrove) |
| Delta Blue Carbon-1 (no. 5) | De-vegetated barren land | Avicennia marina (grey mangrove), rhizophora mucronate (loop-root mangrove) |
| Zhanjiang MAP (no. 6) | Degraded mangrove habitat | Kandelia obovata, aegiceras corniculatum (river mangrove), avicennia marina (grey mangrove), bruguiera gymnorrhiza (black mangrove) and rhizophora stylosa (stilt-root mangrove) |
| VCR Seagrass Restoration (no. 7) | Shallow open water (no vegetation cover) | Zostera marina (marine eelgrass) |

Source: PDDs projects no. 1-7.

The three projects aiming to protect existing mangrove forests (*conservation projects*) are at different growth stages, both regarding projects overall as well as different sites of each project. For example, the Vida Manglar project (no. 2) takes place in eleven sites which show different structural attributes of the mangrove forest in the project area. At each site, forests differ in maturity and density. Maximum height of mangrove trees is between 5-25m, while diameters at breast height range between 20-50cm. Some of the project sites show some selective logging and some include mangrove trees that have been planted only recently.

For the two mangrove restoration projects, the state of the ecosystem before the start of the project intervention is either degraded mangrove habitat or barren land. In the Delta Blue

Carbon-1 project (no. 5), the project area is characterized by a near absence of sources of mangrove propagules, high salinity and presence of livestock that damages any new emerging natural seedlings. Further, local communities log mangroves for fuelwood and livestock fodder. Before the start of the project activities, the project area of the Zhanjiang MAP project (no. 6) was in a similar state.

### 3.3.3 Project area and land ownership

Project area size varies substantially within the project sample. The smallest project, Mikoko Pamoja (no. 4), has a project area of 117 hectares (ha). The largest project, Delta Blue Carbon-1 (no. 5) takes place on a very large area of 350,000 hectares, an area that is larger than the areas of all other projects combined.

All projects take place on land that is either owned by the state, regional states or municipalities (see Table 8). There are no projects that take place on privately owned land. This reflects that wetlands and coastal ecosystems in most countries constitute public land. All projects except for Mikoko Pamoja (no. 4) take place on lands that enjoy some form of protected area status (see section 3.5.1.1 for a detailed discussion on this).

While all projects take place on public land, the specific ownership structures differ between projects, reflecting differences in local land tenure customs and project partnership structures. Project Úrsulo Galván (no. 1) in Mexico takes place on the land of an *ejido*, which is a land tenure system specific to Mexico. Ejidos consist of agricultural communal land on which community members individually farm designated parcels and collectively maintain communal holdings (Schumacher et al. 2019). The land itself remains in the ownership of the Mexican state. The Blue Carbon project is a joint project of all community members of the Ejido. The Vida Manglar project (no. 2) in Colombia takes place on public lands administered by *Regional Autonomous Corporations*. Their responsibilities include land-use management and zoning as well as serving as the supreme environmental authority in their areas of jurisdiction (Blackman et al. 2006). For the initial project phase, the respective entity is the *Regional Autonomous Corporation of the Sinu and San Jorge Valleys*. As the project is designed as a VCS *grouped project*[4], further areas managed by different Regional Autonomous Corporations might be added at a later stage.

**Table 8: Overview of land ownership, project proponents, and other entities involved**

| Project | Project area (hectares) | Land ownership | Project proponent | Other entities involved |
|---|---|---|---|---|
| Úrsulo Galván (no. 1) | 930 | Communal land (ejido) | Ejido Úrsulo Galván | Fundacion San Crisanto, Climate Seed |
| Vida Manglar (no. 2) | 7,561 | Public land administered by the Regional Autonomous Corporation of the Sinu and San Jorge Valleys | Conservation International - Colombia | Instituto de Investigaciones Marinas y Costeras, Regional Autonomous Corporations of Sinu and San Jorge Valleys as well of Sucre, Fundación Omacha, South Pole Carbon Asset Management Ltda. |

[4] A grouped project means that additional instances of the project activity (i.e. avoiding the deforestation of a mangrove ecosystem) can be added to the project if they meet pre-established eligibility criteria.

| Project | Project area (hectares) | Land ownership | Project proponent | Other entities involved |
|---|---|---|---|---|
| Guinea-Bissau (no. 3) | 136,265 | Public land under the institutional control of the Institute for Biodiversity and Protected Areas of Guinea-Bissau | Institute for Biodiversity and Protected Areas of Guinea-Bissau | The World Bank, BioGuinea Foundation |
| Mikoko Pamoja (no. 4) | 117 | Public land owned by the national government and managed by the Kenyan Forest Services | Mikoko Pamoja Community Organization | Mikoko Pamoja Steering Group, Association for Coastal Ecosystem Services |
| Delta Blue Carbon-1 (no. 5) | 350,000 | State property managed by the Sindh Forest and Wildlife Department | Indus Delta Capital Limited Government of Sindh Forest and Wildlife Department | Silvestrum Climate Associates, Blue Ventures, Pollination Group, Pakistan Forest institute |
| Zhanjiang MAP (no. 6) | 380.4 | State property under the management of the Guangdong Zhanjiang Mangrove National Nature Reserve Administration | Third Institute of Oceanography, Ministry of Natural Resources | Guangdong Zhanjiang Mangrove National Nature Reserve Administration, Climate Bridge (Shanghai) Ltd. |
| VCR Seagrass Restoration (no. 7) | 66,452 | Public land owned by the Commonwealth of Virginia | Virginia Department of Environmental Quality | The Nature Conservancy Virginia Chapter, Virginia Institute of Marine Science, University of Virginia |

Source: PDDs projects no. 1-7.

The Guinea-Bissau project (no. 3) takes place in two national parks which are under the institutional control of the *Institute for Biodiversity and Protected Areas (IBAP)* of Guinea-Bissau, which manages all national parks in the country and holds the rights of use for national parks and its resources. While there are communities that hold traditional land use rights in the project area, private ownership is prohibited by law.

In Kenya, where the 4 Mikoko Pamoja project (no. 4) takes place, mangrove forests are owned by the government and managed by the Kenya Forest Services.

The 5 Delta Blue Carbon-1 project in Pakistan (no. 5) takes place on legally state-owned property, which has been declared as protected forest under the Pakistan Forest Act. The ownership of mangroves and all other forest products vest in the state, represented through the Sindh Forest Department. The Zhanjiang MAP project in China (no. 6) takes place on state-owned land with management and use rights being bestowed to the Guangdong Zhanjiang Mangrove National Nature Reserve Administration. In the VCR Seagrass Restoration project (no. 7) in the United States, the project area is under the ownership of the Commonwealth of Virginia.

While all projects take place on public land, in two projects the project proponents – i.e. the organisations proposing the project for registration with a carbon crediting programme –are non-public entities. The proponent of the Vida Manglar project (no. 2) is the Colombian chapter of Conservation International, a non-profit environmental organisation with headquarters in the United States. The project proponent for the Delta Blue Carbon-1 project (no. 5) in Pakistan is a public-private partnership comprised of the Government of Sindh Forest and Wildlife Department and Indus Delta Capital Limited. The latter is a U.K. based private investment company specialising on sustainable and climate resilient development solutions.

While the remaining five project proponents are public entities, partnerships with non-governmental organisations, academia, or private companies that provide specialised expertise required for the implementation of the projects, were formed. The services these parties provide often include support for quantifying the emission reduction or removal impact of the activities or support in marketing and monetizing the carbon credits from the project, amongst others. The VCR Seagrass Restoration project (no. 7) (under development) provides a detailed description of the roles and responsibilities of the different entities involved. The Virginia chapter of the Nature Conservancy, a large non-profit environmental organisation, will implement the seagrass restoration activities and will manage the carbon project, the Virginia Institute of Marine Science will implement seagrass restoration and collect data for carbon monitoring, and the University of Virginia will support the data collection.

### 3.3.4 Involvement of the local community

Coastal ecosystems serve as a vital source of livelihoods for local communities, who often depend on the services these ecosystems provide for their subsistence. It is therefore important that projects aiming at monetizing coastal ecosystems' carbon storage capacity work in harmony with local communities, share project benefits and respect customary, access and land tenure rights.

For *mangrove conservation* projects, community involvement further is a critical component for achieving project objectives, as land-use patterns of local communities often drive the very degradation of mangrove habitats that projects try to prevent. Communities use mangrove trees and shrubs for firewood or livestock fodder and grazing of animals may trample new mangrove seedlings. At the core of projects Vida Manglar (no. 2), Guinea-Bissau (no. 3), and Mikoko Pamoja (no. 4) are therefore lines of strategic interventions that aim at creating alternative livelihoods for local communities inter alia through offering workshops and trainings to institutionalize sustainable mangrove management practices. The Vida Manglar project (no. 2) for example plans to support local communities in developing ecotourism plans, beekeeping, and community orchards as alternative sources of income. The Mikoko Pamoja project (no. 4) will plant a community woodlot to provide alternative sources of timber and fuelwood for the local community to reduce the deforestation pressure on the mangrove habitat.

While their main activity is the planting of mangrove seedlings, *mangrove restoration* projects often also implement complementary activities that support communities in identifying alternative forms of income through workshop and trainings. Regarding mangrove planting, all mangrove restoration projects, Úrsulo Galván (no. 1), Delta Blue Carbon-1 (no. 5), and Zhanjiang-MAP (no. 6) involve local communities in site preparation, planting, and monitoring activities.

Projects use different governance approaches to operationalise community involvement. In two projects, Úrsulo Galván (no. 1) and Mikoko Pamoja (no. 4), the local communities themselves are the owner of the project, while they partner with non-governmental organisations in the project delivery (see section above). In these two projects local communities directly administer project implementation themselves. For the Mikoko Pamoja project (no. 4), a dedicated legal entity – the Mikoko Pamoja Community Organisation (MPCO) – was founded for this purpose. Consisting of democratically elected representatives of the two local villages located in the project area, it provides a means for the communities to cooperatively manage the project. A local project coordinator is responsible for the day-to-day running of the project. In addition, a steering group consisting of staff from the Kenya Marine and Fisheries Research Institute, the Kenya Forest Service, a representative of the Tidal Forests of Kenya project as well as a representative of MPCO provide technical support to MPCO. Plan Vivo rules stipulate that at least 60% of revenues from carbon credits must be allocated to local communities. The Mikoko Pamoja project (no. 4) complies with this requirement by allocating about 65% of carbon revenues to MPCO. Of this approximately 36% are used to fund the work teams that implement project activities, such as nursery teams, community reporters and woodland maintenance teams. Around 26% is allocated for activities determined through the community benefit consultation process and the remaining 3% for expenses such as stationary. The project also has a benefit sharing consultation process which defines the steps that MPCO must take to determine priorities to which activities revenues from carbon crediting will be allocated (see box 1 below). This type of transparency and formalization of benefit sharing arrangements have been identified as a critical element for the success of carbon crediting programmes by bodies such as the Integrity Council for the Voluntary Carbon Market (IC-VCM).

**Box 1. Steps of the community benefit consultation process in the Mikoko Pamoja project (no. 4)**

- MPCO members collect ideas for expenditure from their communities.
- A full MPCO meeting determines priorities and ranks the suggested expenditures.
- Ranked priorities are made public, displayed in the villages and on the project website with one month for further comments from any local resident.
- A confirmation meeting of MPCO is held to determine final priorities for expenditure.
- An annual audit is performed at the end of each financial year to determine how funds were spent.

Source: PDD project no. 4, page 41.

The Delta Blue Carbon-1 project (no. 5) states that it has a benefit sharing and incentives allocation system in place that gives voice and concern to all members of the community through a “classic participatory and representative governance structure” (PDD project no. 5, p. 202). As part of this, village development committees and women organizations have been established that have decision-making power over the benefit distribution and cost sharing arrangement under the project. There is no defined minimum share of revenues from selling carbon credits that must go directly to the communities. The PDD however states that the implementation of the benefit sharing will be further consolidated in the future.

Similarly, the PDD for the Vida Manglar project (no. 2) states that it will design a benefit sharing mechanism, but besides general principles, operational details are not yet provided. The PDD of the Guinea-Bissau (no. 3) project equally mentions that it will use a benefit sharing mechanism that will use a participatory approach to decide who will receive money and where the money will be invested. Giving communities an opportunity to prioritize investments and to make collective decisions. Moreover, benefit sharing will be operationalized by channeling resources through a financial mechanism established by an earlier development cooperation project, called the Fund for Local Environmental Initiatives (FIAL). It is structured as a micro-finance mechanism that is accessible for communities residing in and around the project areas and accepts proposals for small-scale, socio-economic investments with conservation goals. The PDD states that for the purpose of the project's financial analysis the assumption was made that 30% of carbon revenues will be made available to the FIAL. The PDD mentions that this figure was set arbitrarily during the project planning stage, suggesting that the final figure might be different.

Both, the Zhanjiang MAP project (no. 6) and VCR Seagrass Restoration project (no. 7) do not include information on a benefit sharing mechanism in their project description.

An overview of benefit sharing arrangements implemented in the selected projects is provided in Table 9 below.

**Table 9: Benefit sharing arrangements and examples of community involvement**

| Project | Benefit sharing mechanism | Examples of community involvement |
|---|---|---|
| Úrsulo Galván (no. 1) | Yes | Local communities extensively involved in participation, documentation, and governance of the project. |
| Vida Manglar (no. 2) | Yes | Alternative income sources are under development. |
| Guinea-Bissau (no. 3) | Yes | Local communities involved in planting activities and coastal monitoring.<br>Project envisions creating alternative income opportunities, such as ecotourism, sustainable fishing, and nature conservation. |
| Mikoko Pamoja (no. 4) | Yes | Tree nursery teams include "experienced local people" that either work on a voluntary basis or in exchange for payments.<br>Project is "community-led" and claims to ensure local tenure-ship through a Community Forest Association agreement; a fund is established to support projects that benefit the community, with all local people involved in the decision on spending priorities. Additionally, it is planned to create a long-term source of community income. |
| Delta Blue Carbon-1 (no. 5) | Yes | Local communities involved in planting activities.<br>Mangrove Stewardship model: Serving in a ward and watch system is remunerated. |
| Zhanjiang MAP (no. 6) | No | Local communities involved in planting activities. |
| VCR Seagrass Restoration (no. 7) | No | Project incorporates an outreach and education programme for pupils to "foster [...] a sense of stewardship" and create awareness. |

Source: PDDs projects no. 1-7.

### 3.3.5 Gender equality

Blue Carbon projects are well positioned to increase gender equality within the project region as they work directly with local communities. Five out of seven projects include design elements that aim at reducing gender inequality. This includes institutional arrangements such as in the Delta Blue Carbon-1 project (no. 5), which established a specific gender directorate in its management structure as well as project activities that provide job and educational opportunities to women. Two projects did not include any information on gender equality in the project design documents.

An overview of project arrangements to safeguard gender equality is provided in Table 10 below.

**Table 10: Project arrangements to safeguard gender equality**

| Project | Provisions to safeguard gender equality |
|---|---|
| Úrsulo Galván (no. 1) | The project aims at reversing traditional gender roles, inter alia by empowering women to actively participate in collective activities such as work in mangrove nurseries and mangrove monitoring. |
| Vida Manglar (no. 2) | The PDD states that the project will guarantee wage equality between men and women and will implement mechanisms to eradicate gender discrimination. It further states that the project will implement an equal opportunity and anti-discrimination policy, seeking to end all forms of discrimination against women. Equal opportunities for leadership and management positions will be provided if it does not conflict with the cultural characteristics of the communities. |
| Guinea-Bissau (no. 3) | No provisions found. |
| Mikoko Pamoja (no. 4) | The project design document states that the project coordinator will adhere to the principles of fairness and gender rule in employment as stipulated in the Constitution of Kenya. |
| Delta Blue Carbon-1 (no. 5) | A community development, extension and gender development directorate was established as part of the organisational set-up for the project.<br><br>The PDD states that the activities for the female population in the project zone are meant to address the issue of patriarchal culture by enhancing the socio-economic status of women through specially targeted interventions.<br><br>The project plans to train 6,000 women in various crafts to increase their income earning opportunities. This includes crab farming; anchovies fisheries identification/ sorting, grading, and processing; kitchen gardening; handicrafts making; sewing and embroidery training; hygiene and sanitation and midwifery. |
| Zhanjiang MAP (no. 6) | The PDD states that the project aims at improving gender equity inter alia by offering women job opportunities. It is estimated that 60% of the local residents directly involved in the project will be women. Training will be provided on forestation skills. |
| VCR Seagrass Restoration (no. 7) | No provisions found |

Source: PDDs projects no. 1-7.

### 3.3.6 Cost of implementation

The seven project design documents show different degrees of detail when it comes to providing information on project cost structures. A systematic comparison between projects is therefore not possible. It is also not possible to derive more general conclusions on the cost structures of Blue Carbon projects from the information provided in the PDDs. The information found in the PDDs, and presented below, illustrate however costs of different elements related to project implementation.

The Úrsulo Galván project (no. 1) e.g., provides an overview table with several cost items that relate to the establishment of the baseline, i.e. the estimation of the carbon stored in the project area before the start of the project activities. These costs amount to approximately 52,000 US-Dollars (USD) with the largest cost items being rental costs for boats, field work, professional fees as well as verification costs (see Table 11). There is no information on the planting costs and whether this cost will accrue with every monitoring period. It is also unclear how large the share of these costs is in relation to the overall costs of project implementation.

**Table 11: Cost overview for baseline survey provided by the Úrsulo Galván project (no. 1)**

| Item (Spanish) | Item (English translation) | Cost (MXN) | Cost (USD) | Share |
|---|---|---|---|---|
| Cinta diametrica, metrica de 20m, 30m | Measuring tape | 3,090 | 154.50 | 0.30% |
| Vernier de pasta | ? | 700 | 35.00 | 0.07% |
| Kit botiquin portail | Portable first aid kit | 1,200 | 60.00 | 0.12% |
| GPS Garmin resistente | GPS | 7,000 | 350.00 | 0.67% |
| Mochillas de campo | Backpacks | 2,700 | 135.00 | 0.26% |
| Reglas de madera de 1m | Wooden rulers | 300 | 15.00 | 0.03% |
| Pilas AA.15v | Batteries | 3,000 | 150.00 | 0.29% |
| Lamparas impermeables | Waterproof lamps | 1,000 | 50.00 | 0.10% |
| Papelaria y accesorios | Stationery and accessories | 7,000 | 350.00 | 0.67% |
| Cintas: Industrial y peligro | Industrial tape | 3,000 | 150.00 | 0.29% |
| Machetes | Machetes | 1,500 | 75.00 | 0.14% |
| Vivere para las brigadas | Food | 5,000 | 250.00 | 0.48% |
| Pintura, tiner, brochas | Paint, liner, brushes | 6,000 | 300.00 | 0.58% |
| Brujulas | Compasses | 320 | 16.00 | 0.03% |
| Placas | Badges | 973 | 48.65 | 0.09% |
| Numeros de golpes | Stroke numbers | 239 | 11.95 | 0.02% |
| Mapa de puntos | Maps | 450 | 22.50 | 0.04% |
| Tornillos | Screws | 139 | 6.95 | 0.01% |
| Botas | Boots | 2,800 | 140.00 | 0.27% |
| Estadales de 30, 1.30cm | Measurement (30, 1.30cm) | 380 | 19.00 | 0.04% |
| Brujulas de nivel | Level compasses | 600 | 30.00 | 0.06% |
| Limas | Files | 350 | 17.50 | 0.03% |
| Renta con equipo de lancha y operacion | Boat rental equipment | 208,500 | 10,425.00 | 20.01% |
| Honorarios profesionales | Professional fees | 150,000 | 7,500.00 | 14.39% |
| Trabajo campo | Field work | 291,900 | 14,595.00 | 28.01% |

| Item (Spanish) | Item (English translation) | Cost (MXN) | Cost (USD) | Share |
|---|---|---|---|---|
| Viaticos | Per diems | 5,000 | 2,500.00 | 4.80% |
| Apertura de cuenta de dueno forestal | Registry account | 1,400 | 700.00 | 1.34% |
| Verification | Verification | 150,000 | 7,500.00 | 14.39% |
| Mantenimiento | Maintenance | 130,000 | 6,500.00 | 12.47% |
| **Total** | | **1,042,141** | **52,107.05** | **100%** |

Source: PDD project no. 1, page 45.

The PDD for the Zhanjiang MAP project (no. 6) states that the cost for initial mangrove planting is USD 11,340.11 per hectare. Considering that the project plans to plant a total of 380.4 hectare of mangroves, total planting cost would amount to approximately USD 4.4 million. In addition, the PDD states that the cost for management and protection of the planted mangroves would be USD 1,429 per year. This would mean that after the initial investment for the planting of the mangroves, the project has negligible operating expenses for the rest of its lifetime. However, it is unclear whether this includes cost items such as for monitoring and verification. Without further details it is therefore difficult to interpret these figures or to derive more general conclusions on the cost structures of Blue Carbon projects.

The PDD for the Guinea-Bissau project (no. 3) states that there is a project budget plan, including a cash flow analysis, but the latter is not publicly disclosed as part of the project information. Project developers estimate that the required resources for the national park administration to manage the country's five national parks would be USD 1 million per year. The project takes place in two of these parks, however there is no estimate given how much of the above mentioned USD 1 million would be required to realise the project. The PDD states that the carbon revenues will be made available to the national park administration. Assumedly, the project will support efforts to raise some of these resources.

The PDD of the Delta Blue Carbon-1 project (no. 5) states that project developers have conducted a financial analysis and that measures for assessing the financial viability of the project (net present value, cost benefit ratio and internal rate of return) show that it is financially viable. This analysis is however not part of the documents made publicly available via the VCS registry.

A fully-fledged cost analysis as part of the PDD is provided by the Vida Manglar project (no. 2, see Table 12 below). It contains a detailed breakdown between the project's investments, costs, and expenses (see Table 13) as well as a description of the parameters used for the financial analysis. The largest line item in the project budget with USD 5.1 million is expenses. Most of these (about USD 4 million) are associated with the community activities that the project will implement. This includes expenses for trainings and workshops with community members to empower local self-management and governance, disseminate knowledge and skills on mangrove restoration and creating job opportunities and alternatives for economic income. In addition, resources are budgeted for activities related to restoring the mangrove habitat including by cleaning of rivers and streams. A further USD 800,000 in expenses is budgeted for research related activities. The variable cost item of USD 825,809 consists of salary costs for different positions such as forest engineers, biologist, agricultural technicians, motorboat drivers etc. Most investments go into machinery and equipment. For fixed costs, the main line item is payments for public services and administration.

**Table 12: Project expenses Vida Manglar (no. 2) for 2019-2028**

| | Cumulated 2019-2028 (USD) |
|---|---:|
| Investments | 179,612 |
| Variable costs | 825,809 |
| Fixed costs | 182,820 |
| Expenses | 5,085,271 |
| **Total** | **10,556,940** |

Source: PDD project no. 2, pages 70-76.

The Mikoko Pamoja project (no. 4) does not provide a cost analysis in its PDD. It however includes an overview on how the income from carbon credits will be spent (see Table 13). This provides some insights on the likely expense structure of the project. With 36%, the largest share of the revenues will be spent on project activities. This includes salaries for the local teams that plant mangroves, monitor the project area and maintain the community woodlot. A further 26% is allocated to community benefits. Around 21% will be used to finance the annual salary of the local project coordinator. About 6% each will go to the international verifier and for covering the fees charged by Plan Vivo. This means that almost 90% of the revenues will be spent locally.

**Table 13: Distribution of carbon revenues in the Mikoko Pamoja project (no. 4)**

| | Share |
|---|---:|
| Independent verification | 6% |
| Plan Vivo fees | 6% |
| Expenses Mikoko Pamoja Steering Group | 3% |
| Project coordinator annual salary | 21% |
| Project activities | 36% |
| Community benefits | 26% |
| Stationary | 3% |

Source: PDD project no. 4, page 41. Note that numbers provided in the PDD do not add up to 100%. It is assumed that this is due to rounding issues.

## 3.4 Methodological approach

All selected projects are registered with carbon crediting programmes operating on the voluntary carbon market. Therefore, a key question is whether the projects and the resulting carbon credits have environmental integrity. The term environmental integrity refers to the aim that a crediting mechanism must not lead to aggregate Greenhouse gas (GHG) emissions that are higher than they would have been without the use of the mechanism (Schneider and La Hoz Theuer 2019).

To analyse the chances, environmental integrity risks and success factors of the selected Blue Carbon projects, we identified a set of indicators/guiding questions. For developing the indicators for our assessment, we have reviewed existing assessment frameworks such as the Core Carbon Principles of the Integrity Council on the Voluntary Carbon Markets (IC-VCM) and the assessment methodology of the Carbon Credit Quality Initiative (CCQI). We have also considered the High-Quality Blue Carbon Principles and Guidance launched by a collation of business initiatives and non-governmental organisations in 2022 (World Economic Forum et al. 2022).

We consider five major challenges for which we assess a set of indicators/guiding questions which are summarised below. We base our analysis on information that is publicly available in project documents for the selected Blue Carbon projects in the registries of the crediting programmes as well as the crediting methodologies according to which the projects are designed and implemented. The following indicators/guiding questions guide the analysis of the selected projects and the underlying crediting methodologies in the following sections:

- **Ensuring additionality**: Which rules are in place for assessing whether legal requirements for the respective Blue Carbon activities are in place? How is it determined whether the activities are incentivised by subsidies or other financial benefits?
- **Quantifying emission reduction and removal impact**: How are baselines calculated and how are past management practices considered? Is the principle of conservativeness applied? How is uncertainty treated? How is the risk of carbon leakage managed?
- **Addressing non-permanence**: For how long is monitoring of projects required? How is the risk of reversals assessed and which liability rules are in place for compensating for reversals?
- **Environmental and social impact**: How are potential negative social or environmental impacts identified and addressed? How do the projects contribute to sustainable development?
- **Preventing double counting**: Is potential overlap between projects addressed to avoid double issuance of credits? Are carbon credits used for purposes for which double claiming (e.g. with the host country's Nationally Determined Contributions (NDCs)) needs to be avoided? Is the purpose for which credits are used documented?

For each of the five challenges we first briefly explain its importance in the following sections and then describe how the selected projects and the crediting methodologies, which they are based on, address these challenges.

## 3.5 Assessment

### 3.5.1 Additionality

Additionality plays a central role for the concept of carbon credits. Emission reductions or removals are additional "if the mitigation or removal activity would not have taken place in the absence of the added incentive created by carbon credits" (Schneider et al. 2022b). Assessing whether a mitigation activity is additional is however inherently difficult (Broekhoff et al. 2019; Cames et al. 2016; Schneider 2009; Gillenwater 2012; Michaelowa et al. 2019). It requires comparing the activity to a scenario without the added incentives of carbon credits. This scenario is hypothetical and constructing it requires making assumptions about many parameters, e.g., future land prices. Even if applying robust methodologies for estimating future values for these parameters, these estimates are often associated with high uncertainty. Ensuring additionality of mitigation activities in BCE with a hundred percent certainty is thus methodologically impossible. It is however possible to restrict eligibility for participation in carbon crediting programmes to those mitigation activities that have a very high likelihood of being additional. Considering environmental integrity is a key prerequisite and minimizing the risk that project proponents obtain carbon credits for non-additional mitigation activities as much as possible is crucial for any market-based mechanism. If market actors use carbon credits for offsetting their emissions, and the underlying mitigation activity would have happened anyway, this will ultimately result in higher global atmospheric emission levels. Thereby counteracting the very objective of any market-based mechanism.

To minimize these risks, carbon crediting programmes can restrict eligibility of activities to those, for which project proponents:

- Are not obligated to implement them anyway due to legal requirements in the country where the project is proposed to take place (legal requirements);
- Can demonstrate that they have considered revenues from carbon credits at the time when making their investment decision (prior consideration);
- Can demonstrate that additional income from selling carbon credits is required for covering the costs of these activities and/or for mobilizing funders that are willing to invest in them (financial attractiveness);

  OR;

  Can demonstrate that the project activities face non-financial barriers that can be overcome with the help of the carbon crediting mechanisms (barriers).

Most carbon crediting programmes have provisions in place that restrict eligibility along the three aspects presented above. They typically set out these eligibility provisions in their overarching standard documents which contain the general rules that project proponents must follow for registering a project. Some programmes add specific requirements for certain project types. If this is the case, they are typically contained in the project type specific quantification methodology. Projects in the project sample have registrations with the following carbon crediting programmes: Climate Action Reserve, Plan Vivo and Verified Carbon Standard. All of them have eligibility restrictions that aim at preventing the registration of non-additional projects. Their stringency however differs as outlined in the following sections and summarized in Table 14.

**Table 14: Summary table: Overview of additionality provisions of carbon crediting programmes**

| | **Climate Action Reserve** Mexico Forest Protocol | **Plan Vivo Standard** Plan Vivo Standard v.4 | **VCS** VM0007 and VM0033 | **VCS** AR-AM0014 |
|---|---|---|---|---|
| **Legal requirements** | | | | |
| Definition | Law, statute, rule, regulation, or ordinance | Legislation, official policies, regulations, or industry standards | Law, statute, or other regulatory frameworks | Mandatory applicable legislation and regulations |
| Scope of exclusion | All legal requirements | Exemptions exist for legal requirements for | Exemptions exist for legal requirements for | Exemptions exist for legal requirements for |

| | **Climate Action Reserve** Mexico Forest Protocol | **Plan Vivo Standard** Plan Vivo Standard v.4 | **VCS** VM0007 and VM0033 | **VCS** AR-AM0014 |
|---|---|---|---|---|
| | | which project developers can demonstrate that they are not systematically enforced | which project developers can demonstrate that they are not systematically enforced in Non-Annex I countries | which project developers can demonstrate that they are not systematically enforced |
| Frequency of demonstration | At each verification | Every 10-years | At each verification and crediting period renewal | At each verification and crediting period renewal |
| **Prior revenue assessment** | No requirements | No requirements | No requirements | No requirements |
| **Financial attractiveness/ Barriers** | Performance Standard Test | Assessment at project level | Positive list based on applicability conditions | Assessment at project level |

Sources: Standard documents of carbon crediting programmes.

#### 3.5.1.1 Legal requirements

All three carbon crediting programmes require that project developers demonstrate that there are no legal requirements in place that mandate the mitigation activity. Plan Vivo and the VCS however make an exception for projects for which project developers can demonstrate that authorities do not systematically enforce them. Such exceptions entail some non-additionality risks as it is difficult to objectively identify materiality thresholds for non-enforcement of legal provisions. They further might create perverse incentives for authorities to refrain from enforcing legal requirements to not jeopardize eligibility of carbon crediting projects in the respective jurisdiction.

The project documentation for all seven projects in the sample contains a section that elaborates the assessment process that project developers performed for establishing that there are no legal requirements that mandate the implementation of their respective mitigation activities. An issue that all but one project touch upon is the question whether the fact that the project area intersects with an area that enjoys protected area status impacts the likelihood of additionality for the project. These six projects take place in locations that have some form of protected area status (see Table 15). Protected areas often have legal restrictions on certain activities that drive mangrove degradation such as, e.g., mangrove logging or livestock grazing.

**Table 15: Intersection between project areas and protected areas**

| **Project** | **Located in protected area?** | **Type** |
|---|---|---|
| Úrsulo Galván (no. 1) | Yes | Priority conservation area |

| Project | Located in protected area? | Type |
|---|---|---|
| Vida Manglar (no. 2) | Yes | Regional protected areas |
| Guinea-Bissau (no. 3) | Yes | Forest national parks |
| Mikoko Pamoja (no. 4) | No | - |
| Delta Blue Carbon-1 (no. 5) | Yes | Protected forest on state-owned land |
| Zhanjiang MAP (no. 6) | Yes | Nature reserve |
| VCR Seagrass Restoration (no. 7) | Yes | Biosphere reserve, recognized as a national natural landmark of the United States |

Sources: PDDs projects no. 1-7.

The *mangrove restoration* project in Guinea-Bissau (no. 3) for example takes place in the Cacheu and Cantanhez national parks. The alternative land use scenario presented by project developers assumes accelerated deforestation rates in the project area. This scenario would however violate mandatory applicable laws and regulations, which explicitly prohibit deforestation in the project area. Both parks strictly prohibit any logging in national park areas. The project validation report states that the regulations prohibiting deforestation would not be relevant for the additionality assessment, as they only entered into force after the project start date. Following this line of argumentation would however mean that, per the rules of the carbon crediting programme, the project would lose eligibility under the VCS at its next verification. The more relevant issue for the project's likelihood of additionality seems however the non-enforcement of the laws that prohibit deforestation. Given that project developers outline a large funding gap for the national park administration, non-enforcement of logging restrictions might indeed be a plausible scenario for the project area. This is somewhat contradicted by the project's non-permanence risk assessment, which assigns a high score to the project longevity, arguing that the protected area status will likely result in a continuation of the new mangrove management practice established through the project. These points do not mean that there is a low likelihood of additionality for the project, but they illustrate the challenges that project developers face to consistently demonstrate additionality for *mangrove conservation* projects that take place in protected areas.

The *mangrove restoration* project Delta Blue Carbon-1 (no. 5) claims that it is additional because the relevant law – the Pakistan Forest Act – mandates the protection of existing forests but not the replanting or restoration of mangrove forests. This seems to be a plausible line of argumentation as active replanting of mangroves would accelerate the restoration of the ecosystem compared to a baseline scenario in which degraded land is simply put under protection. For *mangrove restoration* projects it is however necessary to demonstrate that the protected areas status would not plausibly lead to natural regrowth of mangrove forests. The project developers have assessed this question and demonstrate in a plausible manner that for the specific project area ecological barriers and land-use patterns would prevent natural regrowth of mangroves. Specifically, the PDD cites two main barriers: first, the absence of mangrove propagules in the area, as they are regularly washed away due to tidal dynamics; and second, the damage to mangrove seedlings caused by trampling or foraging of camels kept within the project area. To substantiate this claim, the PDD includes satellite imagery that shows no evidence of natural mangrove regeneration in the project area over time pre-project implementation, thereby strengthening the case for the project's additionality.

Overall, for BC projects whose project area intersects with already protected areas it is important to clearly describe, how the project activities go beyond those that can be plausibly achieved with the protected area status. The assessment of the project sample shows that project developers seem to prefer implementing Blue Carbon projects in protected areas -– six out of seven projects fall into this category. This preference may be due to the protected status potentially supporting the continuation of the project activity after the end of the carbon crediting programme.[5]

#### 3.5.1.2 Prior revenue assessment

None of the three carbon crediting programmes currently requires project developers to demonstrate that they have considered revenues from carbon credits at the time when making their investment decision. This is associated with non-additionality risks, as project developers may try to register legacy projects that could have proceeded without carbon finance. An assessment of REDD projects has shown that lack of prior revenue assessment requirements can be a non-additionality risk for this project type as many of the analysed projects did start with conservation or grant finance (Calyx Global 2023). These risks seem also relevant for BC projects (especially the subtype *mangrove conservation*) as they might take place in protected areas, which already receive funding for conservation purposes. The analysis of REDD projects however also showed that many projects provided disclosure of prior assessment of revenue on a voluntary basis. In the absence of requirements by carbon crediting programmes this voluntary provision can be an effective approach to alleviate non-additionality risks.

Only one of the seven projects in the project sample provides voluntary evidence of prior revenue assessment. The Delta Blue Carbon-1 project (no. 5), although not required by the VCS methodology, states in its PDD that the two project proponents, Indus Delta Capital Limited and the Government of Sindh Forest and Wildlife Department, entered into a contractual agreement in 2015, which also marks the start of the crediting period. This demonstrates that project partners considered revenues from carbon credits in 2015 when making the decision to proceed with the project, although they submitted the final project design document to the VCS only in 2020.

The incorporation of prior revenue assessment is essential to demonstrate the environmental integrity of any BC project. This is evident by doing a systematic comparison between the initial submission date of a project design document to the carbon crediting programme and the requested start dates of the crediting period of said project (see Table 16 below). For several projects in the sample, PDDs have been submitted more than five years after the start of the mitigation activity (e.g., after the first mangroves have been planted or measures have been undertaken to avoid their deforestation). The Guinea-Bissau project (no. 3) even submitted the document as late as nine years later. Due to information asymmetries, it is impossible to objectively assess today, whether project developers indeed started protecting the mangroves in 2011 with the objective to sell carbon credits in 2020. Without clearly demonstrating this intent, it is unclear whether project mitigation impacts can be attributed to the revenue of selling carbon credits or whether they are financed by other means. As such, the project lacks additionality.

[5] Note by the authors: Six out of seven projects of the sample are implemented within areas designated as protected. This pattern has been highlighted in the summary. One plausible explanation is that implementation in protected areas may be facilitated by the avoidance of land use conflicts. However, this observation may also reflect a sampling bias, and it is possible that future projects will increasingly be established outside of protected areas. Without direct consultation with project developers, the underlying reasons remain speculative. A comprehensive analysis of the project pipeline would be necessary to assess this potential trend.

**Table 16: Time difference between submission date of project design documents and the start of the crediting period**

| Project | Submission date of project design document | Start of crediting period |
|---|---|---|
| Úrsulo Galván (no. 1) | 2020 | 2018 |
| Vida Manglar (no. 2) | 2020 | 2015 |
| Guinea-Bissau (no. 3) | 2020 | 2011 |
| Mikoko Pamoja (no. 4) | 2013 | 2012 |
| Delta Blue Carbon-1 (no. 5) | 2020 | 2015 |
| Zhanjiang MAP (no. 6) | 2020 | 2015 |
| VCR Seagrass Restoration (no. 7) | 2021 | 2015 |

Sources: PDDs projects no. 1 -7.

There are plausible reasons why finalizing PDDs can take several years, such as, e.g., the need to first build capacities on quantifying carbon stocks in the baseline and conduct proper consultation processes. If a project can however successfully operate a mitigation activity for several years without the revenues of carbon credits, there is an equally plausible risk that they were not a decisive factor in the decision to proceed with the project. Requirements to disclose a prior revenue assessment are an effective way to mitigate such risks. They could take on the form of, e.g., a non-binding letter of intent that project developers must submit to the carbon crediting programme, combined with a rule that the start of the crediting period cannot be before the submission date of this letter.

#### 3.5.1.3 Financial attractiveness

There are differentiated non-additionality risks for the two project subtypes *mangrove conservation* and *mangrove restoration.*

At the core of their intervention, *mangrove restoration* projects establish new mangrove ecosystems in barren or degraded lands. There is no economic value in planting mangroves, as they are not a suitable wood species for commercial plantations. Hence, project owners do not accrue any revenues from the project activity. This distinguishes *mangrove restoration* from terrestrial afforestation projects. For the latter, non-additionality risks are often rooted in the fact that they can include regular timber harvesting, which brings along substantial income for project owners.

*Mangrove conservation* projects similarly implement activities that do not generate any income for project owners. These are primarily trainings and capacity building interventions that have costs but do not generate income. Projects help communities to obtain additional economic income (e.g. by starting beekeeping or community woodlots). This income however does not necessarily benefit the project owner, who bears the costs for the trainings. Often these projects take place in settings in which either the project owner or partner organizations already have mandates to manage or administer the project area for conservation purposes. In this context these entities have other funding streams at their disposal, either from national budgets or through development cooperation. A key question to ask for these projects is therefore whether the income from carbon revenues was decisive for project owners to proceed with the project activities. Combining different sources of financing does not necessarily impact the likelihood of additionality. If the share of carbon revenues in the overall funding structure is very low, this might however point to higher non-additionality risks. A related question in blended finance approaches is the attribution of the mitigation impacts to the different funding sources. If all funding sources are required to successfully achieve the emission reductions or removals it makes sense to proportionally attribute them to each funding source. Without attribution the other funding sources would subsidize the carbon credits which would result in market distortions and potentially inefficient allocation of scarce public resources (Schneider und Haase 2023).

Among the three carbon crediting programmes, only Plan Vivo currently requires individual projects to demonstrate that they would not be financially attractive without the revenues from carbon credits or face non-financial barriers that prevent their implementation.

Under the VCS, methodologies VM0007 and VM0033 require the application of module VDM0052 to demonstrate additionality. As stipulated in the module, BC projects are considered automatically additional if they implement one of the activities listed in its eligibility conditions (positive list). Under the VCS rules, methodologies can introduce positive lists if they can demonstrate that “the level of penetration for the project activity [is] no higher than five percent” (VCS 2023, p. 43). For BC projects the tool establishes that the global protection rate of BC ecosystems must be lower than 5 percent to justify automatic additionality. The analysis underpinning the positive list approach in module VDM0052 argues that the activity penetration level for tidal wetland restoration would be ≤ 2.74 percent and for tidal wetland conversation it would be ≤ 3.6 percent. The latter value is calculated by estimating the global share of tidal wetlands that can be considered as being protected. The module’s line of argumentation thus acknowledges that tidal wetland conservation in protected areas might not qualify as an additional activity. However, there are no provisions in the module that exclude such cases from eligibility. When applying AR-AM0014 under the VCS, project developers had to apply the “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities”[6]. This tool includes mandatory steps for performing a barrier and investment analysis for each project. For activities that generate no financial or economic benefits, project developers must document the costs associated with the project activity.

The Climate Action Reserve’s Mexico Forest Protocol requires project developers to demonstrate that proposed projects meet a performance standard test, which assesses whether there is evidence of historic degradation to the mangrove forest caused by anthropogenic disturbances. A demonstration that carbon finance is critical for an individual projects’ implementation is not required.

In terms of minimizing non-additionality risks, the provisions of AR-AM0014 and Plan Vivo seem to be more effective, as they require demonstration of additionality at the project level and include a requirement for performing a barrier or investment analysis. In principle, positive lists can help to reduce the administrative cost of developing BC projects, their lack of project specific assessment requirements might however introduce non-additionality risks.

All projects in the sample argue that they do not have any other income from project activities and hence require funding from carbon credits. Two projects state that they had initial support from other organisations to support their set-up phase (projects no. 5, Delta Blue Carbon-1, and no. 4, Mikoko Pamoja). The Guinea-Bissau project (no. 3), reports that it received international assistance during the crediting period to support national park operations. The Zhanjiang MAP project (no. 6) provides figures for the projected cost for initial planting and management and protection cost. These figures are however difficult to interpret because they are not embedded

[6] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-02-v1.pdf.

into a fully-fledged cost analysis for the project. In the projects PDD, project developers state that the initial costs for mangrove planting would be USD 11,340.11 per hectare. As the project plans to plant a total of 380.4 hectare of mangroves it can be assumed that total planting costs would be in the order of USD 4.3 million. Further, project developers assume annual maintenance costs to be USD 1,429 over a total duration of 40 years. Adding this to the replanting costs, there would be approximately USD 4.4 million in total costs for the project. At the same time project developers estimate that the project would generate a total of 102,156 tonnes in removals over the project lifetime. This would mean that the project would need to sell each carbon credit at an average price of more than USD 40 in order for the revenues to cover the total project costs. Considering that carbon credits from BC projects have been traded at an average price of USD 11.58 in 2023 on voluntary carbon markets (Ecosystem Marketplace 2024), reaching a price above USD 40 per credit over the full project duration might be a figure that will be difficult to achieve. As there is no statement in the PDD on the expected revenue from carbon credits it is unclear what carbon price project developers have applied to calculate revenues from carbon credits. Considering that project developers state that the project will generate no financial or economic benefits other than the revenues from carbon credits it is unclear whether the project is indeed financially viable. On the other hand, the project design document, which was submitted in 2020 states that planting of mangroves has already begun in 2015. This means that project developers must have been able to mobilize other resources to fund the upfront cost for mangrove planting. There is no information in the project design document on other sources of funding that the project receives. It could be plausible that the carbon credits were instrumental in securing a loan for the project, which has been used to fund the mangrove plantation. However, due to the likely inability of the revenues from carbon credits to cover the full project costs, securing a loan would likely have required evidence of other income sources that support the project or act as a guarantee in case the revenues from carbon credits will be lower than the total project cost. This example shows the importance of providing a detailed cost analysis as part of the additionality demonstration. Without detailed documentation it is very difficult to assess whether carbon credits have indeed been instrumental for the project to proceed.

The need for transparent, detailed information on other funding sources for project activities is to demonstrate additionality is further illustrated by the case of the Guinea-Bissau project (no. 3). The PDD details the general difficulties that the country faces in generating sufficient revenues for funding public services and expenses. It further describes the general challenge to raise stable funding for the agency that administers the two national parks, which has been dependent on several short-term grants through international assistance to be able to pay required salaries for park management staff. For 2012, the funding gap is stipulated to have been EUR 90,000. No figures for other years are provided. While this information helps to understand the high-level challenges that the country faces, the PDD provides no information on the cost structure of the proposed project over the full project duration. The fact that there was a salary gap in 2012 does not sufficiently explain why the mitigation activity would not have happened in the absence of the carbon market revenues. It would be more transparent to provide a cost comparison over the full duration of the project lifetime and explain why costs incurring with the project activity cannot be covered with existing resources of the national park administration.

The Vida Manglar project (no. 2) is the only project in the sample that publicly discloses a fully-fledged financial analysis as part of its PDD (see section 3.3.6 and Table 13 above for details). Project developers estimate that implementing the project will require total expenditures of USD 10.6 million in its first ten years. At the time of submitting the PDD, project developers state that they have secured revenues of around USD 3.4 million. These consist of USD 1.3 million in projected income from selling VCS certified carbon credits as well as USD 2.1 million in other funding sources. This means that project developers will need to raise a further USD 7.1 million from other funding sources to implement all project activities (see Table 17 below). These figures provide strong evidence that the project faces financial barriers that hinder its implementation. What is less clear is how the revenues from carbon credits will help to overcome these barriers. If project developers succeed in mobilising the additional USD 7.1 million, revenues from carbon credits would provide about 12% of the overall funding for the project. This indicates that they play a smaller role for the financial viability of the overall project. On the other hand, project developers decided to proceed with the project even in the absence of the remaining USD 7.1 million to make the project financially viable. It could be plausible that carbon credits played a role for this decision as they make up for about 40% of the overall resources secured so far. It remains however unclear whether the project will be able to achieve its estimated mitigation impact without the additional USD 7.1 million from other funding sources.

**Table 17: Cash flow Vida Manglar project (no. 2)**

| | | Cumulated 2019-2028 (USD) |
|---|---|---|
| A | Other funding sources | 2,084,785 |
| B | VCS sales income (projected) | 1,299,268 |
| **C** | **Total income (A+B)** | **3,384,053** |
| **D** | **Total expenditure** | **10,556,940** |
| | **Net cash flow after tax (C-D)** | **-7,127,887** |

Source: PDD project no. 2, page 76.

The above discussion shows that current project documentation would benefit from more stringent requirements to at least conduct a cost comparison analysis, including a disclosure of other relevant funding streams for the project and a demonstration why these streams are not relevant for the proposed activity. This is especially relevant for those BC projects, which intersect with protected areas, as these often rely on multiple funding sources that support conservation efforts. Even if these are not targeted at enhancing carbon storage capacities of mangrove ecosystems, they can still have a positive effect on mangrove restoration or protection, which needs to be considered during the additionality assessment. In addition, carbon crediting programmes should consider how they could incentivize focussing implementation of new BC projects outside of protected areas. The main argument of the VCS additionality tool for considering BC projects as automatically additional is that less than 5% of wetlands can be considered as protected. If, however most BC projects take place in protected areas, this argument might no longer hold, and it would be advisable to introduce a mandatory additionality assessment that assesses additionality on a project-by-project basis.

### 3.5.2 Quantification of the climate change mitigation impact

The theoretical foundation of most climate change related market-based mechanisms relies on the assumption that they facilitate turning emission reductions or removals into a tradable commodity to incentivize economic actors to provide a supply of cost-efficient mitigation solutions. Mechanisms create tradability by defining units that represent a uniform amount of greenhouse gas emissions reductions or removals. The most common metric that mechanisms use for such units is one tonne of carbon dioxide equivalence ($CO_2e$). The principle that each certified carbon credit represents one tonne of $CO_2e$, is an important prerequisite for the functionality and credibility of market-based mechanisms. If carbon credits are traded that do not represent one tonne of $CO_2e$ using them for offsetting one's own emissions would result in higher overall atmospheric GHG levels, raising severe concerns about the environmental integrity of the mechanism.

This is why applying robust approaches for estimating the mitigation impact of a project activity is fundamental for the environmental integrity of any market-based mechanism.

It is a well-established principle in carbon crediting that quantification methodologies should take a conservative approach towards estimating emission reductions and removals of a mitigation activity.[7] This means that the approaches should err towards underestimating the emission impact of an activity. Further, the degree to which emission reductions and removals are underestimated should depend on the uncertainty associated with the quantification. The larger the uncertainty, the more conservative an approach should be chosen.

Judging the conservativeness of a methodology is challenging for three reasons (Schneider et al. 2022a):

- Emission reductions and removals are determined against a counter-factual baseline scenario, which is inherently unknown,
- Mitigation activities can involve significant indirect emission changes upstream or downstream of the activity,
- Some elements of a methodology might lead to overestimation of emission reductions and removals, while others might lead to underestimation or uncertainty. Judging conservativeness of a methodology requires assessing the combined effect of these different elements.

There are four key elements that need to be evaluated to assess the robustness of a quantification methodology:

1. The approach to the selection of carbon pools (CP) and emission sources (ES) for calculating emission reductions or removals
2. The approach to determining baseline emissions
3. The approach to determining project emissions
4. The approach to determining leakage emissions

In the following sections we investigate how the different quantification methodologies (see box 2 below) used for the projects in the sample, approach these four elements.

**Box 2. Quantification methodologies applied by projects in the sample**

- **AR-AM0014 – Afforestation and reforestation of degraded mangrove habitats**

Initially developed for the CDM, AR-AM0014 is the quantification methodology with the most BC project registrations so far (9 registered projects and six in the project pipeline). Except for one project, all are however registered with Verra's Verified Carbon Standard, which allowed registration for projects using the methodology until August 2022. Project no. 6 Zhanjiang MAP, applies AR-AM0014, using version 03.0, which has been active since 4 October 2013.

[7] See for example the principles section of the Article 6.4 activity standard for projects https://unfccc.int/sites/default/files/resource/A6.4-STAN-AC-002.pdf.

► **Plan Vivo Standard – Technical specification for the Mikoko Pamoja project**

Under the Plan Vivo Standard, version 4.0 a technical specification outlining the approach to quantifying the mitigation impact had been developed for each individual mangrove restoration project. Until 30 September 2024, three Blue Carbon projects are registered with Plan Vivo, with a further eight under development. Plan Vivo has made available a new version 5.0 of the Plan Vivo Standard on 28 June 2022, for which a new Blue Carbon quantification methodology is currently developed.

► **Mexico Forest Protocol**

The Mexico Forest Protocol is a quantification methodology eligible under the Climate Action Reserve and has been valid for developing projects since 23 October 2013. Eligible activities include agroforestry, silvopastoral systems, improved forest management, reforestation, restoration as well as small and large urban forestry. As of 30 September 2024, 175 projects using the methodology are registered in the Climate Action Reserve registry, the majority of which implement terrestrial forest projects. Blue Carbon projects play a niche role with currently only two projects being registered. The Úrsulo Galván project (no. 1) uses version 1.5 of the Mexico Forest Protocol, which has been active between 14 September 2017 and 30 March 2020.

► **VM0007 – REDD+ Methodology Framework (REDD+MF)**

VM0007 is a modularized quantification methodology for quantifying the mitigation impact of projects aiming at reducing emissions from deforestation and forest degradation. The methodology is applicable to forest lands, forested wetlands, forested peatlands and tidal wetlands that would be deforested or degraded in the absence of the project activity. It includes specific modules for project activities located on tidal wetlands. As of 30 September 2024, two projects are registered using VM0007 with a further 12 being under development. Projects Vida Manglar (no. 2) and Guinea-Bissau 8 (no. 3) use versions 1.6 (active from 8 September 2020 to 26 November 2023) and 1.4 (active from 3 May 2013 to 8 March 2015) respectively.

► **VM0033 – Methodology for Tidal Wetlands and Seagrass Restoration**

VM0033 is a quantification methodology eligible under Verra's Verified Carbon Standard (VCS). The methodology has been active since 20 November 2015. Eligible activities are project activities which restore tidal wetlands, including seagrass meadows. As of 30 September 2024 one project is registered with the VCS. A further 29 projects are in the pipeline. If all projects finalize registration, VM0333 will become the methodology with most registrations. The Delta Blue Carbon-1 project (no. 5) and VCR seagrass restoration project (no. 7) apply VM0333, both use version 1.0, which has been active between 20 November 2015 to 30 September 2021.

#### 3.5.2.1 Approach to selection of carbon pools and emission sources for calculating emission reductions or removals

All five quantification methodologies contain a section that defines the greenhouse gas assessment boundary for the quantification of the mitigation impacts of the respective BC activities. This section defines the carbon pools (CP) and emission sources (ES) that project developers must consider for estimating baseline, project and leakage emissions.

The following sections discuss the most important carbon pools and emission sources, including an assessment how including or excluding them in the greenhouse gas assessment boundary may lead to over- or underestimation of emission reductions and removals. Table 18 below provides a summary of how projects in the sample have defined their boundary.

Table 19 provides the same summary for the quantification methodologies.

**CP1 Aboveground biomass**

In healthy ecosystems, the vegetation of mangroves and seagrass removes $CO_2$ from the atmosphere – mangroves do so directly from the air, while seagrass absorbs it through the water. The aboveground biomass pool is therefore the main carbon pool affected by Blue Carbon project activities. All quantification methodologies require to always include above-ground biomass in the baseline and project scenario. An exception is VM0033, which allows for its exclusion in the project scenario. Exclusion of aboveground biomass is a conservative approach as it would lead to underestimation of the mitigation impact of a project.

**CP2 Belowground biomass**

Belowground biomass is a material carbon pool for Blue Carbon projects. Researchers estimate that mangrove trees allocate 30-40% of their total ecosystem production to roots, although in some locations, that number can be as high as 70% (Adame et al. 2024). Again, excluding belowground biomass from the project scenario would lead to underestimation of the mitigation impact of the project activity. All quantification methodologies prescribe inclusion of belowground biomass in the baseline and project scenario. Consequently, all projects in the sample include it as well.

**CP3 Litter**

Litterfall production refers to the input of senescent leaves, stipulates, flower parts, propagules, and small branches to the forest floor. Since mangroves are evergreen forests, they produce litter year-round. Although, the volume of litter varies seasonally (Adame et al. 2024). Litter represents a non-material carbon pool for Blue Carbon projects. Under the methodologies VM0007 and VM0033 the inclusion of litter in the GHG assessment boundary is optional. All other methodologies exclude litter. It is anticipated that litter is lower in the baseline than in the project scenario. Excluding litter is therefore conservative. None of the projects in the sample registered under VM0007 and VM0033 have opted to include litter in their greenhouse gas assessment boundary.

**CP4 Deadwood**

Deadwood accumulates to about 2% of the total carbon stocks of mangroves worldwide. A proportion of deadwood will be buried and incorporated into the soil organic pool, while the rest will be either decomposed on the forest floor or exported to other ecosystems through tidal exchange (Adame et al. 2024). Standing deadwood is included in the greenhouse gas assessment boundary under the Mexico Forest Protocol, while lying deadwood is excluded. The other methodologies do not differentiate between standing and lying deadwood and either exclude the pool (Mikoko Pamoja technical specifications) or make its inclusion optional (AR-AM0014 and VM0033). Under VM0007 deadwood must be included if the pool is greater in the baseline than in the project scenario. Blue Carbon projects are likely resulting in more naturally occurring deadwood, which would not occur in the baseline. Excluding the deadwood carbon pool is therefore conservative. In the project sample, five projects opted to exclude deadwood. Only projects Úrsulo Galván (no. 1) and Vida Manglar (no. 2) include deadwood in their greenhouse gas assessment boundary.

**CP5 Soil organic carbon**

One of the most extensive carbon stocks in Blue Carbon projects is in their soils. Mangrove soils have high local (autochthonous) and external (allochthonous) inputs of organic matter, which can be preserved under their anoxic conditions, that slow down microbial decomposition. Soil organic carbon can account for between 50 and almost 100% of the total mangrove carbon stock (Adame et al. 2024). The Mexico Forest Protocol excludes the soil organic carbon pool from its greenhouse gas assessment boundary, stating that accurately measuring soil carbon and associated soil emissions would be too challenging. When developing projects under AR-AM0014 and VR0007, project developers can opt to include the soil carbon pool. Under VM0033 soil carbon is always included. Blue Carbon projects likely contribute to increased soil carbon stocks compared to the baseline. Excluding soil organic carbon from the greenhouse gas assessment boundary is therefore conservative.

Among the projects in the sample the two projects registered with VM0033 (no. 5, Delta Blue Carbon-1 and no. 7, VCR Seagrass Restoration) include soil carbon as required by the methodology. The projects Vida Manglar (no. 2) and Zhanjiang MAP (no. 6) registered under VM0007 and AR-AM0014 respectively made use of the option to include soil organic carbon. The other three projects exclude soil organic carbon.

**CP6 Wood products**

Harvesting can move the carbon that is stored in mangrove forests to harvested wood products. This carbon pool includes end-use wood products such as furniture, floor and buildings. Compared with terrestrial forestry projects, this carbon pool plays a small role for mangrove projects. Mangrove timber is mainly used for firewood or charcoal production (Adanguidi et al. 2020). Coastal communities however also use mangrove wood as poles and planks for construction of houses, fencing, boats and for making furniture and utensils (Riungu et al. 2022; Scales und Friess 2019). Except for VM0033 none of the quantification methodologies includes wood products in their greenhouse gas emissions boundary. Exclusion is conservative for *mangrove restoration* projects as they take place on previously barren land and exclusion therefore leads to underestimation of emission reductions and removals. For *mangrove conservation* projects, exclusion of this carbon pool might lead to overestimation as less mangrove wood is used in the project scenario compared to the baseline. Local communities might replace wood which they harvested from the project area through wood from other areas. The effect might however be small as subsistence logging for wood products is not a key driver for deforestation in mangrove habitats. None of the six mangrove projects in the sample accounts for harvested wood products.

Next to carbon pools, the following emission sources are relevant for the project type:

**ES1 Burning of woody biomass**

Site preparation and management of the project area may involve controlled burning of biomass. While this is not a common forest management technique for mangrove habitats, some methodologies such as AR-AM0014, VM0033 and VM0007 include the resulting emissions in their greenhouse gas assessment boundary. If relevant, excluding emissions from biomass burning potentially leads to the overestimation of the mitigation impact of the project. This risk does not apply for seagrass restoration projects which take place in shallow waters and do not involve use of fire for ecosystem management. None of the projects in the sample apply burning of biomass in site preparation or habitat maintenance.

**ES2 Production of methane by microbes**

Coastal ecosystem sediments provide anaerobic conditions that facilitate the degradation of organic matter to methane ($CH_4$) and nitrous oxide ($N_2O$). The effect of Blue Carbon projects on methane production is uncertain and depends on the type and subtype of Blue Carbon interventions. $CH_4$ fluxes are generally lower in seagrass ecosystems when compared with mangrove ecosystems (Adame et al. 2024). Decreases in $CH_4$ emissions could occur if projects end land use practices or prevent converting coastal ecosystems to land use practices that are methanogenic such as rice or shrimp paddies and wet pastures or where projects involve increasing water flows to existing mangrove habitats (Williamson und Gattuso 2022). Creation of new mangrove habitat on barren land on the other hand likely involves increases in methane emissions. Newer research suggests that assumptions that saline conditions of coastal ecosystems prevent $CH_4$ production in sediments are not accurate (Rosentreter et al. 2021). Factors further influencing $CH_4$ production in sediments include bioturbation burrows. Other studies further suggest that mangrove stems can directly release $CH_4$ to the air (Zhang et al. 2022). Methane is therefore a potentially material emission source for Blue Carbon projects.

The extent of methane emissions from coastal ecosystems is however still subject to scientific debate. A study of subtropical estuarine mangroves wetlands estimated that mangrove $CH_4$ could counterbalance the cooling effects of their $CO_2$ removal by 24% over a time horizon of 100 years (Liu et al. 2020). Other studies suggest that $CH_4$ and $N_2O$ emissions combined might offset the entire $CO_2$ removal impact of Blue Carbon projects (Rosentreter et al. 2021; Al-Haj and Fulweiler 2020). A more recent study cautions that these estimates would be the result of a bias towards ecosystems dominated by freshwater input and do not accurately account for the suppression effect of saline conditions on methane production in many ecosystems that do not have freshwater inputs (Cotovicz et al. 2024). The exact extent of the suppression effect of saline conditions on methane production itself is still unclear and some studies argue that it might be less dominant than previously thought (Rosentreter et al. 2021).

Currently only VM0033 requires project developers to include the production of methane by microbes in the greenhouse gas assessment boundary. Project developers may however not account for methane emissions if they can demonstrate that the conditions for $CH_4$ production in the baseline and project scenario will not be different.

Among the two projects registered with VM0033 only project no. 7, VCR Seagrass Restoration, includes methane production in its greenhouse gas assessment boundary. Project no. 5, Delta Blue Carbon-1, includes methane but states that methane emissions are not expected to change with the project activity because salinity in the project area would be above the salinity threshold where methanogenesis occurs in both the baseline and project scenario.

Excluding methane emissions introduces uncertainty around the mitigation impact of projects and may lead to overestimation of emissions reductions or removals.

#### ES3 Denitrification/nitrification

Coastal ecosystems can be either a $N_2O$ source or sink. The amount of $N_2O$ that individual coastal ecosystems produce depends on several biotic, hydrological, anthropogenic and climatic drivers (Rosentreter et al. 2021). Studies suggest that there is large temporal and spatial variability in $N_2O$ emissions in mangrove ecosystems. For example researchers found that mangrove ecosystems are a source of $N_2O$ in the dry season and a sink in the wet season (Adame et al. 2024). Overall, the net effect of Blue Carbon projects on $N_2O$ emissions is not yet fully understood. It is however likely that future increases in anthropogenic nitrogen loading will increase them (Rosentreter et al. 2021). Excluding $N_2O$ emissions from the greenhouse gas assessment boundary will lead to uncertainty. It can either lead to underestimation of the mitigation impact of Blue Carbon projects or to overestimation. The likelihood of either effect is unknown. Only VM0033 includes denitrification in the greenhouse gas assessment boundary. Emissions may however be excluded in the baseline. Of the two projects registered with VM0033, project no. 5, Delta Blue Carbon-1, excludes emissions in both the baseline and the project scenario, project no. 7, VCR Seagrass Restoration, includes it in the project scenario.

**ES4 Burning of biomass in organic soil**

Fire triggers changes in soil microbial communities. It leads to carbon loss due to burning of organic soil layers, which can persist for years after the fire. Compared with terrestrial forests, fire events in mangroves are rare. Mangroves are sometimes described as firebreaks because of their low fuel load and because mangrove wood is too wet to burn due to the inundation at high tide (Wade et al. 1980). An observed increase in fire events in the Sundarbans mangroves and in estuarine wetlands in Australia suggest that fire frequency in mangrove habitat might increase with changing climatic conditions due to global warming (Mahmood et al. 2021; Glasby et al. 2023). Burning of biomass is a potential major source of emissions. The resulting $CO_2$ emissions are accounted for as losses of carbon stocks in the relevant carbon pools (CP1 to CP2). Emissions of $CH_4$ and $N_2O$ from such fires would need to be separately accounted for as emission sources. Excluding these emissions would contribute to overestimating emission reductions and removals from project activities. Among the quantification methodologies only VM0033 includes these $CH_4$ and $N_2O$ emissions from burning of biomass in its greenhouse gas assessment boundary. Among the two projects registered with VM0033, project no. 5, Delta Blue Carbon-1, excludes the emission source stating that prescribed burns are not a project activity. Project no. 7, VCR Seagrass Restoration, takes place in shallow waters for which fire risks are not prevalent.

**ES5 Fossil fuel use**

Project activities such as site preparation and maintenance may involve fossil fuel use. This could for example include patrolling the mangrove area by boat or the use of equipment to maintain community wood lots or orchard planting. Due to these activities, emissions may increase compared with the baseline scenario. Among the quantification methodologies, the Climate Action Reserve (CAR), Mexico Forest Protocol, VM0007 and VM0033 include fossil fuel use in their greenhouse gas assessment boundary. All of them allow however for exceptions. Under the Mexico Forest Protocol only emissions from site preparation are included. Under VM0007, $CO_2$ emissions may be conservatively excluded in the baseline and $CH_4$ and $N_2O$ from fossil fuel use are considered negligible in both the baseline and project scenario. Further, $CO_2$ emissions in the project scenario can be neglected if they are excluded in the baseline. VM0033 excludes $CH_4$ and $N_2O$ from fossil fuel use in both the baseline and project scenario stating that this would be a conservative approach. All projects in the sample exclude emissions from fossil fuel use, stating that they are insignificant or the same in baseline and project scenario. Project no. 5, Delta Blue Carbon-1, specified that it considers emissions insignificant because the project does not involve moving soils. Excluding emissions from fossil fuel use in the project scenario adds uncertainty and likely leads to overestimation of the mitigation impact. As Blue Carbon projects do not involve harvesting or other activities requiring heavy machinery, the effect may however be small.

**ES6 Use of fertilizers**

Fertilizer application contributes to global $N_2O$ emissions and reducing its production and use offers important mitigation potential (Menegat et al. 2022). In addition, fertilizer production consumes substantial amount of energy, which might result in high $CO_2$ emissions if this energy is generated with fossil fuels. In afforestation projects, fertilizer use would take place while tending to mangrove seedlings. Broadly, there are two options for mangrove planting in restoration projects. In the first option workers pick and collect propagules off mangrove trees and plant them directly in the restoration area. Here no fertilizers are applied. In the second option, mangrove nurseries raise seedlings until they are ready for permanent planting.

Mangrove nurseries might use fertilizers to support seedlings growth. Fertilizer application however is not common, and studies suggest that it can increase mortality of mangroves (Miah und Moula 2019; Lovelock et al. 2009; Mack et al. 2024). The *mangrove restoration* projects Delta Blue Carbon-1 (no. 5) and Zhanjiang MAP (no. 6) both use nurseries for seedling raising but like all projects in the sample explicitly exclude fertilizer application in their project activities. As they are not using fertilizers, all projects exclude nutrient application from their greenhouse gas assessment boundary. This is consistent with the respective quantification methodologies that consider emissions from nutrient application as negligible. Excluding this emission source might lead to uncertainty if fertilizers were used in nurseries. The fact that all projects in the sample forego nutrient application suggests that nutrient application is not common for Blue Carbon projects.

The *mangrove restoration* project Vida Manglar (no. 2) in addition supports activities that aim at reducing the application of fertilizer and pesticides. For this subtype of Blue Carbon projects exclusion likely leads to underestimation of emission reductions as these projects might support activities that reduce fertilizer use observed in the baseline. Exclusion of the emission source is therefore conservative.

**Conclusions**

Overall, the approach to selecting carbon pools and emission sources under the different quantification methodologies can lead to both over- and underestimation of emission reductions and removals. The extent differs between the respective pools and sources. The largest underestimation likely results from the exclusion of the soil organic carbon pool. Given the uncertainties and high costs associated with estimating the effects of mitigation activities on this pool, an exclusion appears to be an effective strategy to simplify project development without undermining the conservativeness of the quantification. The extent of underestimation might further justify excluding some of the smaller pools and emission sources, such as, e.g., harvested wood products, fossil fuel use, or nitrification, from the greenhouse gas assessment boundary whose exclusion would otherwise result in overestimation. An emission source that currently introduces uncertainty on the overall mitigation impact is methane emissions from microbes. Further research is required to better understand the extent of methane emissions associated with establishing or reforesting mangrove habitats. In the meantime, the uncertainty should be reflected through appropriate uncertainty deductions to ensure conservativeness of the calculated net mitigation impact of Blue Carbon projects.

**Table 18: Greenhouse gas assessment boundary of projects in the sample**

| | Úrsulo Galván (no. 1) | Vida Manglar (no. 2) | Guinea-Bissau (no. 3) | Mikoko Pamoja (no. 4) | Delta Blue Carbon-1 (no. 5) | Zhanjiang MAP (no. 6) | VCR Seagrass Restoration (no. 7) |
|---|---|---|---|---|---|---|---|
| CP1 Aboveground biomass | Included | Included | Included | Included | Included | Included | Included |
| CP2 Belowground biomass | Included | Included | Included | Included | Included | Included | B: Included<br>P: Excluded |
| CP3 Litter | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded |
| CP4 Deadwood | Included | Included | Excluded | Excluded | Excluded | Excluded | Excluded |
| CP5 Soil organic carbon | Excluded | Included | Excluded | Excluded | Included | Included | Included |
| CP6 Wood products | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded |
| ES1 Burning of woody biomass | Excluded | B: Excluded [a]<br>P: Included [b] | B: Excluded<br>P: Included | Excluded | Excluded | Included | n/a* |
| ES2 Production of methane by microbes | Excluded | Excluded | Excluded | Excluded | Included | Excluded | Included |
| ES3 Denitrification/nitrification | Excluded | Excluded | Excluded | Excluded | Included* | Excluded | Included |
| ES4 Burning of biomass in organic soil | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded | n/a* |
| ES5 Fossil fuel use | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded | B: Excluded [a]<br>P: Included ($CO_2$) [b] |
| ES6 Use of fertilizers | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded |

Source: PDDs for projects no. 1-7.

[a] B = Baseline scenario.

[b] P = Project scenario.

*Not relevant, because project takes place in shallow waters with no fire risk.

**Table 19: Carbon pools and emission sources considered in relevant Blue Carbon quantification methologies**

| Carbon pool (CP)<br>Emission sources (ES) | AR-ACM0014 | CAR Mexico Forest Protocol | Plan Vivo – Mikoko Pamoja | VCS VM0007<br>*REDD projects only** | VCS VM0033 |
|---|---|---|---|---|---|
| CP1 Above-ground biomass | Included | Included [a] | Included | Included | Included [b] |
| CP2 Below-ground biomass | Included | Included | Included | Included | Included [b] |
| CP3 Litter | Excluded | Excluded | Excluded | Optional | Optional |
| CP4 Dead wood | Optional | Included [c] | Excluded | Included [d] | Optional |
| CP5 Soil organic carbon | Optional | Excluded | Excluded | Optional | Included |
| CP6 Wood products | n/a | Excluded | n/a | Included [e] | Included |
| ES1 Burning of woody biomass | Included ($CH_4$, $N_2O$) [f] | n/a | n/a | Included ($CH_4$, $N_2O$) [f g] | Included [i] |
| ES2 Production of methane by microbes | n/a | n/a | n/a | n/a | Included [h] |
| ES3 Denitrification/nitrification | n/a | n/a | n/a | n/a | Included [h] |
| ES4 Burning of biomass in organic soil | n/a | n/a | n/a | n/a | Included [i] |
| ES5 Fossil fuel use | n/a | Included ($CO_2$) [j] | n/a | Included [k] | Included ($CO_2$) [l] |
| ES6 Use of fertilizers | n/a | Excluded | n/a | Included [m] | n/a |

Source: Quantification methodologies AR-ACM0014, CAR Mexico Forest Protocol, Plan Vivo Mikoko Pamoja, VCS VM0007 and VCS VM0033.

*VM0007 includes different greenhouse gas assessment boundary requirements for REDD, ARR and WRC activities.

[a] Shrubs and understory excluded.

[b] May be conservatively omitted in the project scenario.

[c] Lying deadwood excluded.

[d] Only mandatory if pool is greater in baseline than project scenario.

[e] Only mandatory if project involves harvesting.

[f] $CO_2$ is excluded because it is accounted as a change in carbon stock.

[g] $CH_4$ and $N_2O$ can be conservatively excluded in the baseline and must be included in the project scenario if fire occurs.

[h] May be conservatively excluded in the baseline.

[i] Implicitly included through the fire risk premium in the baseline.

[j] Mobile $CO_2$ emissions from site preparation included. Stationary $CO_2$ emission and those for ongoing project operation and maintenance excluded. $CH_4$ and $N_2O$ excluded.

[k] May be conservatively excluded in the baseline. $CH_4$ and $N_2O$ considered negligible. $CO_2$ emissions in the project scenario can be neglected if excluded in the baseline.

[l] $CO_2$ may be conservatively excluded in the baseline. $CH_4$ and $N_2O$ conservatively excluded in the baseline and project scenario. $CO_2$ is a potential major source of emissions in an RWE project scenario, where movement of soil material with machines and trucks occurs. Not included in a project scenario where planting or sowing occurs without soil movement (e.g., mangrove planting).

[m] $CO_2$ and $CH_4$ emissions considered as negligible in the baseline and project. $N_2O$ may be conservatively excluded in baseline and project.

#### 3.5.2.2 Approach to determine baseline deforestation or afforestation rates

To be able to judge the effectiveness of a mitigation activity of a carbon crediting project, one needs to compare emission levels in the greenhouse gas assessment boundary measured after implementation of the mitigation activity against a reference level that represents emission levels without it. This reference level is commonly referred to as *baseline emissions or removals* in carbon crediting projects. Carbon crediting programmes commonly use ex post quantification (i.e. actual performance) to measure emission levels after implementation of the mitigation activity. Baseline emissions are however a prediction. It is inherently unknowable how emission levels would have developed in the greenhouse gas assessment boundary without the mitigation activity.

Carbon crediting programmes usually require project developers to apply scenario techniques to determine baseline emissions. This involves establishing various scenarios how emission levels could develop in the absence of the mitigation activity, holding all other factors constant. Project developers then determine which of these scenarios is the most likely by predicting behaviour and evolution of several key variables, which are likely to influence emission levels. The emission level observed in the most likely scenario is then set as baseline emissions. The fact that baseline emissions are inherently unknown requires proper accounting of uncertainty to avoid overestimation of the real emission impact of a mitigation activity.

For Blue Carbon projects, challenges with determining baseline emissions differ between *mangrove conservation* and *mangrove restoration* projects.

##### 3.5.2.2.1 Mangrove conservation projects

For projects conserving existing mangrove habitat, uncertainty in establishing baseline emissions is particularly high. The rate of future mangrove destruction in a specific habitat depends on many unknown factors, such as changes in political, economic, and social conditions. Research indicates that key human drivers for mangrove deforestation are conversion to rice and shrimp aquaculture (Hagger et al. 2022) and to a lesser extent palm oil (Richards und Friess 2016). These products are globally traded commodities, suggesting that factors such as future global shrimp demand and changes in consumer preferences might influence pressure on mangrove ecosystems. Predicting how these factors evolve over a period of one or more decades is inherently difficult and results in considerable baseline uncertainty.

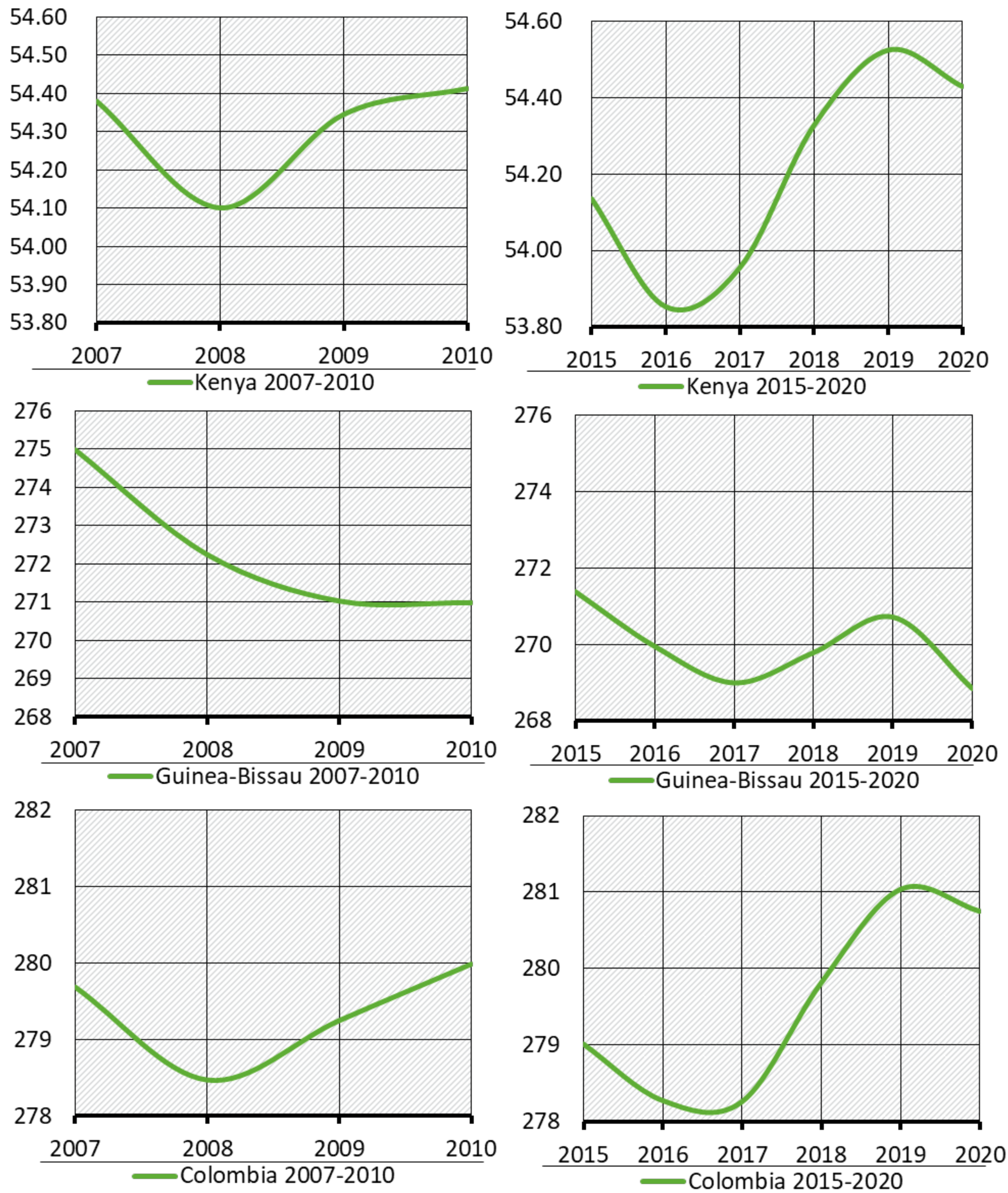
Another factor that influences the extent of uncertainty is interannual variability in mangrove losses and that trends change even over relatively short time periods. This is illustrated by Figure 1 that shows changes in annual mangrove extent for Colombia, Guinea-Bissau, and Kenya – which are the three countries with mangrove conservation projects in the sample. The figure shows net change in hectares of mangrove forests over two distinct time series:

- Net change over 2007-2010, with 2007 as a base year.
- Net change over 2015-2020, with 2015 as a base year.

The data show that, except for the period 2007-2010 in Guinea-Bissau, years with mangrove loss or growth fluctuate in all countries during both time periods. The data source, the web platform Global Mangrove Watch[8], unfortunately does not include data for the period 2010-2015, this is why it is not possible to construct a longer time series of mangrove stocks between 2007 and 2020.

[8] https://www.globalmangrovewatch.org.

**Figure 1:** **Mangrove extent over time in 1'000 hectares in selected countries of the project sample**




Source: Global Mangrove Watch web platform. Data as of 31 May 2025.

How fluctuations in historical mangrove loss rates introduce uncertainty in baseline emission estimates is illustrated by the approach followed by the Vida Manglar project (no. 2). The project applies the quantification methodology VM0007, version 1.6, under the Verified Carbon Standard. The methodology determines the baseline deforestation rate as the average historical deforestation rate in a reference region. The reference region should have similar characteristics as the project region. The choice of the reference region and the historical period are thus important factors influencing the level of baseline deforestation rates.

The project area hosts 7,561 hectares of mangrove forests in the 27,171 hectares of the Cispatá Bay Integrated Management District (DMI Cispatá) on the shore of the Gulf of Morrosquillo, which runs about 80 kilometres along the Caribbean cost of Colombia. In 2006, the government declared the DMI Cispatá as a regional protected area for the conservation of mangroves. The DMI Cispatá is subject to an integrated management plan, which divides the area into different use zones. Zones include strictly protected areas and areas that allow sustainable use of mangroves and other resources.

Project developers used the entire mangrove stock of the Gulf of Morrosquillo (except for the project area) as the reference region for making projections of future deforestation rates in the project area in the baseline. Most of these mangroves are located in the following two areas along the Gulf of Morrosquillo:

- Regional Integrated Management District (DRMI) Mangrove and lagoon ecosystem Ciénaga de la Caimanera;
- Regional Natural Park (PRN) Mangrove System of the Boca de Guacamayas.

Both areas consist of mangroves, mud plains, beaches and coastal lagoons and are rich in biodiversity (Ramirez 2017). While both areas experienced heavy mangrove loss in the past (Ballut-Dajut et al. 2017), the government put them under protection in 2008. Ciénaga de la Caimanera has the same protection status as the DMI Cispatá, allowing for sustainable use of resources. Boca de Guacamayas has a higher protection status, meaning resources cannot be extracted (see Table 20).

**Table 20: Comparison of characteristics of project area and main areas of the reference region of project Vida Manglar (no. 2)**

| | Cispatá Bay | Ciénaga de la Caimanera | Boca de Guacamayas |
|---|---|---|---|
| | Project area | Part of reference region | Part of reference region |
| Hectares | 27,171 | 2,125 | 3,759 |
| Protected since | 2006 | 2008 | 2008 |
| Protected area type | Integrated Management District (DMI) | Regional Integrated Management District (DRMI) | Regional Natural Park (PRN) |
| IUCN Management Category | IV - Habitat or species management area | IV - Habitat or species management area | II - National Park |
| Use zones | Conservation, restoration, sustainable use | Conservation, restoration, sustainable use | No-take, restoration, recreation, subsistence fishing |

Sources: (Ramirez 2017; CITES 2016).

Note that the Project Design Document defines the project area for the Vida Manglar project (no. 2) as the DMI Cispatá which covers an area of 27,171 hectares see (INVEMAR 2010), page 30. Other parts of the PDD state that the project area is

7,561 hectares of mangrove forests. This however is only the part of the DMI Cispatá covered with mangrove forests. Hence, to ensure comparability with the two areas in the refence region, the project area size is indicated as 27,171.

With 2,125 and 3,759 hectares respectively, both areas are considerably smaller in size than the project area. Ciénaga de la Caimanera is located on a main road that connects major cities and coastal towns in the Gulf of Morrosquillo. Cispatá Bay and Boca de Guacamayas are more remote and there is no road access for large parts of both areas. Access to markets was identified as a strong driver of mangrove loss. Proximity of habitats to cities indicates less transportation time of commodities to processing plants and shipment hubs (Hagger et al. 2022). This might suggest that Ciénaga de la Caimanera faces higher deforestation pressures than the other two areas. Besides these caveats, the regions have similar protection status and vegetation.

Annual unplanned mangrove deforestation in the reference region is calculated for a 12-year reference period, using data for four intervals: 2003-2006, 2006-2009, 2009-2013, and 2013-2015. Based on this, an annual average is calculated for the full reference period 2003-2015 (see Table 21).

Deforestation levels are very heterogenous between the four intervals. The first interval 2003-2006 shows very high deforestation rates in the reference area, resulting in mangrove loss of 1,054 hectares. In the other three intervals deforestation rates are much lower. For example, in the interval immediately ahead of the project start date in 2015, deforestation decreased to 26 hectares.

**Table 21: Deforestation rate in reference region in project Vida Manglar (no. 2)**

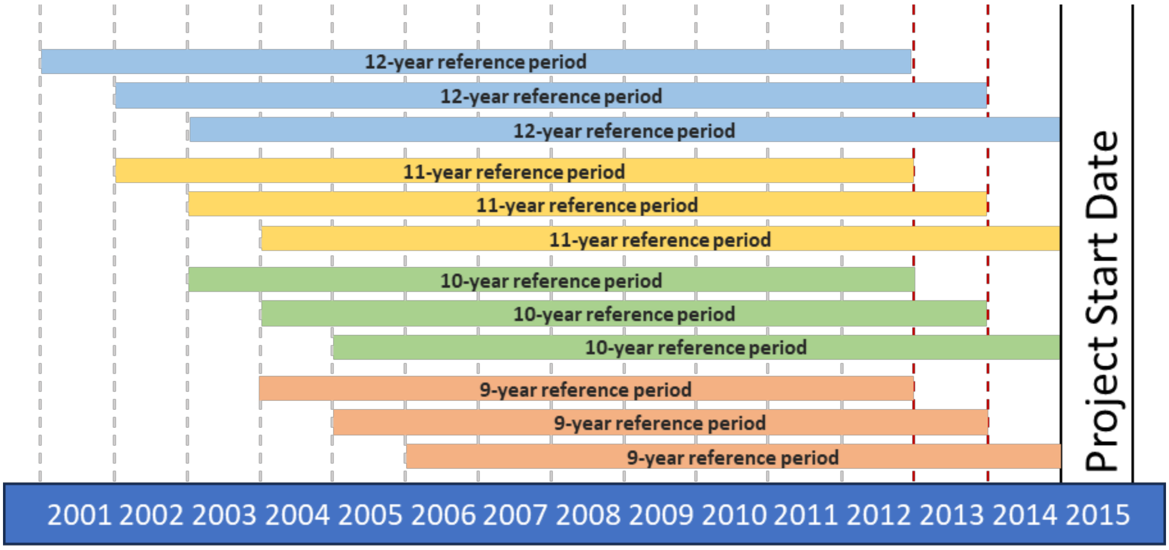
| Interval | Unplanned deforested area in reference region (hectare) | Unplanned deforested area in reference region (hectare) per year |
|---|---:|---:|
| 2003-2006 | 1,054 | 351 |
| 2006-2009 | 259 | 86 |
| 2009-2013 | 479 | 120 |
| 2013-2015 | 26 | 13 |
| **Annual average 2003-2015** | | **143** |

Source: PDD for project no. 2, page 199.

The choice to use a 12-year reference period is consistent with the requirements of the selected quantification methodology VM0007 under the Verified Carbon Standard. Version 1.6 of VM0007 requires that the reference period's start year must be between 9 and 12 years in the past and its end year within two years before the project start date.[9] This means that the latest eligible *reference period start year* for a project with a *start date* of 2015 equals to 2013 minus 12, which is 2001. Overall, the methodology provides flexibility for project developers to choose from 12 different reference periods as illustrated in Figure 2.

[9] VM0007, v1.6, page 21.

**Figure 2** **Eligible options under VM0007 (v1.6) to set the historical reference period for a project with a 2015 start date**




Source: Own representation.

In the case of Vida Manglar project (no. 2), the choice whether the reference period is 9 or 12 years long makes a substantial difference for calculating the annual average deforestation rate in the reference region. If the interval 2003-2006 is included in these calculations (12-year reference period) the annual average amounts to 143 hectares. If this interval is not included (9-year reference period) the annual average deforestation would be about 73 hectares – almost only half the rate calculated under the 12-year reference period. This means that this project would overestimate baseline emissions by 96% if the actual – but unknown – baseline deforestation in the project area would correspond to the values observed in the 9 years prior to the start of the project. Conversely, if the project would use a 9-year reference period and the actual – but unknown – baseline deforestation rate in the project area would correspond to the values of the 2003-2006 interval, the project would underestimate emission reductions by 96% or more. This shows that using historical values for projecting future deforestation trends is associated with very high uncertainties. Considering that the principle of conservativeness means to err towards underestimation of emission reductions, a 9-year reference period ending in 2014 for this project would be more conservative than a 12-year period with the same end date.

Given that the two key areas of the reference region – Ciénaga de la Caimanera and Boca de Guacamayas – received protected area status only in 2008, it is questionable whether the high deforestation rate calculated for the interval 2003-2006 is a good reference value for projecting future baseline deforestation in the project area, which itself is a protected area since 2006. Moreover, the deforestation rates in the reference region observed a considerable decline over time. This trend is not reflected in the baseline, which assumes an average value over a long historical reference period.

Applying the annual average deforestation rate calculated for the reference region to the project area further means that project developers assume that in the baseline scenario 67% of the mangroves in the project area would be deforested by the end of the 30-year crediting period (see Table 22). This is a very assertive assumption, considering that the area is protected and that the drivers of deforestation are local communities who currently use the land surrounding the mangroves in the project area for cattle ranching and subsistence farming.

In comparison, the two other projects in the sample which also claim carbon credits for *mangrove conservation activities* – the project in Guinea-Bissau (no. 3) and Mikoko Pamoja (no. 4) – use far less assertive deforestation rates to determine baseline emissions. The project area of the Guinea-Bissau project (no. 3) consists of two areas in two National Parks in Guinea-Bissau, called Cacheu and Cantanhez. The project area for this project is much larger than the one of the Vida Manglar project (no. 2) (see Table 22).

If applied to the mangrove stock in the project area, the historical average annual deforestation rate calculated for the reference region would result in losses of 2.9% and 3.5% of mangrove stock for Cacheu and Cantanhez National Park respectively by the end of the first 10-year crediting period. If extrapolating these values for a hypothetical 30-year crediting period (assuming the annual deforestation rate would remain constant) to make them more comparable with the Vida Manglar project (no. 2), losses would amount to 8.7% and 10.5% respectively (see Table 22).

The Mikoko Pamoja project is much smaller and mangrove stock in the project area consist of 107 hectares of established and 10 hectares of newly planted mangrove forest. The deforestation rate over a hypothetical 30-year crediting period is similar to the Guinea-Bissau project (no. 3) (see Table 22).

When comparing these numbers, it is important to consider that there are notable differences between the project areas. The DMI Cispatá where the Vida Manglar project (no. 2) takes place is less strictly protected than the two National Parks in the Guinea-Bissau project (no. 3). Further, the mangrove stock is much smaller, both factors making the stock likely more vulnerable to deforestation pressures. On the other hand, recent research suggests that while mangrove loss is less severe in protected areas, the extent of protection is not always a good measure of conservation success. In a global study, researchers combined remote sensing data on mangrove habitat with data on protection level according to the IUCN management categorization (Heck et al. 2024). The study shows that human-driven mangrove loss between 2010-2016 was lowest in protected areas that allowed sustainable use of resources such as categories IV-VI. With these caveats, the deforestation rate calculated for the Vida Manglar project (no. 2) can still be considered comparably aggressive.

**Table 22: Comparison of deforestation assumptions in the baseline scenario for projects Vida Manglar (no. 2), Guinea-Bissau (no. 3) and Mikoko Pamoja (no. 4)**

| Project | Vida Manglar (no. 2) | Guinea-Bissau (no. 3) | Mikoko Pamoja (no. 4) |
|---|---|---|---|
| (First) Crediting period | 30 years | 10 years | 20 years |
| IUCN management category | IV – Habitat or species management area | II – National Park | n/a |
| Mangrove stock in project area (hectares) | 7,561 | Cacheau: 33,596<br>Cantanhez: 14,195 | Forest: 107<br>Plantation: 10 |
| Share of mangrove stock in the project area assumed to be deforested by end of (hypothetical) 30-year crediting period | 67% | Cacheau: 8.7%<br>Cantanhez: 10.5% | Forest: 8.13%<br>Plantation: 8.25% |

SourcePDDs for projects no. 2-4.

It can be observed that flexibilities on how to establish baseline deforestation rates may lead to uncertainty or overestimation of a project's mitigation impact. An issue that is well studied for in terms of terrestrial forestry projects, which claim credits for emission reductions from avoided unplanned deforestation (Haya et al. 2023b; West et al. 2023). The above examples suggest that these issues are also relevant for the subtype of Blue Carbon projects.

Large uncertainties in baseline emissions further create a challenge for clearly attributing emission reductions measured during project implementation to the project activities. If project developers assume a deforestation rate for the project area which they derive from a reference region and period which are not good matches for the project area, emission reductions calculated for the project could be partially an artefact of a wrongly set baseline. An in-depth assessment of VM0007 carried out by the Carbon Credit Quality Initiative (CCQI) further analyses this, as well as others issues that arise when determining baseline emissions using this methodology (CCQI 2024). While the analysis is limited to terrestrial forestry projects and version 1.7 of the methodology, many of the issues identified also apply for Blue Carbon projects that claim emission reductions from mangrove conservation.

#### 3.5.2.2.2 Mangrove restoration projects

Projects that aim at restoring degraded mangrove habitat through replanting activities are also subject to baseline uncertainty. However, this is to a lesser extent than mangrove conservation projects. The main issue involving uncertainty is the applicability of the "without-project scenario" identified by project developers and the likelihood that this will continue in the future.

The approach to the identification of the baseline scenario by project no. 5, Delta Blue Carbon-1, illustrates how uncertainties around baselines for mangrove restoration projects can look in practice. The project takes place in the Indus River delta in Pakistan. The project area covers 350,000 hectares, and project developers plan to plant 224,997 hectares of new mangrove forest in this area. The area is characterized by degraded mangrove habitat with high salinity, almost no presence of mangrove propagules and trampling of new seedlings by livestock. The Indus River delta had experienced heavy mangrove loss until the 1980s.[10] This trend however has been reversed and mangrove forest coverage expanded from 41,053 hectares in 1988 to 99,627 hectares in 2024, representing an increase of 58,578 hectares (Sanaullah et al. 2025). This reversal is the result of continuous restoration efforts by local communities led by the Sindh Forest Department, which is also the proponent of the project no. 5, Delta Blue Carbon-1 (Malik 2022). The Indus River delta area is well-known for mangrove restoration efforts and currently holds three Guinness World Records for planting the maximum number of mangrove saplings within a single day (Khan 2018). The Government of Pakistan in 2019 further launched the "10 billion trees tsunami" a large-scale tree-planting-drive with the aim to plant 10 billion new trees across the country, which will include about 43.3 million mangrove plants (UN Environment 2021).

In the project documentation, project developers argue that the most likely scenario is the continuation of pre-project land use, which would mean that the project area would remain degraded mangrove habitat. There are however a few uncertainties around this assumption, which the project does not account for. Given the many restoration activities in the Indus River delta and the success of the Sindh Forest Department to mobilize other sources of funding for mangrove planting, there is a risk that in the baseline at least parts of the project area would be restored. It is difficult to assess the degree and likelihood of this risk, but the assumption of a continuation of pre-project land use might not be conservative for the entire project area. The resulting risk for over-crediting however is likely to be small for this particular project, considering the size of the project area and the speed of implementation. Replanting of all

[10] Main factors included the (1) reduced freshwater flow into the delta due to dams and agricultural use, which increased salinity levels, (2) the clearing of mangroves for agriculture and aquaculture, and (3) the use of young mangrove plants as fodder for the growing livestock population.

224,997 hectares is scheduled to be completed between 2015 – 2026. Considering that the net mangrove gains in the Indus River delta of 58,578 hectares took more than 35 years between 1988 and 2024 to attain – a goal which would be hardly attainable without proper financing channels, such as the carbon market project at hand. The project further deducts 1.1% of the project area when calculating removals in the project scenario to account for removals through baseline vegetation.[11] This approach is more robust than the approach used by the other mangrove restoration project in the sample – Zhanjiang MAP (no. 6), where project developers assume that net GHG removal from existing vegetation is zero in the baseline. Allowing project developers not to account for growth in baseline carbon stocks is a methodological weakness observed also in some terrestrial afforestation methodologies.

An innovative approach to better account for baseline uncertainty in afforestation projects is the establishment of control areas, which can be used to verify the validity of the baseline on an ongoing basis. Under this approach projects will only receive credits for removals that exceed those which occur on the control areas. The requirement to use control areas can be an effective tool to capture any mangrove replanting that might have occurred due to other factors than the incentive of the Blue Carbon project. Its robustness depends on sufficiently detailed requirements how control areas should be defined and selected. The ACR carbon crediting programme applies this concept already in its methodology "Afforestation and Reforestation of degraded land". The VCS offers an extra-certification (the VCS ABACUS label) for projects that apply this approach under its methodology VM0047 – Afforestation, Reforestation and Revegetation since 2024.

#### 3.5.2.3 Approach to quantification of carbon stocks in the baseline and project scenario

From a scientific standpoint, there are several critical issues regarding the $CO_2$ drawdown and storage in coastal Blue Carbon restoration, impacting its role as a climate mitigation strategy both for carbon-offsetting in BC projects and for inclusion in NDCs. Large variations in space and time in existing data sets and large uncertainty in the measurement of carbon fluxes and storage affect certification and may result in over-crediting (Willamson and Gattuso, 2022). Moreover, the project-specific individual quantification procedures using field data, chronosequences, models, literature data, proxies and general default values add uncertainty, with the former being the most reliable and the latter being the most uncertain data base.

Measuring the amount of carbon which a forest stores is very challenging. This applies to terrestrial forests and, for several reasons, even more so to their mangrove counterparts. First, mangrove forests accessibility is distributed unevenly - areas closely to canals being easier to access than those farther inland. This is a major impediment to ensuring an unbiased placement of field plots for measurement of biomass and soil carbon content. Secondly, many of the default values provided by methodologies or values available in peer-reviewed literature have been derived from very small sample sizes. Noteworthy, data availability continues to improve (Zhong et al. 2023; Duarte de Paula Costa, Micheli und Macreadie 2022). In the following we discuss key methodological challenges for measuring the three most important carbon pools of mangrove forests and illustrate these from findings from our project sample.

**Above- and belowground biomass**

The most common approach to measure the amount of above- and belowground biomass in a project area is to establish sample plots for collecting vegetation field data and use these data as inputs for allometric equations to estimate overall tree biomass in each plot. All projects in the

[11] The figure 1.1% was calculated by determining the mangrove vegetation in four sample plots using satellite data. In each of the sample plots, 0.2%, 0.8%, 0.7% and 2.7% of the area was covered with mangroves. 1.1% is the average across all four sample plots.

sample follow this approach. Dimensions that project owners typically measure in sample plots are the number of trees per plot, as wells as tree diameter at breast height (DBH) or canopy diameter of each tree. Allometric equations then allow using these measurements to estimate the total above- and belowground biomass in each plot (see box 3 below). The values determined for the plot are then scaled to estimate the amount of biomass accumulation in the entire project area. Project owners usually divide project areas into different strata to account for different planting years or other factors such as expected homogeneity in tree growth. Scaling from field plots therefore happens on the level of each stratum. Finally, project owners apply factors to determine the fraction of carbon contained in one tonne of dry mangrove above- and belowground biomass respectively. These factors are usually either based on default values contained in the respective quantification methodology or derived from peer-reviewed literature. The projects in the sample use factors ranging between 0.451 and 0.5 (see Table 23). Many quantification methodologies for terrestrial forests use 0.5 as a default value. Studies have suggested that using a ratio of 0.5 would be a potential source of overestimation of carbon stocks (Martin et al. 2018). The project sample shows that this is likely not an issue for Blue Carbon projects, as most projects apply lower values. One project – Delta Blue Carbon-1 (no. 5) – applies factors differentiated by above- and belowground biomass. Considering that mangrove trees accumulate a significant portion of their biomass in the roots and that the belowground biomass fraction is smaller than the aboveground fraction, this contributes to conservativeness of estimates.

**Box 3. What are allometric equations?**

- Allometry literally means “different measure” and refers to the scaling relationship between the size of a body part and the size of the body as a whole (Shingleton 2010). Tree allometry establishes quantitative relations between some key characteristic dimensions of trees which are easy to measure and other properties, which are more difficult to assess. A dimension that is relatively easy to measure is, for example the tree diameter at breast height (DBH), which field workers can determine by using a simple tape measure. A dimension, which is difficult to assess is the volume or biomass of a tree. Mangrove allometric equations therefore establish relationships between dimensions such as DBH or a mangrove tree’s canopy diameter and its total biomass. Scientists derive them by measuring dimensions such as DBH or canopy height in a sample of trees. Afterwards they excavate each tree in the sample and separate it into its aboveground (stem, branches, and leaves) and belowground (fine roots and large roots) materials. Afterwards they weigh each material in dry condition to determine the overall above- and belowground biomass of the tree. They then use the resulting values to establish a regression equation for estimating tree biomass based on e.g., DBH or canopy diameter.

The robustness of the estimates for above- and belowground biomass depends to a large extend on the sample design and appropriateness of the allometric equations used. It is important that the number of sample plots is adequate for the size of the project area and that the stratification of sample plots appropriately represents differences in growing conditions (Haya et al. 2023b). Mangroves typically grow in areas which are characterized by lands criss-crossed with small river estuaries and canals, which separate the land mass in numerous very small islands. Mangroves tend to grow faster on the edges of these islands i.e. where they are close to water. Growth on the inland – or mangrove hinterland tends to be slower. To avoid biases, sample plots must be located both on the edges of mangrove forests as well as their inland to capture different growing conditions within a project area. Often this is however not possible because the inland is inaccessible due to thickness of the mangrove forest. Projects therefore tend to move randomly assigned locations of sample plots to the nearest accessible point in the project area in case the originally assigned location is inaccessible.

Among the projects in the sample, only project no. 5, Delta Blue Carbon-1, took additional measures to address potential bias and uncertainties from plot distribution due to inaccessibility of planted areas. In the project documentation, the project developers acknowledge that they had to locate biomass plots nearer to the edge of the planted areas. To verify that the biomass levels observed in the sample plots are nonetheless representative of the entire plantation area, the project conducted an additional analysis comparing the normalized difference vegetation index (NDVI)[12] for areas located on edges and hinterlands. Further, areal images using drone flights were produced, to confirm that plot location does not lead to biases in estimating overall biomass in the project area.

**Table 23: Key variables used by projects to quantify above- and belowground biomass**

| Project and size of project area | Carbon fraction in dry mangrove biomass | Number of sample plots | Source and specifics of allometric equation |
|---|---|---|---|
| Úrsulo Galván (no. 1)<br>*930 hectares* | 0.5 aboveground biomass*<br>Source: unspecified | 124 plots | (Smith und Whelan 2006)<br>*Avicennia germinans* in South Florida – 8 trees<br>(Day et al. 1987)<br>*Laguncularia racemose and rhizophora mangle* in Mexico – 10 trees each |
| Vida Manglar (no. 2)<br>*7,561 hectares* | 0.451 Source: (IPCC 2014) | 23 plots | *Rhizophora mangle* and *Avicennia germinans* in the project area – 60 trees |
| Guinea-Bissau (no. 3)<br>*136,265 hectares* | 0.47 Source: (IPCC 2006) | 260 plots | (Chave et al. 2005)<br>Several species in two datasets:<br>29 trees in French Guinea<br>55 trees in Guadeloupe |
| Mikoko Pamoja (no. 4)<br>*117 hectares* | n/a | n/a | n/a |
| Delta Blue Carbon-1 (no. 5)<br>*350,000 hectares* | 0.48 aboveground biomass<br>0.39 belowground biomass<br>Source: (Kauffmann und Donato 2012) | 163 plots | (Chatting et al. 2020)<br>*Avicennia marina* in Qatar – 17 trees |
| Zhanjiang MAP (no. 6)<br>*380 hectares* | 0.47 Source: Default value in CDM AR-TOOL 14 based on (IPCC 2006) | 14 plots | *Kandelia obovata* – 48 trees<br>*Aegiceras corniculatum* – 37 trees<br>*Avicennia marina* – 51 trees<br>*Rhizophora stylosa* – 40 trees |

Source: Project Design Documents, Monitoring Reports *= value prescribed by the methodology. Allometric equations for Úrsulo Galván are provided by a specific tool (CALCBOSC) containing equations for several tree species in Mexico.

Measurement of carbon stocks in the project sample is based on a large range in the number of plots (see Table 23). The number shown in the table represents the number of plots that will be used for ex-post measurements of carbon stocks for *mangrove restoration* projects (no. 1, Úrsulo

[12] The Normalized Difference Vegetation Index (NDVI) is a satellite-based vegetation index derived from the near-infrared and red light reflected by the vegetation and captured by the sensor of the satellite. The NVDI correlates directly with vegetation productivity and provides information about the spatial distribution of biomass (Pettorelli et al. 2005).

Galván, no. 2, Delta Blue Carbon-1, and no. 6, Zhanjiang MAP) and the number of plots to estimate baseline carbon stocks for *mangrove restoration* projects (no. 2, Vida Manglar and no. 3, Guinea-Bissau). Methodologies AR-ACM0014 and VM0033 require project developers to apply the CDM tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" to calculate the number of sample plots for each stratum. The tool provides an equation that determines the plot number in relation to the estimated standard deviation of biomass stocks in each stratum as well as the weight of the stratum in the total project area and acceptable margins of error. Through iterative calculations the tool strives to achieve a minimum number of 30 plots but allows the application of a simplified equation where less than 5% of the project area is monitored. Low numbers of sample plots introduce uncertainty around estimates of above- and belowground biomass. Leading to an increased risk of selected plots not adequately representing ecological dynamics and forest structure of the entire project area.

Uncertainty of allometric equations and potential selection bias in choosing such equations are further challenges when determining biomass estimates in mangrove projects. Researchers estimate that allometric uncertainty can contribute to about 30-75% of the total uncertainty of biomass estimates (Vorster et al. 2020). They further found that local equations tend to have the lowest total uncertainty. Among the projects in the sample, only one project – Vida Manglar (no. 2) – used local data from the project area to determine the allometric equations, the other projects rely on equations that have been established using tree samples in other countries. All of them however explain in their project documentation how the equation chosen is appropriate for the project location, i.e. showing that they have been constructed for the same mangrove species and that sample regions represent similar ecologic conditions as the project region. One project – Guinea-Bissau (no. 3) – relies on allometric equations established through samples in other countries but conducted own sampling to confirm the appropriateness and conservativeness of the selection. The Úrsulo Galván project (no. 1) was able to draw on a comprehensive database of allometric equations that is provided by the carbon crediting programme for biomass quantification of all projects registered under the Mexico Forest Protocol.

Researchers identified low sample size (10-20 trees sampled per species) as a predictor for high uncertainty in allometric equations (Vorster et al. 2020). The allometric equations used by projects in the sample suggest that this is a relevant issue for mangrove projects. Only three projects (no. 2, Vida Manglar, no. 3, Guinea-Bissau, and no. 6, Zhanjiang MAP) use allometric equations that were constructed using more than 20 sample trees, the others are based on lower numbers. If allometric equations are based on only a few tree samples, the risk increases that the observed relationships between observed dimensions (DBH, canopy diameter) and biomass are not representative for the entire project area. At the same time the equations used by the projects in the sample represent what is available in peer-reviewed literature. This points to the need to further refine existing allometric equations for different mangrove species. This would however come at a cost, not only financially. As sampling involves excavation of mangrove trees and hence their destruction, larger sample sizes also would at least temporarily result in mangrove loss. Blue Carbon projects could potentially play a role in creating better allometric equations. They could support creation of new, larger samples on their project area, coupled with a commitment to replant the number of trees that they excavate for field measurements. As crediting periods of mangrove projects are between 20-60 years, project duration might be sufficient for the replanted trees to mature to avoid any mangrove loss.

In summary, factors introducing uncertainties around biomass estimates in mangrove projects are the selection of appropriate allometric equations, the number of sample trees used to construct these equations, as well as location and placement of sample plot design for ex-post measurements of removals and the applied value for the fraction of carbon in biomass. Uncertainty means that approaches can either lead to over- or underestimation of removals and avoided emissions. The degree of over-or underestimations is likely high with the likelihood of either over-or underestimation being uncertain. The projects in the sample show that additional measures such as areal imagery via drone flight or excavations in the project area to confirm applicability of allometric equations can help to reduce these uncertainties, however only to a certain extent.

**Soil organic carbon**

In Blue Carbon projects there are two soil organic carbon variables that are of interest. The first is carbon stocks in the project area and the second the carbon accumulation rate. The latter reports how much carbon accumulates in the soil over time.

The first variable is particularly relevant for *mangrove conservation* projects, as it provides critical information on the amount of carbon stored within the mangrove forest in the project area. Data which is essential, for accurately estimating the potential carbon emissions resulting from deforestation. Researchers usually measure carbon stocks through sediment coring and analyses of organic soil carbon content and bulk density (Adame et al. 2024). Among the project sample four out of seven projects include soil carbon in their GHG assessment boundary. Among those, only one project – Vida Manglar (no. 2) – uses field measurements from the project area to determine carbon stocks in the baseline. Here, field workers collected soil cores from 23 permanent plots between 2012-2015 (see Table 24). The spatial variation in carbon stocks was high among plots (30-1,200 t C $ha^{-1}$ in 50 cm long cores) and mainly related to differences in plot location (fringe forest, average stock 83 t C $ha^{-1}$; basin forest, average stock 757 t C $ha^{-1}$). The only other project that considered soil core measurements in the project design is the *mangrove restoration* project no. 5, Delta Blue Carbon-1. Here, field workers collected eight soil cores throughout the project area, which in this case is degraded mangrove habitat. Project developers however did not use them as the basis for performing the ex-ante calculations of the potential emission impact of the project. The other two projects that account for soil carbon did not measure carbon stocks because they either assume them to be zero in the baseline (no. 6, Zhanjiang MAP) or the values they use for carbon accumulation rates have been already discounted for in the baseline carbon stock (no. 7, VCR Seagrass Restoration).

**Table 24: Approach to determine soil carbon stocks**

| Project | Number of bore cores | Average SOC stock | Spatial variation |
|---|---|---|---|
| Vida Manglar (no. 2) | 23<br>Depth: 0-15; 15-30; 30-50cm | 83 t C $ha^{-1}$ (fringe mangroves)<br>757 t C $ha^{-1}$ (basin mangroves) | 30-1,200 t C $ha^{-1}$ |
| Delta Blue Carbon-1 (no. 5) | 8<br>Depth: 100cm | 163.6 t C $ha^{-1}$ | 82.9 – 206.2 t C $ha^{-1}$ |

Source: PDDs, Monitoring Reports projects no. 2 and no. 5.

The values in Table 24 suggest that there is a high variation in soil carbon stocks between geographic regions, age classes and coastal geomorphic settings. But collected soil core values in both project areas also show a high variation between the cores. This again underlines the importance of robust sampling approaches that use appropriate stratification to ensure representativeness of the sampling plots. The depth of the bore cores also is a factor for the representativeness of the measures. Research suggests that deltaic mangrove soils are much deeper than 1m (Kauffman et al. 2020). Whereas most soil cores are taken at a depth of 1m or less. Limiting analyses of soil carbon stocks to the top meter of soils might therefore result in underestimation of carbon stocks in the respective regions.

For *mangrove restoration* projects, the relevant variable is the soil accumulation rate. Project developers need this rate to calculate the carbon removals resulting from mangrove or seagrass planting. The quantification methodologies AR-AM0014 and VM0033 contain different requirements for calculating soil accumulation rates. Projects registering with AR-AM0014 must use a default value of -0.5 t C $ha^{-1}$ $yr^{-1}$ to calculate soil removals for the first 20 years after planting. After 20 years the methodology requires to set the rate to 0, as biomass production reaches a steady-state and no additional carbon is sequestered. Projects registering with VM0033 can chose between several options, including a default value of -1.46 t C $ha^{-1}$ $yr^{-1}$, historical or chronosequence-derived data, or values based on field-collected data. They must further apply a deduction to account for the percentage of sequestration resulting from allochthonous soil organic carbon. This deduction again must be based on published values, field-collected data, or modelling. For published values, VM0033 refers to an approach developed by researchers in 2018 to account for allochthonous carbon (Needelman et al. 2018).

**Table 25: Soil carbon accumulation rates used by projects in the sample and Intergovernmental Panel on Climate Change (IPCC)**

| Project/Source | Default value in methodology | Field observations |
|---|---|---|
| Delta Blue Carbon-1 (no. 5)<br>*VM0033* | -1.46 t C $ha^{-1}$ $yr^{-1}$<br><br>Adjusted by the project to -0.11 t C $ha^{-1}$ $yr^{-1}$ after mandatory deduction for allochthonous carbon, using the approach by (Needelman et al. 2018) | -1.9 t C $ha^{-1}$ $yr^{-1}$<br><br>-1.46 to -1.37 $ha^{-1}$ $yr^{-1}$ after deducting allochthonous carbon<br><br>Based on 5 soil cores in Indus River delta |
| Zhanjiang MAP (no. 6)<br>*AR-AM0014* | -0.5 t C $ha^{-1}$ $yr^{-1}$ | n/a |
| VCR Seagrass Restoration (no. 7)<br>*VM0033* | Not allowed for seagrass restoration projects | Values after deduction of allochthonous carbon:<br>-0.6 t C $ha^{-1}$ $yr^{-1}$ for age classes 1-12<br>-1.17 t C $ha^{-1}$ $yr^{-1}$ for age classes >12 |
| (IPCC 2014)<br>Wetland Supplement | Mangroves: -1.62 t C $ha^{-1}$ $yr^{-1}$ (range: 0.10 – 10.2 t C $ha^{-1}$ $yr^{-1}$)<br><br>Seagrass meadows: -0.43 t C $ha^{-1}$ $yr^{-1}$ (range: 0.09 – 1.12 t C $ha^{-1}$ $yr^{-1}$) | n/a |

Source: Project Design Documents, Monitoring Reports.

The portion of allochthonous carbon is an important factor for assessing the climate mitigation impact of soil carbon stocks. Allochthonous carbon refers to carbon that is absorbed in another location, transported to the project location and stored therein. For example, carbon could be originally absorbed by a terrestrial ecosystem and deposited via rivers into the coastal area. In contrast, autochthonous carbon is the carbon absorbed and stored in the same location. It results from mangrove, seagrass or marsh vegetation uptake of $CO_2$. Only newly absorbed autochthonous carbon leads to additional removals. Allochthonous soil carbon in e.g. mangrove deposits, possibly imported from hinterland soils, results from the uptake of $CO_2$ in a different location and was possibly taken up a long time ago, i.e. it does not represent additional $CO_2$ uptake as a result of project activities and is, hence, not climate-active in that particular mangrove ecosystem (Williamson und Gattuso 2022). The portion of allochthonous carbon varies largely among Blue Carbon ecosystems, but it can be as high as 70-90 % (Jennerjahn 2021; Kusumaningtyas et al. 2019); Ricart et al., 2020).

Among the quantification methodologies, VM0007 and VM0033 explicitly require project developers to deduct allochthonous soil carbon in the project scenario. For the CDM methodology AR-AM0014 it is unclear if the default value for soil carbon accumulation, which is substantially lower than the default value in VM0033 (see Table 25), includes a deduction for allochthonous carbon or not. Accordingly, in the project sample allochthonous carbon deductions are only performed in the two projects registered under VM0033, Delta Blue Carbon-1 (no. 5) and VCR Seagrass Restoration (no. 7).

In the long-run, the Delta Blue Carbon-1 project (no. 5) plans to use field-collected data for calculating a site-specific soil carbon accumulation rate. For the ex-ante estimation of project removals, and the project's first two monitoring reports, project owners, however, applied the default value set out by VM0033, -1.46 t C $ha^{-1}$ $yr^{-1}$. They further applied the mandatory deduction prescribed in VM0033 for the portion of allochthonous carbon, selecting the procedure developed by Needelman et al. (2018). This procedure allows estimating mineral-protected (recalcitrant) allochthonous carbon in tidal wetland systems using field collected soil data and literature-derived default values of the recalcitrant carbon that accompanies mineral deposition. The resulting adjusted soil accumulation rate that the project used for quantifying removals in its first two monitoring reports is -0.11 t C $ha^{-1}$ $yr^{-1}$(which corresponds to a 92% deduction from the default value). This approach likely leads to underestimation of soil removals from the project and is therefore conservative. In this case the combination of the VM0033 default value with the procedure developed by Needelman et al. (2018) results in conservative estimates for the project, which robustly avoids over-crediting.

In terms of the VCR Seagrass Restoration project (no. 7) the project description states that the values for GHG emissions from soils "have been discounted for baseline soil carbon dioxide, allochthonous soil carbon, soil methane, and soil nitrous oxide emissions as measured in bare sediment and therefore represent the net GHG emissions impact from soil as a result of seagrass restoration". The documentation further mentions that the calculations used to derive the data are provided in supplementary documents to the project design. These were not available in the VCS registry at the time of writing, not allowing for a further assessment of the project's approach to account for allochthonous carbon.

The Vida Manglar project (no. 02) assessed the portion of allochthonous carbon in mangrove soils as well. Under the quantification methodology applied by the project – VM0007, deduction of allochthonous carbon is optional for calculation of baseline emissions and removals. It is however mandatory for the project scenario unless project developers can demonstrate that the allochthonous carbon would have been returned to the atmosphere in the form of carbon dioxide in the absence of the project. In the project documentation, project developers argue that soil carbon in the project areas is produced in situ and therefore allochthonous carbon needs not to be deduced neither in the baseline nor project scenario. They base this assumption on findings from a peer-reviewed study that was conducted in the area and investigated mangrove soils and sediments from the Sinu River in 70 km distance of the mangrove forest (Völkel et al. 2018). Further insights on the relevance of allochthonous carbon determinations are provided in Jennerjahn (2025). All values used by the mangrove projects in the sample amount to lower emission factors than the emission factor for soil carbon provided in the 2013 Wetland Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see Table 25). This suggests that the Supplement's emission factor might not be conservative, likely requiring an update with more recent data. It further should be clarified whether this factor includes a deduction for allochthonous carbon, which is unlikely considering its value. Further updates of the emission factor should therefore not only clarify this point but also explore the feasibility of deriving a standardized deduction factor for allochthonous carbon.

#### 3.5.2.4 Determination of project emissions

Emission sources stemming directly from the execution and maintenance of project activities in Blue Carbon projects play a small role compared to other project types. Most projects in the sample exclude emission sources such as fertilizer use or fossil fuel use as they are likely negligible are determined to be non-existent. This is consistent with the requirements of the quantification methodologies at hand. This applies not only for $CO_2$ but also to $CH_4$ and $N_2O$ emissions from soils, which all projects exclude from the greenhouse gas assessment boundary or determine that they are negligible. From the existing literature it is however unclear how large the effect of methane ($CH_4$) and nitrous oxide ($N_2O$) emissions in Blue Carbon Ecosystem (BCE) is. Some studies suggest that the effect of $CH_4$ and $N_2O$ emissions combined might be able to counterbalance the $CO_2$ mitigation impact (Rosentreter et al. 2021; Al-Haj and Fulweiler 2020). Exclusion of $CH_4$ and $N_2O$ emission from soils might therefore result in serious over-crediting. However, a recent meta study indicates that the negative effect of methane emissions from mangrove ecosystems is much smaller than previously thought (Cotovicz et al. 2024). It found previous global-scale assessments – already constrained by a limited number of studies and data - were biased towards ecosystems characterized by substantial freshwater input and/or highly impacted by anthropogenic activities. In general, freshwater-dominated systems have higher methane emissions because of high methanogenesis in the soil/sediment. In saltwater-dominated systems sulphate reduction is the major decomposition process for organic matter which largely suppresses methanogenesis, hence, methane emission.

Until further research provides more clarity on the effect of mangrove restoration activities on $CH_4$ and $N_2O$ emissions, excluding them from the greenhouse gas assessment boundary introduces uncertainty around the mitigation impact of projects and may lead to overestimation of emissions reductions or removals.

#### 3.5.2.5 Determination of leakage emissions

Another factor that may impair the climate mitigation effect of a BC project is the so-called "leakage" effect, i.e. any increase in GHG emissions outside of the project area but related to the project activities. Leakage is a long-known problem not only for BC projects, however, the current practices to address it are not considered sufficient and reliable (Filewod und McCarney 2023; Ullman et al. 2013). Leakage can occur in different forms. Ecological leakage refers to changes in GHG emissions from ecosystems that are hydrologically connected to the project area. For example, rewetting of soils in a project area may affect the hydrological properties of areas downstream and outside the project area. In turn leading to an increase of emissions due to tree dieback there. Leakage can also occur due to shifting of an activity outside the project area as a direct effect of activity shifts within the project are. GHGs are still emitted, just elsewhere. Accurately determining links between these different effects and thus direct leakages is extremely difficult. A number of theoretical and practical challenges impair the effectiveness and accuracy of leakage assessments - either the reliability of project analysis will be low, or the costs of analysis will be high, or both (Filewod und McCarney 2023; Richards und Andersson 2001). Accuracy is further impaired through the indirect effects of market leakage, which are very difficult to differentiate from (other) background economic activity, hence an accurate determination of market leakage related to a specific intervention or project is hardly possible (Filewod und McCarney 2023).

Ecological and activity-shifting leakage is usually addressed by individual projects as it is required by all three carbon crediting programmes. However, market leakage is only addressed generally by Verra and is not considered in the Climate Action Reserve and Plan Vivo programmes. The Guinea-Bissau project (no. 3), for example, has a leakage belt that is regularly monitored in order to detect any potential activity-shifting leakage from the project. The Delta Blue Carbon-1 project (no. 5) addresses leakage by referring to the applicability criteria of VM0033, which state that activity-shifting leakage and market leakage do not occur. Similarly, ecological leakage is also considered not to occur. This appears to be reasonable, given that the tidal range and sediment delivery observed in wetlands outside the project area remain within the system's tolerance level, as stated in VM0033. To avoid activity-shifting leakage of fuelwood needs by community members, the Mikoko Pamoja project (no. 4) created Casuarina woodlots within the project area. In turn counteracting the potential risk of activity-shifting leakage of cutting mangroves in- and outside the project area. Similar activities are conducted by the Delta Blue Carbon-1 project (no. 5).

#### 3.5.2.6 Resulting mitigation impact

The climate mitigation impact of existing BC projects and those under development varies significantly. It ranges in orders of magnitude from thousands (e.g. project no. 4, Mikoko Pamoja project) to millions (e.g. project no. 5, Delta Blue Carbon-1) of tonnes of $CO_2$e per year. The impact depends to a large extent on the size of the project area and on whether besides accounting for above- and belowground biomass, soil carbon is accounted for.

The smallest project, Mikoko Pamoja, has an area of only 117 ha and carbon pools considered for measuring its removal impact only consist of above- and belowground biomass. Consequently, its annual carbon credits of 2,500 t $CO_2$e are at the lower end of the range. In contrast, the largest BC project worldwide, Delta Blue Carbon-1 (no. 5) in Pakistan, has an area of 350,000 ha, and includes biomass and soil carbon pools when quantifying its removal impact, leading to carbon credit issuance of 2,407,629 t $CO_2$e per year. The Guinea-Bissau project (no. 3) is also at the upper end of the range with an area of 136,265 ha and annual carbon credits of 920,436 t $CO_2$e. Interestingly, the Vida Manglar project (no. 2) with an area of only 7,561 ha generates annual carbon credits of 31,310 t $CO_2$e. In contrast to other projects, it also includes deadwood[13] for quantifying its removal impact. The Úrsulo Galván project (no. 1) in Mexico with an area of 930 ha issued carbon credits of about 1,600 t $CO_2$e per year in 2019 and 2020. The VCR Seagrass Restoration project (no. 7) has a large area of 66,452 ha and plans to issue annual credits of 1,349 t $CO_2$e.

Table 26 summarises the estimated emissions impact of BC projects in the project sample.

[13] Definition according to the VCS module "VMD0002 Estimation of carbon stocks in the dead-wood pool (CP-D), version 1.0, pages 4-5: "Dead wood included in the methodology comprises two components – standing dead wood that is fully dead (i.e. absence of green leaves and green cambium) and lying dead wood".

**Table 26: Estimated emission impact of BC projects in the project sample**

| Project | Activity type | Crediting period | Project area (ha) | Estimated average annual issuances (tCO2e) | Estimated total issuances over crediting period (tCO2e) |
|---|---|---|---|---|---|
| Úrsulo Galván (no. 1)<br>*Mx Forest* | Afforestation/ Restoration | 30 years | 930 | 1,600[#] | NE |
| Vida Manglar (no. 2)<br>*VM0007* | Avoided deforestation | 30 years | 7,561 | 31,310 | 939,296 |
| Guinea-Bissau (no. 3)<br>*VM0007* | Avoided deforestation | 20 years | 136,265 | 90,330 | 1,806,617 |
| Mikoko Pamoja (no. 4)<br>*Plan Vivo* | Avoided deforestation Afforestation/ Restoration | 20 years | 117 | 2,112 | 42,240* |
| Delta Blue Carbon-1 (no. 5)<br>*VM0033* | Afforestation/ Restoration | 60 years | 350,000 | 2,407,629 | 142,050,139 |
| Zhanjiang MAP (no. 6)<br>*AR-AM0014* | Afforestation/ Restoration | 40 years | 380.4 | 2,554 | 102,156 |
| VCR Seagrass Restoration (no. 7)<br>*VM0033* | Seagrass restoration | 30 years | 66,452 | 1,349 | 40,486 |

Source: Project Design Documents, Monitoring Reports.

[#] For the years 2019 and 2020.

* Calculated by multiplying the annual average with duration of crediting period.

It is likely that the large variation in annual credits resulting from very different project area sizes reflects location-, ecosystem- and activity-specific variations among the BC projects. However, a varying level of expertise in calculating GHG emissions and carbon stocks and the available local measurement data from the project area can also be an important source of error or calculation uncertainty among BC projects.

#### 3.5.2.7 Monitoring mechanisms

All carbon crediting programmes require a monitoring of the impact of project activities on GHG emission sources, sinks and reservoirs, as well as on other relevant indicators. Following the initial verification of a BC project, which includes a full monitoring, regular monitoring and reporting is required that varies in frequency among the carbon crediting programmes. The monitoring is conducted by the project developer, but results are reported to and verified by the verification bodies accredited under the respective carbon crediting programmes. The Verra VCS Standard (version 4.5) requires monitoring at least every five years, which is also the maximum length of the project verification period. The Climate Action Reserve provides general guidelines on monitoring in their Reserve Programme Offset Manual and then specifies details of monitoring periods and plans in specific protocols depending on the time of the "permanence commitment". Projects must commit to maintaining carbon sequestered due to project activities for a minimum of 30 years up to 100 years, secured through a contractual agreement. The time period they chose is referred to as "permanence commitment" by CAR. Projects that make a 100-year permanence commitment are eligible to establish a 100-year crediting period, those with a permanence commitment <100 years are limited to a 30-year crediting period. Accordingly, the Mexico Forest Protocol states that annual monitoring is required for a period of 100 years following the final issuance of carbon credits to a project, or for the length of time remaining in the Forest Project's permanence commitment, or for the length of time the project remains active (Climate Action Reserve 2022). The recent Plan Vivo Standard (version 5.0) requires annual reporting, including progress monitoring and a summary of carbon monitoring, while monitoring of its livelihood and ecosystem indicators must be conducted at least once within its five-year verification periods.

As monitoring is mandatory in all carbon crediting programmes, all investigated BCP projects provide monitoring reports. Uncertainties in the monitored parameters/data depend on the spectrum of applied methods and calculation options foreseen in the respective quantification methodology (see discussion in previous chapters). These reports can be extensive as, for example, in the Vida Manglar project (no. 2), which reports not only on emission reductions and removals (ERRs), but also on CCBS (Climate, Community & Biodiversity Standards)-relevant indicators. The data basis is quite broad and robust compared to other projects. The Guinea-Bissau project (no. 03) mainly monitors change in forest area and related carbon stocks through a combination of remote sensing, field data on vegetation and data from literature. In 2023, the large Delta Blue Carbon-1 project (no. 5) already provided a second monitoring report, which is extensive because it also includes reporting on CCB-relevant indicators. The Mikoko Pamoja project (no. 4) registered under the Plan Vivo programme provides the mandatory annual monitoring reports, which include short summaries of monitoring progress regarding the carbon, livelihood and ecosystem indicators. However, it is reported that forest monitoring is conducted three times a year by local forest scouts.

### 3.5.3 Addressing non-permanence

Another key aspect for high-quality BC projects is the "permanence" of the emission reductions or removals. It is crucial for crediting programmes to address the risk of non-permanence of credited mitigation impacts to ensure environmental integrity: If the preserved or enhanced carbon stock achieved through Blue Carbon projects are released back to the atmosphere at a later point in time, net global emissions will be higher if these credits were used to compensate for emissions. If such reversals occur and are not compensated for, a crediting programme will effectively have over-issued carbon credits. This would invalidate the emission reduction or removal claim and hence the integrity of the crediting mechanism (Schneider et al. 2022b). Thus, whatever management interventions are planned, they need to warrant that avoided GHG emissions or sequestered carbon in a BC project are maintained in the long run. Even if credits from these projects were not used for offsetting purposes, reversed mitigation impacts would still undermine efforts to meeting long-term climate objectives as well as the effectiveness of the funding for these projects.

The risk of non-permanence is influenced by three factors (see Schneider et al. 2024; Böttcher et al. 2022):

- **The extent to which carbon reservoirs are susceptible to natural or human-caused reversal risks**. As with other mitigation activities that enhance or preserve carbon reservoirs, particularly in the land use sector, Blue Carbon projects that enhance carbon storage in coastal ecosystems face significant reversal risks. They are subject to natural disturbances such as storms, droughts or diseases (unintentional reversals), as well as human influence that may imply project mismanagement or abandoning project activities altogether. This is because changes in local conditions can render activities, which keep carbon stored, unattractive (intentional reversals) (Schneider et al. 2022b; Anderegg et al. 2020; Böttcher et al. 2022). To ensure long-term mitigation impacts, both natural and human-caused risks need to be carefully assessed and mitigated.

- **The size and scale of carbon reservoirs**: The size and scale of a carbon reservoir determines the extent to which extreme weather or oceanographic events can lead to a release of carbon to the atmosphere. Emission reductions of smaller projects may be completely reversed in the event of the project ecosystem being disturbed by, e.g., a cyclone. While reductions of larger-scale projects is likely to be partially, rather than completely reversed. This is because extreme events typically only affect part of a large area, rather than the entire reservoir. Likewise, when faced with intentional changes of management practices or changes in land use, large-scale carbon reservoirs at, e.g. jurisdictional scale, tend to be more robust. In contrast, smaller scale carbon reservoirs, are more easily and quickly depleted by these changes. Therefore, while the same type of disturbances can occur at both scales, the consequences are often more limited and more easily manageable at larger scales.
- **Whether and how human-caused drivers of depleting carbon reservoirs are addressed:** Economic dependence on agricultural products, logging for timber and fuel as well as infrastructure or urban development activities are major drivers of the depletion of carbon reservoirs. Most notably through deforestation and subsequent land-use change. These underlying drivers need to be addressed in order to reduce the risk of reversals effectively.

The reversal risk is high for all types of Blue Carbon activities. The specific risks vary between activities as different biospheric reservoirs are vulnerable to different hazards as outlined in box 4.

**Box 4. Reversal risks of Blue Carbon activities**

**Mangroves**: Carbon sequestration in mangroves may be reversed due to natural hazards such as coastal squeeze, loss of low-lying or submerged land or vegetation, erosion, increased decomposition of soil or remineralisation (Cooley et al.). For example, in the Sundarbans of Bangladesh, mangrove gains due to large-scale mangrove afforestation were largely offset by substantial losses from shoreline erosion (Hagger et al. 2022). Likewise, droughts, severe storms and marine heatwaves can cause mangrove die-offs and hence risk carbon reversals (Cooley et al.; Krauss und Osland 2019). Reversals may also occur due to human-induced land cover conversion, which has led to mangrove deforestation (Cooley et al.; Duke et al. 2021). Primary drivers of this being aquaculture and agriculture (Friess et al. 2019). Likewise, infrastructure and urban development activities have historically led to mangrove deforestation due to land cover conversion (Friess et al. 2019). Further human risks are the extraction of timber or other wood products alongside proximate drivers such as conversion to salt ponds or activities associated with oil and gas production (Friess et al. 2019).

**Seagrass meadows:** Carbon sequestration in seagrass meadows may be reversed due to natural hazards such as coastal squeeze, loss of low-lying or submerged land or vegetation (Cooley et al.), water quality degradation (Waycott et al. 2009) or ultraviolet irradiance (Duarte 2002). In addition, carbon may be released if floods and cyclones damage seagrass meadows in the project area (Duarte 2002). Also human interventions such as aquaculture, siltation, costal construction or fishing cause area loss in seagrass meadows and could therefore result in reversals of GHG mitigation impacts in the project area (Duarte 2002; Thomsen et al. 2020).

**Tidal marshes**: Similar to mangroves and seagrass meadows, tidal marshes' ability to store carbon may be threatened by natural hazards such as coastal squeeze, loss of low-lying or submerged land or vegetation as well as erosion (Cooley et al.). In addition, invasive species and environmental pollution have been identified as major drivers for loss in tidal marshes in e.g. China (Gu et al. 2018). Major human drivers of saltmarsh loss are coastal land reclamation (Gu et al. 2018; European Commission (EC)) along with agriculture, the salt industry and urban sprawl (Díaz-Almela et al. 2019).

As pointed out, non-permanence risks cannot be excluded in Blue Carbon activities, they need to be addressed and mitigated.

The following approaches are available for addressing non-permanence (Schneider et al. 2022b; Schneider et al. 2024):

- **Assessing and reducing non-permanence risks** by requiring non-permanence risk assessments and excluding mitigation activities with higher risks from eligibility and/or requiring measures to mitigate the risks.
- **Compensating for reversals:**
  - **Crediting based on monitoring and compensation for reversals**: Monitoring of carbon stocks over long time periods and provisions for cancelling other credits in case a reversal occurs. Key features in the programmes' provisions include for how long monitoring is required and how the responsibility of compensating for reversals is assigned. All types of reversals (intentional and unintentional ones) should be compensated for (by project owners and/or pooled buffers). It should also not be allowed to update the baseline after a reversal has occurred.
  - **Crediting based on issuance deductions**: Issuing credits only for a fraction of the mitigation achieved to account for possible future reversals.
  - **Temporary crediting:** Issuing temporary carbon credits that expire after a certain time period, which need to be replaced by other credits as they expire (Marland und Marland 2009; Maréchal und Hecq 2006; Marland et al. 2001; Sedjo und Marland 2003). This approach is not applied by any of the crediting programmes analysed in this study.
- **Tonne-year accounting**: Issuing only fractional amounts of credits for each year that carbon remains stored. However, this approach only fully accounts for reversals if occurring reversals do not exceed the number of non-credited emission reductions or removals. In addition, the approach provides insufficient incentives to avoid reversals, which may result in moral hazard, i.e., selecting activities with high reversal risks (CCQI 2022). This approach is also not applied by any of the crediting programmes analysed in this study.

As temporary crediting and tonne-year accounting are not used by any of the crediting programmes analysed in this study, we focus in our analysis on the other approaches for addressing reversals.

#### 3.5.3.1 Reducing reversal risks through risk assessments and eligibility restrictions

Verra's VCS and CAR's Mexico Forest Protocol both require conducting risk assessments that consider various reversal risks of Blue Carbon projects. Verra's VCS provides a software-based tool that allows to conduct a risk analysis – the Agriculture, Forestry, and Other Land Uses (AFOLU) Non-Permanence Risk Tool (NPRT). The risk rating in several risk categories

((1)internal risks regarding the design and management of the project, (2) external risks relating to land tenure, stakeholder engagement and political risks as well as (3) natural risks regarding extreme weather events) is done numerically through adding risk values (VERRA 2024). The risk analysis considers a time horizon of 100 years. Projects with a non-permanence risk rating above 60% will be excluded unless mitigation measures can limit the risk to 60% or less. Excessively high sub-risks also lead to project exclusion. The risk assessment must be updated in case of reversals (VERRA 2024). Even though the risk assessment is verified, it is nevertheless based on the subjective judgment of project proponents and might therefore be subject to uncertainty.

The project-specific risk rating approach in the Mexico Forest Protocol is fairly similar to Verra's procedure, as risks in different categories are assessed. Each identified risk category in a project results in a percentage reduction of credits, ranging from 0% to 8% of the 100%. These reductions are combined to determine the total amount of credits the project must contribute to the pooled buffer. The risk rating is adjusted to the project duration as project proponents can choose between permanence commitments of 100 years or less. For projects with a permanence commitment less than 100 years, less credits are issued and the risk of reversal is considered to be shorter because of the shorter time period for which the carbon must remain stored (Climate Action Reserve 2022).

Project owners are incentivised to maintain the mitigation results achieved, as a percentage of credits in the reserve will be redistributed to project owners over time. CAR Mexico uses a tonne-year approach and considers the risk of reversals to be declining over time. No provisions are in place to exclude projects with particularly high reversal risks. Risk assessments are updated at every verification (Climate Action Reserve 2022).

Plan Vivo does not require deriving a reversal risk based on a specific risk assessment. For all projects 20% of credits issued have to be placed in the risk buffer. “Risks to the maintenance of the carbon benefits” must be identified for a minimum period of 50 years, “significant risks” must be mitigated, and reversal risks must not exceed an “acceptable level”, yet this is not further defined in the requirements for projects. Reversal risks must be re-assessed at least every 10 years throughout the project period (Plan Vivo 2023).

Additionally, all three carbon crediting programmes require project owners to ensure legal titles to the land used in mangrove projects. This works as an additional mechanism to address the risk of reversals. As, in theory, clear legal titles allow project owners to implement measures that protect the project from intentional reversals by preventing adverse land management practices (Schneider et al. 2022b).

#### 3.5.3.2 Monitoring and compensating for reversals

In practice, it is not possible to guarantee the maintenance of avoided emissions or removals in perpetuity. Consideration of a time horizon of 100 years has turned out as a “best practice” approach in the voluntary carbon market. From a private investment perspective, such a time span is similar to an indefinite commitment (Böttcher et al. 2022; Schneider et al. 2022b).[14] Yet, even a 100-year “permanence” does not fully compensate for, but only delays the planetary harm of the GHG emissions (Schneider et al. 2024).[15]

[14] Other studies suggest ranges between 42 and 150 years to consider carbon sequestration permanent (Marland et al. 2001; Fearnside 1997; Fearnside et al. 2000; Tipper und Jong 1998; Moura Costa und Wilson 2000; Bird 1997; Dobes et al. 1998).

[15] The reason for this lies in the timescale mismatch between the geological and the active modern carbon cycle. The production of fossil fuels and isolation from the active carbon cycle lasts for tens to hundreds of millions of years (Berner 2003). In other words, once a carbon atom is removed from the Earth’s surface, i.e. the active carbon cycle, and it enters the geological rock cycle it takes

To assess whether a project results in reversals, the project proponents need to monitor for their occurrence. The longer the monitoring period for identifying reversals, the higher the chance of being able to identify and thereby address these reversals. Therefore, a robust approach for addressing reversals requires a sufficiently long monitoring period (Schneider et al. 2022b).

The VCS requires monitoring carbon stocks for a minimum of 40 years from the start of the first crediting period (VERRA 2023b, S. 13). Yet, at the same time, Verra's provisions suggest that monitoring is only required through the end of a project's crediting period (the provisions are not fully clear in that regard). The minimum crediting period for AFOLU projects is 20 years, the maximum total project crediting period can extend to up to 100 years. At its discretion, Verra itself may agree to monitor a project where the crediting period is less than 40 years (VERRA 2023b, S. 13).

CAR Mexico offers projects the possibility to choose between a "permanence period" of 100 years and shorter permanence periods. Project owners commit to maintaining carbon sequestered due to project activities for the defined time period, secured through a contractual agreement (Climate Action Reserve 2022, S. 28). If a permanence period of 100 years is chosen, the crediting period is 100 years. For shorter permanence periods, the crediting period is at least 30 years. The longer carbon stocks are maintained, the more credits are issued (up to a maximum of one credit per tonne of carbon sequestered). The number of credits issued is proportional to the length of the commitment (Climate Action Reserve 2022, S. 165). Monitoring is required for a period of 100 years following the final issuance of credits to a project **or** for the length of time remaining in the project's permanence commitment (as explained above) **or** for the length of time the project remains active (this is not further explained) (Climate Action Reserve 2022, S. 61). This suggests that the minimum time period for monitoring is 30 years.

Plan Vivo requires project owners to monitor the project interventions during the crediting period (10 to 50 years). Reversal risks must be monitored (i.e. reported in regular monitoring reports, see section 3.5.2.7) for at least 50 years (Plan Vivo 2023).

In addition to monitoring of reversals, crediting programmes must have provisions in place to compensate for reversals. These include two main approaches:

- **Pooled buffers** are often used to compensate for **unintentional reversals**. Projects must place a fraction of credits issued in the buffer reserves. In case of a reversal, carbon credits are cancelled from the buffer reserve that corresponds to the amount of emissions caused by the reversal. A best practice approach to address reversal risks over long time periods is to cancel credits in the buffer at the end of the time period for which monitoring and compensation for reversals is required. Also, rules should be in place that make sure that pooled buffers can continue to operate if the crediting programme concluded. In order to effectively address non-permanence, the buffer reserve must carry a sufficiently large amount of carbon credits to cover for potential reversals. Rules should also be in place how compensation is ensured in case of insolvency of the crediting programme or the project owner (Schneider et al. 2022b).

about 200 million years for it to return to the active modern carbon cycle. The latter covers the exchange between atmosphere, biosphere, soils and the ocean and acts on timescales of days to thousands of years. In this context, the burning of fossil fuels by humans means short circuiting the system and moving a portion of carbon from the geological into the modern cycle in an instant. This imbalance is the reason for the unprecedented increase of atmospheric $CO_2$ and global warming in the industrial era. Consequently, any human activity for GHG removal and storage, including increasing the efficiency and/or area of BCE (Johannessen und Christian 2023), only refers to the modern carbon cycle and cannot close the anthropogenically caused imbalance between the modern and the geological carbon cycle through fossil fuel burning.

- Project participants are usually liable for any **intentional reversals**. This avoids moral hazard risk posed by intentional reversals. Requiring insurance can additionally ensure that compensation of reversals will happen. These approaches may be accompanied by **contractual or legal approaches,** which use contracts, legal restrictions or land use or other existing legislation to minimise the risk of reversals. Project owners can also be required to have legal titles to the land or legally binding arrangements can be put in place that require a project owner's consent to undertake any activity that might lead to intentional reversals. In the case where project participants are unable to compensate for reversals (e.g. due to insolvency), a backstop can enhance the robustness of the provisions to address non-permanence (e.g. using the pooled buffer reserve) (Schneider et al. 2022b).

All three crediting programmes have mechanisms in place to compensate for reversals, including a pooled buffer.

The VCS makes project proponents liable for compensating for *intentional* reversals while the pooled buffer compensates for *unintentional* reversals. For unintentional reversals, project proponents must contribute additional credits to the buffer if credits in the pooled buffer cannot fully cover the reversal. Only projects with a non-permanence risk contribute to VCS's pooled buffer. A project's contribution to the pooled buffer is determined by a risk assessment; the minimum risk rating and corresponding contribution to the buffer is 12% (see section 3.5.3.1). Credits in the pooled buffer will be cancelled at the end of the project or monitoring period, depending on whichever occurs later. If no verification report is submitted, buffer credits will be put on hold (50% after 5 years, 100% after 10 years). After 15 years, buffer credits equivalent to all credits issued to the project will be cancelled and the project becomes inactive. In case of unavoidable reversals or when a crediting period must be renewed, the baseline carbon stocks can be reassessed, which may impede full accounting for reversals (VERRA 2023a; VERRA 2023b).[16]

The pooled buffer established under CARs Mexico Forest Protocol compensates for unintentional reversals, but, at its discretion, CAR may use the pool for any other reversals that may occur. Projects must replenish the pooled buffer after a reversal, but projects may only continue if carbon stocks are still above approved baseline levels after the reversal. In case of unintentional reversals, no pooled buffer dividends will be distributed until the pooled buffer has been fully replenished. Additionally, in case of intentional reversals, project owners must retire an amount of credits corresponding to the reversal. Thus, project owners must compensate for intentional and unintentional reversals. The pooled buffer only holds contributions from forest projects which are all subject to non-permanence risks. The contribution to the pooled buffer is determined through a risk assessment. No information is available whether credits in the pooled buffer are cancelled at the end of a project (Climate Action Reserve 2022).[17]

Plan Vivo requires project owners to compensate for intentional reversals. Credits in the pooled buffer are used for unintentional reversals (but the project must make additional contributions if credits from the project in the pooled buffer cannot fully cover the reversal). All verified projects must assign 20% of their carbon benefits to a pooled risk buffer. Risk buffer credits

[16] As of February 2024, 234 projects from 45 countries implementing various mitigation activities in the land use sector contribute to the pooled buffer. The three largest projects account for 19% of all credits deposited in the pooled buffer at the time of issuance. The average fraction of carbon credits that projects with a reversal risk deposited in the pooled buffer reserve is 13% (see VCS Registry, https://registry.verra.org/app/search/VCS).

[17] 167 projects from Mexico and the US contribute to the buffer reserve as of December 2023. The three largest projects account for 13% of all credits deposited in the pooled buffer at the time of issuance. The average fraction of carbon credits that projects with a reversal risk deposited in the pooled buffer reserve is 19% as of December 2023 (Berkeley Public Policy 2023).

must be cancelled in case of reversals. The project's remaining balance of credits contributed to the risk buffer will be cancelled at the end of the project. Only projects with a non-permanence risk contribute to the buffer (Plan Vivo 2023).

Projects that are implemented in different ecosystems and across different regions contribute to each of the pooled buffers so that reversal risks are diversified across different ecosystems.

None of the carbon crediting programmes have rules or safety measures set in place for how pooled buffer reserves are managed in case the programme ceases to exist, e.g., due to insolvency.

**Conclusion**

In terms of the approaches of the selected crediting programmes to reduce the risk of non-permanence, all three programmes require some sort of risk assessment. While Verra's VCS and CAR's Mexico Forest Protocol require project owners to determine an overall reversal risk (which then defines the amount of credits that a project must contribute to the pooled buffer reserve to manage reversal risks), Plan Vivo does not require deriving an overall reversal risk. However, only under VCS, a specific threshold is defined regarding the magnitude of the reversal risk which projects may not exceed in order to be eligible for crediting. Plan Vivo only defines such a threshold in general terms ("acceptable level"). Under CAR's Mexico Forest Protocol, projects high reversal risks may still receive credits. This could undermine the ability of the buffer pools of the programmes to cover larger scale reversals and might therefore threaten the integrity of the issued carbon credits.

In addition, all three crediting programmes allow for monitoring periods that are significantly shorter than 100 years. The intended duration of the selected Blue Carbon projects ranges between 20-60 years (see Table 4 in section 3.1Table 4). Some monitoring activities might continue after the end of a project, but if reversals occur after monitoring ceases, they will not be compensated for, which will cause over-crediting. In this context, the Delta Blue Carbon-1's (project no. 5) 60-year project duration appears to be a more robust basis than the 20-year duration of other projects, e.g., Vida Manglar (no. 02). CAR attempts to address the reversal risk over a longer time frame by discounting the value of issued carbon credits based on the length of the commitment period compared to the 100-year benchmark.

Regarding compensation of reversals, all three carbon crediting programmes make project owners liable for identifying and compensating both, avoidable and unavoidable reversals. Additionally, they have pooled buffer reserves in place which are in principle a suitable instrument to insure projects against reversals.

However, the approach of using a pooled buffer depends on whether it is sufficiently capitalised. VCS, Plan Vivo and CAR deposit approximately 13%-20% of carbon credits on average in the pooled buffers.[18] This fraction may be insufficient in light of a recent study showing that California's cap-and-trade programme, requiring a buffer contribution of 6%-19%, is substantially undercapitalised (Badgley et al. 2022). Besides, limited transparency on buffer credits in the registry used by Plan Vivo impedes observing how the buffer reserve evolves over time and how vulnerable it is to reversals in individual projects (S&P Global Inc. 2024). Undercapitalised buffers may threaten the environmental integrity of a crediting programme since they may not be able to compensate for potential future reversals.

[18] The contribution of the selected blue carbon projects to the respective pooled buffers ranges from 7.1 % in the Vida Manglar project (no. 2) to 15 % in Mikoko Pamoja project (no. 4) (see Table 4).

Table 27 summarises the approaches to address non-permanence of the three carbon crediting programmes which the selected Blue Carbon projects are registered with.

**Table 27: Overview of approaches to address non-permanence of carbon crediting programmes for standards of the project sample**

| | **VCS** | **Climate Action Reserve**<br>Mexico Forest Protocol v3.0 | **Plan Vivo Standard**<br>Plan Vivo Climate Project Requirements, Version 5.1 |
|---|---|---|---|
| **Risk assessment and eligibility** | Risk assessment in place.<br>Projects with a non-permanence risk rating above 60% will be excluded unless mitigation measures can limit the risk to 60% or less. Excessively high sub-risks also lead to project exclusion. The risk assessment is updated in case of reversals. | Risk assessment in place.<br>Project owners are incentivised to avoid reversals, as a percentage of credits in the reserve will be redistributed to project owners over time (CAR Mexico uses a tonne-year approach and considers the risk of reversals to be declining over time). No provisions are in place to exclude projects with particularly high reversal risks. Risk assessments updated at every verification. | Risk assessment in place (but no resulting overall reversal risk determined).<br>Significant risks must be mitigated (but no specific guidance). Reversal risks must not exceed an "acceptable level" (not defined).<br>Reversal risks must be re-assessed at least every 10 years throughout the project period. |
| **Legal titles** | Project owners must document legal titles to the carbon reservoirs/the land. | The project owner must demonstrate legal ownership of the land or jurisdiction over the forest/project area. | Project participants (implementing party) must demonstrate statutory or customary rights that enable the implementation of the project activities. |
| **Monitoring period** | Monitoring must be done for at least 40 years. Yet, at the same time, Verra's provisions suggest that monitoring is only required through the end of a project's crediting period. The minimum crediting period for AFOLU projects is 20 years, the maximum total project crediting period is 100 years. Verra itself may agree to monitor a project where the crediting period is less than 40 years at its discretion. | Projects define a "permanence commitment" of 100 years or less. If the permanence commitment is 100 years, the crediting period is also 100 years. If the permanence commitment is less than 100 years, the crediting period is 30 years.<br>Monitoring is required for a period of 100 years following the final issuance of credits to a project **or** for the length of time remaining in the project's permanence commitment **or** for the length of time the project remains active. | Project coordinator must monitor the project interventions during the crediting period (10 to 50 years).<br>Reversal risks must be monitored for at least 50 years. |

| | **VCS** | **Climate Action Reserve** Mexico Forest Protocol v3.0 | **Plan Vivo Standard** Plan Vivo Climate Project Requirements, Version 5.1 |
|---|---|---|---|
| **Compensation liability** | Project proponent for intentional reversals, pooled buffer for unintentional reversals. For unintentional reversals, project proponents must contribute additional credits to the buffer if credits in the pooled buffer cannot fully cover the reversal. | The pooled buffer compensates for unintentional reversals, but CAR may use the pool at its discretion for any reversal that may occur.<br>Projects must replenish the pooled buffer after a reversal, but projects may only continue if carbon stocks are still above approved baseline levels after the reversal. Thus, project owners must compensate for intentional and unintentional reversals. | Project owners must compensate for intentional reversals. Credits in the pooled buffer are used for unintentional reversals (but the project must make additional contributions if credits in the pooled buffer cannot fully cover the reversal). |
| **Compensation mechanism** | Pooled buffer, contribution is determined by a risk assessment (at least 12% of issued credits must be placed in the buffer). Credits in the pooled buffer will be cancelled at the end of the project or monitoring period. Only projects with a non-permanence risk contribute to the buffer. | The risk assessment determines the contribution to the pooled buffer. No information is available whether credits in the pooled buffer are cancelled at the end of a project. Only projects with a non-permanence risk contribute to the buffer. | All verified projects must assign 20% of their carbon benefits to a pooled risk buffer.<br>Credits in the pooled buffer will be cancelled at the end of a project. Only projects with a non-permanence risk contribute to the buffer. |
| **Insolvency of the carbon crediting programme** | No provisions in place in case of insolvency of Verra. | The risk of project owners turning bankrupt is addressed in the financial risk assessment determining the contribution to the buffer reserve.<br>However, there are no provisions in case of insolvency of CAR. | No provisions in place in case of insolvency of Plan Vivo. |

Sources: VCS Standard v4.5; VCS Registration and Issuance Process v4.4; VCS AFOLU Non-Permanence Risk Tool v4.2; CAR Mexico Forest Protocol v3.0; Plan Vivo Standard; Plan Vivo Climate Project Requirements, Version 5.1.

### 3.5.4 Environmental and social impacts

The impact of carbon crediting projects goes beyond GHG emissions reductions and removals. Those impacts might relate to social and environmental factors, which influence the overall outcome and perception of such projects. Further, projects might contribute to sustainable development, not only through emissions reductions, but also by progressing other sustainable development goals (e.g. through job creation). Hence, two aspects have to be distinguished:

- The robustness of the environmental and social safeguards that project developers must apply to prevent negative impacts of a project,
- The degree to which projects promote and assess benefits that go beyond carbon crediting and contribute to sustainable development, the potential positive impacts of a project.

The following provides an overview of how the three carbon crediting programmes, projects in our sample are registered with, approach these aspects and which sustainable development impacts the projects report on.

#### 3.5.4.1 Safeguards

All major carbon crediting programmes have established environmental and social safeguards (E&S safeguards) with the aim to ensure that carbon market projects do no harm on other social and environmental goods and are aligned with development priorities. These safeguards include the possibility for global as well as local and affected stakeholders to voice concerns and demand fair treatment and, when appropriate, redress or compensation. The requirements of carbon crediting programmes vary in their stringency and comprehensiveness and are mostly not project type specific as they uniformly apply to all project types that are eligible for registration. This means that Blue Carbon projects must comply with the same E&S safeguard requirements as all other project types.

While carbon crediting programmes set the requirements which projects must meet, responsibility for compliance is with the project owners. Exceptions however exist, the Mexico Forest Protocol of the Climate Action Reserve. It contains specific safeguard provisions, which are tailored to the local context of the projects in Mexico which are often owned and implemented by ejidos and local communities (see section 3.3.3. for details on landownership structures in these projects). In all cases, information on compliance with E&S safeguard requirements in project design documents and monitoring reports is subject to external verification.

There is a growing body of research that has assessed the robustness of carbon crediting programmes' E&S safeguards, inter alia by comparing them to international benchmarks such as the Performance Standards of the International Finance Corporation (IFC) (Lauer et al. 2024; Wissner und Schneider 2022; Siemons et al. 2025), see also the assessments of the Carbon Credit Quality Initiative[19]. A main finding of this research was that requirements sometimes lacked operationalizable guidance in form of clear instructions that project developers must abide with. The VCS for example required project proponents to identify and address any negative environmental and socio-economic impacts of the project. It however did not further specify what this entails. For example, through providing a specific list of environmental goods such as air, water, biodiversity, which project proponents must consider when assessing potential negative impacts of their activities. Since the publication of this research, many carbon crediting

[19] See documents under section 6.1 "Robustness of the carbon crediting program's environmental and social safeguards", available at https://carboncreditquality.org/resources_evaluation.html.

programmes have updated their E&S safeguard provisions in line with the Core Carbon Principles of the IC-VCM. With these updates, carbon crediting programmes closed some of the gaps identified in the literature, while others remain. The VCS provisions, for example, now include more specific instructions on the type of impacts that must be avoided by all projects.

Generally, Blue Carbon projects bear more risks to disturb social cohesion in local communities than to negatively impact the environment. Mangrove replanting, for example, largely relies on workers planting samplings by hand, which avoids disturbance of the soil with heavy machineries. As replanting happens on degraded lands there are also low risks to negatively impact existing vegetation. Negative impacts on the environment are further limited, as projects only plant mangrove trees. Thus, lowering risks that projects introduce invasive species in the project area. Use of fertilizer could create a risk for water and soil quality in mangrove projects. None of the projects in the sample apply fertilizers in mangrove nurseries. Suggesting that this might be a less relevant risk for the current set of mangrove projects registered with the VCM.

The main risk to undermine social cohesion through Blue Carbon projects stems from the fact that these projects involve changes in the land-use practices pre-project implementation. Mangrove conservation projects sometimes introduce or enforce restrictions to using mangrove habitat for economic activity, mangrove restoration projects similarly alter the way local populations can use previously degraded mangrove habitat. In terrestrial REDD projects changes in land use practices have led to local disputes and in some cases researchers have reported human rights violations in these projects (Haya et al. 2023a). There are no known cases to date where Blue Carbon projects have led to similar problems. Risks for this project type are however material, underlining the importance of robust social safeguards.

A key safeguard in this context are provisions requiring project developers to obtain free, prior, and informed consent from local communities for the project activities. All three carbon crediting programmes have respective provisions in place. The Climate Action Reserve requires that project developers convene an assembly with all community members before the start of any project. Provisions include detailed requirements on the topics which must be discussed at the Assembly. Decision-making can either rely on formal or traditional authorities or an assembly act which can be adopted by a simple majority of present community members. The Plan Vivo Standard requires projects to follow a free, prior, and informed consent (FPIC) process which enables local communities with statutory or customary land or resource rights in the project area to negotiate the conditions under which the project is designed, implemented, monitored and evaluated. The standard further includes detailed requirements on the design of the FPIC process, its inclusiveness and eligible decision-making mechanisms. The VCS provisions stipulate that a project may affect property rights only if FPIC is obtained and transparent agreements have been reached that include provisions for just and fair compensation. Provisions further include requirements on the minimum information that project developers must disclose before establishing such an agreement.

The enforcement of social and environmental safeguards undoubtedly strongly depends on how the provisions of the carbon crediting programme are enforced and put into practice on the ground in the projects. Recently, land use projects (especially REDD projects) in the VCM have been criticized for human rights violations. While there are currently no accounts of similar accusations for the few existing BC projects, robust safeguard provisions, proper enforcement and local monitoring is needed to ensure that BC projects do not negatively impact the environment and local communities.

#### 3.5.4.2 Sustainable Development Impacts and Associated Co-Benefits

While programme provisions are critical for ensuring minimum environmental and social safeguards, the overall sustainable development impacts of projects can still vary considerably. Projects in the VCM may catalyse significant positive social and economic benefits that go beyond GHG emission reductions. The available literature suggests that sustainable development impacts depend, to a degree, on the project type but clearly depend on the individual project and local context (e.g. Wissner et al. (2022), Hernández-Orozco et al. (2022), Nilsson et al. (2016)). Further, while projects within the VCM might claim various co-benefits, these claims need to be assessed, verified and reported in a transparent manner. Clear programme provisions to promote, assess and monitor sustainable development impacts can improve the overall impact of carbon credit projects. Making the impacts not only more transparent but also more credible.

The carbon crediting programmes considered in this report, vary in their provisions on sustainable development impacts or so-called co-benefits. However, this does not imply that if projects are under no obligation to assess or to report on these impacts, these positive impacts beyond GHG reductions do not exist. Additionally, it should be noted that even if specific programme provisions for the assessment and reporting on sustainable development are in place, their robustness and enforcement among individual projects varies (similar to ensuring safeguards above). An example is the Kasigau Corrido REDD+ project in Kenya which claimed to contribute to the sustainable development goals (SDGs) in terms of gender equality (SDG 5) certified via VCS with the additional standards CCBS and SDVISta. However, recent investigations revealed systemic sexual abuse and harassment.[20]

The most recent standard version in the Verra VCS programme (version 4.7, April 2024) requires explicitly that a project has to demonstrate how its activities actively contribute to the United Nations Sustainable Development Goals (SDGs) and the host country's SDG objectives. The Climate Action Reserve requires project developers to monitor a project's contributions to the SDG and to report on this by using an SDG reporting tool at each verification. Plan Vivo requires that smallholder and community projects show how they generate climate, livelihoods and environmental benefits compared to a baseline. The CCBS and Sustainable Development Verified Impact Standard (SDVISta) require the assessment and reporting of sustainable development impacts in a qualitative and quantitative manner (Schneider and Wissner 2022).

Climate change mitigation through carbon-offsetting is seen as the primary goal of Blue Carbon projects. However, BC projects usually also aim at improving environmental conditions, ecosystem health and the livelihoods of the local population. BC projects are considered a natural climate solution in the frame of nature-based solutions addressing global challenges related to climate, food security and sustainable and just development (Chausson et al. 2020; IUCN 2012; Macreadie et al. 2021; Nesshöver et al. 2017).

Besides carbon storage, Blue Carbon ecosystems supply a multitude of other ecosystem services, also referred to as co-benefits. Water purification, nutrient removal, coastal protection and fisheries enhancement - to name only some (e.g. Macreadie et al., 2021, and references therein; Hagger et al., 2022). BC projects are typically restoration and conservation projects which aim at improving ecosystem structure, functions and services. First, by stopping ongoing degradation and further mainly through reforestation and by hydrology restoration. Alongside these interventions, projects often include activities that benefit biodiversity and the livelihoods of the local population, e.g. by creating job opportunities in the management and monitoring of the

[20] Hengeveld, M. (2023) – Offsetting human rights: Sexual abuse and harassment at the Kasigau Corridor REDD+ Project in Kenya, available at: https://www.somo.nl/offsetting-human-rights/.

project activities, or offering trainings for locals, which empower them to establish their own sustainable businesses like ecotourism.

Looking at the projects investigated for this report, all BC projects mention positive effects of the project on environmental and socio-economic conditions in the project area - some more, some less extensive. The Vida Manglar project (no. 2) in Colombia demonstrates in detail its positive effects on biodiversity and local communities through "increased capacity for local territorial governance and natural resource management" and "economic empowerment of vulnerable groups and increased job opportunities in the project area" (p. 313 and 299 in the PDD of project no 2, Table 5). The Guinea-Bissau project (no. 5) similarly details a number of benefits for the environment and biodiversity in its project plan, while specific community benefits, except for consultation and participation in management meetings, are not mentioned. The verification report states that no potential negative environmental and/or socio-economic impacts were identified. Plan Vivo certified Mikoko Pamoja project (no. 4) in Kenya initially aimed at supporting local mangrove communities through protecting and sustainably using the mangrove ecosystem in a payment for environmental services (PES) scheme that includes generating carbon credits for the VCM. The project claims numerous co-benefits, for example, it enhances the community's income and creates jobs for the local population as well as community enterprises, for example in ecotourism. Moreover, project developers state that it has positive effects on flora, fauna, habitats and sediment stability.

The extensive Delta Blue Carbon-1 project (no. 5) in Pakistan also has a focus on community benefits and states that the project will generate 21,000 jobs. It is additionally verified with the Verra CCBS and therefore, besides mangrove reforestation, explicitly mentions a number of social benefits. Such as: participatory planning and awareness raising, access to education, sustainable fisheries, access to safe drinking water and healthcare, community-based business development and income generating activities for women. The VCR Seagrass Restoration project in the United States (no. 7) with its major goal to plant seagrass in areas, which formerly had a large cover that was lost to diseases and hurricanes, is not claiming direct social impacts. It is argued that the restored ecosystem will provide numerous ecosystem services besides carbon sequestration, e.g., food, nursery and spawning habitat, and refuge for blue crab, bay scallops, and numerous other invertebrates and fish species. Moreover, negative socio-economic impacts are not expected. As seagrass is the preferred habitat of bay scallops, which once were abundant and supported a commercial fishery, the restoration of the seagrass may also allow for restoration of scallops in the project area. The Zhanjiang MAP project in China (no. 6) forecasts until the end of the project in 2055 that (i) a total number of 300 (160 of which female) community members have improved skills and/or knowledge, (ii) a total number of 300 people (including 160 women) are expected to be employed in project activities, (iii) a total number of 300 people (including 160 women) have improved livelihoods or income generated, (iv) 20,279 hectares are managed significantly better by the project, and (v) a number of two globally critically endangered or endangered species are benefiting from reduced threats as a result of project activities (see PDD for project no. 6 section 3.2).

### Preventing double counting

Double counting occurs if the same mitigation outcome is counted more than once towards the achievement of a mitigation goal (Fearnehough et al. 2020; Schneider und La Hoz Theuer 2019). There are three types of double counting that can be distinguished:

- Double issuance of credits for the same mitigation outcomes, e.g. by two different crediting programmes;

- Double use of credits that are cancelled twice in a programme's registry;[21]
- Double claiming by two different parties who use the same credit to achieve different climate targets.

Any of these types of double counting can lead to higher net emissions in the atmosphere and thus undermine the environmental integrity of a crediting mechanism (Schneider et al. 2015; Prag et al. 2013; Fearnehough et al. 2020; Böttcher et al. 2022; Schneider et al. 2022b; Siemons et al. 2023).

For Blue Carbon projects, there is a potential risk of **double issuance due to indirect overlaps between projects**. Double issuance may occur when a Blue Carbon project takes place in the same geographic area as a project reducing firewood consumption (e.g. efficient cookstoves or household biodigester projects). The aim (and the outcome) of these two projects is the reduction of wood gathering. Thus, the two projects might claim the same removals or emission reductions. This risk could be addressed during the project appraisal process by implementing systematic checks whether the project area overlaps with that of other carbon market projects (Schneider et al. 2022b). Provisions to address this risk of double issuance through indirect overlaps between Blue Carbon and other mitigation projects are currently not implemented by any programme considered in this study.

Additionally, the risk of **double claiming** is relevant for all carbon crediting programmes, including Blue Carbon projects. A removal achieved by a Blue Carbon project can be claimed by the host country or jurisdiction that report lower emission levels to achieve its Nationally Determined Contribution (NDC). At the same time, the removal could be claimed by another country or entity that acquires the carbon credit.

To avoid double claiming of mitigation results by two countries towards their NDCs, mitigation activities need to be **authorized under Article 6** of the Paris Agreement. The host country selling authorized carbon credits needs to make '**corresponding adjustments**' to their reported emissions, i.e. increase its emissions balance upwards by the number of credits sold. The buyer country needs to make (downwards) 'corresponding adjustments' to its emissions balance under Article 6 of the Paris Agreement in order to use these credits towards its NDC (Schneider et al. 2022b).

Double claiming can also occur between host countries if Blue Carbon projects and buyers on the voluntary carbon market. This is the case if private actors purchase and claim credits from projects on the VCM and the same mitigation outcome is simultaneously accounted by a country towards meeting its NDC (Fearnehough et al. 2020). To avoid this, the host country of the Blue Carbon project would need to authorise the mitigation activity for "other purposes" under Article 6 of the Paris Agreement, which includes use on the VCM (see also Reise et al. 2025).[22] Similar to double claiming by two countries, the host country would also need to apply 'corresponding adjustments' to its emissions balance (corresponding to the authorised credits) (Schneider et al. 2022b).[23]

[21] Double use is a general risk of carbon markets and can be addressed by transparent registries that provide comprehensive information on credited projects and on the use of carbon credits. This is generally the case for the three crediting programmes relevant for this study.

[22] This also includes use of carbon credits by an aeroplane operator towards its compliance obligation under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

[23] The decisions under Article 6 of the Paris Agreement thus make it possible for project developers on the voluntary carbon market to seek Article 6 authorisations from host countries which imply that host countries need to apply corresponding adjustments to their emissions balance. However, there is an ongoing debate about the question whether authorised or non-authorised carbon credits should be used in the voluntary carbon market and for which kind of claims such credits can be used (Kreibich und Hermwille 2020; Fearnehough et al. 2020; Streck et al. 2023).

To avoid double claiming, carbon crediting mechanisms, as well as countries participating in these mechanisms need to have rules in place to track emission reductions and removals that are authorised and transferred for Article 6 purposes. To this end, the purpose for which credits are used must be clearly documented (i.e., the beneficiaries, the goal that is achieved through credits, calendar years) and transparently documented by the programme. If credits are to be used towards an NDC, programmes should require that the authorisation for such use be documented and make the earmarking for such use visible in the registry. Similarly, a tag should be available in the registry for credits, which are authorised by host countries for use on the VCM (Schneider et al. 2022b).

With the revision of its programme manual in April 2024, the Climate Action Reserve put provisions in place that require host country authorisation if credits are to be used under Article 6 of the Paris Agreement. For this purpose, corresponding adjustments, the authorisation letter by the host country, as well as the purpose a credit is used for (NDCs, CORSIA obligations or use on the voluntary carbon market) will be documented in the registry (Climate Action Reserve 2024). The VCS has rules in place to avoid double claiming of credits under Article 6 and established corresponding labels in its registry (VERRA 2023b). A clear documentation of purposes for which credits have been used is in place in VCS's registry. Plan Vivo currently does not have any provisions on corresponding adjustments or authorisation under Article 6 in place. In Plan Vivo's registry, no transparent information on the purposes for which retired credits are used is available.

For countries that have economy-wide absolute emission reduction targets, emissions and removals from Blue Carbon ecosystems potentially fall within the scope of their NDCs; yet this depends on whether these countries report on emissions and removals from Blue Carbon ecosystems in their GHG inventories. Currently, only a limited number of countries do so (see Green et al. 2021; Reise et al. 2024). With regard to the countries where the selected Blue Carbon projects are implemented, reporting is most advanced in the USA. Double claiming of removals from the VCR Seagrass Restoration project (no. 7) by the US and buyers of the credits of this project could therefore be an issue.

# 4 Summary and conclusion

Coastal ecosystems store carbon primarily in mangrove forests, seagrass meadows and tidal marshes. Despite some of them benefitting from a certain degree of protection, global carbon stocks in these ecosystems have declined over recent decades. For mangrove forests, the primary drivers of this loss include land-use pressures through rice cultivation and aquaculture, minor drivers are the use of the habitat for fuelwood collection and subsistence farming.

Carbon credits offer an opportunity to attach an economic value to the carbon storage function which coastal ecosystem provide. As such, they offer a potential source of funding for activities aimed at restoring degraded coastal habitats or safeguarding existing ones from further degradation.

However, unlike other forms of financing, such as philanthropic contributions or development assistance, the use of carbon credits as a funding mechanism introduces a critical responsibility. If used to meet climate mitigation targets, each credit issued permits a corresponding tonne of $CO_2$ emissions elsewhere, making the environmental integrity of the credit essential. If credits are issued without ensuring additionality, permanence, and conservative carbon accounting, the result may be a net increase in global emissions. In effect, society could be subsidising new coastal ecosystem protection and restoration efforts with higher levels of atmospheric $CO_2$ – a counterproductive outcome. This emphasises the need for stringent safeguards, robust methodologies, and strong oversight mechanisms to ensure that carbon crediting genuinely supports climate mitigation rather than undermining it.

There are many different project types, with Blue Carbon projects being a more recent addition to the portfolios of carbon crediting programmes in the voluntary carbon market. They currently play a small role, reflected by a comparatively low number of issuances. This may change in the future, as the level of interest in the project type picks up and a pipeline of more than 50 projects is currently under development.

This report attempted a systematic assessment of the specific risks and opportunities, which may arise when using carbon crediting mechanisms to finance the protection and restoration of coastal ecosystems, with a particular focus on their effectiveness in enhancing carbon storage and reducing emissions. The assessment draws on empirical evidence from a small sample of seven projects registered with carbon crediting programmes in the voluntary carbon markets. The sample represents about one third of all registered Blue Carbon projects at the time of writing. It is skewed towards mangrove conservation and mangrove restoration projects, as there are currently no registered seagrass or tidal marsh restoration projects. Inputs for the assessment were project design documents and monitoring reports as well as other documentation made available through the registries of the carbon crediting programmes under which the projects are registered. The assessment also considered rules of carbon crediting programmes applying to all project types, where relevant. Finally, peer-reviewed literature as well as grey literature was used to contextualise the observations from the project sample and inform the analysis.

Main findings and conclusions regarding the following dimensions were:

- **Additionality**: Project activities like mangrove replanting, forest patrols, and training programmes to create alternative economic livelihoods for local populations incur costs but do not generate income for project owners. All projects in the sample clearly demonstrated that financial incentives were necessary to implement the mitigation activities. However, it was less clear whether revenues from carbon credits were the only available funding source and what role they played for the overall financial viability of the projects. In several cases, agencies managing the sample projects had previously received development assistance or philanthropic contributions for similar activities, including project preparation. However, project design documents provided limited information about project costs and the role of other funding sources, preventing a full evaluation of the materiality of associated non-additionality risks. A related observation from the project sample for all cases is that submission of PDDs to the respective carbon crediting programme took place only *after* the replanting or conservation activities had already begun. It is common practice in carbon markets to allow registration after the start of mitigation activities as preparing the necessary analysis and documentation for registration can take several years. However, if projects operate for a long time without receiving carbon credit revenues, it becomes increasingly difficult to determine whether the prospect of carbon financing was a decisive factor in initiating the project. In one extreme instance, project developers submitted their PDDs nine years after project activities had commenced.

The assessment also found that project developers currently prefer to implement Blue Carbon projects in areas that already hold some form of protected status, such as national parks. This overlap between project sites and protected areas introduces some risks of non-additionality, as certain activities assumed to occur in the baseline scenario – such as mangrove logging—are already prohibited under protected area regulations. Risks might however be low in cases where these restrictions are not enforced. Moreover, the preference for locating projects within protected areas suggests that current Blue Carbon projects may not yet contribute meaningfully to global targets like the Convention on Biological Diversity's (CBD) 30x30 initiative, which aims to expand the global network of protected areas. Yet, it is important to note that this finding is based on a small sample of early-mover projects, and future projects may shift this trend. Project developers may also have legitimate reasons for focusing on protected areas, as these locations often present fewer risks of conflict with local communities, given that land-use restrictions are already in place and do not need to be newly introduced.

Overall, and despite these concerns, there is no evidence from the project sample to suggest that non-additionality risks for Blue Carbon projects are more pronounced than for other types of projects. The main risks for individual projects arise from their intersection with protected areas and the potential availability of alternative revenue streams. While these integrity concerns exist, there are two key measures that carbon crediting programmes can implement to further reduce non-additionality risks. First, they should require project developers to publicly disclose a comprehensive financial analysis, including a detailed breakdown of costs and a clear distinction between carbon market revenues and other funding sources. This information could also help guide the scaling-up of similar projects. Second, carbon crediting programmes should require project developers to submit a notification of intent as soon as they decide to proceed with the project. This could help reduce uncertainties in cases where project documentation is submitted after the mitigation activities have already begun. One project in the sample already provided such information on a voluntary basis.

- **Quantification:** Quantifying carbon benefits in coastal ecosystems is complex, and results are inherently associated with uncertainties. Coastal ecosystems exhibit high spatial and temporal variability in carbon dynamics, making it challenging to develop standardized measurement approaches for carbon quantification methodologies. The main carbon pools are above- and belowground biomass as well as soil organic carbon, while key emission sources are microbial methane production and fossil fuel use. Quantification methodologies include all relevant carbon pools and emission sources in the greenhouse gas assessment boundary. However, they allow the exclusion of certain minor emission sources, which could lead to overestimation of emission reductions or removals, though likely not substantial.

Potentially substantial overestimating risks are associated with the approaches to estimating baseline deforestation rates in mangrove *conservation* projects as the respective methodology offering registration for this subtype provides project developers with considerable flexibility in selecting reference areas and periods. One project in the sample, for example, assumes that baseline deforestation would result in the loss of 67% of mangrove carbon stocks by the end of the project crediting period. Considering that the project takes place in a protected area, this may be a very aggressive assumption. In contrast, mangrove *restoration* projects are less affected by systemic baseline uncertainty as in many cases mangrove habitat would remain degraded lands without the project interventions. However, individual projects may overestimate carbon removals if they fail to account for the possibility that restoration might have occurred through alternative funding sources under the baseline scenario. This risk is particularly relevant in areas with a history of successful mangrove restoration activities. Addressing this matter would be relatively straightforward. For example, by requiring project developers to apply conservative deductions to the credited project area in such contexts.

Measuring the effect of project activities on changes in carbon pools occurring between baseline and project scenario is inherently uncertain. The lack of long-term data on carbon fluxes, especially in restored ecosystems and for non-mangrove habitats like seagrasses and saltmarshes, makes the estimation of these changes challenging. For biomass, the main uncertainties result from the selection of appropriate allometric equations, the number of sample trees used to construct these equations, as well as location and placement of sample plot design for ex-post measurements of removals. Carbon estimates in all sample projects are affected by these uncertainties. Whether these are more likely to lead to over- or underestimation of emission reductions or removals in the project sample was inconclusive for projects in the sample. Organic soils are by far the largest carbon pool of Blue Carbon ecosystems and at the same time the most difficult to monitor. Obtaining necessary data requires specialised expertise and access to laboratory equipment. Measurement is further associated with high costs and therefore field data are scarce and based on few samples. Soil carbon quantification remains highly uncertain and could lead to overestimation if projects use field-data which are not representative of the full project area or if refined scientific research finds that default values overestimate soil accumulation rates. For other projects, adverse selection due to the flexibility in the VCS methodology could therefore become an issue. A further cause of uncertainty is the accounting for methane emissions from microbes. None of the sample projects currently accounts for methane emissions which is consistent with the requirements of the respective quantification methodologies. In line with the precautionary principle, carbon crediting programmes should closely monitor emerging scientific evidence on methane emissions from mangrove replanting and be prepared to adjust methodologies accordingly.

- **Non-permanence:** Non-permanence is a further critical concern in Blue Carbon projects due to the inherent vulnerability of coastal ecosystems to both human and natural disturbances. Unlike engineered carbon removal solutions, durability of carbon sequestration depends on maintaining ecological integrity of the project area. However, factors such as extreme weather events, sea level rise, erosion, pollution, and land-use pressures pose ongoing risks of carbon reversals—that is, the release of previously sequestered carbon back into the atmosphere. While carbon crediting programmes require buffer reserves or risk discounting to account for such uncertainties, the adequacy and transparency of these measures vary.

Most Blue Carbon projects have a duration of 20-40 years and therefore do not qualify for permanent removals, which would require maintaining carbon stocks in these ecosystems for 100 years or more. Additionally, in the case of the VCS, monitoring by the project developer may cease after the end of the crediting period. Also, none of the crediting programmes seems to have liability mechanisms in place in case the programme ceased its operations. These challenges can undermine the integrity of Blue Carbon credits, particularly if these were used for offsetting claims. There is a need for stronger liability mechanisms, and continuous monitoring to ensure that claimed mitigation benefits are not lost over time. Yet, reversal risks can never be fully avoided for Blue Carbon projects. This is a finding that applies not only to Blue Carbon projects but all projects that monetize the carbon storage function from ecosystems.

- **Safeguards, benefit-sharing and contribution to SDG goals:** Coastal ecosystems are rich in biodiversity and highly vulnerable to environmental stressors. Further, about 15% of the global population live within 10 kilometres of the coastline. Often this includes local communities which depend on coastal ecosystems for livelihoods and subsistence. Like any other project activity in these ecosystems, Blue Carbon projects should not negatively affect the environment they operate in or the local communities relying on these ecosystems. Stringent environmental and social safeguards (E&S safeguards) are a key instrument to ensure that projects follow inclusive design processes and include effective environmental management plans which avoid, minimize and compensate for any negative impacts. All carbon crediting programmes under which the sample projects are registered have E&S safeguards. Further, in the process of aligning with core carbon principles of the Integrity Council for the Voluntary Carbon Markets (IC-VCM) many recently improved their E&S safeguard provisions. These, however, do not apply to the sample projects, which have received registration before these updates. Two projects in the sample included a description of elaborate benefit-sharing systems in their project documentation. These included project governance structures which include direct involvement of local communities in project steering as well as arrangements for distributing revenues from monetization of carbon credits to local communities. One project set a minimum floor of 60% of revenues to go to local communities. Blue Carbon projects potentially have high co-benefits which benefit biodiversity and the livelihoods of the local population, e.g. by creating job opportunities in the management and monitoring of the project activities, or offering trainings for local communities, which empower them to establish their own sustainable businesses like ecotourism. This report, however, did not involve interviews or field visits to validate if the arrangements and benefits described in the project design documents work well or materialize on the ground. Answering this question would benefit from further empirical research. Overall, because of their location in vulnerable ecosystems which are home to local communities, exerting utmost precaution in project design and implementation appears to be appropriate. To date there are no known reports of Blue Carbon projects being involved in negatively impacting the environment or lead to conflict over land use. This finding is, however, based on a very small number of projects, which all take place in already protected areas with existing protection regimes which might offer less potential for conflict. For the more than 50 projects in the pipeline close monitoring will be required to ensure that they comply with all safeguards.
- **Double counting:** Risks of potential indirect overlaps between BC projects and other mitigation projects are not addressed by any programme considered in this study. Additionally, potential risks for double claiming exist if a national NDC covers BC activities. Currently, CAR and the VCS have rules in place to avoid potential double claiming by

requiring the host country to apply corresponding adjustments while rules are lacking for Plan Vivo. Without such rules, there is a danger that Blue Carbon credits could undermine rather than complement national mitigation efforts.

In conclusion, the report shows that integrity risks are material when using carbon credits as a funding mechanism for new measures to conserve and restore coastal ecosystems. These risks relate to all core dimensions of crediting – additionality, quantification, permanence, safeguards and double counting. The project sample shows that there is evidence that risks also materialize in concrete projects on the ground.

The sample projects, however, also highlight the availability of design choices which very likely lead to conservative estimates of carbon removals in mangrove restoration projects. A straightforward approach seems to be to forego accounting of soil organic carbon stocks until there are more robust ways to measure the effect of mangrove replanting on this carbon pool. Revenues from monetizing biomass carbon stocks may still be significant, although further insight into cost data would be needed to determine if they are sufficient to fully cover restoration costs. One methodology already does not allow to account for soil carbon, suggesting that this might be a financially viable model for some mangrove restoration projects.

In the meantime, Blue Carbon projects could directly help to reduce uncertainties in quantifying soil organic carbon if they would commit to regularly measuring changes in the soil carbon pool and making these data available to the scientific community. For example, if the more than fifty projects currently under development collectively agreed to periodically collect field data using statistically robust measurement techniques, it could significantly advance the creation of a reliable global database on soil carbon accumulation rates. Given that crediting periods for these projects range from 20 to 60 years, such a database could generate meaningful time series that would inform both project development and a better understanding of carbon flux dynamics in these ecosystems. Carbon crediting programmes and public agencies could support these efforts by creating a platform that connects individual projects, fosters peer-to-peer learning, and builds communities of practice to support measurement efforts and facilitate data exchange between projects and the scientific community.

Close cooperation between scientists and project developers would contribute significantly to solving the identified problems and also advance academic research, creating a win-win situation. The knowledge required to develop carbon quantification methods is produced and made available by academic science. Until now, that has been the end of their job. Blue carbon project developers and implementers apply this knowledge and carry out the necessary activities for quantifying GHG fluxes. Closer involvement of scientists in project development would help to ensure that scientific methodologies are correctly applied and capacities of field staff strengthened It would further benefit both sides: The projects would have a much more robust data base, and academic science would have the opportunity to acquire time series data that contribute to scientific progress.

Even if projects use design choices which approach quantification conservatively, certain integrity risks such as the non-permanence risks of avoided emissions and removals remain. This means that caution should be applied when using resulting carbon credits for meeting mitigation targets. Stronger liability mechanisms and continuous monitoring are crucial. In the absence of stronger rules by carbon crediting programmes, projects could unilaterally address these concerns by voluntarily agreeing to monitor project areas for up to 100 years after the end of the crediting period and to compensate any reversals that occur during this period. Alternatively, credits from Blue Carbon projects could be issued as temporary credits with a limited validity, accompanied by requirements from the crediting programmes to replace these credits with permanent mitigation activities upon their expiry. Again, here more dialogue between project developers, carbon crediting programmes and interested buyers of Blue Carbon credits could be useful. In a market that moves towards credits which provide more reassurance of environmental integrity, inability to demonstrate sufficient arrangements to demonstrate permanence might become an impediment over time to sell carbon credits from Blue Carbon projects. This might point to the need to open a space for all actors in the market to explore how institutional arrangements could be created that effectively monitor and compensate for any reversals in coastal ecosystems.

Finally, conserving or restoring coastal ecosystems could also be a viable project type for companies shifting away from traditional carbon offsets. Instead of using offsets to meet emission reduction targets, these companies could contribute directly to global climate protection efforts through ecosystem-based initiatives such as coastal ecosystem conservation and restoration efforts.

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